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Supply and demand of ecosystem services of urban green spaces in deprived areas: Perceptions from Kumasi, Ghana

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ABSTRACT

Urban green spaces (UGS) contribute to human health and wellbeing. However, few studies have focused on cities in the Global South, mainly examining them on a citywide scale without considering deprived areas where residents lack basic facilities and sufficient income. Consequently, there is limited understanding of the relationship between the availability of UGS and associated ecosystem services (ES), and what is actually demanded for by residents in such deprived areas. Therefore, this study aims to assess (i) the perceived supply and (ii) the perceived demand for ES of UGS in selected deprived urban areas; and (iii) to determine the potential gap(s) between these perceived supply and demand aspects. A mixed-method approach was adopted for the study, incorporating GIS methods, household surveys, and key informant interviews. As case studies, the study was conducted in two deprived areas in Kumasi, Ghana – Dakodwom and Ayigya Zongo. The findings reveal that land scarcity and encroachment have led to a limited supply of UGS in these areas. Nevertheless, residents appreciate the few available UGS and ES, demonstrating adaptation to their limited resources. They particularly highlighted the cultural ES provided by these UGS. The high demand for these services, surpassing their supply, shows significant gaps, emphasising the need for comprehensive urban planning and management decisions. Such decisions should involve all stakeholders and be underpinned by effective legislative support.

1. Introduction

Access to a clean, healthy, and sustainable environment is a universal human right (United Nations, 2022). As already more than half of the world's population live in urban areas (United Nations, Department of Economic and Social Affairs, 2019), urban green spaces (UGS) provide crucial benefits to improve the quality of life and wellbeing of urban populations, also called ecosystem services (ES) (Enssle and Kabisch, 2020; Shackleton et al., 2021). UGS refer to all urban green of either natural, semi-natural, or artificial elements located within, around, and between urban areas at all spatial scales (Cilliers et al., 2013; Jones et al., 2022). Examples of these UGS include parks, street trees, lawns, greenways, gardens, urban agriculture, playgrounds, sports fields, wetlands, and any undeveloped green area (Adegun, 2019; Girma, Terefe and Pauleit, 2019; Jim, 2004; Wu et al., 2022). The World Health Organization (WHO) is frequently credited with recommending a standard of 9 m^2 UGS per person (de la Barrera et al., 2023) and the Accessible Natural Greenspace Standards (ANGSt) advocate that all residents should have access to 'natural' UGS within a 300 m radius of their homes (Handley et al., 2003). UGS can deliver manifold ES that can be categorised into regulating, cultural, and provisioning services (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2013) (see Table 1 for examples).

In Sub-Saharan Africa (SSA), UGS and the ES they provide are competing with other land demands due to high population growth combined with fast urbanisation (Asabere et al., 2020). SSA housed 376 million urban dwellers in 2015, and this number is expected to rise to 1.3 billion by 2050, an increase in urban population from 39% to 58% (United Nations, Department of Economic and Social Affairs, 2018). This trend threatens UGS due to increasing commercial and residential

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land demand (Cobbinah and Darkwah, 2016; Essel, 2017; Quagraine, 2011). This physical urban expansion leads to the destruction or shrinking of UGS (Asabere et al., 2020), and the separation of urban residents from nature (Adjei-Mensah, 2014). Related to that is a decrease of ES provided by UGS; in SSA, UGS provide ES such as medicinal plants, food or wood fuel, temperature and water flow regulation, recreation, and aesthetics (du Toit et al., 2018) (Table 1).

Special attention needs to be paid to deprived urban areas regarding UGS and their ES provision in SSA. Many cities in SSA are growing too fast for urban economies and infrastructures to meet the basic needs of new urban residents; hence, many newcomers are forced to live in deprived urban areas (du Toit et al., 2018). Urban deprivation has many dimensions, including lack of education and training, inadequate income, lack of access to basic facilities and services, including UGS, and low levels of social cohesion (Baud et al., 2008; Wan and Su, 2017). Africa has the highest share of urban residents living in deprived urban areas (du Toit et al., 2018) as hubs of poverty with low socio-economic status (Cruz-Sandoval et al., 2020; Roy et al., 2018). Usually, deprived urban areas have few UGS of lower quality (Roy et al., 2018) than well-off areas (Cruz-Sandoval et al., 2020) and lower per-capita UGS (McConnachie and Shackleton, 2010). However, residents of these deprived urban areas depend more on the ES of UGS for their subsistence (Cilliers et al., 2013; du Toit et al., 2018) and are largely affected by a decrease in coverage, quality, and accessibility to such ES (Derkzen et al., 2017). In practice, this means, for example, poorer residents relying on drinking water provided from rivers instead of piped water, collecting fuelwood for cooking instead of using electric or gas stoves, and hunting and fishing instead of buying food elsewhere (Shackleton, 2021). Thus, UGS crucially support the livelihoods of dwellers in deprived urban areas and improve their quality of life (Adegun, 2018).

Large differences in the types of ES of UGS needed by the urban poor versus the more affluent are also a matter of socio-environmental justice (Kabisch and Haase, 2014; Langemeyer and Connolly, 2020; Sharifi et al., 2021) and need a clear analysis of demand and supply of ES. In their framework for including justice in ES research, Langemeyer and Connolly (2020) ask for integrating perceptions and recognition of ES benefits, the distribution of built infrastructure, and ES availability with a procedural view on institutions. The perception and recognition of ES benefits can be related to the "demand" for ES, while the distribution of ES availability is linked to the ES supply. "Supply" here refers to the ES provided by UGS, and "demand" refers to the need for ES of UGS by residents (Syrbe et al., 2017). In deprived urban areas one may find a mismatch between the supply of and demand for ES of UGS (Burkhard et al., 2012). In general, knowledge about the perceived supply of and demand for ES in urban areas can help understand the relationships between humans and urban nature, and inform planning and management decisions (Casado-Arzuaga et al., 2013). Many studies analyse perceptions of UGS and ES by residents in SSA cities (reviewed by du Toit et al., 2018; Cobbinah et al., 2021; Roy et al., 2018), often focusing on the perception side alone. Others focus on the supply of UGS in deprived urban areas (e.g., McConnachie and Shackleton, 2010). Lindley et al. (2015) compare the demand for and supply of ES in five African cities from expert perspectives without incorporating the perception of residents.

Table 1
Examples of ES provided by UGS in Sub-Saharan African cities used in the empirical survey.

Provisioning Services	Regulating Services	Cultural Services
▪ Medicinal Plants ▪ Food ▪ Wood Fuel ▪ Livestock grazing and fodder	▪ Temperature regulation ▪ Water flow and runoff regulation ▪ Erosion control ▪ Air quality regulation ▪ Noise reduction ▪ Windbreak ▪ Soil protection ▪ Nutrient deposition	▪ Recreation ▪ Aesthetics ▪ Social cohesion ▪ Sense of place ▪ Heritage, cultural and historical values

Source: Adapted from du Toit et al. (2018)
Note: Respondents also had the option to name other ES.

To address this knowledge gap, this study investigates how residents of deprived urban areas in Kumasi, Ghana, perceive the relationship between the supply of and demand for ES of UGS. We argue for a user-centred perspective, including residents' perceptions as UGS should serve the needs of local residents.

Kumasi, the second-largest city in Ghana, is a compelling case for UGS in deprived urban areas. Kumasi was called the "Garden City of West Africa" in the 1960 s after a detailed landscape plan created green belts and urban parks (Essel, 2017). In the meantime, Kumasi has lost much of its UGS due to urbanisation (Adjei-Mensah, 2014; Quagraine, 2011). Land cover changes in the city and the loss of UGS specifically have been documented for Kumasi (Essel, 2017; Quagraine, 2011), as well as the implications for flooding (Abass et al., 2020) and air temperatures (Essel, 2017). Deprived urban areas with poor environmental conditions have increased in Kumasi, and their negative environmental impacts have been studied (Takyi et al., 2020). Some studies have investigated the perceptions of ES of UGS (e.g., Asare, 2021; Diko and Hollstein, 2023; Dumenu, 2013), but to the best of our knowledge, no study has yet investigated the perceptions of ES of UGS by residents of deprived urban areas in Kumasi.

The study focuses on two deprived urban areas in Kumasi – Dakodwom and Ayigya Zongo – to compare the perceived supply of and demand for ES in a deprived area with relatively few UGS and a deprived area with more UGS available. The study specifically addresses the following objectives: to assess the level of (i) perceived supply of and (ii) perceived demand for ES of UGS in selected deprived urban areas; and (iii) to determine the potential gap(s) between the perceived supply and demand in the areas. Section 2 presents the case study area, data, and methods. Section 3 describes the results, Section 4 discusses them, and Section 5 concludes.

2. Materials and methods

2.1. Case study area

Kumasi is the capital of the Ashanti Region, approximately 270 km north of Accra (Ghana Statistical Service GSS, 2014). Kumasi's many commercial and industrial activities have attracted many migrants seeking better opportunities (Takyi et al., 2020). This, in turn, led to the growth of existing areas and the expansion of new deprived areas, which often encroach on UGS (Takyi et al., 2020). Contrary to its Garden City of West Africa accolade, Kumasi's number and size of UGS has decreased (Adjei-Mensah, 2014; Essel, 2017; Quagraine, 2011), with a 44% loss in vegetation cover between 1986 and 2014 in parallel to a 61% increase in non-vegetation areas (Nero, 2017). This is due to physical urban expansion and poor management practices (Quagraine, 2011). Furthermore, the conditions of existing parks in Kumasi are very poor, with declining ES (Adjei-Mensah, 2016; Quagraine, 2011) and a loss of about 90% in the greenery of most parks after the 1960 s, with many rezoned for other uses (Oduro-Ofori et al., 2014). However, in its 2013 supporting document for the Greater Kumasi Urban Development Plan, the Town and Country Planning Department of the Ministry of Environment, Science, Technology, and Innovation (Ministry of Environment, Science, Technology and Innovation (MESTI), 2013) emphasised the planning standard of 5 m^2 of "passive recreational facilities" per person or not less than 10% of development area for settlements with a minimum of 2500 persons. Passive recreational facilities are public open spaces such as parks, gardens, or playgrounds as opposed to active recreation areas such as indoor and outdoor sports facilities (Ministry of Environment, Science and Technology MEST, 2011) and to be equally distributed over the settlement area (MESTI, 2013).

A study by Takyi et al. (2020) identified thirteen deprived areas in Kumasi. These deprived areas are usually occupied by migrants from other parts of Ghana (Adubofour et al., 2013; Amoako and Cobbinah, 2011; Doe and Aboagye, 2020; Takyi et al., 2020) and display poor sanitation and environmental conditions, inadequate infrastructure and services, sub-standard buildings, congestion, and small-income jobs (Amoako and Cobbinah, 2011; Takyi et al., 2020). Most houses in the area are compound houses, where several households share the same housing unit, including bathrooms and kitchens. Two of the deprived urban areas in Kumasi were selected for this study, one deprived area with some UGS (Dakodwom) and the other with very few UGS (Ayigya Zongo) (see Fig. 1). We verified UGS availability in the two areas through Google Earth Pro and during the fieldwork. The rationale for comparing two deprived areas in our study is to assess the impact of differing levels of UGS availability within communities of similar socio-economic characteristics, as both deprived areas are classified as migrant settlements (Abunyewah et al., 2014; Amoako and Cobbinah, 2011). Also, both are close to the central business district (CBD) and are surrounded by mostly built-up areas. This comparison is key in understanding how UGS availability, within similar socio-economic conditions, influences residents' access to ES.

Dakodwom is located along the Ahodwo-Santasi road, about 1.5 km south-west of Kumasi's CBD (Takyi et al., 2020). In 2009, the population of the area was estimated to be about 2223 in 320 households, showing a 27% increase from 2000 to 2009 (Dakpallah, 2011; Kumasi Metropolitan Assembly KMA, 2010; López, 2010). Established over a century ago by migrants from Ghana's Central Region, mainly of Fante ethnic background, Dakodwom evolved into a renowned hub for "Fanti kenkey", a maize-based food, and charcoal production (Abunyewah et al., 2014). The settlement's name originated from the nearby "Dakwadwom" river where the first settlers lived (Abunyewah et al., 2014). Despite its long history, Dakodwom faces challenges like poor sanitation with open-space liquid waste disposal, and indiscriminate solid waste dumping around existing dumpsites (López, 2010). Although residents enjoy secure land tenure without eviction threats, the crowded housing stems from the settlement's unplanned nature (Abunyewah et al., 2014).

Ayigya Zongo is a suburb of the Ayigya community in the eastern part of Kumasi. Ayigya Zongo was estimated to have a population of 7344 in 1440 households in 2009 (Kumasi Metropolitan Assembly KMA, 2010). Ayigya Zongo is bounded to the south-east by the Kwame Nkrumah University of Science and Technology (KNUST). The increase in commercial activities in KNUST attracted many people to Ayigya Zongo, leading to higher demand for housing and increasing prices (López, 2010). This has motivated some of the low-income residents to live in the Zongo area of the Ayigya community with its lower cost of housing (López, 2010; Takyi et al., 2020) but at the same time with inadequate facilities and services, poor sanitary conditions, and small income jobs (Takyi et al., 2020). Housing in the area is sub-standard, characterised by congestion and frequent extensions of buildings (Amoako and Cobbinah, 2011).

2.2. Research approach

Our study focused on ES and UGS in two deprived urban areas in Kumasi – Dakodwom and Ayigya Zongo. The following elements of the socio-ecological systems (SES) research framework as described by de Vos et al. (2021) were relevant for the study design: interactions between the social and ecological parts of the system, using multiple methods, adressing multiple stakeholders' views, and a strong tie between the research design to the research question linked to a societal problem. The problem identification in our research was guided by scientific literature and insights from local experts and practitioners in UGS and planning, reflecting the multi-dimensional nature of SES research. We adopted a mixed-method data collection and analysis approach, integrating qualitative, quantitative, and spatial analysis techniques within a case study's framework (Yin, 2013). This approach allowed for triangulation and completeness in our research, ensuring the validation of both quantitative and qualitative methods to complement each other (Bryman, 2016; Creswell et al., 2006; Tonon, 2015). The combination of these methods delivered a comprehensive account of the study context (Bryman, 2016). Additionally, the diverse disciplinary backgrounds of our researchers, spanning architecture, planning, urban geography, and environmental science, along with the main author's

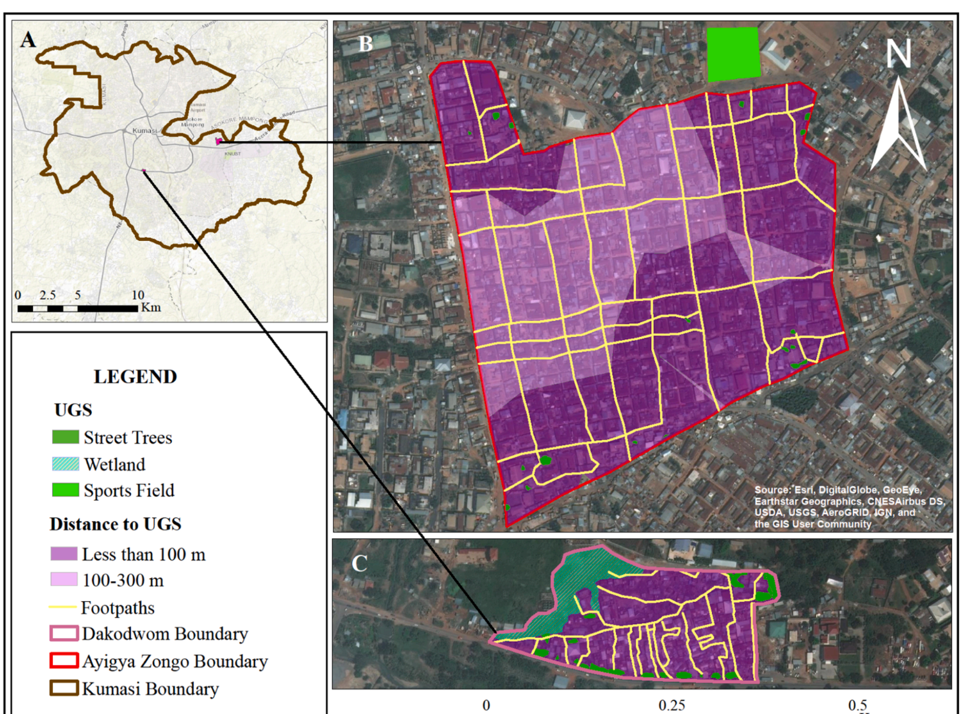

Fig. 1. : Location of the case study areas in Kumasi (A) and the case study areas – Ayigya Zongo (B); Dakodwom (C).

local knowledge, highlight the importance of gradients of collaboration in SES research.

Data used for the study included both primary and secondary. Primary data were collected through a household survey and key informant interviews. Secondary data included aerial images and other spatial data, and census reports (see supplementary material S1).

2.2.1. Household survey

The household survey was conducted in Twi, a local language, using a semi-structured questionnaire designed into four sections, each focusing on the aspects of UGS and ES within the case study areas. The Twi language was used because not all residents can express themselves in English and it is the predominant language spoken by residents in both areas with migrants in Dakodwom from the Central Region of Ghana speaking Fanti, similar to Twi. Conducting the survey in Twi also ensured accessibility and understandability for participants, significantly enhancing the data's quality and reliability. The survey combined 10 close-ended and 5 open-ended questions, enabling a balanced collection of quantitative and qualitative data (see supplementary material S2).

In the first section, 'Supply of ES of UGS', respondents were presented with a list of potential ES provided by UGS in SSA, based on literature (referenced in Table 1, du Toit et al., 2018). They were asked to estimate the distance from their houses to the nearest UGS using predefined distance ranges. Participants were also asked to select all the ES they perceived to be available in their areas, with the option to describe additional services. They were further requested to identify the types of UGS that provide these ES, such as parks, street trees, gardens, wetlands, sports fields, or others, allowing for multiple responses. The second section, 'Demand for ES of UGS', focused on respondents expressing a need for more UGS and ES. They could select from the initial list of UGS and ES or others that they deemed necessary for their areas. This section also included a question on the preferred distance between their houses and the nearest UGS. Respondents were asked to choose from predefined distance ranges. The third section included an open question on how to improve the UGS situation: 'In your opinion, what should be done about urban green spaces in your community for the effective provision of benefits?'. The final section gathered demographic information about the respondents, as detailed in supplementary material S2. The structured approach of combining close-ended and open-ended questions ensured comprehensive data collection on both the current supply and the communities' demand for ES of UGS, as well as gathering in-depth insights into potential improvements.

KoBoToolbox (https://www.kobotoolbox.org/) and the KoBoCollect App were used to survey 246 households (105 in Dakodwom and 141 in Ayigya Zongo) in person by six field assistants from 25th February, 2021–23rd March, 2021. These sample sizes were derived from the total number of households in the two areas (320 in Dakodwom and 1440 in Ayigya Zongo) following Yamane's (1967) formula. A systematic sampling approach was employed to randomly select houses for the survey. The total number of houses in each case study area was divided by their respective sample sizes to establish the interval between the houses selected for the survey. Accordingly, the first house surveyed in each area served as the starting point for these intervals. For multiple-household housing units, we selected the first household we met; if the household was not willing to participate, the next available household within the house was approached. To select participants within each household, a mixed-method approach was adopted. Primarily, household heads were the intended respondents, selected through purposive sampling. However, to accommodate practical constraints and ensure broader participation, any household member aged 18 or above was eligible to participate in the survey, should the household head be unavailable. This method ensured a diverse range of responses while adhering to practical sampling requirements.

2.2.2. Key informant interviews

The key informant interviews (see interview guides in supplementary material S3) were conducted (in English) from 20th February 2021–17 th March 2021 via Zoom video conference to aid in-depth discussion (Bryman, 2016). Five key informants were purposively selected based on their interests, availability, and knowledge of the research phenomenon. They were experts in UGS and deprived urban area planning or management. The experts included officials from the Physical Planning Department (PPD), KMA, the Development Planning Unit (DPU), KMA, the PPD, Oforikrom Municipal Assembly (OMA), and two Senior Lecturers from the Department of Planning (DoP), KNUST, Kumasi. The interviews focused on (1) the ES provision by UGS in the two case study areas, (2) the demand from residents in the areas, (3) the gap between the levels of supply and demand, and (4) the way forward for bridging the gap.

2.2.3. Spatial data

In this study, UGS were defined to include areas with either natural, semi-natural, or artificial green elements such as grass, trees, or shrubs located within and around the two deprived urban areas. For the two cases, these include street trees, gardens, sports fields, and wetlands. UGS types and footpaths were manually digitised from the 2021 ArcGIS online basemap (World Imagery), as there were no data on UGS available from local planning authorities or open sources. UGS within a 300 m buffer (Handley et al., 2003) from the boundaries of the two communities were included in the analysis to incorporate surrounding UGS as service-providing areas to Dakodwom and Ayigya Zongo (Syrbe et al., 2017). The buffer size was chosen based on the ANGSt recommendation of UGS accessibility within 300 m (Handley et al., 2003) but does not relate to 'natural' UGS only. The corresponding 300 m buffer areas for the settlements were referred to as Buffered Dakodwom and Buffered Ayigya Zongo (Fig. 2).

GIS operations were executed in ArcGIS 10.8.1 to compute the sizes of the different types of UGS digitised. The UGS identified via satellite images were validated during fieldwork by the field assistants. The network analysis tool in ArcGIS 10.8.1 was applied to determine which parts of the settlements are within an acceptable travel distance to walk to the available UGS. Since the main means of access in the two communities are narrow and untarred (Amoako and Cobbinah, 2011), the digitised footpaths were used to build the network dataset. The service area function of the network analyst tool was applied to determine the number of houses within an acceptable travel distance to access the available UGS, thus, within 300 m (Handley et al., 2003). To calculate the number of residents within each category of the distances, the number of houses found on the satellite images was multiplied by the average household size (3.9) and the average number of households per house (3) (Ghana Statistical Service GSS, 2014).

2.2.4. Data analysis

Both quantitative and qualitative techniques were applied in analysing the data collected. Quantitative respondents' data were analysed with the IBM Statistical Package for Social Sciences (SPSS 27) software through descriptive statistics, mainly based on the gender, age, and level of education of the respondents. To assess the potential gap(s) between the supply of and demand for ES of UGS in the two selected areas, the supply and demand aspects were matched. The first step was to assess the relationship between the available UGS and the population of Dakodwom and Ayigya Zongo. This led to the determination of UGS per capita of the two areas. The calculation was done only within the two areas and included the 300 m buffer range (see Fig. 2).

Qualitative data were analysed with ATLAS.ti 9 software through content analysis (Erlingsson and Brysiewicz, 2017). The transcribed interviews were initially carefully reviewed, familiarised with, and analysed through inductive and deductive coding (Elo and Kyngäs, 2008). The generated codes were categorised to identify broader themes to represent trends and patterns in the data. Four themes were generated

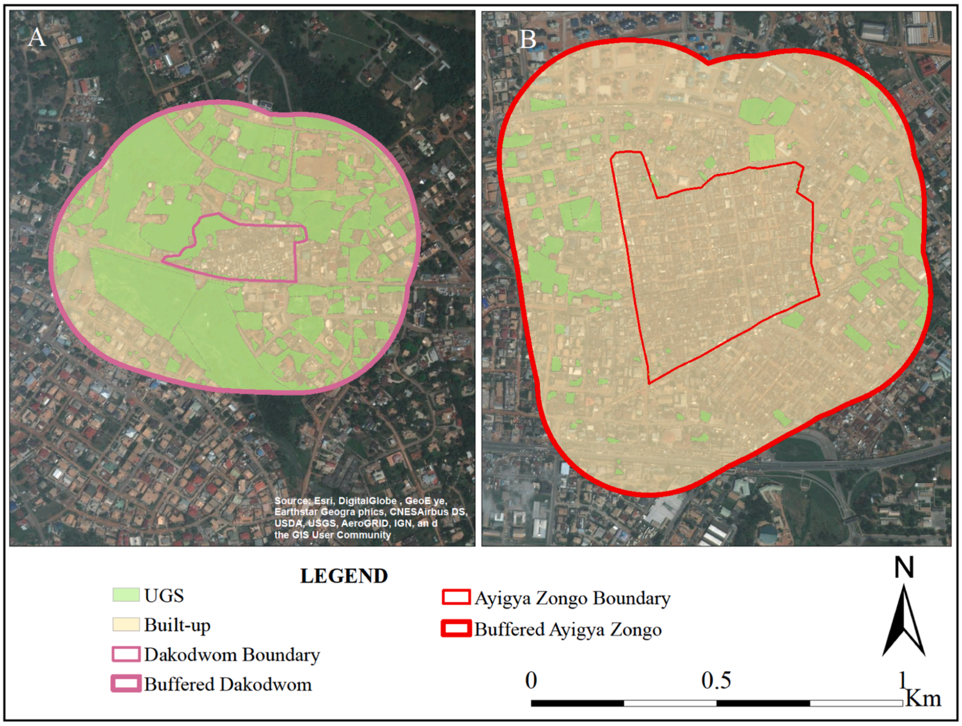

Fig. 2. : UGS map considering a 300 m buffer from the boundaries of the case study areas. Dakodwom (A); Ayigya Zongo (B).

including the (i) supply of (ii) demand for ES of UGS, (iii) potential gap (s) between the supply and demand aspects, and (iv) policy implications. Quotations were generated to complement the quantitative analysis. Further, inferences were made based on the key informant interviews and the household survey responses. This helped in reporting similarities and differences associated with the views and information received from the experts and the households. To enhance the validity and credibility of the findings, the quantitative and qualitative analyses were triangulated (Bryman, 2016).

3. Results

3.1. Demographic characteristics of household survey respondents

The household survey results (Table 2) show that most respondents in the two case study areas are females. Overall, a larger share of respondents was in the 18–45 age cohort, thus, indicating a young population in both areas. Furthermore, most of the respondents have attained some level of formal education, with Dakodwom (83.8%) having a slightly larger portion of respondents with formal education than Ayigya Zongo (78.0%).

3.2. Supply of ES of UGS in Dakodwom and Ayigya Zongo

In the analysis of the supply of ES, satellite images show three main types of UGS (street trees, wetlands, and sports field) available in Dakodwom and Ayigya Zongo. Both have street trees while Dakodwom includes wetlands (Fig. 1). For Ayigya Zongo, a sports field is located just outside the area's boundary. In Dakodwom, the total UGS area constitutes 22.7% of the total land area, sharply contrasting with 0.4% in Ayigya Zongo (Table 3). The results indicate few available UGS in both areas, with Ayigya Zongo having less than Dakodwom. The key informant interviews indicated that UGS had been largely encroached on in these deprived urban areas. The low level of UGS availability, especially in Ayigya Zongo was emphasised during the key informant interviews:

Table 2
Demographic characteristics of household survey respondents.

	Dakodwom (N=105)		Ayigya Zongo (N=141)	
Variable	**Frequency**	**%**	**Frequency**	**%**
Gender				
Male	44	41.9	55	39.0
Female	61	58.1	86	61.0
Total	**105**	**100**	**141**	**100**
Age				
18–25	9	8.6	27	19.1
26–35	38	36.2	41	29.1
36–45	24	22.9	34	24.1
46–55	18	17.1	21	14.9
56–65	11	10.5	13	9.2
66+	5	4.8	5	3.5
Total	**105**	**100**	**141**	**100**
Highest Level of Education				
1. No Formal Education	17	16.2	31	22.0
2. Basic (Primary, Middle and JSS/ JHS)	49	46.7	54	38.3
3. Post Middle/ Sec. Cert./Diploma (Teacher training/ College of education, Agric, Nursing, University Diploma, HND, etc)	2	1.9	5	3.5
4. Secondary (SSS/SHS and Secondary)	36	34.3	44	31.2
5. Tertiary (Bachelor's Degree and Postgraduate or higher)	1	1.0	7	5.0
Total	**105**	**100**	**141**	**100**

"The current state of Ayigya Zongo does not make much provision for UGS. There is already limited land available for making such provisions. Also, people are more interested in the physical structures than the soft landscape or green spaces. People prefer putting in more physical structures even within their private spaces than green spaces that will help promote environmental health within their spaces". (Physical Planning Official, PPD, OMA)

Table 3
Available UGS from satellite images.

	Dakodwom	Ayigya Zongo
Type of UGS	**Size (ha)**	**Size (ha)**
Street Trees	0.26	0.08
Wetland	0.78	-
Total UGS Area	**1.04**	**0.08**
Total Land Area (TLA)	4.58	22.25
Percentage of UGS per TLA	22.7%	0.4%
	Buffered Dakodwom Size (ha)	**Buffered Ayigya Zongo Size (ha)**
Total UGS Area	**18.27**	**6.34**
Total Land Area (TLA)	57.56	90.31
Percentage of UGS per TLA	31.7%	7.0%

> *"Honestly, to be very sincere with you, given the level of densities and the high demand for residential spaces, many of these green areas tend to be actually converted into buildable areas although they are ecologically sensitive. If there are assets that they [residents] find useful they have a way of protecting them. But in the case of these areas that we are talking about considering the fact that the density sizes are extremely high, especially in the Ayigya Zongo area, many of the green areas have gradually been encroached upon. So, you only find a few areas that are the only remaining water channels, these ones you find some green spaces around them. In the case of the Dakodwom area however, due to where they are located, you realise that there are a number of wetlands or ecologically sensitive areas around. So, in that case, you find that there are few areas where there are still greens" … (Senior Lecturer of the DoP, KNUST, Kumasi, Ghana)*

> *"… the only green area around will have to be the wetland separating Dakodwom and the Regional Coordinating Council which can be described as a no-go area. But as we speak it has been encroached upon to the highest point and I cannot foresee any [green space] being preserved …" (Physical Planning Official, PPD, KMA)*

Buffered Dakodwom (31.7%) has a higher share of UGS within a 300 m buffer (Fig. 2) than Buffered Ayigya Zongo (7.0%) (Table 3). Both settlements have more UGS surrounding them than within.

The household survey results (Fig. 3) confirmed the available types of UGS found on the satellite images in Dakodwom and Ayigya Zongo. However, respondents identified an additional UGS type: gardens. These were not captured in both areas from the satellite images. Gardens were not visible on the satellite images because some of these gardens are mainly located at the balconies and corridors of the residents, consisting of plants cultivated in containers, pots, or shacks close to their dwellings, especially in Dakodwom (Fig. 4 C).

Examining the estimated distance from residential houses to the nearest UGS, the GIS network analysis shows that all the residents in Dakodwom (100%) travel less than 100 m to the nearest UGS from their homes (Fig. 1). Conversely, in Ayigya Zongo, 59.9% and 40.1% of the residents have access to the nearest UGS within distances less than 100 m and 100–300 m respectively (Fig. 1). This implies that a larger share of the residents in both areas has access to available UGS within an

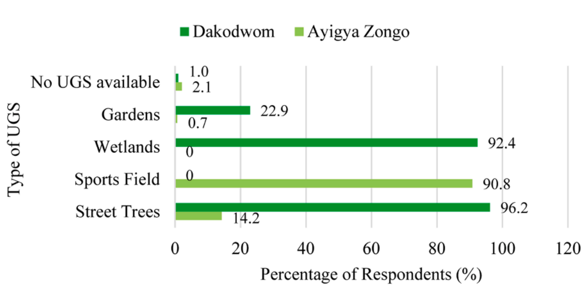

Fig. 3. **:** Types of available UGS identified by respondents.

acceptable distance (0–300 m). The results of the household survey confirmed those of the GIS analysis, where the majority of the respondents expressed that they have access to the nearest UGS within a shorter travel distance (0–300 m) in Dakodwom (83.8%) and Ayigya Zongo (69.5%).

The household survey results (Fig. 5) show that regulating ES (53.1%) were perceived to be more available in Dakodwom, especially temperature regulation (33.3%). Residents' perceptions of Dakodwom were supported by one of the key informants:

> *"… the few available green spaces in Dakodwom serve as a source of windbreak for the residents. Also, because the area [Dakodwom] is crowded the available green spaces help in circulating air in the area". (Senior Development Planning Official, DPU, KMA)*

On the contrary, cultural services (85.5%) were perceived by residents to be more available in Ayigya Zongo (Fig. 5). Recreational activities were the perceived highest cultural ES (78.7%) available in Ayigya Zongo. In general, provisioning services were least perceived to be available in the two areas (Fig. 5) with a relatively higher share in Dakodwom than in Ayigya Zongo (Fig. 5). Additionally, the respondents associated the ES with the type of UGS that they believe provides such services. In total, 65% of the ES in Dakodwom were associated with street trees (Fig. 5), mostly regulating services, followed by cultural services, with provisioning services being the least. One respondent in Dakodwom mentioned that: *"…the available street trees, for example, help in cooling the environment…"*. The wetlands in Dakodwom were associated with 22% of the perceived ES, including provisioning services (medicinal plants and livestock grazing and fodder) and regulating services (water flow and runoff regulation and erosion control) (Fig. 5). Moreover, 13% of the ES in Dakodwom were associated with the gardens which included provisioning services (food) and cultural services (recreation and aesthetics) (Fig. 5).

For Ayigya Zongo, a larger share of the perceived ES (86%) was associated with the sports field and predominantly provided cultural services (Fig. 5). One of the respondents in Ayigya Zongo elaborated that: *"…we undertake sporting activities and exercises on the sports field"*. Furthermore, 10% of the ES in Ayigya Zongo were associated with the few street trees with regulating and provisioning services being the majority (Fig. 5). Only 4% of the perceived ES in Ayigya Zongo were associated with gardens which consisted of provisioning services (medicinal, plants, food, and livestock grazing and fodder) (Fig. 5).

3.3. Demand for ES of UGS in Dakodwom and Ayigya Zongo

The analysis of the demand for additional UGS for ES provision reveals that the majority of respondents in both Dakodwom (59.0%) and Ayigya Zongo (68.8%) expressed the need for additional UGS in their areas. Table 4 presents the demographic characteristics of the respondents demanding for additional UGS for ES provision. The proportion of males (59.1%) and females (59.0%) demanding for more UGS was similar in Dakodwom. Contrarily, in Ayigya Zongo, the percentage of females (73.3%) was higher than males (61.9%). In terms of age, a higher percentage of the respondents in the 26–35 age cohort demanded for more UGS in both Dakodwom (71.1%) and Ayigya Zongo (78.0%). This is followed by those in the 56–65 age cohort for Dakodwom (63.6%) and the 18–25 age cohort for Ayigya Zongo (77.8%). In general, a higher percentage of the respondents with no formal or only basic education demanded for additional UGS than those with post middle, secondary, and tertiary education in Dakodwom. However, the opposite of this finding exists in Ayigya Zongo.

The results on preferred locations for additional UGS show that a larger share of the respondents in both Dakodwom (44.8%) and Ayigya Zongo (57.5%) prefer to have UGS with their communities. This is confirmed by the results on preferred distances to these additional UGS. A larger share of the respondents preferred to travel shorter distances (less than 100 m and 100–300 m) for UGS access in both Dakodwom

Fig. 4. **:** Pictorial evidence of available UGS in the case study areas. Street trees in Dakodwom (A); Wetland in Dakodwom (B); Garden in Dakodwom (C) and Sports field in Ayigya Zongo (D).

(46.7%) and Ayigya Zongo (54.6%).

Table 5 provides an overview of the types of UGS and ES residents demand for in both areas. A higher proportion of respondents expressed a desire for sports fields in both Dakodwom (45.7%) and Ayigya Zongo (48.5%). For instance, one Dakodwom resident mentioned, *"If there is one [sports field] available for the kids it will be cool"*. Moreover, in Ayigya Zongo, a relatively higher percentage of respondents (27.0%) demanded for street trees compared to Dakodwom (18.1%). Similarly, there was a slightly greater demand for gardens in Ayigya Zongo (26.2%) than in Dakodwom (22.9%). Wetlands were the least demanded type of UGS in both areas, with Ayigya Zongo showing a relatively higher percentage than Dakodwom (Table 5).

The household survey results highlight that cultural services were the most demanded in both Dakodwom (41.7%) and Ayigya Zongo (79.6%) (Table 5). Recreational activities were demanded for the most in both areas (Dakodwom (42.9% of respondents and Ayigya Zongo 56.0%). There was a relatively higher demand for cultural ES in Ayigya Zongo than in Dakodwom. Moreover, regulating services were the second category of ES that the respondents were demanding for with a higher percentage in Ayigya Zongo (37.9%) compared to Dakodwom (22.8%); temperature regulation and air quality regulation were more prominent. The respondents least demanded for provisioning services (Ayigya Zongo 17.8%; Dakodwom 10.4%). Overall, Ayigya Zongo demonstrated a relatively higher demand across all three categories of ES compared to Dakodwom. This disparity could be attributed to the varying benefits that the more abundant UGS in Dakodwom provide to its residents compared to those in Ayigya Zongo.

3.4. Potential gaps between the supply of and demand for ES of UGS in Dakodwom and Ayigya Zongo

In this section we present the results of the analysis of the alignment between UGS supply and community needs in Dakadwom and Ayigya Zongo, focusing on four types of matches: between available UGS and

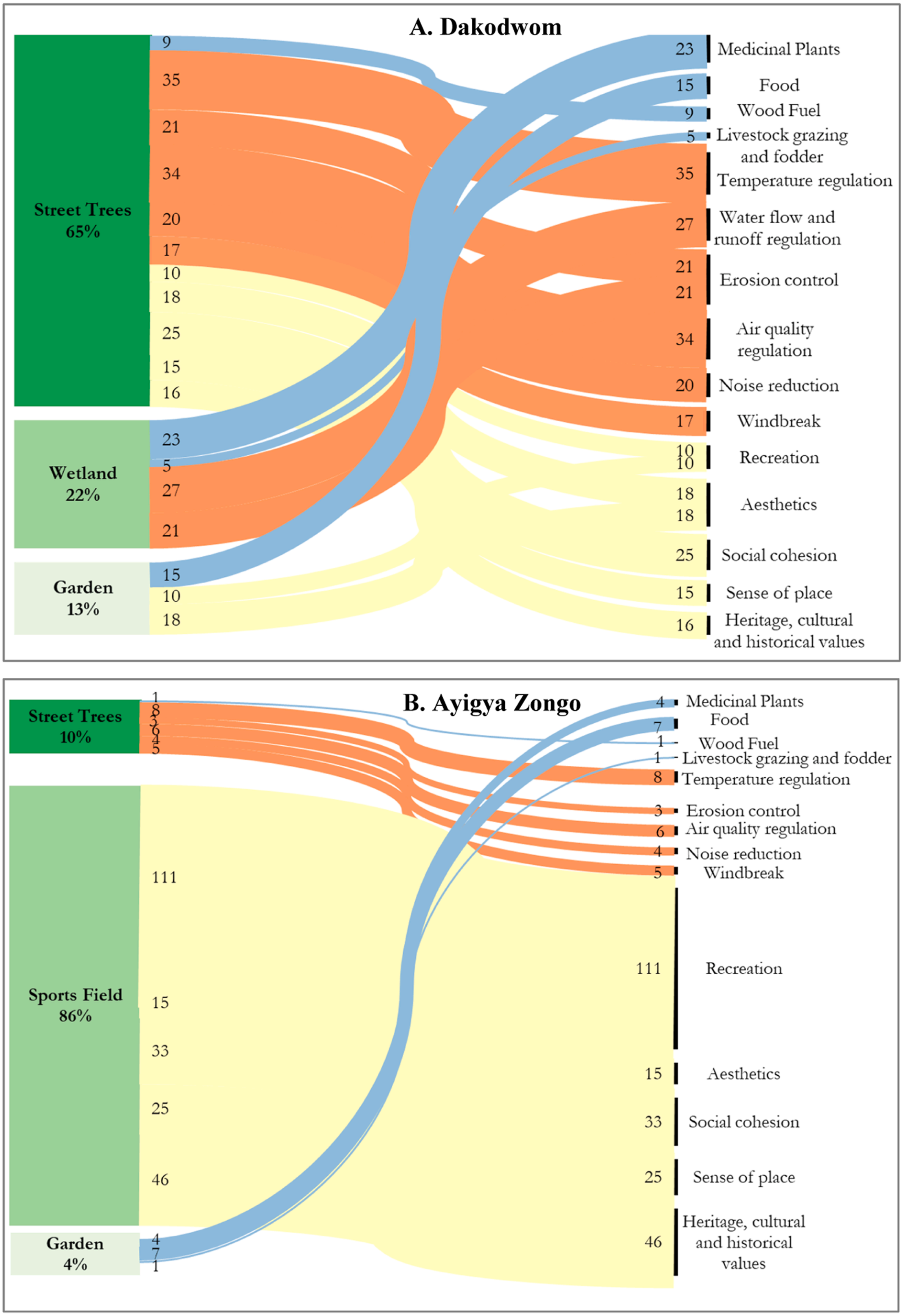

Fig. 5. **:** Available UGS and provided provisioning (blue), regulating (orange), and cultural (yellow) ES.

population, between the type of UGS perceived to be supplied and demanded, between estimated and preferred distances to the nearest UGS, and the match between perceived ES supplied by available UGS and those demanded by respondents.

The study investigated the match between available UGS and population. The results show that UGS per capita for Dakodwom is 4.7 m^2 and 0.1 m^2 for Ayigya Zongo (Table 6). The survey results show that a considerable share of the respondents expressed being satisfied or very

Table 4
Demand for additional UGS considering demographic characteristics of respondents.

	Dakodwom			Ayigya Zongo		
UGS Demand	**Total**	**Yes %**	**No %**	**Total**	**Yes %**	**No %**
Gender						
Male	44	59.1	40.9	55	61.8	38.2
Female	61	59.0	41.0	86	73.3	26.7
Total	**105**			**141**		
Age						
18–25	9	44.4	55.6	27	77.8	22.2
26–35	38	71.1	28.9	41	78.0	22.0
36–45	24	54.2	45.8	34	55.9	44.1
46–55	18	50.0	50.0	21	61.9	38.1
56–65	11	63.6	36.4	13	69.2	30.8
66+	5	40.0	60.0	5	60.0	40.0
Total	**105**			**141**		
Highest Level of Education						
1. No Formal Education	17	58.8	41.2	31	58.1	41.9
2. Basic (Primary, Middle and JSS/JHS)	49	61.2	38.8	54	74.1	25.9
3. Post Middle/ Sec. Cert./ Diploma (Teacher training/ College of education, Agric, Nursing, University Diploma, HND, etc)	2	0	100.0	5	80.0	20.0
4. Secondary (SSS/SHS and Secondary)	36	61.1	38.9	44	68.2	31.8
5. Tertiary (Bachelor's Degree and Postgraduate or higher)	1	0	100.0	7	71.4	28.6
Total	**105**			**141**		

Table 5
Types of UGS and ES Demanded for by respondents.

	Dakodwom (N=105)	Ayigya Zongo (N=141)
Type of UGS	**%**	**%**
Street Trees	18.1	27.0
Sports Field	45.7	48.2
Gardens	22.9	26.2
Wetlands	1.0	3.5
Ecosystem Service	**%**	**%**
Provisioning		
Medicinal plants	12.4	12.8
Food	14.3	14.2
Wood fuel	2.9	2.8
Livestock grazing and fodder	-	4.3
Total	**10.7**	**17.8**
Regulating		
Temperature regulation	21.0	15.6
Water flow and runoff regulation	4.8	2.8
Erosion control	6.7	11.3
Air quality regulation	21.0	21.3
Noise reduction	3.8	9.2
Windbreak	5.7	12.1
Total	**22.8**	**37.9**
Cultural		
Recreation	42.9	56.0
Aesthetics	19.0	14.9
Social cohesion	22.9	33.3
Sense of place	7.6	19.1
Heritage, cultural and historical values	22.9	28.4
Total	**41.7**	**79.6**

satisfied with UGS availability in both Dakodwom (41.9%) and Ayigya Zongo (49.7%). In the open-ended questions of the survey, the residents linked this level of satisfaction mainly to the limited land space in the areas which does not permit the creation of more green spaces:

Table 6
Size of available UGS and population.

Area	UGS Size (m^2)	Population	UGS Per Capita (m^2)
Dakodwom	10,414.9	2223	4.68
Ayigya Zongo	819.0	7344	0.11
Dakodwom + Buffered Dakodwom	193,067.1	4118	46.9
Ayigya Zongo + Buffered Ayigya Zongo	64,231.9	13,206	4.9

"There is no space and perhaps we [residents] are squatters so we are in no position to complain".

"We are content with it [green space] for now because nothing can be done since there isn't space."

"They [green spaces] are enough based on the community size".

"Because the houses here [in Dakodwom] are very close to each other so I don't think there can be more [green spaces]". (Four respondents in Dakodwom)

"There is no land available for such green spaces here"

"Because the place is a slum so there will not be enough space for them [green spaces]".

Due to land issues here [Ayigya Zongo], there is no room for green spaces". (Three respondents in Ayigya Zongo)

A further analysis considering the addition of UGS within a 300 m buffer (Fig. 2) from the boundaries of the two areas shows UGS per capita of 46.9 m^2 and 4.9 m^2 respectively for Dakodwom and Ayigya Zongo (Table 6). The results show that the residents in Dakodwom can benefit substantially from surrounding UGS (Buffered Dakodwom).

Regarding the match between the type of UGS perceived to be supplied and demanded for by respondents, results in Table 7 show that a larger share of respondents who perceived the supply of UGS types do not demand for more UGS and vice versa in both Dakodwom and Ayigya. Although Ayigya Zongo has a sports field close by, about half of the respondents asked for an additional sports field, similar to respondents from Dakodwom. This is likely due to the high number of users in Ayigya Zongo, as one respondent explains: *"With our population, it is too small for us when we are having activities there"*. Moreover, Ayigya Zongo has more respondents than Dakodwom who did not perceive the supply of street trees and gardens and demanded for such UGS. One of the respondents in Ayigya Zongo expressed that *"there are few trees here, so it would be helpful if we have more trees to cool the environment"*. This could be associated with the lower supply of street trees and gardens in Ayigya Zongo compared to Dakodwom. Some of the respondents who did not perceive the supply of a particular UGS type and did not demand for such UGS were with the views that: *"there is no land for extra trees"* – one respondent in Dakodwom, *"our buildings are even built close to each other, and this tells that there are no spaces around for gardens or trees"* – one respondent in Ayigya Zongo. These expressions by the respondents explain that they recognise the high built-up densities leading to encroachment on UGS, hence, they do not demand for more UGS.

From the perspectives of the respondents, the estimated (supply) and the preferred (demand) distances to UGS in both areas were matched to determine potential gap(s). In the survey, the respondents demanding for additional UGS indicated their preferred distances for accessing them. A larger share of the respondents preferred to travel short distances (0–300 m) to UGS in both areas (Dakodwom 46.7% and Ayigya Zongo 54.6%). A comparison between the GIS analysis and the perceived estimated distances to UGS shows that a higher percentage of the respondents in both areas could reach the available UGS with shorter distances (sub-section 3.2.2). This implies that the requirement of many

Table 7
Variations in perceived supply of and demand for types of UGS by respondents.

Type of UGS			Dakodwom					Ayigya Zongo		
			Demand					Demand		
			Yes	No	Total			Yes	No	Total
Street trees	Supply	Yes	15	86	101	Supply	Yes	7	13	20
		No	4	0	4		No	31	90	121
		Total	19	86	105		Total	38	103	141
Sports field		Yes	0	0	0		Yes	60	68	128
		No	48	57	105		No	8	5	13
		Total	48	57	105		Total	68	73	141
Gardens		Yes	7	17	24		Yes	1	0	1
		No	17	64	81		No	36	104	140
		Total	24	81	105		Total	37	104	141
Wetlands		Yes	0	97	97		Yes	0	0	0
		No	1	7	8		No	5	136	141
		Total	1	104	105		Total	5	136	141

Low (0) — High (141) counts

respondents would be met in the two areas in terms of physical accessibility to UGS.

The perceived ES provided by the available UGS in Dakodwom and Ayigya Zongo were also matched with what ES were demanded for by the residents. The study results in Table 8 show that a larger number of respondents who perceived the availability of cultural services, especially recreational services in Ayigya Zongo, demanded even more. The opposite exists in Dakodwom. This shows that there is a higher interest in cultural services in Ayigya Zongo than in Dakodwom. Further, a larger number of the respondents who did not perceive the supply of regulating and provisioning services did not demand for more in both Dakodwom and Ayigya Zongo.

4. Discussion

This study aimed at assessing the levels of perceived supply of and perceived demand for ES of UGS in two deprived areas in Kumasi – Dakodwom and Ayigya Zongo; and determining the potential gap(s) between the perceived supply and demand in the areas. In the following, we first discuss the supply of and demand for UGS as such (4.1) and then for ES (4.2). Afterwards, we discuss implications for urban planning and management (4.3) and the limitations of our study and future research (4.4).

4.1. Land scarcity affecting UGS supply and demand

There are only a few available UGS in both Dakodwom and Ayigya Zongo. The situation in Ayigya Zongo is more alarming, with UGS constituting only 0.4% of the total land area (Section 3.2). A comparison with the WHO standard of 9 m^2 UGS per capita shows a substantial deficit for both settlements. Dakodwom almost meets the lower, Kumasi-specific standard of 5 m^2 per person (MESTI, 2013), while Ayigya Zongo clearly falls short of this as well. Adjei-Mensah (2016) reported the UGS per capita of Kumasi as 4.7 m^2 in 2016, also indicating a significant deficit at the citywide scale considering the WHO standard and barely reaching the Kumasi-specific standard. The key informant interviews show that UGS in these deprived urban areas have largely been encroached on as there is limited land space. Hence, these UGS compete with other uses such as residential and commercial, and they are eventually taken over. This finding confirms other studies on Kumasi (Adjei-Mensah, 2014; Cobbinah and Darkwah, 2016; Essel, 2017; Quagraine, 2011) and many other African cities (Cobbinah et al., 2021; Cobbinah and Darkwah, 2016; Girma, Terefe, Pauleit et al., 2019). The situation in the Global South, especially SSA is pervasive where higher growth rates coupled with weak planning systems often permit developments to take place before they are being planned for (Angel et al., 2011; Cobbinah and Darkwah, 2016; Cobbinah et al., 2015; Jim, 2004; Mpofu, 2013).

Contrarily, there are relatively more UGS within a 300 m buffer from the boundaries of the two settlements. The surrounding areas of the two settlements, especially Dakodwom, are better off economically. This supports findings in the literature of a higher UGS availability in well-off areas compared to deprived areas (Cruz-Sandoval et al., 2020; Roy et al., 2018). These surrounding UGS could serve as service-providing areas to Dakodwom and Ayigya Zongo (Syrbe et al., 2017). However, the surrounding UGS are used by residents living there and parts of the UGS are private gardens and a golf course (outside Dakodwom) and, thus, not accessible.

Despite the low supply of UGS and ES, residents report comparatively high levels of satisfaction with UGS availability (Section 3.4). In the open-ended question on satisfaction, residents frequently mentioned the lack of space in the areas as a limiting factor for adding more UGS and as a reason for not complaining about the situation. Other locational factors such as affordable housing, proximity to job opportunities, and other infrastructure are then likely more relevant in the decision to move to the areas or stay there. This is similar to what Berhe et al. (2014) called "adaptation" when comparing the subjective and objective quality of life in Mekelle, Ethiopia: Residents with low objective quality of life, for instance regarding access to public health facilities, valued other factors as higher and, therefore, still reported high levels of satisfaction. One resident stated that they could not complain about a lack of UGS since they were squatting there, indicating possibly a lack of agency as a community.

4.2. ES supply and demand

Aggregating over the different ES studied here, most residents perceive that the UGS provide some ES, similar to findings by Cobbinah et al. (2021) for two slum communities in Accra. However, when looking at the individual ES studied here, residents for most ES reported little supply and also did not demand for more ES of the same type (Table 8) with the exception of temperature regulation and recreation (see below). The overall rather small gap between supply and demand contradicts findings by Lindley et al. (2015) who found large gaps between demand for and supply of ES in Addis Ababa, Dar es Salaam, and Saint Louis based on expert judgements. This lack of more demand for ES by

Table 8
Variations in perceived ES supplied by available UGS and demanded for by respondents.

			Dakodwom					Ayigya Zongo		
Ecosystem Service			Demand					Demand		
			Yes	**No**	**Total**			**Yes**	**No**	**Total**
Provisioning										
Medicinal plants	**Supply**	**Yes**	5	18	23	**Supply**	**Yes**	3	1	4
		No	8	74	82		**No**	15	122	137
		Total	13	92	105		**Total**	18	123	141
Food		**Yes**	7	8	15		**Yes**	3	4	7
		No	8	82	90		**No**	17	117	134
		Total	15	90	105		Total	20	121	141
Wood fuel		**Yes**	2	7	9		**Yes**	1	0	1
		No	1	95	96		**No**	3	137	140
		Total	3	102	105		**Total**	4	137	141
Livestock grazing and fodder		**Yes**	0	5	5		**Yes**	1	0	1
		No	0	100	100		**No**	5	135	140
		Total	0	105	105		**Total**	6	135	141
Regulating										
Temperature regulation		**Yes**	13	22	35		**Yes**	2	6	8
		No	9	61	70		**No**	20	113	133
		Total	22	83	105		**Total**	22	119	141
Water flow and Runoff regulation		**Yes**	4	23	27		**Yes**	0	0	0
		No	1	77	78		**No**	4	137	141
		Total	5	100	105		**Total**	4	137	141
Erosion control		**Yes**	3	18	21		**Yes**	2	1	3
		No	4	80	84		**No**	14	124	138
		Total	**7**	98	105		**Total**	16	125	141
Air quality regulation		**Yes**	12	22	34		**Yes**	1	5	6
		No	10	61	71		**No**	29	106	135
		Total	22	83	105		**Total**	30	111	141
Noise reduction		**Yes**	4	16	20		**Yes**	1	3	4
		No	0	85	85		**No**	12	125	137
		Total	4	101	105		**Total**	13	128	141
Windbreak		**Yes**	3	14	17		**Yes**	3	2	5
		No	3	85	85		**No**	14	122	136
		Total	6	99	105		**Total**	17	124	141
Cultural										
Recreation		**Yes**	5	5	10		**Yes**	65	46	111
		No	40	55	95		**No**	14	16	30
		Total	45	60	105		**Total**	79	62	141
Aesthetics		**Yes**	8	10	18		**Yes**	6	9	15
		No	12	75	87		**No**	15	111	126
		Total	20	85	105		**Total**	21	120	141
Social cohesion		**Yes**	6	19	25		**Yes**	19	14	33
		No	18	62	80		**No**	28	80	108
		Total	24	81	105		**Total**	47	94	141
Sense of place		**Yes**	6	9	15		**Yes**	12	13	25
		No	2	88	90		**No**	15	101	116
		Total	8	97	105		**Total**	27	114	141
Heritage, cultural and historical values		**Yes**	8	8	16		**Yes**	24	22	46
		No	16	73	89		**No**	16	79	95
		Total	24	81	105		**Total**	40	101	141

Low (0) High (141) counts

the residents in our study may well be related to the adaptation to the experienced reality in the communities and the higher prioritisation of other factors already mentioned above. Also, issues of low awareness and knowledge might play a role in the low scores for supply and additional demand for some of the specific ES mentioned in our study.

Our study indicates varying supply and demand for regulating, provisioning, and cultural ES. *Regulating services*: Dakodwom has comparatively more street trees, and consequently, regulating services, and temperature regulation specifically, were perceived to be the highest ES provided in the area. Temperature regulation was also highlighted in other studies on informal settlements by Oluwafeyikemi and Julie (2015) for Lagos and, Gopal and Nagendra (2014) for Bangalore. These studies revealed that plants close to the dwellings of residents provide temperature regulation, which is quite similar in Dakodwom (Fig. 4 C). Contrary to Dakodwom, the relatively fewer available street trees in Ayigya Zongo are related to a lower perceived supply of regulating services. Therefore, a larger share of the respondents demanded for street trees to provide regulating services such as temperature and air quality regulation. The perception of residents of Ayigya Zongo and Dakowdom also contrasts with findings by (Asare, 2021) regarding the perception of flood regulation in Kumasi: While that ES type was hardly mentioned in our study, it was – next to landscape aesthetics – the dominant ES mentioned in (Asare, 2021). This is no surprise since the latter focused on neighbourhoods in Kumasi along riverbanks, so residents in these areas are very aware of this ES.

Cultural services: The residents of both areas showed more interest in cultural ES, specifically recreational activities which were also found elsewhere (Roy et al., 2018). In the open questions, these cultural ES were largely associated with the sports field providing recreational activities in Ayigya Zongo, similar to the Kya Sands informal settlement in Johannesburg (Adegun, 2019). Hence, the majority of the respondents demanded a sports field in Dakodwom. The younger age of the respondents might have influenced the demand for more sports facilities. In general, such cultural services help in improving the socio-cultural wellbeing of the residents in deprived areas through social interaction, place of belonging, community bondage, and aesthetical values (Adegun, 2017, 2019; Thompson et al., 2016).

Provisioning services: Surprisingly, provisioning services were the least ES perceived to be available in the two areas (Section 3.2). Only few residents make use of food and fuel wood provided by the UGS, and respondents in Dakodwom perceived more provisioning services compared to Ayigya Zongo, likely due to the larger number of gardens in Dakodwom. Correspondingly, a larger share of the respondents demanded for provisioning services such as food and medicinal plants and more gardens in Ayigya Zongo than in Dakodwom. The low perceived supply of fuel wood by UGS may be due to UGS being street trees, gardens, wetlands, and a sports field, but not a forest which could supply more fuel wood. Also, access and affordability of alternative fuel sources are important: In Dumenu's (2013) study on ES provision by an urban forest in Kumasi, respondents did not mention food or fuel wood provisioning as ES provided by the forest. That may be related to the respondents being university staff and students who do not have to rely on food and fuel wood from the forest. In addition, the low proportion of residents naming provisioning ES deviates from the studies reviewed by du Toit et al. (2018) who found that provisioning services are perceived to be more available to the residents of deprived urban areas and small towns. One reason could be that the review also includes studies on small towns (e.g., Shackleton et al., 2018) where more and larger UGS are available than in deprived urban areas embedded in built-up areas of large cities. Also, a tradition and feasibility of urban agriculture (Davies et al., 2021) may lead to higher perceived supply and demand for provisioning ES in deprived urban areas.

4.3. Implications for urban planning and management of UGS in deprived urban areas

More attention to UGS in deprived urban areas directly relates to SDG 11, target 11.7, which emphasises universal access to safe, inclusive, and accessible, green and public spaces by 2030 (United Nations, 2017) and as a universal human right (UN, 2022). Also, adaptation to climate change via nature-based solutions requires sufficient UGS. Our study found a large lack of UGS in both communities, and these findings are consistent across the satellite images, perceptions of residents, and the key informants. Bridging this gap requires a collaborative effort of all stakeholders (local planning authorities and other government agencies, traditional authorities, and residents) to ensure effective planning and management of UGS in the deprived urban areas. In this process, residents' adaptation to the current situation of little available space and perceived low agency over changing the situation requires further attention. Further, the low ratings of other ES might also point to a lack of awareness. Awareness, agency, and willingness to change are necessary for residents to engage in the planning and management of UGS.

Protecting and creating new UGS would require manifold changes (see also Cobbinah et al., 2021). The most challenging change would be to lessen the pressure on deprived urban areas by providing housing and other infrastructure for the growing population so that urban land can be reserved for UGS. However, one-size-fits-all solutions are inadequate here (Myers, 2021). Another change required is legislative backing, which the Land Use and Spatial Planning Act. (2016) of Ghana provides. Hence, there is a need for strict enforcement of the Act to empower the local planning authorities to take the lead role in the planning and management of UGS in the areas. Another key requirement would be capacity building in terms of logistics, personnel, and funding for the institutions involved. Moreover, making UGS a priority by all stakeholders is important, especially the residents in the areas through awareness, knowledge, and agency.

These challenges are not only relevant for Kumasi. Decreasing the inequality concerning UGS and associated ES distribution in the Global South, especially SSA is a challenge both for urban planning (Haase et al., 2017; Haq, 2011) and UGS management (Haq, 2011). Due to the limited land space in deprived settlements, planning for UGS within nearby areas would be a good way of improving overall access to UGS by the residents. This decision could be informed by local and international standards mentioned in this study (Girma, Terefe and Pauleit, 2019; Handley et al., 2003; MESTI, 2013). Further, innovative nature-based solutions such as green roofs could be adopted as a local solution to increase UGS in deprived urban areas without reducing the land available for residential use (Herzog and Rozado, 2019).

4.4. Limitations of the study and future research

This study primarily relied on residents' perceptions to report the supply of ES, introducing the limitation of subjective bias. These perceptions could be influenced by factors such as gender, cultural background, educational level, and socio-economic status, potentially skewing the understanding of ES supply and demand. The majority of the participants in our survey were females. This deviates from many African cities where household heads are mostly male. However, the trend conforms to the GSS census data (Ghana Statistical Service GSS, 2012), which reports more females than males for Kumasi, Ashanti Region, and the national level. Also, respondents were rather young in both areas. This could be attributed to Kumasi's pivotal location with many resources and opportunities which pulls migrants from different areas of Ghana (Takyi et al., 2020), most of them young (Agyei-Mensah and Owusu, 2010). Sultana et al., (2022) suggest that differentiating perceptions of ES among various demographic groups, such as by gender and age, can bring a more focused analysis and help in understanding these biases. Future research should include expert analysis alongside fieldwork data collection or a modelling approach to corroborate and compare these perceptions. This would provide a more comprehensive and objective understanding of the actual supply of ES and help identify knowledge or perception gaps.

The sampling methodology used in this study combined systematic sampling for house selection with convenience sampling for choosing a household and a member within each house. This may have introduced a bias towards residents who were available at home during the survey times, often excluding those who might be at work or engaged elsewhere. Such a bias could disproportionately represent the views of residents more frequently present in the area.

Furthermore, a deeper analysis of the types of UGS and the specific ES they provide would greatly benefit future research. Understanding the relationship between different types of UGS and the ES they offer can inform more targeted and effective urban planning and management strategies, as highlighted by (Nastran et al., 2022). Overall, while this study sheds light on the residents' perspectives on UGS and ES in deprived urban areas, acknowledging and addressing these limitations will be crucial for future research aimed at developing a more holistic and balanced understanding of UGS and ES in urban settings.

5. Conclusion

This study investigated the relationship between the perceived supply and demand for ES of UGS in two deprived areas of Kumasi, Ghana: Dakodwom and Ayigya Zongo. Combining GIS and social science methods, it integrated resident and expert perspectives to identify gaps in ES of UGS provision. The findings indicate limited availability of UGS, especially in Ayigya Zongo where only 0.4% of the land area is UGS. This scarcity, primarily due to land encroachment and availability constraints, results in significant per capita deficits in UGS, particularly in Ayigya Zongo.

Despite these challenges, residents in both areas value the available UGS. In Dakodwom, the focus was on regulating services from street trees and wetlands, while in Ayigya Zongo, cultural services from a sports field were more appreciated. Notably, residents have adapted to the low UGS supply for ES provision, expressing general satisfaction despite the obvious deficiencies. This adaptation, influenced by land scarcity, suggests resilience but highlights a suppressed demand for more UGS. Future research should look into this adaptive satisfaction with UGS.

Additionally, the preference for cultural services over regulating and provisioning services may indicate limited awareness of the full spectrum of benefits that UGS offer. This trend poses challenges for climate change adaptation strategies in such urban settings, where nature-based solutions could be vital. Therefore, increasing awareness of UGS benefits is essential for all stakeholders to support sustainable ES provision in deprived urban areas. This study is relevant to cities in the Global South, especially SSA facing similar challenges of land scarcity affecting UGS and ES provision, disproportionately affecting residents in deprived areas.

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CRediT authorship contribution statement

Rexford Osei Owusu: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Javier Martinez:** Conceptualization, Supervision, Writing – review & editing. **Nina Schwarz:** Conceptualization, Supervision, Writing – review & editing.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Grammarly and ChatGPT 4.0 for language editing. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2024.103742.

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