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The Spatio-Temporal Dynamics of Urban Green Spaces in Gweru City, Zimbabwe

Produce Mukwenyi & Adrod Sachingoma

Department of Sciences and Technology, Mkoba Teachers College, Gweru, Zimbabwe

Email: pmukwenyi@gmail.com

Abstract: *The recognition of urban green spaces (UGS) is critical for sustainable strategies globally. UGS serve a critical function that spans the socioeconomic, environmental, and climatic divides, but their survival is jeopardised by the insatiable resource needs associated with perceived growth in developing nations. We used an explanatory sequential approach to conduct a situational analysis of Gweru City, Zimbabwe, to understand the spatio-temporal dynamics of UGS. Five Landsat pictures from 2000 to 2019 were utilised. At a five-year interval, four land use/land cover (LULC) clusters were identified using maximum likelihood classification: water bodies, green spaces, bare ground, and built-up areas. This was confirmed using real-world data with very high metrics (OA: 94%-97%; Kappa: 0.91-0.96). In addition to the use of satellite images, interviews with residents were used to supplement the data collected through the analysis of satellite images. Accordingly, the findings revealed that UGS in Gweru municipality has decreased by 5% during the last two decades (2000-2019). These findings were supported by locals who acknowledged that UGS were deteriorating in the suburbs, particularly in high-density areas. The terrible circumstances, according to the interviews, were caused by human activities, administrative deficiencies, natural disasters, and geology. As a result, current urban management approaches must support UGS, particularly in cities throughout the globe. Comprehending these variables is crucial for well-informed decision-making and efficient urban design and development.*

Keywords: *Classification, GIS, Land use, Land cover, Remote sensing, Urban green spaces*

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1. Introduction

Green spaces are described as personal and communal open places with artificial or natural vegetation that are both, directly and indirectly, reachable to city dwellers (Şenik & Uzun, 2022; Basu & Nagendra, 2021). City parks, gardens, playgrounds, outdoor leisure areas, urban trees, plots of land, wetlands, woods, and woodlands are examples of such green places (Jones et al., 2022; Sonti et al., 2020). Green spaces expedite recuperation from diseases (Jabbar, Yusoff & Shafie, 2021), provide citizens with an area for energetic human engagement and provide nutritional supplements in the context of fresh vegetables and fruit (Vargas-Hernández, Pallagst & Zdunek-Wielgołaska, 2023; Walsh et al., 2022), foster a sense of connection and community bonding (Reyes-Riveros et al., 2021), are fantastic places for children to engage and they enhance curiosity and acquiring knowledge (Broda, 2023), alleviate climate patterns, enhance urban air quality, protect biodiversity and encapsulate luxurious residential of cities (Amiraslani, 2022). Such benefits spawned the planning concepts such as Garden City and Green Belt. In addition, green fingers and greenways were also introduced (Kohout & Kopp, 2020). Despite these benefits, urban green zones are under considerable degradation.

Globally, studies reveal the alarming pace at which urban green areas are declining in many regions. Research which was carried out in 25 European municipalities found that 41% of the green spaces were lost due to diverse terrestrial uses (Ignatieva et al., 2020). It was reported in the United States of America that around 1.4 million hectares of greenery were destroyed owing to rapid population increase in major cities (Matsa, Musasa & Mupepi, 2021a, b). As for Africa, studies in selected cities show that the problem of green space vanishing is worse. For instance, it was noted that in South Africa, several cities had no more than 10% of their overall area occupied by green spaces (Venter et al., 2020). Green areas account for less than 3% of the City's total area in Lagos, Nigeria (Oduwaye, 2013). Kumasi (Ghana) had a total area of 25km^2 in 1950, which expanded to 182km^2 in 1963 and 252km^2 in 2011 (Poku-Boansi & Inkoom, 2011). Heinous statistics such as these indicate how bad the situation is in and around cities in both developed and developing nations. Most researchers blame the demise of urban green zones in most cities on numerous challenges.

Therefore, the purpose of this study was to examine the spatio-temporal dynamics of urban green spaces in Gweru City in the Midlands Province of Zimbabwe using a mixed-method approach. As such, it was guided by the following specific research objectives: assessing Gweru City's urban green space distribution and extent from 2000 to 2019, examining how Gweru City's urban green areas have changed throughout time, and analysing the variables influencing the spatio-temporal dynamics of Gweru City's urban green areas. This will assist the city planners, decision-makers, estate developers, residents and the government to understand the importance of conserving green spaces in the city.

2. Literature Review

The researchers have demonstrated that rapid urbanisation and urban sprawl are the chief causes of the extinction of UGS due to the increasing demand for houses caused by an unimaginable increase in population (Fanan, Dlama, & Oluseyi, 2011; Fuwape & Onyekwelu, 2011; Honu, Chandy, & Gibson, 2009). In addition, other root drivers of the vanishing of urban greenery include the absence of political will and managerial support to safeguard urban green spaces; weak institutional framework to support it (African Green City Index, 2011), and loss of dependable data to monitor either the widening or extinctions of green spaces (Urban Green Spaces Taskforce, 2002); unofficial settlements which manipulate the immediate forests in their enviro for firewood; insufficient resources (vehicles and manpower) and lack of custodianship of green spaces (Hammond, 2011; Kumasi Metropolitan Assembly, 2010). All these elements are destructive to the sustainability of urban green spaces in both more economically developed and less economically developing countries, therefore it is necessary to study the situation in Gweru City, Zimbabwe.

In Zimbabwe, there is scant information on the status of green areas in her cities and Gweru has not been spared. The authors have found that in Gweru City, the green areas are diminishing at a rapid rate due to the insatiable human needs such as housing, firewood and poverty as well as political discord between the central government and the resident establishments, that is, the local authorities. The dissonance originates from the fact that the central government is under the jurisdiction of the Zimbabwe African National Union-Patriotic Front (ZANU-PF) while the local authorities in most urban areas are under the Movement Democratic Change (MDC). As such, the central authority officials oversee the daily running of cities. This is so even though cities are under the control of MDC officials which is an opposition party. Each entity strives to outwit the other for political mileage (Mungwari, 2017; Teddy & Vhutuza, 2017). This harms the green areas as political elites flout council by-laws. As a result, they develop dwellings in undesignated places such as marshes. Besides, some individuals are taking advantage of the lawlessness to damage the plants in their nearby settings. There are communal gardens strewn across the city that have subsequently ceased operating owing to the theft of the gates, tanks and electrical lines that were designed to ensure a consistent water supply throughout the year. This might have maintained the city green throughout the year. Some open churchgoers even harm the greenery surrounding their holy locations to warm themselves throughout the night. All these possibilities, among others, have inspired researchers to investigate the spatio-temporal dynamics of the greenery in Gweru City from the turn of the new century (2000 to date).

The spatio-temporal examination has emerged as a powerful instrument for decision-makers, spatial policymakers, community organizations, and stakeholders operating inside a given environment to obtain insights, establish appropriate strategies and policies produce information for spatial planning, develop detailed land use plans, and comprehend what is happening (Sisay, Teshome & Demel, 2016). Examining the link between urban green space use and the components that regulate their usage may give useful information for choosing green space locations in urban planning (Fangzheng et al., 2017). As a result, spatio-temporal analysis aids decision-makers in ensuring long-term growth and grasping the dynamic forces of fluctuating contexts (Teferi et al., 2013). To effectively continue managing the urban environment, the current debate on the importance of the urban panorama approach needs accurate geographical data on the history and contemporary circumstances of green areas in urban centres (Molla, Ikporukpo & Olatubara, 2018). As a result, data on geographical and temporal assessments of green spaces is becoming increasingly crucial to strengthening urban green space planning in metropolitan locations. To achieve this, the researchers chose to apply geospatial methodologies such as Remote Sensing (RS). This, among others, has encouraged researchers to analyse the spatio-temporal changes in green spaces in the City of Gweru from the start of the new century (2000 to date).

Remote sensing (RS) is the process of gathering information about objects or places using electromagnetic radiation (light) without physically touching them (Chuvieco, 2020). The use of RS was proved to be efficient in monitoring LULC changes (Fonji & Taff, 2014). RS has been demonstrated in the literature to be a crucial device for effectively monitoring and controlling LULC fluctuations in a given region at a cheap cost, in little time, and with exact accuracy (Himeur et al., 2022; Singh et al., 2020; Yasir et al., 2020). Furthermore, remote sensing gives the benefit of reaching locations where conventional techniques of data gathering are unavailable, such as mountainous terrain (Gaffey & Bhardwaj, 2020; Liu et al., 2020). Some of the fundamental constraints of remote sensing are the inability of many sensors to gather data and information under cloud cover, as well as the difficulty of distinguishing separate phenomena if their reflectance is the same, such as bare ground and cultivated land. Extremely high-resolution satellite imaging is relatively expensive, and the resolution of the satellite images may be too coarse for extensive mapping and discerning small contrasting areas (Fonji & Taffi, 2014). Nonetheless, it is the single tool accessible for resource inventory and land use, as well as the identification, monitoring, and measuring of evolving patterns on the earth's surface (Fonji & Taffi, 2014). Hence, it is crucial to apply remote sensing in this research for a spatio-temporal change in urban green areas in Gweru City.

Several studies in Zimbabwe examined the relationship between population growth and urbanisation. Marondedze & Schütt (2019), for example, looked into the patterns of land use and land cover modification in Harare, Zimbabwe. The goal was to examine spatiotemporal urban LULC changes, the axis and trends of development, as well as the causes driving urban expansion in the Harare Metropolitan Province during the last three decades. Matsa et al. (2021a) conducted a spatio-temporal study of urban area growth in Zimbabwe between 1990 and 2020, with an emphasis on Gweru City. Matsa et al. (2021b) investigated the loss of urban green areas in Gweru City as a result of increasing land use/cover changes between 2000 and 2019. However, Matsa et al. (2021b) did not consider residents as key players in the demise of green spaces in the city.

3. Methodology

3.1 Study area

The study was carried out in Gweru City, the provincial capital of the Midlands Province of Zimbabwe. It is located in the central watershed at 19^0 South of the equator and 29^0 North of the Greenwich meridian (Figure 1). The city has an aggregate land cover of 164.5 km2 and a total population of 161, 294 currently residing in the urban area (Zimbabwe National Statistical Agency, 2022). Peripheral areas such as Vungu have since been engulfed by the rapidly expanding city. The municipality is marked by winds, which are most prevalent from August to November and have a mean speed of 8.0 to 9.3 knots (Kurebwa & Muvandi, 2014). The city's annual rainfall averages 500-700mm, with dry intervals in the middle of the year. The rainy season begins in October and lasts until April (Jerie, 2016). The vegetation in Gweru is predominantly savannah grassland with scattered trees. However, unprecedented infrastructural and residential expansion, anthropogenic activities, and unsustainable agricultural practices have caused severe urban green space depletion.

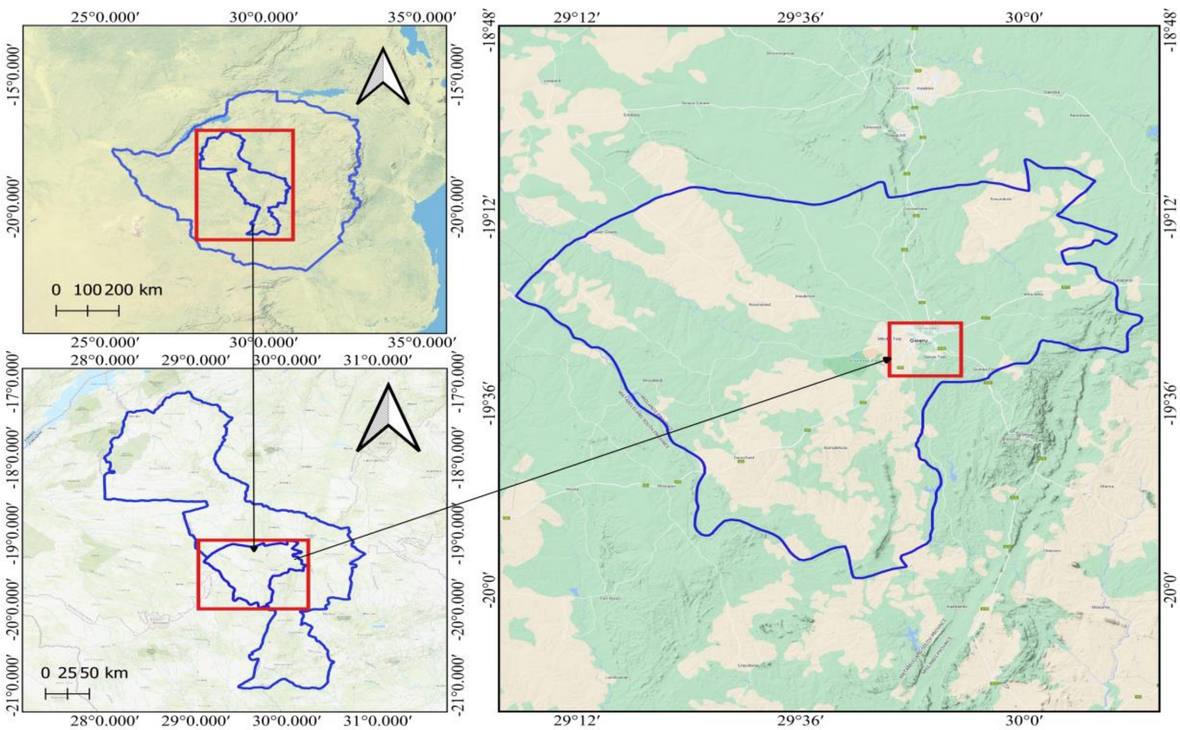

Figure 1: Gweru City

The depletion of green spaces has altered the general climatic condition of the city resulting in the shrinking and drying up of wetlands such as dams, rivers and streams which supply water for both domestic and industrial purposes. In addition, this has resulted in other suburbs running dry and others having water rationing.

3.2 Data collection and sources

The study used a mixed-method data collection approach, combining both quantitative and qualitative tools and sources. Quantitative data in the form of spatial were downloaded from the U.S Geological Survey (USGS) Earth Explorer database, which has unrestricted access with extended temporal coverage of the dataset. Five datasets were acquired for this study; name, Landsat 4 MSS, Landsat 7 EMT, and Landsat 8 TIRS. Data availability and the percentage of cloud coverage determined the selection of these various years for the satellite images used. For effective data accuracy, the researcher carried out ground-truthing through field observations. A total of 200 field points were collected with 50 each from various land classes. The LULC classes served as the basis for image analysis, classification, and accuracy assessments. Table 1 shows a summary of Landsat datasets used in the study.

Table 1: Landsat images used for UGS analysis

Satellite	Path/row	Resolution	Acquisition Date	Source	Remarks
Landsat 4 MSS	170/73	30m x 30 m	24/09/2000	USGS	Dry season data
Landsat 7 ETM	170/73	30m x 30 m	20/09/2005	USGS	Dry season data
Landsat 7 ETM	169/72	30m x 30m	21/09/2009	USGS	Dry season data
Landsat 8 OLI	169/72	30m x 30m	26/09/2015	USGS	Dry season data
Landsat 8 OLI	169/72	30m x 30m	23/09/2019	USGS	Dry season data

OLI-Operational Land Imagery, ETM-Enhanced Thematic Mapper, MSS-Multispectral Scanner

The study also used structured interviews and observations as qualitative data collection methods. This was meant to buttress and provide meaning to spatial data analysis (quantitative), particularly on the drivers of UGS dynamics. As such, the Gweru residents with diverse demographics were recruited. This was intended to gain rich information on the drivers that led to the demise of UGS in the city. Residents with 18 years and above were interviewed as they are active and constantly using green spaces for socialisation, relaxation, and educational discussions. Thus, to cover the breadth of the study area, the study used stratified and random sampling techniques. Stratified sampling was used to identify both high, medium and low-density suburbs upon which the study used random sampling to recruit the participants for interviews. Face-to-face interviews were conducted and lasted approximately 10 minutes and were tape-recorded to ensure that no information was missed. Several interviews were carried out until data saturation occurred. Informed consent was sought before the interviews as part of ethical considerations.

In terms of observation, the study determined observable areas such as parks, gardens, and recreational areas. This was intended to capture a comprehensive picture of the distribution and conditions of urban green spaces in the city. The parameters which were observed included number of visitors, activities taking place, duration of stay, and use of amenities. This provides the study with a structured framework for data collection. Direct observations were carried out during weekends from around 2 pm to 4 pm. This is a period where almost every resident finds time for relaxation and social activities. The observations lasted for a month and this produced enough evidence of what prevails in different geographical areas of the city. Images were also collected to support the observations made during the research period.

3.3 Data analysis

Quantitatively, spatial data processing was done using ArcGIS 10.2 and the Environment for Visualising Images (ENVI 5.3). In this research, image processing approaches included geometric, atmospheric, radiometric corrections, and classification adjustments as well as image enhancement. The images were all projected to Universal Transverse Mercator (UTM) zone 36 south and georeferenced to World Geodetic Systems (WGS84). Quick atmospheric correction and the gap-fill techniques in ENVI were used to fix images that included scan lines and atmospheric distortions. For image classification, supervised classification methods were used. The training data from ground-truthing and field observation was used to categorise images using the maximum likelihood technique. Four classes of photographs were identified: built-up area, bare ground, green space, and waterbody. The different LULC classes used in the research are detailed in Table 2. The methods of post-classification change analysis were used to ascertain how the categories of land cover had changed over time. To ascertain the alterations in LULC classes, an inter-pixel analysis of the classes was carried out. MS Excel was also used to estimate the yearly and percentage rates of change for the various land cover groups. The referenced data (50 points per class) and classification data were used to create a confusion matrix, from which the degree of accuracy in the classification was calculated using the user, producer, overall accuracies, and Kappa coefficient.

Table 2: Land use/cover classification categorisation

Land cover classes	Description of each land use/cover class
Waterbody	This is an area submerged in water and this includes river streams, wetlands and dams.
Greenspace	Area covered by vegetation (hibiscus, lawn, orchard, bushland, woodlands, etc.)
Bare ground	This is an area of the earth's surface covered by bare soil and rock outcrops
Built-up area	Earth's surface is covered by concrete and buildings (houses, factories, industries etc.)

Source: Author

Qualitatively, thematic analysis was used to analyse the data that was obtained from the surveys and interviews. The data was transcribed and coded to identify recurring themes, patterns, and categories. This analysis assisted the researcher in determining the drivers of UGS dynamics in Gweru City. In addition, content analysis was carried out to analyse the qualitative data from the field observation. The observations were recorded and analysed in the identification of common features of UGS, such as amenities, quality, and user experiences. This analysis provided insights into the physical aspects and user perspectives of green spaces. Finally, the findings from both quantitative and qualitative data were integrated to provide a comprehensive understanding of the spatio-temporal dynamics of urban green spaces in the city of Gweru. The qualitative data assisted in the interpretation and contextualization of the quantitative results. This helped the researcher to have a deeper understanding of the social, economic, and environmental aspects of UGS dynamics in the municipality.

4. Results and Discussion

The main objective of this study was to examine the spatio-temporal dynamics of urban green spaces in Gweru City in the Midlands Province of Zimbabwe using a mixed-method approach. As such, it was guided by the following specific research objectives: assessing Gweru City's urban green space distribution and extent from 2000 to 2019, examining how Gweru City's urban green areas have changed throughout time, and analysing the variables influencing the spatio-temporal dynamics of Gweru City's urban green areas. The results of these objectives are presented below.

4.1 Classified images' accuracy assessment analysis

Accuracy assessment levels of the classified images revealed high overall accuracy and Kappa coefficient values of the study epochs (Table 3). From the five different periods of the study, the highest overall accuracy (97%) was recorded in 2005 and 2019 respectively whereas the lowest (94%) was recorded in 2000 and 2015. The 2009 image classification recorded an overall accuracy of 96%. This gives an averaged overall accuracy of 95.6 % across all the epochs of the study. A similar trend of the overall accuracy assessment also prevailed on the values of the Kappa Coefficient values. The highest Kappa coefficient (0.96) was recorded in 2005 and 2019 respectively and the lowest (0.92) was recorded in 2000 and 2015. In 2009 it was 0.94. The Kappa coefficient values for all the periods of the study averaged 0.94

Table 3: Accuracy assessment of green spaces and associated land use and cover

Year	Classification accuracy (%)	Kappa Coefficient statistics
2000	94	0.92
2005	97	0.96
2009	96	0.94
2015	94	0.92
2019	97	0.96

Source: Authors

It can be interpreted that some miscalculations of LULU classes resulted in differences in the overall accuracy and Kappa coefficient values of the study period. This was a result of the differences in image qualities. Nevertheless, with all the Kappa coefficient values above 0.8 and within the range of 0.81 to 1.0 (Adusu et al., 2021), it can be concluded that limited deviations existed between the classified image and the reference data used for accuracy assessment analysis. The result resonates with a study carried out by Adusu et al. (2021) on the effects of urban growth on the historical land use/land cover in the Sunyani Municipality of Ghana.

4.2 Urban green spaces distribution analysis for the period 2000 and 2019

The results (Table 4) revealed that green spaces during the study period were declining and that the built-up area was increasing.

Table 4. Composite LULC changes (2000-2019)

Class	Class cover (km^2)									
	2000		2005		2009		2015		2019	
	Area	%	Area	%	Area	%	Area	%	Area	%
Waterbody	18	0	15	0	12	0	7	0	5	0
Green space	2813	17	2101	13	1981	12	1020	6	893	5
Bare ground	5718	35	4814	29	4051	25	3022	18	2147	13
Built-up	7902	48	9521	58	10407	63	12402	75	13406	81
Total	16451	100	16451	100	16451	100	16451	100	16451	100

The study shows that the greatest decrease in green spaces occurred between 2009 and 2015. It sharply decreased by 6% from 12% in 2009 to 6% in 2015. The lowest decrease (1%) was experienced between the periods (2005-2009) and (2015-2019), respectively. The decrease in green spaces was 4 % between 2000 and 2005. This trend shows that Gweru municipality is rapidly urbanising. The findings confirm previous studies in South Africa (Venter et al., 2020), Nigeria (Oduwaye, 2013) and Ghana (Mensah, 2014a, b). Matsa et al. (2021a, b) confirmed this in their study on the loss of green spaces in Gweru City.

The changes in UGS can be visualized and interpreted in Figure 2 below.

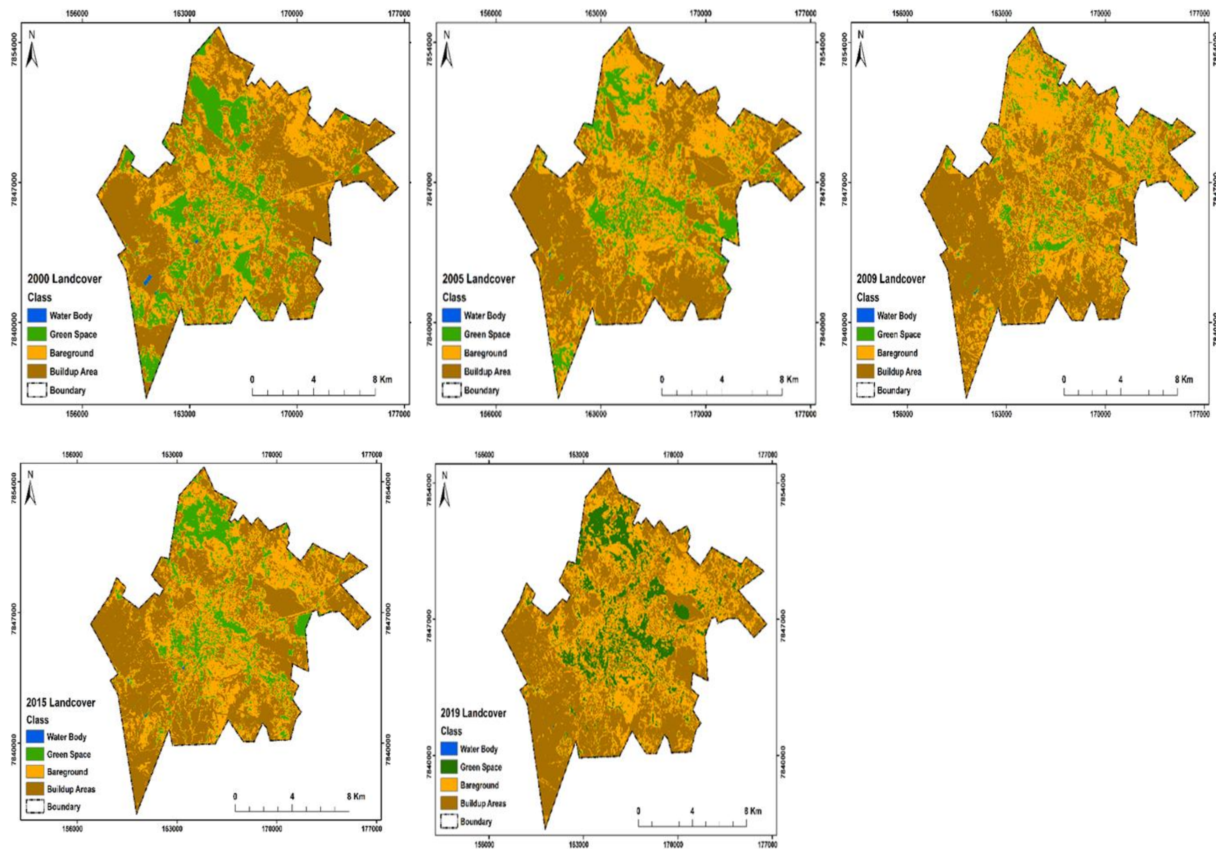

Figure 2: Variations analysis of urban green spaces in Gweru City (2000-2019)

The field observations showed that green spaces were rapidly deteriorating in the western suburbs where high-density suburbs are concentrated. These suburbs included Mkoba Villages (1-21), Mtapa, Ascot, Mambo, Woodlands. These areas are densely populated and were created for the black majority during the colonial period. Ever since that era, the green spaces are still deteriorating in high-density suburbs. Pockets of green spaces are mostly concentrated in the central and northern parts of the city. The central pockets include both medium (Nashville, Athlone, Irvine and Northlea) and low-density suburbs (Ridgemont, Lundi Park, Tatenda Park etc) and the areas surrounding the central business district (CBD) (Kopje, Winsor Park, Zimbabwe Military Academy). Most of these areas were under a few white minorities before the independence of 1980. The results conform with the results by Venter et al. (2020) who discovered that the distribution of green spaces is positively skewed towards low-density suburbs in South Africa. They attributed this to the apartheid era where the white minority owned vast urban lands.

4.3 The magnitude and annual rate of urban green space dynamics

The magnitude and rates of urban green spaces were fluctuating over the two decades (2000-2019). Table 5 indicates that between 2009 and 2015, green spaces decreased by 961 km^2 at an annual rate of -8.1 %. However, overall, between 2000 and 2019 the results show that the green spaces deteriorated by 1920 km^2 at an annual rate of -3.6%. Generally, the results depict that over a short period (2009-2015), green spaces can be severely fragmented but if the analysis is carried over a long period (2000-2019), it can give a false impression that the rate at which green spaces are declining is negligible. This has a bearing on policymakers and all the stakeholders as they would think that everything is normal. Therefore, it is imperative for city authorities to periodically (five-year periods) assess green spaces in their area of jurisdiction.

Table 5: The magnitude and annual rate of urban green space dynamics

Class	Magnitude (km^2)					Rate per annum (%)				
	00-05	05-09	09-15	15-19	00-19	00-05	05-09	09-15	15-19	00-19
WB	-3	-3	-5	-2	-13	-3.3	-5.0	-6.9	-7.1	-3.8
GS	-712	-120	-961	-127	-1920	-5.1	-1.4	-8.1	-3.1	-3.6
BG	-904	-763	-1029	-875	-3571	-3.2	-4.0	-4.2	-7.2	-3.3
BA	1619	886	1995	1004	5504	4.1	2.3	3.2	2.0	3.7

Source: Author

These results are in line with a study that was carried out at Hova Farm in Bindura District. Mukwenyi et al. (2021) discovered that analysing land use and cover trends over a long period gives a false impression to farm management, hence they called for a periodical assessment of five-year intervals. A similar study by Latifovic, Pouliot & Nastev (2010) in Canada revealed the same observation when they studied land cover for regional aquifer characterization.

4.4 Variables influencing spatio-temporal dynamics of urban green spaces dynamics

To gain valuable insight into the drivers influencing urban green space dynamics, the researcher decided to interview Gweru residents to gain insightful information on their perception of what is prevailing in the city. Four major themes emerged from the interviews and observations. These included human activities, administrative deficiencies, natural disasters, and geological influence.

Human activities such as construction, transportation, accessible markets, industrialisation, different cultural practices, and population growth emerged as the major causes of the UGS dynamics in the city of Gweru. The residents expressed concern that the above-mentioned human activities were destroying pockets of green spaces in the city (Grigoletto et al., 2021). For example, they pointed out that due to high population growth, the estate developers ended up consuming the green spaces in the nearby hinterlands to build houses to accommodate the ever-growing list of houses. This had a ripple effect on people in the neighbourhoods as the overtures triggered conflicts. To make matters worse, the residents reported that to accommodate the residents, the city council gazetted in circular number 20 of 2004 that the sizes of stands in high-density suburbs be in the range of $80m^2$-$150m^2$. The sizes are too small for a family of five that intends to construct a 5 roomed house. This leaves the stand without an area for greening the environment (Figure 3). This is similar to what was discovered by Wu et al. (2019) in Shanghai, China. They discovered that small-sized stands have a huge impact on the establishment of green spaces in the city. Similarly, Ye, Hu & Li (2018) discovered the same trend in Macau City in China.

Figure 3: Small-sized stands in Gweru city's high-density suburbs (Source: Fieldwork)

The other key theme that arose from the interviews and observations was administrative deficiencies. The residents listed a plethora of administrative deficiencies such as inconsistent policy from the government, political interference, poor urban planning, corruption, lack of green spaces database, poor by-law enforcement practices, lack of collaborative governance, tag-off war between the central government and lack of community engagement. For instance, the residents highlighted that there is always a tug-of-war between the Zanu-PF and MDC (Mugwari, 2017; Teddy & Vhutuza, 2017). The central government is run by the ruling party (Zanu-PF) and the MDC oversees the running of municipalities. Due to the political orientation, each party thrives to undo the other as a way of luring votes so that they remain in power. As a result, the by-laws on environmental protection are not observed. This results in the haphazard construction of houses and this leads to the demise of green spaces in the city. The impact of administrative deficiencies on green space dynamics was also discovered in countries such as Ghana (Mensah, 2014a) and Zimbabwe (Marambanyika, Dube & Musasa, 2022; Matsa et al., 2021a, b; Mandishona & Knight, 2019; Chirisa & Muzenda, 2014).

Natural disasters such as persistent drought due to climate were also cited as one of the major drivers of urban green space dynamics in Gweru City. The residents expressed that due to drought they can hardly establish green spaces due to water rationing. Some suburbs' have not received water from the municipality since its establishment. They rely on borehole water for domestic chores and to establish at least a garden hits a brick wall even if they are interested in establishing green spaces. Linked to natural disasters was the geology of the area. Residents pointed out that their area is rocky to such an extent that it becomes difficult to establish green spaces due to the rocky nature of their places of residence. Some residential areas are even on steep slopes with shallow soils. Under such circumstances, green spaces cannot grow as they easily wither. This resonates well with a study that was carried out in the city of Leipzig in Germany (Kraemer & Kabisch, 2022). Kraemer and Kabisch highlighted that drought conditions affected the inner-city parks of Leipzig City as the vegetation wilted.

5. Conclusion and Recommendations

5.1 Conclusion

Using a mixed method approach, the research evaluated the spatio-temporal dynamics of UGS in Gweru City and discovered that green spaces are depleting at a faster rate. Several implications may be made from the results. The scope and existing distribution of urban green areas in Gweru City are shown by the research. It points out places where there are insufficient green spaces, emphasising the need for focused initiatives to provide fair access to these areas in various neighbourhoods and communities. Human activities, administrative deficiencies, natural disasters, and geology were the variables cited as the factors influencing the spatiotemporal dynamics of urban green areas revealed by the qualitative study. Comprehending these variables is crucial for well-informed decision-making and efficient urban design. The historical research shows how Gweru City's urban green areas have changed throughout time. In light of the demands of urban growth, this emphasises the need for ongoing monitoring and flexible management techniques to guarantee the long-term viability and preservation of green areas.

5.1 Recommendations

The study's results lead to the following suggestions being put forth:

1. Equitable Distribution: The fair distribution of urban green areas across various neighbourhoods and communities ought to be a top priority for urban planners and legislators. This may be accomplished by making deliberate interventions in underprivileged regions, such as creating new green spaces or improving the ones that already exist.

2. Improving Accessibility: In Gweru City, initiatives should be taken to make urban green areas more accessible. This may be accomplished by improving the transportation system, constructing paths for bicyclists and pedestrians, and making sure that communities and green areas are connected.

3. Stakeholder Engagement: When it comes to the development, creation, and upkeep of urban green spaces, interacting with locals, local authorities, and other stakeholders is essential. By involving them and soliciting their feedback, we can make sure that the green areas serve the community's needs and preferences.

4. Sustainable Management: To protect and improve Gweru City's urban green areas, sustainable management techniques must be used. This includes routine upkeep, the preservation of biodiversity, and the incorporation of green infrastructure into the procedures involved in urban planning.

5. Long-term Monitoring: To track changes over time and evaluate the efficacy of management measures, ongoing monitoring of urban green areas is required. This may help with evidence-based decision-making and provide insight into adaptive management strategies.

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