

Reviewing The Ecosystem Services Provided By Urban Green Spaces In Africa

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Abstract: Urban green spaces are an important ecological infrastructure as they provide a range of ecosystem services and goods that are vital to human well-being and maintain the biodiversity in cities especially in this urbanizing world. Thus, to analyze the state of knowledge on research already performed on urban green spaces ecosystem services in African cities, a literature review about urban forestry was carried out using Google Scholar engine. The analysis of the one hundred and forty seven (147) selected papers reveals an uneven geographical distribution of urban forestry research in Africa. Countries like South Africa, Nigeria, Benin and Ghana recorded the highest number of publications on ecosystem services studies, in opposite to others. On the African continent, studies about urban green spaces ecosystem services draw attention to a wide range of ecosystem services that can be obtained from urban trees especially after the year 2018 where the number of scientific articles published increased to an average of seventeen (17) publications per year. Results highlighted that the most ecosystem services categories studied related to urban forest ecosystem services are regulating services (88 studies), followed by cultural ones (72 studies) compared to provisioning services (48 studies) which received the least attention from respondents. This review also revealed that studies on green spaces remain very limited at African scale. Consequently, scientific research should focus on urban forestry in these developing countries experiencing rapid and uncontrolled urbanization coupled with climate change noxious effects.

Keywords: Green spaces, ecosystem services, biodiversity, urban forestry, cities, Africa.

Introduction

The beneficial effects of nature and green spaces on people are proven. Their importance has become a major environmental necessity at both a local and an international level [1], [2]. Today, more than half of the world's population lives in cities, and according to the United Nations World Urbanization Prospects [3], this figure will rise to two-thirds by 2050 such as in Africa. The consequences of such rapid urbanization trends are environmental problems as well as the strengthening of climate change effects leading during the last decade to an increase in interest regarding the assessment of how urban green spaces can contribute to mitigating global warming [4].

In this increasingly urbanized world, the presence of natural elements contributes to the quality of life and brings many benefits in terms of social, economic, environmental and even health functions [5]. These benefits reflect the positive impact on human well-being [6]. Urban ecosystem services are therefore seen as the benefits that people derive from the functioning of nature in cities [7], [8].

According to [9], the ecosystem services that are most relevant to human health can be broadly categorized: air filtration, biodiversity conservation, climate stabilization, habitat maintenance, natural hazard mitigation, food, fuel and fiber production, water filtration, water regulation, and the provision of aesthetic environments and recreational opportunities. This range of benefits that human populations derive, directly or indirectly, from ecosystem functions is called ecosystem services [10] and is divided into four categories: provisioning services, regulating services, cultural services, and supporting or sustaining services [11], which are related to human wellbeing [11], [12].

For instance, when it comes to adapting to climate change, urban greenery is seen as an important solution because it contributes to biodiversity conservation and enables cities to manage storm water regulation and the urban heat island effect [13], [14]. A good quality of life for humans is therefore highly dependent on ecosystem functions, i.e. the ecosystem services that urban nature provides to human society [15].

Nevertheless, in some parts of the world, research and related knowledge exchange on the ecosystem services provided by urban green spaces remain limited [8], [16].

This paper aims to get deeper insights into the ecosystem services provided by green spaces in urban areas. For achieving this goal, we undertake a systematic literature review to synthesize and evaluate existing literature relevant to our topic, to gain a broad understanding of the topic, and to prepare for original research.

I. Methodology

The adopted methodological approach in this literature review consists of splitting the research process into four phases such as: data collection strategy, studies selection criteria, content analysis, and statistical analysis (Figure 1).

1.1. Data collection strategy

We systematically reviewed the academic literature about ecosystems services provided by urban green spaces in Africa using Google Scholar engine. The search string composed terms that expressed the geographical area of interest “Africa”, and the topic of interest “ecosystem services”. The search has no limitations according to the date of publication and includes scientific papers published in English and French languages. Due to the fact of our review cannot be considered exhaustive, we consider it to cover the largest parts of the available literature throughout Africa. Thus, a total of 1,128 papers were recorded including those we further identified from the reference lists of the relevant articles not picked up by the initial search.

1.2. Studies selection criteria

The abstracts of the retained papers were screened manually to include publications within the scope of this review based on the following guiding criteria: concentrating on urban areas, investigation with focus on ecosystem services, goods or benefits provided to an urban population, and explicitly includes the expression “ecosystem services”, as well as terms that further specified the subtopic of interest “the urban forests”, “urban green infrastructures” or “urban trees”, otherwise describes the link between the environment and benefits provided to urban populations. Finally, we selected 147 papers split up into 132 articles, 3 PhD thesis, 3 Master thesis and 9 reports.

1.3. Content analysis

The content of the 147 selected studies was classified according to the geographic locations, the publication years, the ecosystem services categories and the ecosystem services types.

1.4. Statistical analysis

The results analysis and graphs were performed using Excel software.

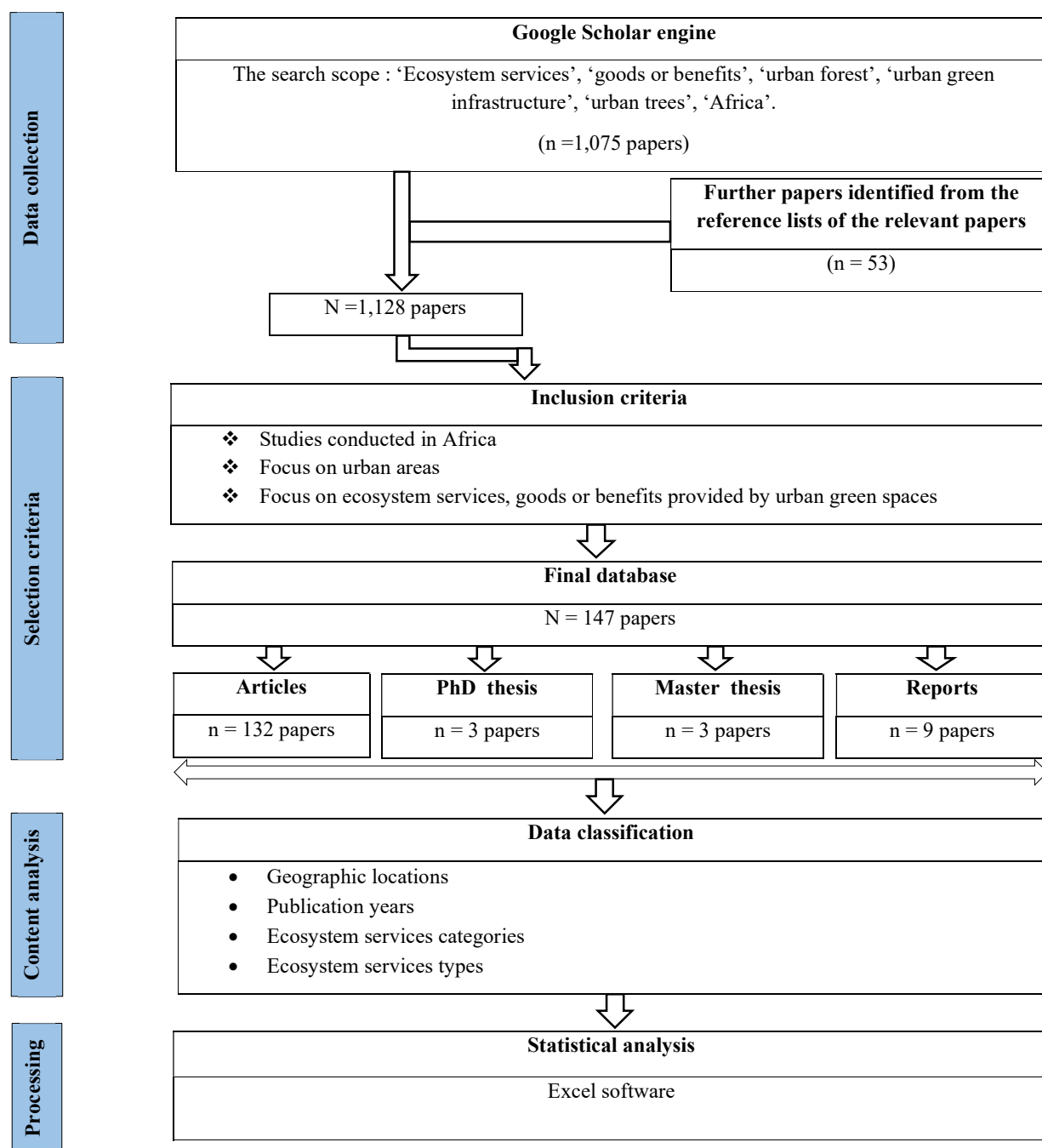


Figure 1: Steps of the literature review

II. Results

2.1. Geographical interest in urban green spaces ecosystem services studies.

Forty two (42) countries throughout Africa have been inspected by our review. Results revealed that South Africa was the most studied (17 papers), followed by Nigeria (13 papers) then, come Benin and Ghana respectively with 12 and 11 papers ([Figure 2](#)).

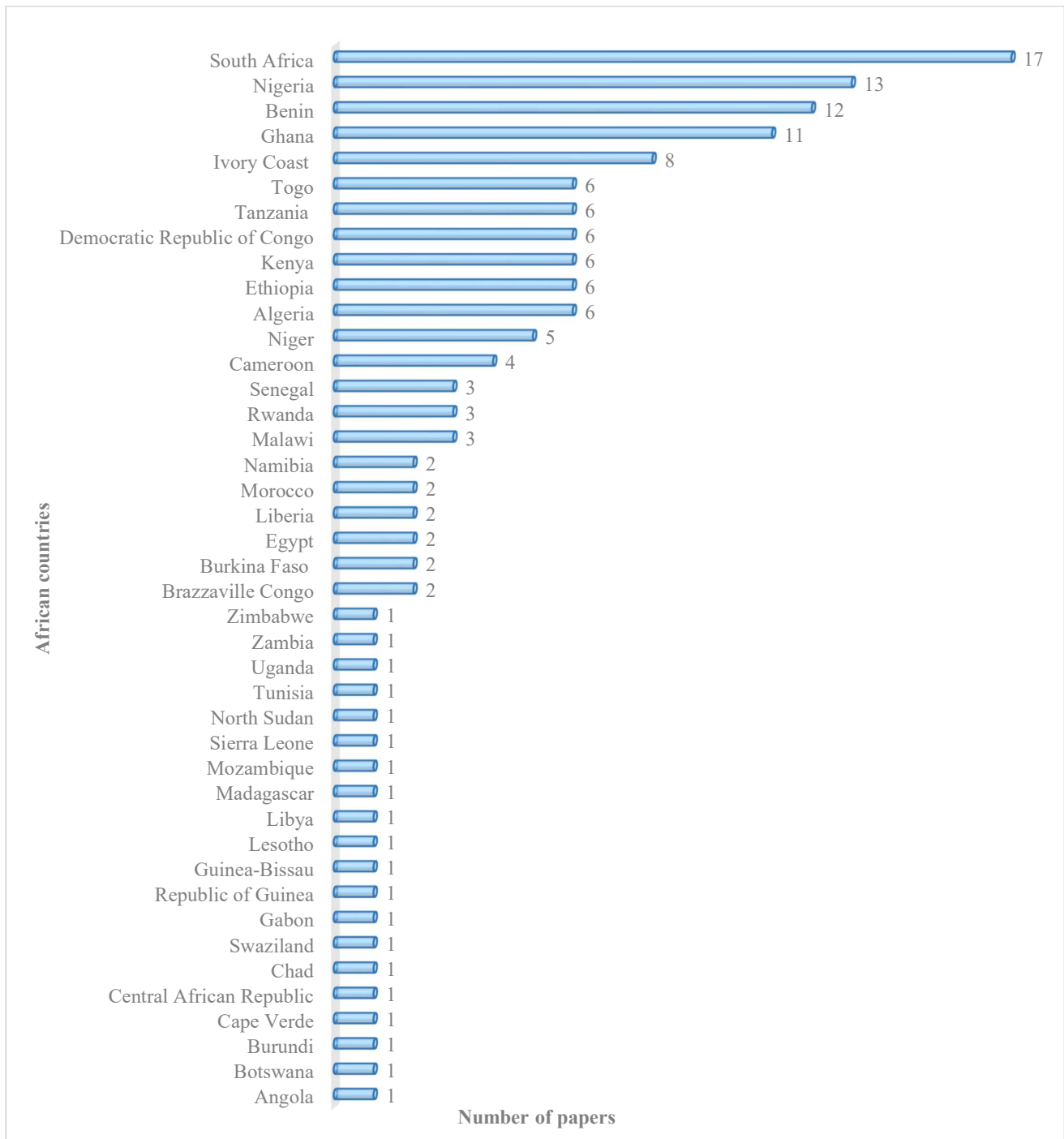


Figure 2: Geographical distribution of urban green spaces ecosystem services studies.

2.2. Dynamics in the number of publications

Results show an increase trend in the number of publications since 2011 with an average of five (5) publications per year noticed from 2011 to 2017, and it increases to an average of seventeen (17) publications per year after 2018 (Figure 3).

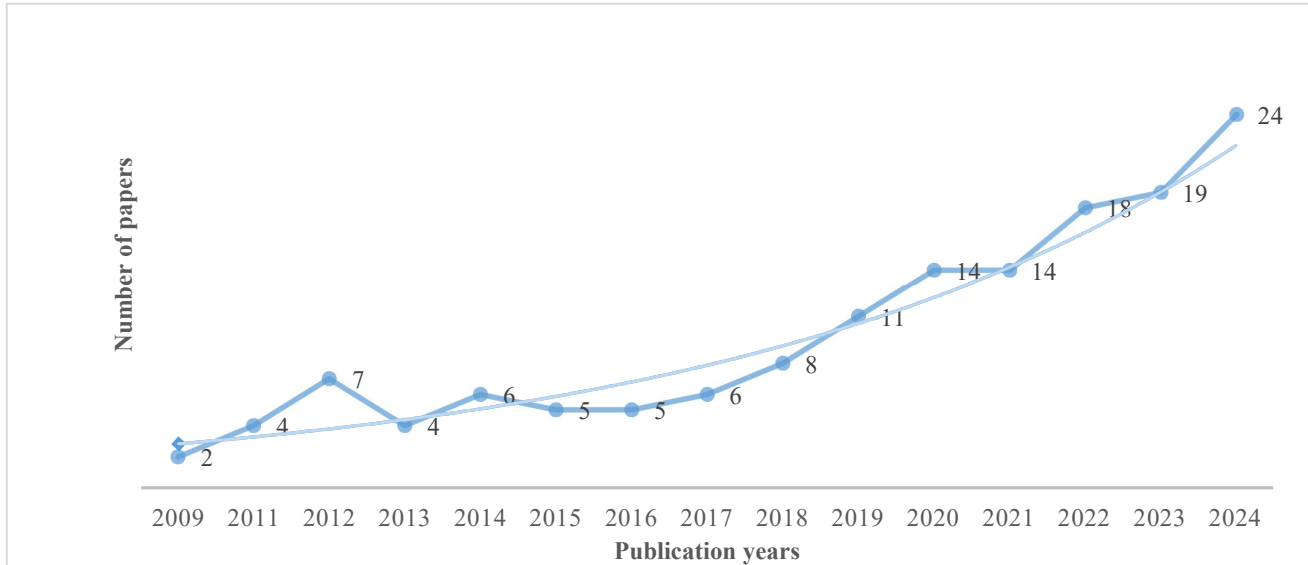


Figure 3: Dynamics in the number of publications

2.3. Ecosystem services

2.3.1. Ecosystem services categories

Based on this literature review, the ecosystem services that respondents believe deriving from vegetated areas in African cities are classified into four ecosystem services categories: provisioning, cultural, regulating, and supporting services. In terms of ecosystem services studied, regulating services were the most assessed (88 studies) followed by cultural services (72 studies) then, come supporting services (54 studies). However, provisioning services (48 studies) received the least attention from research (Figure 4).

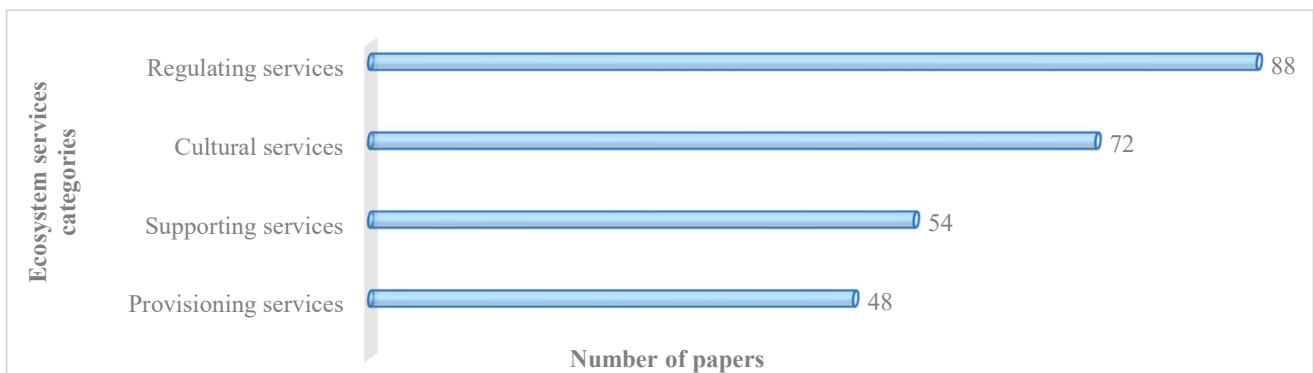


Figure 4: Ecosystem services categories

2.3.2. Ecosystem Services Types

As [17], we listed the specific ecosystem services assessed in the selected papers per category from Table 1 to 4 by indicating the number of studies that assessed particular ecosystem services as well as countries and references.

2.3.2.1. Regulating services

Temperature, air quality, water flow and shade regulations are by far the most assessed regulating services (Table 1). Several findings in African cities like in Grand-Popo, Benin [18], in Bamenda, Cameroon [19], in Derna, Libya [20] and in Bou-Saada, Algeria [21] highlighted that urban green spaces are of particular importance as they offer shading and cooling, to mitigate the urban heat island effect and with regard to water flow and air pollution.

Table 1: Specific regulating ecosystem services

Services	Studies	Countries and references
Temperature regulation	46	Algeria ([21] ; [22]), Benin ([23] ; [24] ; [25] ; [26]), Burkina Faso ([27]), Burundi ([28]), Ethiopia ([29] ; [30]), Cameroon ([19] ; [31]), Democratic Republic of Congo ([32] ; [33]), Ghana ([34] ; [35]), Ivory Coast ([36]), Kenya ([37] ; [38]), Liberia ([39] ; [40]), Madagascar ([41]), Morocco ([42]), Namibia ([43]), Niger ([44]), Nigeria ([45] ; [46] ; [47] ; [48] ; [49]), Senegal ([50]), South Africa ([17] ; [51] ; [52] ; [53] ; [54] ; [55] ; [56] ; [57]), Tanzania ([29] ; [58] ; [59] ; [60]), Togo ([61]), Tunisia ([62]), Zambia ([63]).
Air purification	33	Benin ([23] ; [24] ; [25] ; [26] ; [64] ; [65] ; [66]), Burundi ([28]), Brazzaville Congo ([67]), Cameroon ([19]), Ethiopia ([30] ; [68]), Ghana ([34] ; [35] ; [69] ; [70]), Morocco ([42]), Namibia ([43]), Niger ([44]), Nigeria ([45] ; [46] ; [47] ; [48]), South Africa ([17] ; [54] ; [55] ; [71] ; [72]), Tanzania ([60] ; [73]), Togo ([61] ; [74]), Zambia ([63]).
Water flow regulation	28	Benin ([23] ; [24] ; [25] ; [26]), Brazzaville Congo ([67]), Cameroon ([19]), Democratic Republic of Congo ([32]), Ethiopia ([30] ; [75] ; [76]), Ghana ([34] ; [35]), Ivory Coast ([77]), Libya ([20]), Namibia ([43]), Niger ([44]), Nigeria ([45] ; [47] ; [78]), Rwanda ([79]), South Africa ([17] ; [54] ; [55] ; [56] ; [57]), Tanzania ([59] ; [60]), Togo ([74]).
Shade	25	Algeria ([21]), Benin ([18] ; [24] ; [25] ; [65] ; [66]), Brazzaville Congo ([67]), Chad ([80]), Democratic Republic of Congo ([81]), Ghana ([34] ; [82]), Ivory Coast ([77] ; [83]), Kenya ([84] ; [85]), Namibia ([86]), Niger ([44]), Nigeria ([45]), Sierra Leone ([87]), South Africa ([17] ; [53] ; [88]), Tanzania ([58]), Togo ([74] ; [89]).
Carbon storage	11	Benin ([90]), Burkina Faso ([91]), Brazzaville Congo ([92]), Democratic Republic of Congo ([85]), Ghana ([93]), Ivory Coast ([94] ; [95]), Niger ([96]), Senegal ([97]), South Africa ([98]), Togo ([99]).
Wind breaks	8	Algeria ([21]), Benin ([18] ; [26]), Brazzaville Congo ([67]), Ghana ([34] ; [35]), Nigeria ([100]), Tanzania ([60]).
Noise reduction	7	Algeria ([101]), Benin ([23] ; ([24] ; [26]), Cameroon ([19]), Ethiopia ([30]), Ghana ([35]).

2.3.2.2. Cultural services

Aesthetic value and recreation are the most studied cultural services (Table 2). According to [64], [67], and [106] studies conducted respectively in Parakou (Benin), in Dolisie (Brazzaville Congo) and in Abuja (Nigeria), urban green spaces are an important public good that provide cities the value of recreational services and enhance aesthetic beauty.

Table 2: Specific cultural ecosystem services

Services	Studies	Countries and references
Aesthetic value	46	Algeria ([102]), Benin ([18] ; [23] ; [25] ; [26] ; [64] ; [65] ; [66]), Burundi ([28]), Brazzaville Congo ([67] ; [92]), Cameroon ([31]), Chad ([80]), Democratic Republic of Congo ([33] ; [81]), Ethiopia ([75]), Ghana ([34] ; [35] ; [70] ; [82] ; [103] ; [104]), Guinea ([105]), Ivory Coast ([36] ; [77] ; [95]), Kenya ([84]), Morocco ([42]), Namibia ([43]), Niger ([44]), Nigeria ([45] ; [47] ; [49] ; [100] ; [106] ; [107]), Rwanda ([103]), South Africa ([17] ; [51] ; [53] ; [71] ; [88]), Tanzania ([58] ; [60]), Togo ([74] ; [108]).
Recreation	42	Angola ([109]), Benin ([25] ; [26] ; [65] ; [66]), Burundi ([28]), Cameroon ([19] ; [110]), Chad ([80]), Democratic Republic of Congo ([32] ; [33] ; [81]), Egypt ([111]), Ethiopia ([30] ; [103]), Ghana ([34] ; [35] ; [82] ; [112]), Kenya ([84] ; [85]), Madagascar ([41]), Malawi ([113]), Morocco ([42]), Namibia ([43] ; [86]), Niger ([44]), Nigeria ([45] ; [47] ; [49] ; [100] ; [106] ; [114]), Rwanda ([115]), South Africa ([17] ; [51] ; [56]), Tanzania ([58] ; [60] ; [73] ; [116]), Togo ([74]).
Social cohesion	22	Benin ([23]), Brazzaville Congo ([92]), Cameroon ([19]), Democratic Republic of Congo ([32] ; [33]), Gabon ([117]), Ghana ([35] ; [69] ; [70]), Ivory Coast ([77] ; [94]), Kenya ([84]), Namibia ([43] ; [86]), Nigeria ([45] ; [48] ; [49] ; [100] ; [118]), South Africa ([17] ; [51] ; [55]).
Tourism	8	Benin ([23] ; [26]), Brazzaville Congo ([92]), Ghana ([35]), Kenya ([119]), Mozambique ([119]), South Africa ([53]), Togo ([74]).
Education	7	Angola ([109]), Benin ([26]), Ghana ([34] ; ([112]), Kenya ([84]), Tanzania ([73]), Togo ([74]).

2.3.2.3. Supporting services

The [Table 3](#) highlighted that urban green spaces play a significant role as refuge for many animals and plants species. This contribution of urban forest in city's biodiversity conservation has been revealed by many African authors, specialist in urban ecology such as in Windhoek, Namibia [\[43\]](#), in Franceville, Gabon [\[117\]](#), in Marrakech, Morocco [\[120\]](#), in Alexandria, Egypt [\[121\]](#) and in Diffa, Niger [\[122\]](#).

[Table 3:](#) Specific supporting ecosystem service

Services	Studies	Countries and references
Habitat for species	54	Algeria ([123] ; [124]), Benin ([23] ; [25] ; [26] ; [65] ; [66] ; [125] ; [126] ; [127]), Brazzaville Congo ([67] ; [92]), Cameroon ([19]), Chad ([80]), Democratic Republic of Congo ([32] ; [128] ; [129] ; [130]), Egypt ([121]), Ethiopia ([75]), Gabon ([117]), Ghana ([34] ; [82] ; [131] ; [132]), Ivory Coast ([77] ; [94] ; [95] ; [133] ; [134]), Kenya ([135]), Madagascar ([41]), Morocco ([120]), Namibia ([43]), Niger ([122] ; [136] ; [137]), Nigeria ([45] ; [49] ; [138] ; [139]), North Sudan ([140]), Senegal ([97] ; [141]), South Africa ([17] ; [51] ; [53] ; [142]), Tanzania ([60] ; [73]), Togo ([89] ; [99] ; [108] ; [143]).

2.3.2.4. Provisioning services

It has been proven that urban trees play an important role in providing potential services within cities. Nevertheless, these services are the ecosystem service types that received the least attention from research ([Table 4](#)).

Table 4: Specific provisioning ecosystem services

Services	Studies	Countries and references
Food provision	38	Angola ([109]), Benin ([18] ; [25] ; [26] ; [64]), Botswana ([144]), Brazzaville Congo ([67]), Cape Verde ([144]), Central African Republic ([144]), Chad ([80]), Democratic Republic of Congo ([32]), Ghana ([35] ; [104]), Guinea-Bissau ([144]), Ivory Coast ([36] ; [77] ; [95]), Lesotho ([144]), Malawi ([145]), Namibia ([43]), Niger ([44]), Nigeria ([45] ; [47] ; [78] ; [100] ; [118]), Senegal ([50]), South Africa ([17] ; [54] ; [88] ; [146] ; [147]), Swaziland ([144]), Togo ([89]), Tanzania ([58] ; [60]), Uganda ([148]), Zimbabwe ([149]).
Medicinal plants	29	Benin ([18] ; [23] ; [64] ; [65] ; [66]), Brazzaville Congo ([67] ; [92]), Chad ([80]), Democratic Republic of Congo ([33]), Ghana ([34] ; [35] ; [82]), Ivory Coast ([36] ; [77] ; [95]), Malawi ([145]), Namibia ([43]), Niger ([44]), Nigeria ([45] ; [47] ; [78] ; [100]), Senegal ([50]), South Africa ([17] ; [57] ; [88]), Togo ([74]), Uganda ([148]), Zimbabwe ([149]).
Fuel wood	18	Benin ([18] ; [23] ; [25] ; [26]) Brazzaville Congo ([67]), Ghana ([34] ; [35]), Malawi ([145]), Namibia ([43]), Niger ([44]), Nigeria ([45] ; [78] ; [100]), Senegal ([50]), South Africa ([17] ; [53] ; [147]), Zimbabwe ([149]).
Building materials	7	Ghana ([32]), Malawi ([145]), Nigeria ([45] ; [78]), South Africa ([17] ; [53]), Zimbabwe ([149]).

III. Discussion

Our review article investigated thoroughly urban forestry related to ecosystem services in forty two (42) countries geographically focused on the African continent. A total of one hundred and forty seven (147) papers were included in this literature review. Then, results showed that about 37 percent (%) of studies were carried out in only four countries notably South Africa, Nigeria, Benin and Ghana (Figure 2). This could be attributed to both their urbanization level and their highest number of urban populations [150]. In this increasingly urbanized world, the presence of natural elements contributes to the quality of life and brings many benefits in terms of social, economic, environmental and even health functions [5]. In spite of the inescapable importance of the urban forestry, there is an insufficiency of studies in some countries which are represented by only one or five studies. This could be linked to limited resources and investments to support such studies [151]. There is therefore a need for more studies in these deficit countries.

Studies on ecosystem services provided by urban green spaces are becoming increasingly important. Indeed, the number of scientific papers published on ecosystem services of urban forests in Africa has increased to an average of seventeen publications per year after 2018 (Figure 3). A similar trend was observed in Rabat (Morocco) by [152] in their literature review on the economic valuation of ecosystem services in Africa. This could be linked to the United Nations' commitment to make cities and human settlements more inclusive, safe, resilient and sustainable [153], following the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties and the Conference of the Parties (COP21) in Paris in 2015, which called on several countries and cities to develop strategies and applications to support urban green infrastructure and nature-based solutions, especially with regard to the positive ecosystem services of urban biodiversity [154], [155].

Urban ecosystem services are seen as the benefits that people derive from the functioning of nature in cities [7]. Referring to the Figure 4, regulating and cultural services are the ones to which people attach the most interest, compared to provisioning services whose value is greatly underestimated by respondents. This could be explained by the fact that provisioning services do not cover the urban population needs especially due to their limited availability in terms of food, fuel wood and Building materials.

It is interesting that despite their relatively small size, urban green spaces exhibit a capacity for regulating services, at least at a small scale. In a study conducted by [21] in Bou-Saada (Algeria), it was shown that urban vegetation plays a thermoregulatory

role, helping to combat heat islands effects and creates cool islands in arid urban areas, the cooling of the ambient temperature is due to the evapotranspiration phenomenon. This could be explained by the fact that evapotranspiration process not only absorbs thermal radiation but also releases moisture to cool the ambient air and create a more comfortable microclimate [156]. Air pollution from transportation, industry, domestic heating, and solid urban waste incineration is a major problem for environmental quality and human health in the urban environment, it leads to increases in respiratory and cardiovascular diseases. Vegetation in urban systems can improve air quality by removing pollutants from the atmosphere, including ozone (O₃), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO) and particulate matter less than 10 µm (PM₁₀) [157], [158]. Several studies show that urban forests play critical role in reducing air pollution by intercepting particulates [25], [28], [46], [82]. Shading is a common benefit provided by most planted trees, depending on their size and crown shape [18]. The presence of urban vegetation reduces the amount of surface runoff after rainfall by intercepting and storing water in the leaves and stems [159]. As shown in many studies conducted in African cities such as in Addis Ababa (Ethiopia) by [30], in Dar es Salaam (Tanzania) by [60] and in Lomé (Togo) by [74], urban drainage system loading can reduce and minimize the risk and occurrence of flooding by mitigating runoff after rainfall events. Traffic, construction, and other human activities make noise a major pollution problem in cities, affecting health through stress. According to [160], plants can attenuate noise pollution through absorption, deviation, reflection, and refraction of sound waves. Vegetation plays a significant role in arid and semi-arid cities where wind actions are remarkable and harmful [161]. African researchers have proven that urban vegetation is the best filter-interchange screen for wind erosion control [18], [26], [60]. Another co-benefit of vegetation relevant in urban areas as municipalities set their climate mitigation targets, is carbon storage in aboveground biomass that is considered as a major contributor to the mitigation of global warming and adaptation to climate change [91], [96]. Furthermore, knowledge of the tree's role in regulating the climate remains very low among the population. This could be linked to the lack of sensitization towards different actors on the climate change phenomenon and the role of urban trees in terms of mitigation and adaptation [64].

Because urban environment may be stressful for inhabitants, the recreational aspects of urban ecosystems are among the highest valued ecosystem services in cities [64], [67], [106]. Urban parks are therefore attractive for a variety of reasons: to get some fresh air, to take a walk, or to engage in recreational activities [162], [163]. Urban green spaces play an important role as providers of aesthetic value [104]. Several studies have shown an increased value of properties with greater proximity to green areas [164], [165], [166]. Another study conducted by [106] in Abuja (Nigeria) indicated that urban parks are an important public good that provide cities the value of environmental services and enhance aesthetic beauty. Benefits attributed to green spaces include the mood improving [167], stress reducing [168], and the strengthening of community bonds [169]. Studies conducted respectively in South Africa [51], in Ivory Coast [77] and in Kenya [84] supported the conclusion that attachment to green spaces in cities can also give rise to other important societal benefits, such as social cohesion, promotion of shared interests, and neighborhood participation [170].

Urban green spaces act as small-scale urban biodiversity hotspots. It was recognized in 1992 at the second environmental congress in Kyoto that vegetation is the best means of structuring habitat in developing countries. Urban systems can play a significant role as refuge for many animals and plants species [51], [65], [134], [136]. These green spaces are havens for significant diversity of plants, birds and insects, and in particular can harbor large numbers of indigenous plant species as was shown in the study by [142] where a total of 156 vascular plants species, 35 tree species and 44 faunal species were recorded in Cape Town gardens. According to [131], urban forests contain modest amount of tree diversity which differ widely among urban green spaces types. This author reports that common street and public park tree species in Kumasi include: *Cassia siamea*, *Cedrela odorata*, *Terminalia catappa*, and *Peltophorum pterocarpum*.

According to respondents, food and medicinal use are the most important needs from urban green spaces. This particular attention could be explained by the fact that many African countries depend directly on this category of services to meet their basic needs [67], [171]. [18] showed in their study that medicinal use or pharmacopoeia is provided by species such as *Cocos nucifera*, *Azadirachta indica*, *Coccoloba uvifera*, *Acacia auriculiformis*, *Mangifera indica*, *Eucalyptus camaldulensis*, *Calotropis procera* and *Citrus lemon*. This was also shown in the study conducted in Zimbabwe by [149] were about 34% of respondents indicated that they obtain medicinal products from peri-urban forests. According to [23], wood energy is the main service

provided by vegetated areas in the town of Allada (Benin). For details, the most felled urban tree for firewood is *Mangifera indica*, used in charcoal production and brick firing [67]. In some African cities, such as Masvingo City (Zimbabwe), green spaces supply residents with building timber according to 54% of respondents who declared obtaining building materials from the peri-urban zones [149].

IV. Conclusion and recommendation

This review was carried out with the purpose of inventorying ecosystem services that are provisioned by urban green spaces in Africa. Results revealed a significant uneven distribution of studies on ecosystem services of urban green spaces at African countries scale. Consequently, future research should focus on the least studied countries to improve knowledge and understanding about the ecosystem services provided by urban green spaces in these African cities subjected to an accelerated spread of their urban fabric. Then, in terms of publications trends, the number of papers published on urban green spaces ecosystem services is significantly on the rise. This review also highlighted that regulating services are the predominant categories of ecosystem services studied, while provisioning services are often overlooked. Finally, we globally noticed through this review the lack of sufficient data about urban green spaces ecosystem services in Africa, especially in this context of rapid urbanization and global warming. While the idea of ecosystem services is a very popularized concept that is successfully integrated and practiced in a number of current environmental research fields, those related to urban areas remain a very much less known and studied. As result, few studies about urban green spaces ecosystem services have been performed in African countries mainly due to the fact that urban forestry studies are not yet regarded as an important field of research in most African cities where numerous pressures on green spaces exist.

By way of recommendation, this review emphasizes the need for immediate integration of urban forestry in African universities' curricular in order to ensure improved representation of African continent regarding urban forestry literature.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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