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Amenity trees and green space structure in urban settlements of Kigali, Rwanda

J.L. Seburanga[a,c,*], B.A. Kaplin[b], Q.-X. Zhang[c], T. Gatesire[a,d]

[a] National University of Rwanda, Faculty of Science, University Avenue, Box 117, Huye, Rwanda
[b] Department of Environmental Studies, Antioch University New England, 40 Avon St., Keene, NH 0343l, USA
[c] School of Landscape Architecture, Beijing Forestry University, Beijing 100083, PR China
[d] DFGFI-Karisoke Research Center, P.O. Box 1005, Musanze, Rwanda

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ABSTRACT

According to the national policy, overall forest and agroforestry cover in Rwanda is to increase up to 30% land cover by 2020. On the other hand, demographic data reveal that Rwanda's urban areas are among the fastest-growing on the continent. Unfortunately, there is only little information of the effects of such a rapid urbanization on tree cover and green space structure, knowing that data on urban plant assemblages in the country are rather rare. The paper discusses developments in Kigali's green spaces with regard to its rapid rate of expansion. An integrated approach of research, combining results from interview sessions, desk-based investigations, walk-over and vegetation surveys, and photogrammetric analyses of remotely acquired imagery was applied. The findings suggest that the city green space network consists of plant assemblages largely dominated by alien species (75%). Tree cover fraction averaged at around 10–35%. No significant difference was observed between field-drawn and photogrammetric-based fraction of tree cover estimates; making the later a quick but cheap tool for rapid tree cover evaluation. Cultivated forests, urban woodlots and domestic garden tree stands are far the most dominant types of green spaces in terms of coverage of city surface area. Street tree communities and institutional gardens appear to be the most intensively designed green space layouts. Both distribution and species composition in domestic gardens were socioeconomic-driven. For instance, palm trees were characteristic of fortunate quarters while fruitbearing ornamental such as *Psidium guajava* and *Persea americana* were common within scattered and informal settlements. *Markhamia lutea*, *Erythina abyssinica*, *Euphorbia candelabrum*, *Phoenix reclinata* and *Acacia sieberiana* are among native taxa that thrive to keep a place in the city. *Euphorbia tirucalli*, a native tree that is widespread in home compound fences within informal settlements, is significantly declining as modern housing expands and concrete-based fences replace live enclosures.

Introduction

Tree stands around homesteads, whether deliberately cultivated or allowed to grow naturally, have been recognized as an essential feature of human settlements (FAO, 1985). In cities, plant communities can provide a wide range of ecological services including the conservation of biological diversity, air and soil pollutant removal, carbon sequestration, oxygen renewal, ground water recharge, soil protection, and urban cooling effects through the increase in evapo-transpiration and wind course regulation (Bolund and Hunhammar, 1999). Used in home gardens, in neighborhood woodlots or in larger patterns such as screening and shading effects within urban parks, institutional grounds, i.e. non-built-up surroundings of a complex of buildings that house a hospital, a church, a school or alike, and street verges, trees play a key role in shaping landscapes by playing important ecological, social and economic functions (Nowak et al., 2002) and by adding beauty to the surrounding of human life (Fourie, 2005).

Although they cover less than 3% of the global terrestrial surface, cities share about ¾ of carbon emissions and industrial wood demand, and around 60% of residential water consumption (Singh et al., 2010). According to the road map vision 2020, through which Rwanda aims to transform its economy into a middle income country by the year 2020 (Minecofin, 2012), the proportion of urban dwellers was to increase from 12 to 30% (Minecofin, 2000).

According to national strategic plan for the forest sector, overall forest and agroforestry cover in Rwanda was planned to increase from 20 (in 2006) to 23.5% (in 2012); with a target to reach 30% land cover by 2020 (Nafa, 2010; Minecofin, 2000). On the other hand,

* Corresponding author at: National University of Rwanda, Faculty of Science, University Avenue, Box 117, Huye, Rwanda. Tel.: +250 784860448.
E-mail address: seburanga@yahoo.fr (J.L. Seburanga).

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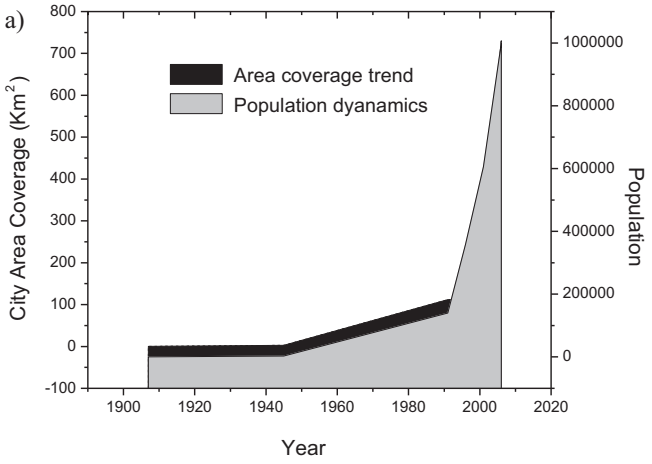
a)



b)

Land use type	% Cover
Forests	24.0
Cemeteries	0.5
Landfills	0.1
Airport Coverage	34.0
Institutional Lands	5.1
Public gardens	0.6
Swamp Areas	18.2
Roads	0.3

Fig. 1. Kigali city growth and land use profile.

demographic data from Sano (2007) reveal that Kigali, the capital city of Rwanda, has registered an increase of more than 700% in population in just ac15 years period, from 1991 to 2006 (Fig. 1). In such a context, there are serious concerns over the dynamics of green spaces around Kigali's urban areas, knowing that landscape planning and design is yet to be extensively explored in the country.

Rwanda's current forestry policy was initiated in 2004 and updated in 2010. With an initial goal to achieve a total forest land cover of 30%, forests had already expanded by 37% since 1990 such that, in 2011, it received an international award as the 'world's most inspiring and innovative forest policy' (Minirena, 2013). In the area of urban forestry, it is equally promising as it recognizes that more effort should be made to take Rwanda's urban tree planting to a higher standard by insuring that urban forests are not a luxury an important component the livelihood of urban population. Key strategic actions include: [1] creation of mandatory boulevards in all urban neighborhoods; [2] inclusion of tree plantation in urban planning; [3] provision of urban authorities with technical support in tree nursing and husbandry; and [4] involvement of private service providers in the management of urban forests for leisure and recreation purposes (Minifom, 2010). Unfortunately, the policy does not address issues arising from low levels of specialization of stakeholders in urban forestry-related fields of study, i.e. landscape architecture, landscape planning, and green space design.

This study aims at discussing past and current developments as well as future orientations in green spaces with regard to the rapid rate of urbanization in Rwanda. Specifically, it has the objective to analyze the relationship between Kigali's urban setting and its green structure, the dynamics of urbanization and related green space change.

Materials and methods

An integrated approach of research, combining results from interview sessions, desk-based investigations, walk-over and vegetation surveys and a photogrammetric analysis of remotely acquired imagery was applied. Walk-over surveys were used as a source of ancillary data and consisted in walking around the study site with a map, recording any species or landscape feature of interest or missed during the formal vegetation survey.

Study site

The study was conducted in Rwanda, a small landlocked country in Central-Eastern Africa, located at 2°00 South latitude and 30°00 East longitude. The entire urban region of capital Kigali was surveyed within its official boundaries as defined per Organic Law No N° 29/2005 of 23/12/2005 determining the administrative entities of the Republic of Rwanda (Minijust, 2012). Created in 1907 as a small colonial outpost with little link to the outside world, the city has now grown into a modern metropolis (Kigali city, 2012). As one of the fastest growing cities on the African continent, it is characterized by high annual area and population growth rates [more than 700% from 1996 to 2006 (Fig. 1)]; rates at which, had they been sustained and applied to all cities, Rwanda could become a city–state in just 22 years to come. According to the provisional results of the 2012 population and housing census, the population of Kigali amounted to 1,135,428 inhabitants in 2012, suggesting a milder increase of 148% from 2002 (765,325 inhabitants) (Nisr, 2012).

As of 2001, the fraction of public gardens represented just a tiny proportion (0.6–1%) of overall green cover in Kigali city, estimated at more than half of total land and mainly composed of urban forests and swamps (Kist, 2001). The current estimates are much different because of recent developments in the area of city beautification. This study explores current trends in tree population and green space development within the city's settlements. Four types of settlements were investigated, namely [1] scattered homestead systems, [2] village clusters, [3] spontaneous and [4] western style residential neighborhoods. The surveyed scattered settlements and villages clusters are located within the outer ring of the city, which is characterized by a kind of mosaicked farmland interwoven with rural-like built-up areas. On the other hand, western style residential neighborhoods and spontaneous urban settlements, also hereafter referred to as informal settlements, were sampled within the metropolitan area. They lie, more or less, within the inner core of the city and consist of land with continuous closely spaced buildings (Forman, 2008).

Data acquisition and analysis

Photogrammetric data

A 0.4 km × 0.4 km grid was overlaid on the city image. All residential grid cells were counted, labeled and stratified into four settlement types: scattered homesteads, cluster villages, spontaneous and formal residential neighborhoods. In total, 16 snapshots of residential landscape layout were taken, enhanced and supervisedly classified into two land cover categories (tree cover and non-tree cover) and converted into numeric formats (Thomas et al., 2008). Fig. 2 illustrates the path followed to extract image metrics using the Information Tool of Erdas Imagine 9.1 software.

The ultimate statistical report sheet (step 5 on Fig. 2) offered all the information needed in order to compute the fraction of cover for either land use type, namely [1] values of image width and height, extracted from the 'layer information data', as well as [2] the minimum, maximum and mean pixel values, retrieved from the 'statistical report'. The fraction of tree cover ($F_{TC} = X/N$) was then