

Socio-ecological systems and biodiversity conservation in African city: Insights from Kano Emir's Palace gardens

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Published online: 29 November 2012

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Abstract Urban biodiversity management in most African countries is at a peripheral stage. At the same time, African urban areas substantially remain poorly planned and intensively growing. This study explores the socio-ecological system as an alternative approach to explore African indigenous urban biodiversity management. For this purpose, we mixed conventional scientific investigation methods to explain the biodiversity conservation in the ancient gardens of the Kano palace in northern Nigeria. This multidisciplinary approach has successfully unveiled a harmonious relationship of humans and ecosystems in the context of African cultural values and heritage systems. The paper reveals that the palace gardens offer an avenue for intersection of a wide range of ecological and cultural activities. These include biodiversity conservation, recreation, security and surveillance, climate hazards proofing, and sacred dimensions. The findings of this study show that it is possible to address challenges confronting Africa's urban biodiversity through the combination of scientific and indigenous systems.

Keywords Biodiversity · Conservation · Socio-ecological system · Urban · Kano palace gardens

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Introduction

Urban biodiversity management in most African countries is at a peripheral stage. This is a common situation in developing countries where urban planning systems accord low priority to biodiversity (Qureshi and Breuste 2010). However, the neglect is at cost of urban environmental sustainability. In Africa, the externalities of cities on biodiversity widen rapidly (WWF 2010). The United Nations designates about 70 % of African urban areas as slums (UN Habitat 2003). This situation raises a question on the ability of urban biodiversity to thrive well in the slum-dominated cities. Nevertheless, studies indicate that informal urban settings and land uses like urban agriculture contribute significantly to conserving urban biodiversity (Piracha and Marcotullio 2003; Mouget 2005; Drechsel and Varma 2007; Qureshi and Breuste 2010). Cilliers and Siebert (2011) highlight some of the basic functions and features of flora and fauna in the human dominated urban areas in both developed and developing countries. Thus, weak urban planning systems are not pretext to disregard urban biodiversity in informal urban settings. For a city aspiring to be sustainable, Lehmann (2010) suggests that it preserves its open spaces, gardens and parks. Western style urban parks and gardens may be lacking in most traditional African cities and slums. Under Africa's atmosphere of planning uncertainty, it becomes imperative to harmonise conventional and nonconventional ways of urban biodiversity management. Researchers in developed and developing countries uphold the roles of knowledge and institutions in understanding urban biodiversity (Boraiah et al. 2003; Yli-Pelkonen and Niemela 2005). Institutions play key role in sustainability in human societies, as they are embodiment of norms, values and conventions that shape people's behaviours and how resources are used (Short 2007). In that regard, Gerber and Veuthey (2007) observed that in Africa, myths, mysteries and tales remain part of institutions that determine people's relations with the environment. This understanding may be desirous though it may not be globally rife. Nevertheless, it is important to look at the indigenous environment for traditional good practices and perspectives. In northern Nigeria, the failure of formal conservation has been associated with lack of appreciation of indigenous biodiversity management strategies (Etkin 2002). In view of this, urban administrators and managers need to appreciate the potentials of knowledge, values and institutions for urban biodiversity management. Due to overwhelming human impacts in the city, fusion of social and ecological aspects of urban ecosystems is important for drafting solutions (Kohsaka 2010). Thus, the use of planned cities' parks management approaches in unplanned or semi-planned urban areas may not be effective or sustainable. Where that is done, it creates a climate of confusions, conflicts and contradictions. It is evident that several studies focus on public gardens and parks for biodiversity management (Ward et al. 2010; Nagendra and Gopal 2011; Menke et al. 2011). Linking urban ecological and cultural processes in cities could help in resolving or understanding the negative impacts of Third World urbanisation on the urban ecosystem. This is because cities are products of and themselves socio-ecological systems embedded with multi-scalar capacity to address sustainability risks (Sassen 2009). This capacity lies in opportunities that policy frameworks (national, sub-national or supra national) offer as mechanisms for fostering sustainability almost in every city. The intensity of interactions of social and ecological systems in cities underscores the role of interdisciplinary research which is glaring in many studies (Pickett et al. 2001; Yli-Pekonen and Niemela 2005; McDonald and Patterson 2007; Kohsaka 2010). In the city, there are interfaces and interactions between people and urban ecosystems like, for example, gardens. Urban gardens in particular are noted for promoting local ecological knowledge and ecosystem services in many western cities (Hostetler 1999; Savard et al. 2000; Strohbach et al. 2009; Barthel et al. 2010).

Urban infrastructure decay in Africa is associated with poor governance, dependence on Euro-American planning perspectives and professionals (Parnell et al. 2009). This is a common challenge in African cities and that can be at the detriment of traditional urban land management practices. Therefore, it is interesting to look at the potentials of the indigenous systems. Indigenous systems create value systems, which reflect worldviews and/or cultural views on the environment. Such values are considered as institutions that play a key role in promoting conservation. Colding et al. (2003) suggested that “informal institutions may offer advantages relative to formal measures of conservation”. A reason for this can be that people internalise landscapes into their beings or perceive them as observable and cognizable features (Johnston 1998). Informal biodiversity conservation entails private initiatives by individuals, corporations and communities (Langholz and Krug 2004; Carter et al. 2008). One important question is how do we script and relay this to African cities facing biodiversity crises. If we take the example of Kano city, rapid urbanisation has done serious damage to the biodiversity as reported in Maiwada (2000) and Barau (2010a). In contrast to that, there is a view that older cities and their older roads and parks harbour higher species richness and diversity (White et al. 2005; Pickett et al. 2011). The situation of Kano city in this context is ambivalent. Ancient Kano city may not harbour a rich biodiversity, but it may only harbour biodiversity hotspots at micro scale. However, in spite of such experiences, African cities can harness approaches such as the Singapore Index (Chan 2011) to reconstruct urban biodiversity based on their heritage ecosystems. Our focus in this study is on Kano Emir’s Palace. Royal palaces have provided good examples of the juxtaposition of cultural and ecological values. For example, researchers in Saudi Arabia queried relations of urbanisation, modernisation and land use change and ancient palaces, citadels and castles (Al-Sheikh 2010). Elsewhere, palace managers themselves respond to the challenges. In the United Kingdom, new initiatives to uphold sustainability are emerging at Buckingham, Balmoral, Sandringham, Kensington, Marlboro House and other palaces. The initiatives involve energy saving, biodiversity protection and promotion, recycling and noise reduction mechanisms (The Royal Household 2008/2009). Such efforts are meaningful especially if we consider the fact that landscape changes affect different organisms at different scales (Hostetler 1999).

The goal of this paper is to investigate the social and ecological dynamics of the royal gardens of the Emir’s Palace. The specific objectives are as follows: to identify the gardens’ spatial coverage, floral and faunal composition; identify the gardens’ ecosystem services; and to examine the role of governance in conserving the palace biodiversity.

Conceptual underpinnings

Social/socio-ecological systems (SES) underscore scenarios of interactions between humans and biophysical environment through institutional regulations (Klůvankova-Oravská and Chobotova 2007). The authors maintain that institutions affect behaviours by determining the course of resource use through conventions, norms and rules governing the society. The socio-ecological approach aims to bridge social and natural sciences and upholds convergence of sustainability frameworks in observing cultural landscapes (Matthews and Selman 2006; Short 2007). The strength of the SES lies in its interdisciplinary capacity to understand problems and solutions in a more elaborate and integrated manner (Kangas et al. 2005; Cordell and Kerschner 2007). Variants of SES include coupled human and natural systems (CHANS) and social-economic-natural complex systems (SENCE) (Marcotullio 2008; Alberti 2011; Wang et al. 2011). The identified SES variants reflect urban dynamics and applications. Another capability of SES is its combined appreciation of cultural values, local participation, knowledge, and governance of natural resources (Liu et al. 2007). In this study, we applied this approach due to its penchant for interdisciplinarity and capacity to identify and

link the seemingly fragmented cultural and natural research areas. Another justification is the high probability that researchers would find it much easier to measure ecological aspects of developed cities (Rees and Weckernagel 1996), but certainly not in Africa where formal and informal urban spaces converge. There are agitations for citizens, scientists and urban managers to liaise in salvaging urban green areas (Jim 2011). The SES approach can be seen to be in a better position to harmonise disciplinary fragmentation through its linear and nonlinear capabilities. In the same context, the SES is important particularly for the ancient cities that remain substantially traditional in many fronts. The influence of old customs associated with ancient cities can create human-ecological balances (Taheri 1990). Old cities like Kano need to keep substantial proportions of biodiversity in order to benefit from its functions and services. Several studies have explored the influence of legends, myths, beliefs and other narratives on decisions and human-nature relations (Lyle 1996; Berndt 1994; Mathews and Stead 1998; Gunnell 2006; Gunnell 2008). In keeping with interdisciplinary research, this study combined field based ecosystem assessments and studies of cultural dimensions of ecosystems.

Methods and materials

The study site

According to Barau (2007a), Gidan Rumfa—the Kano palace—was constructed between 1479 and 1482. Gidan Rumfa is the largest traditional palace in Sub-Saharan Africa (Nast 1996), as well as the oldest continuous seat of traditional authority in Nigeria (Ibrahim 2001; Ado-Kurawa 2008). The historic importance of the palace makes it attractive for visits by the Queen of England, the US President, and the British Prime Minister among the roll call of dozens of world leaders (Barau 2007a). The Kano Palace covers approximately 14 ha surrounded by walls of 6–9 m height from outside and average of 5 m height from within the palace complex (Archnet 2010). The high walls of the palace surround the royal gardens (*sheka* in Hausa). The garden at the East (*shekar Gabas* in Hausa) and the West (*shekar Yamma* in Hausa) of Gidan Rumfa are located between latitude 11°59'29.02 N and longitude 8°31'11.96E. The western garden has a length of 325 m and an average width of 85 m, while the eastern garden has an approximate length of 370 m and an average width of 45 m. The two gardens constitute about 45 % of the total palace land area, the built up area cover roughly 30 % of the palace while the open spaces represent about 25 % of the total palace land area. The Kano palace is located on the Sudan savannah ecological region (Fig. 1). In the Sudan savannah, grasses and herbs dominate the landscapes and ecologists attribute the sparse distribution of trees to pedological conditions and use of fire (Deveineau and Fournier 2007). The trees species commonly found within 30 km radius of Kano city include: *Parkia biglobosa*, *Acacia albida*, *Anogeissus leiocarpus*, *Diospyros mespiliformis*, *Ziziphus spina-christi*, *Butyrospermum paradoxum*, *Vitex doniana*, *Acacia nilotica*, *Ficus sycomorus*, *Albizia chevalieri*, *Commiphora kerstingii*, *Sclerocarya birrea*, *Ficus spp.*, *Tamarindus indica*, *Balanites aegyptiaca*, *Guiera senegalensis*, *Terminalia macroptera*, *Bomax costatum*, *Lannea acida*, *Ziziphus mauritiana*, *Combretum micranthum*, *Piliostigma thoningii* (Cline-Cole et al. 1990).

Data collection and analysis

From the point of view of the socio-ecological approach, we considered the Kano palace as an institution, a cultural landscape and an individual household. Liu (2010) argued that

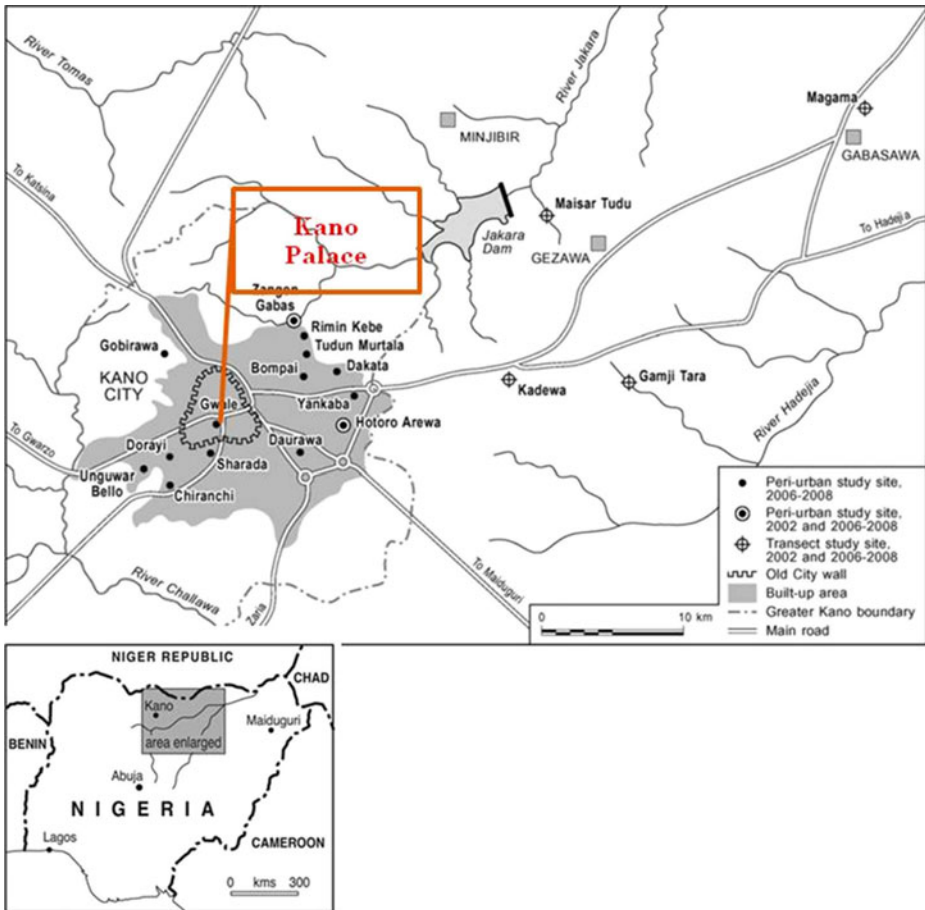


Fig. 1 Map of the study area showing urban Kano and the location of Kano Palace (adapted from Maconachie et al. 2009; Maconachie 2012)

environmental impacts of households and by implication smaller unit areas could be more intensive than large-scale areas. Taken as a household, the palace demonstrated interplays of environment and institutions. From the point view of landscape structure metrics (Leitao et al. 2006), the paper considered the palace gardens as habitat patches within the larger Kano city region. The data for this research were drawn from fieldwork, image interpretation, oral interviews and personal communications. Ground truthing was conducted to confirm the vegetation distribution as shown on the 2009 Google Earth image. The fieldwork was carried out in the rainy season of July 2010. The field and laboratory measurements aimed at:

- Identification of gardens size, trees morphological features (trees height, trunk width, canopy size)
- Identification of the major tree and bird species
- Analysis and comparison of tree diversity between the two gardens

We carried out measurements and observations at eight sets of 15 m×15 m quadrats mounted randomly and respectively within the two gardens. The selection of quadrat size

was based on the overall size of the gardens and the need to cover as much as possible the diverse tree and bird species in the gardens. The Google Earth image dated 2009 enabled measuring the size of the gardens as well as the selection of sites for placement of the eight quadrats in the two gardens (see Fig. 2). The quadrats were placed randomly and the placement was limited to parts of the gardens that were accessible to the researchers. The inaccessible areas were about one-quarter of the total gardens areal coverage. These inaccessible parts of the gardens were in the southern direction of both gardens. These areas constitute part of the Emir's private quarters in the east. In the western side, the inaccessible areas are the royal cemetery. We used the Google Earth image for a quick environmental scanning of vegetation clusters distribution in and around Kano city.

For examination of the gardens trees physical attributes (height, width, canopy) we used a 30 m tape (metric/inches) and a DBH (diameter at breast height) tape as used in studies around Kano and beyond (Arzai and Aliyu 2010; Nagendra and Gopal 2011). For birds' distribution, we observed bats and cattle egrets in the gardens during the field exercise between morning and afternoon hours for one day. In another day, from outside the gardens, we observed the departure of the bats from the palace in the evening and arrival of the cattle egrets at the same time. For the analysis of trees diversity, we used Shannon Index to calculate tree diversity using the Diversity Applet Software (Eck and Ryan 2009).

For the qualitative side of the research, we conducted oral interviews with a selection of palace residents. The selection of the respondents aimed at ascertaining historical, cultural



Fig. 2 Kano palace gardens are situated at the western and eastern edges of the palace. The palace's built up areas are located between the two gardens as shown in this Google Earth image

Table 1 The seven respondents answered open-ended questions based on their experiences with the Kano palace and its royal gardens

History of gardens	Ecosystem services	Management of the garden and residents' experiences
How long have these gardens been around?	What are the uses of the gardens?	What are the mysteries, myths associated with the gardens?
What are the structural and functional changes that affect the gardens over time?	What are the environmental functions of the gardens	What role does the Emir play in conserving the gardens?
	What are the disservices of the gardens?	Do you have any additional personal experiences with the gardens?

and functional values of the gardens. Socio-cultural values are part of the ecosystem services that are quantifiable at different spatial scales (Millennium Ecosystem Assessment 2003; Sherrouse et al. 2011). The seven respondents included four females and three males. We used snowball-sampling method to recruit them. Thus, one person (a local palace cultural researcher) facilitated identifying other persons that he thought had relevant information on the subject of research. We employed this sampling method because it is appropriate for a group of people with peculiar experiences on a given object of research (Wright and Stein 2005). Similarly, this sampling method is often used where small size groups of research participants are involved (Chromy 2008). The respondents were selected based on their age, sex, length of stay, familiarity with the gardens, and roles in the palace administration. Incidentally, all the respondents were born at the Kano palace and lived within it for at least 50 years. Two of the respondents (male and female) are high-ranking palace officials, while the rest belong to the low ranks. These research participants responded to the eight enquiries given in Table 1.

The interview conducted was of an informal conversational type (McNamara 1999). For this study, the respondents answered the questions in three informal groups (females, male officials and male servants). In general, in recording the responses we ignored repetitions of answers. We coded the respondents as RF1-4 and RM1-3 representing the respondents. RF for the four female respondents while RM for the three male respondents. Research has established that many spatial and social aspects of the Kano palace have gender dimension (Nast 1992). Each section of the palace interior space and activity from passageways to granaries are controlled by female slaves and concubines. In the course of field work, we observed that the private quarters of the Emir's wives and concubines have access routes to the gardens. This makes the gardens out of bounds to males for most parts of the year.

Results

Kano Palace gardens size, trees, bird species composition and other physical characteristics

Based on the measurements using Google Earth tools, we found that the western garden covered approximately 3 ha, while the eastern garden was approximately 2 ha. The Kano palace gardens harboured trees of varying physical characteristics and origin. There was no significant difference between the two gardens in terms of their physical attributes (Fig. 3). The distribution of species in the two gardens was almost same, except that both the number of trees and the number of trees harbouring birds were higher in the western garden (Fig. 4).

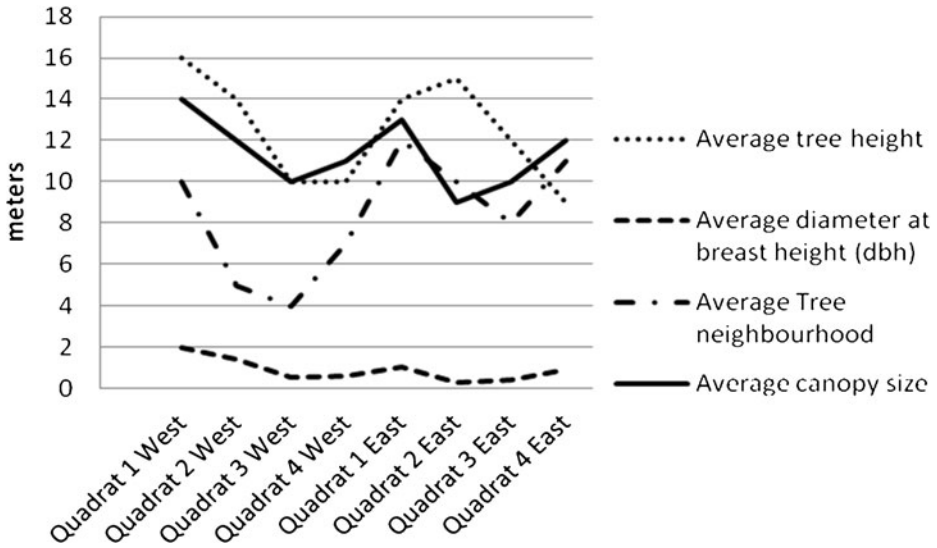


Fig. 3 Tree species physical characteristics in the Kano Emir’s palace gardens show similarities across the eight research plots. Probably many trees were planted at the same time

It is noteworthy that we observed some birds that we could not identify by species names. These bird species flew from one tree to another. Based on observation and measurement, the gardens developed a two-storey profile of an *emergent layer* of tall trees and an *understorey layer* composed of shorter and immature trees, shrubs grasses and garden floor covered by a thick layer of leaf fall. The intersecting canopy of the mature trees created permanent shade in some parts of the garden (see Table 2). We captured some of these scenarios in Figs. 5, 6, 7 and 8.

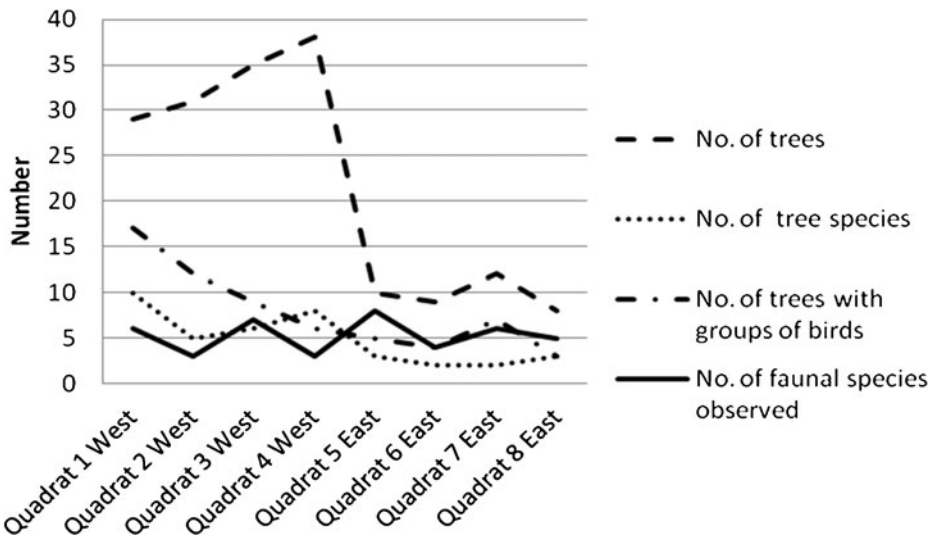


Fig. 4 Distribution of trees harbouring birds (cattle egret) and bats. These numbers were higher in the western garden, and the number of trees was also higher in the western gardens

Table 2 The floral and faunal composition in the Kano Emir's palace gardens was diverse. The trees species that belong to the lower profile are marked as "under-storey"

Floral composition		Faunal composition
Local plant species	Exotic species	Birds/Other animals
1. <i>Balanites aegyptiaca</i> (Desert date)	1. <i>Azadirachta indica</i> (Neem)	1. <i>Bubulcus ibis</i> (Cattle egret)
2. <i>Ficus thonningii</i> (Common wild fig)	2. <i>Mangifera indica</i> (Mango)	2. <i>Columbina passerina</i> (Dove)
3. <i>Adansonia digitata</i> (Baobab)	3. <i>Psidium guajava</i> (Guava) (under storey)	3. <i>Corvus albus</i> (Pied Crow)
4. <i>Tamarindus indica</i> (Tamarind)	4. <i>Carica papaya</i> (Pawpaw) (under storey)	4. <i>Columba livia</i> (Ferral Pigeon)
5. <i>Khaya senegalensis</i> (Mahogany)	5. <i>Vitis xx</i> (Grape)	5. <i>Eidolon helvum</i> (Fruit Bat)
6. <i>Borassus aethiopicum</i> (Deleb palm)	6. <i>Delonix regia</i> (Flamboyant) (under storey)	–
7. <i>Lawsonia inermis</i> (Henna)	7. <i>Citrus sinensis</i> (Orange) (under storey)	–
8. <i>Acacia nilotica</i> (Egyptian mimosa)	8. <i>Ficus spp.</i> (Fig) (under storey)	–
9. <i>Calotropis procera</i> (Sodom Apple) (under storey)	–	–
10. <i>Phoenix dactylifera</i> (Date palm)	–	–
11. <i>Parkia biglobosa</i> (Locust bean)	–	–
12. <i>Moringa oleifera</i> (Horseradish tree) (under storey)	–	–

Investigating the species composition and distribution between the two gardens is important. The Shannon Index analysis revealed that exotic species invaded the palace gardens (naturalised) leading to compositional and distributional imbalance within and

**Fig. 5** The two royal gardens are neither planned nor managed like typical urban parks



Fig. 6 The two gardens harbour two dominant faunal species (bat and cattle egret). The hovering of bats in the sky is an indicator of movements in the gardens and this is considered as part of security service that the gardens offer to the palace



Fig. 7 The ancient gardens are increasingly dominated by exotic species like Neem (*Azadirachta indica*) which is commonly found in both gardens



Fig. 8 In some parts of the two gardens both exotic and local tree species are fairly mixed giving a picture of a gallery forest rather than Sudan savanna vegetation type

between the two gardens. The values in Table 3 show that the gardens have a high degree of tree species diversity considering the influence of the lower value of D_1 as compared to H_1 and H_{\max} of the Shannon index. Similarly, there was a sharp contrast in tree species abundance and distribution between the two gardens. The high value for evenness indicated the extent of trees species similarity between the two gardens.

Ecosystem goods and services of the Kano Palace

In this section, we derived our results from the respondents. RF-1 stated that many people from Kano city came to the palace to look for some parts of trees (leaves, bark, roots, grafts, flowers) for medicinal uses. From within the palace, residents also used some of the garden's (waste) products for various domestic uses, e.g. cooking. RM-2 highlighted the camels' droppings seen in the western garden. He added that every year camels were introduced into the gardens to graze for no less than 10 days. The camels were brought into the palace for the biannual *durbar* festivals during (*Muslim eid* days). Thus, the gardens produce goods in the form of grasses, shrubs, and tree leaves that the camels feed on. RM-3 added that occasionally the fodders were also fed to the palace horses. The respondents concurred that the

Table 3 Tree diversity analysis in eastern and western gardens

Species	21
Individuals	49
H_1	4.03
$H_1 \max$	4.39
D_1	0.35
Evenness	91.8

gardens gave security to the palace from the windy storms of the rainy season, which wrecked roofs of many houses in the city. RM-1 identified the microclimatic aspects of the palace. He opined that the gardens made the palace cooler than many parts of the city.

Socio-cultural services of the Kano Palace gardens

As a cultural and administrative hub, the Kano palace attracts attention of researchers. On its royal gardens, Nast (1992) argued that Emir Abdullahi Bayero (ruled 1926–1953) loaned the idea to develop palace gardens after his visit to England in the early 1930s. RF-1, 2, 3, 4 dissented with this argument; they asserted that the palace gardens have been in existence since the time of the palace construction in the 15th century. RM-1 added that he was a child (in the late 1940s) when the ornamental and fruit bearing plants were introduced to the *sheka* during the reign of Abdullahi Bayero. Similarly, RF-3, and RF-4 now in their seventies were of the opinion that no one could tell when *sheka* was set up. The functions of the *sheka* changed significantly over time. RF-2 aged over 70 related that during the reign of Abdullahi Bayero, the gardens were used for grazing the Emir's cattle. Hence, the western garden used to be called *shekar Namalinga* (after the name of a herdsman). Similarly, RF-3 observed that in the last 60 years, concubines used the gardens for recreational purposes. The concubines moved to the gardens in the afternoon for relaxation. According to RF-2, in the last 50–60 years, the palace male servants used the gardens for laundering. In the opinion of Nasiru Wada Khalil, a Kano palace historian (in personal communication, August 2010), the two palace gardens had a security purpose. He claimed that they stood as buffer zones between the palace main buildings and the surrounding houses outside the palace. Adding on this, RF-1 asserted that the peacocks (none was spotted during the field exercise) in the gardens sent alerts with their cries whenever somebody entered the gardens. During the fieldwork, we observed that cattle egrets and bats hovered all over the palace as a response to our movements. RM-3 noted that it was normal for the birds to act that way. He added that they did the same when security patrol helicopters flew over the gardens when heads of state or government (local/foreign) visited the palace. In another perspective, RF-2 observed that the gardens helped in noise filtering between the outside (city) and the palace residential spaces.

Both gardens are now fenced and thus became inaccessible to most palace residents. The western garden retained its long time purpose of serving as burial ground for some emirs and some palace dignitaries. On the other hand, a portion of the eastern garden was not only fenced but also attached to the personal quarters of the Emir. RM-1 asserted that the Emir used this garden for relaxation: hiking, cycling and driving using a mini vehicle. We also observed a satellite dish, overhead water reservoir and solar cell platform located in the eastern garden. The summary of the ecosystem services from the royal gardens is given in Table 4 based on Millennium Ecosystem Assessment (2003). According to RF-1, there was an interesting relationship between the Emir and the peacocks of the palace. The peacocks

Table 4 An overview of ecosystem services in the Kano palace gardens

Provisioning	Regulating	Supporting	Cultural
Food and medicinal	Reduction of windstorm impacts	Support for biodiversity	Recreational
Animal feed	Urban noise filtering	Locations for palace infrastructure	Burial ground
	Favourable microclimate	–	Spiritual/ historic
–	–	–	Security

were conditioned to the sounds of the royal guns and sirens, which signal the arrival or exit of the Emir from the palace either on horseback or in a motorcade. The flock of peacocks always ushered in the Emir with their cries.

Myths and mysteries of the palace gardens

The Kano palace residents anchored some mysteries to these royal gardens. They believed that spirits reside in these ancient gardens. All our respondents believed that the gardens could be no-go-areas during the noon or at night. RF-2 alleged that the residents of the palace heard a loud and unusual yelling and crying raising from eastern garden to western garden at nightfall of the day Emir Muhammadu Sanusi was deposed as Emir of Kano (ruled 1953–1963). The respondents also believed that several people in the palace have at one time or another encountered apparitions. They noted that in the past, the palace residents believed that some of the trees in the palace could not be cut down. The palace residents thought that if a tree is uprooted in a day time, it would raise on its trunk intact the following day. RF-2 related that 1 day they were staging *wasan gauta* (a local children's night play) in the palace and as they moved near a baobab tree (still standing green) between the western garden and the palace clinic, they saw fire apparition covering that tree. In the same connection, during the fieldwork, we noticed a freshly fallen branch of the said baobab tree. RM-3 explained that the palace residents would not use its leaves, which were otherwise commonly used for local delicacies. He pointed that people were afraid of the tree. The respondents concurred that the gardens were not considered as safe places for people because of the fear of spirits.

Role of local governance, values and responsibility

It is clear that the palace gardens have outlived many emirs that ruled Kano. Thus, the role of the individual emirs on the conservation of the gardens could not be ignored. The emirs played a central role in the conservation and protection of the gardens because they had the sole power of the palace administration. Likewise, the present Emir (Ado Bayero, ruled since 1963) has played a crucial role in the management of the palace gardens. His Principal Private Secretary (in a personal communication held in August 2010) asserted that the “Emir sanctions cutting of any tree, anywhere in the palace.” He added, “he has also planted more trees adding to the plant diversity of the palace.” The Emir also played the role of intermediary between the gardens and the palace residents. While the emir cherished conservation of the gardens, he also protected people from the challenges posed indirectly by the gardens (ecosystem disservices). Ecosystem disservices in this context are nuisance associated with some species found in the gardens. According to RF-1 and 2, the current Emir always ordered punishment to be meted out on children that pluck unripe fruits. They also recalled an incidence where he ordered for removal of a stubborn monkey from one of the gardens for recurrent damages it caused to palace residents. At a point in time, the Emir also directed that an ostrich kept in one of the garden to be slaughtered after it plucked a labourer's eye. RM-3 pointed that peacocks caused damages to the roofs of many rooms in the palace. The Emir's private secretary interpreted the motivations and commitment of the Emir to the tree conservation based on the Islamic injunction that there is eternal reward in planting trees.

Discussion

The tree composition in the gardens significantly contrasted with Sudan savannah vegetation in terms of physical attributes such as tree density or neighbourhood. Observations and

interpretation of the Google Earth image of Kano shows that the Kano palace gardens constitute the largest concentration of urban greenery. In spite of the environmental factors that prevent high tree density in the Sudan savannah (Devineau and Fournier 2007), the Kano palace gardens have high density of trees. The Kano palace gardens do not fully represent all the Sudan savannah tree species as identified in Cline-Cole et al. (1990). Nevertheless, species like *Parkia biglobosa*, *Acacia nilotica*, *Khaya senegalensis*, *Tamrindis indica* found in the gardens could represent a picture of pre-existing native vegetation. Another point is that those species mentioned in Cline-Cole et al. (1990) are otherwise only found in the rural areas.

There are many implications for neglect of urban biodiversity in the process of urban development in Africa. Kano has sustained one of the highest population densities in sub-Saharan Africa (Paden 1973; Barau 2006). Consequently, the city has progressively lost scores of its open spaces, scrublands, and ponds through urbanisation, gentrification and densification (Maiwada 2000; Imam 2002; Barau 2007b, 2010). This development leads to elimination of vital urban ecosystems. The Kano palace emerges as the major evidence of the past or traditional landscape characteristics of the ancient city. Though Kano city has a compact form, however urban land use intensification and fragmentation could undermine its ecological functions as it occurred in other places (Savard et al. 2000; Tratalos et al. 2007). In contrast to the ecologically unfriendly patterns of urban intensification in Kano, the palace gardens create a conducive environment for proliferation and security of numerous plant and animal species. In Kano, the responsibility of urban ecosystem management falls under various urban development agencies and local governments. The failure of these institutions to sustain and improve the city green areas may be due to neglect or erosion of indigenous biodiversity conservation traditions (Etkin 2002). This is common in urban areas of developing countries where exotic species dominate public parks and gardens (Negendra and Gopal 2011). In contrast, the traditional institution persist in the Kano palace and that is in favour of the biodiversity. The Kano palace gardens also represents some aspects of ecosystem disservice though not in the dimension identified in Lyytimaki and Sipila (2009) and Dobbs et al. (2011). In fact, based on our findings, we can argue that the positive sides of ecosystem services of the Kano palace gardens exceedingly outweigh the identified disservices. The role of governance is reflected in the way and manner conflicts are resolved between the people and the gardens.

Though we did not measure microclimate aspects of ecosystem services through conventional scientific approaches, the palace residents related their conviction and satisfaction to these services based on their long time experiences. This is one of the merits of the SES approach; it allows people to participate and share their felt experiences and local knowledge (Liu et al. 2007). Nevertheless, it will be important to investigate if further studies would show the degree of impacts of these services and functions. In general, various studies affirm a wide range of services accruable from urban ecosystems, in particular pollution control, carbon sequestration, biodiversity conservation, and water cleansing (Jim and Chen 2008; Alberti 2010; Dobbs et al. 2011). The palace gardens are likely to contribute in the same direction.

In this study, we could show a strong relation between local traditions and conservation of the urban biodiversity. The ecological functions and services of these gardens have been least researched for long. The origin of the royal gardens is shrouded in arguments and counter-arguments (Nast 1992; Saad 1981). Thus, one of the limitations of this research is its inability to explore the age of the trees. We could also not explain in depth the gender dimensions of the gardens since women and children had far greater dominance and role than men around the gardens. The

significant role of women in the palace spaces has received ample attention (Nast 1992, 1996). Women play a leading role in domestic security, protocols, food supply and entertainment among others. For centuries, the emirs of Kano regardless of reigns and dynasties have maintained and improved the gardens. However, one important question is why other residents in the city could not particularly maintain local species of trees in their individual dwelling places. We want argue that what makes it work in the Kano place is the combination of leadership and responsibility, myths and mysteries which constitute the institutions of sustainability (Short 2007). On a general note, it is important to highlight that the gardens offer an avenue for intersection of a wide range of ecological and cultural activities. These range from biodiversity conservation, recreation, security and surveillance, climate hazards proofing, and sacred dimensions.

Conclusions

There is urgency to respond to unprecedented decline of urban biodiversity in Africa. Due to stereotyped failure of urban planning systems in African cities, it is important to explore alternative ways. The SES is an important platform for exploring the potentials of African indigenous traditions and values such as oral traditions. The oral traditions could be used in formal and informal education to enhance the course of urban biodiversity conservation. In the northern Nigerian city of Kano, the raging crises of urban growth undermine the city's biodiversity. However, the potentials of *sheka* royal gardens in improving urban biodiversity management are vast. The ability of royal gardens to retain some aspects of biodiversity heritage of the city symbolises the essence of African environmentalism, which thrives on local folkloric traditions and beliefs and value systems. This environmentalism is practiced through participatory responsibility to take care of what the past generations left for the posterity. Nowadays most cities in the global south face multiple challenges. These range from poor funding, dilapidated green infrastructure, and informality in spatial organisation among others. In view of the need for more policy and participatory centred solutions, it is important to recourse to socio-ecological systems in managing the urban biodiversity. In the context of urban biodiversity, many cities of the developing countries may fail to meet the expectations of biodiversity conventions or index systems. Therefore, it is important for stakeholders to consider integrating the indigenous knowledge systems into the mainstream local and global biodiversity management agenda. The integration would give opportunities for exploring alternatives to understanding urban biodiversity in the climate of urban spatial informalities.

Acknowledgments We thank Nasiru Wada Khalil for his tremendous role in the conduct of field aspect of this research. The authors are indebted to the two anonymous reviewers of this article for improving the work significantly. Special thanks to Dr Roy Maconachie of Bath University in the UK for permission to use the map. Google Earth is also appreciated.

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