INVESTIGATION OF URBAN GREEN SPACE (UGS) ACCESSIBILITY IN ADELAIDE METROPOLITAN AREA USING NETWORK ANALYST

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ABSTRACT:

Urban Green Space (UGS) is one of the essential components of the urban systems for promoting quality of life in urban areas and sustainability. Planning and designing accessible public green spaces are critical for urban life as cities' most available natural environment. Walkable accessibility of UGS is one of the essential indicators of people's health and wellbeing. This paper aims to evaluate the walking accessibility of UGS through Adelaide Metropolitan Area at the local councils level using Network Analyst in GIS. The results show that the councils of Norwood Payneham and St Peters, Charles Sturt and the City of Adelaide have the most walking accessibility to UGS for the residents in their area. In contrast, Mount Barker, Playford and Adelaide Hills councils have the least walking accessibility. Therefore, UGS distribution is unequal throughout the study area, and local councils close to or around the inner part of the metropolitan area have more accessible green spaces.

1. INTRODUCTION

Urban Green Space (UGS), generally available in urban areas, can bring vital benefits to urban liveability (Lopes and Camanho, 2013). The balanced distribution of UGS throughout the city and accessibility to UGS promotes healthy behaviours such as cycling and walking, public health improvements, and urban residents' socialisation (Gebel et al., 2011; Gong et al., 2014; Maas et al., 2006). For example, access to public parks close to homes has been highly correlated with physical activity (Frank et al., 2007; Giles-Corti et al., 2005). Several studies have shown a positive correlation between the presence of UGS and people's wellbeing, including a good sense of health and reduced risk of mortality (Maas et al., 2009; Mitchell et al., 2007). UGS is regarded as a quasi-public good (Li et al., 2022; Chen et al., 2019), and generally, it is provided by the local governments (MacKenzie et al., 2019). Planning and designing accessible public green spaces are essential for urban life as cities' most available natural environment (Zhu et al., 2022). Accessibility of UGS is one of the significant criteria for sustainable development translation (Yoong et al. 2017) and high-quality life (Chan & Lee 2008; Dempsey, N et al. 2011). Accessible public UGS, including urban forests, parks, and community gardens, provide ecosystem services and increase general public health through psychological wellbeing and physical activity for residents (Sugiyama et al., 2008; Lee et al., 2015; Shi et al., 2020; Xiao et al., 2017). In other words, as UGS has positively affected people's mental and physical health, equal access to UGS for all people, regardless of their characteristics, is vital to better public health (Liu et al., 2021). On the other hand, walkability is a widely used indicator to determine how useful an area is for people to walk from chosen destinations (Lwin et al., 2011). Walkable access to parks and green spaces as an essential indicator has been recently recommended for urban residents' physical activity and the greening of the residential areas (Hu et al., 2022; de Keijzer et al., 2020). UGS with high walkable accessibility provide benefits in promoting social connection, physical activity, mobility, and psychological pleasure (Carr et al., 2010), related to urban livability and sustainability. According to previous studies, different factors cause challenges to accessibility to UGS, including education (Chen et al., 2020), economic situation (Dennis et al., 2020), and race (Venter et al., 2020).

No	Method	Authorities and Organisation	Metric Type	Metric Used in This Article
1	No person should live more than 300 m from their nearest area of green space	Natural England of UK	Proximity	Proximity Distance to the nearest UGS (m)
2	The UK urban dwellers should have access to 20 ha of urban green space within a 300 m distance to the place of residence	Natural England of UK	• Proximity • Area based provision	Accessible UGS within 500 m around SA1 boundary (km2)
3	Can access any green site within 300 m of minimum administrative boundary	Natural England of UK	• Proximity • Area based provision	Distance to the nearest UGS (m)
4	Provision should be made of at least 2 ha of accessible natural greenspace per 1000 population	Natural England of UK	• Population Share	UGS per capita (m2)
5	Every resident should have access to UGS of a minimum of 0.5 ha within a 500 m distance from home	Berlin's Department of Urban Development and the Environment	• Proximity • Area Based Provision	Accessible UGS within 500 m radius
6	A minimum green provision of 60 m2 per-capita within a 500 m radius around households	Netherlands	• Proximity • Population Share	Accessible UGS per capita within 500 m of SA1 area (m2)
7	Every household in Germany should have access to urban green space within walking distance	National Strategy on Biological Diversity in Germany	• Proximity	Distance to the nearest UGS (m)
8	The SDG indicator of urban greenness is the total amount of green area in square meters	European Commission, Joint Research Centre of EU	• Area Based Provision	UGS cover (%)
9	People should have access to urban green within 15 min walking distance, which is approximately 900–1000 m	European Environment Agency (EEA)	• Green Space Catchment • Proximity	People living within 1000 m of UGS
10	Cities provide a minimum of 9 m2 of green area per	World Health Organisation	• Population Share	UGS per capita (m2)

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	inhabitant			
11	Residents live within a 15 min walk of green areas	World Health Organisation	• Green Space Catchment • Proximity	People living within 500 m of UGS People living within 1000 m of UGS
12	Every household will be within a 10-min walk from a park	Green Plan 2030, Singapore	• Green Space Catchment • Proximity	People living within 500 m of UGS People living within 1000 m
13	Create 20% more and better green space in urban areas in Australia by 2020	Program of greener space, better places, Australia	• Area Based Provision	UGS cover (km2)
14	A target of increasing urban green cover by 20% in metropolitan Adelaide by 2045	Government of South Australia	• Area Based Provision	UGS cover (%)
15	Parkland thresholds per 1000 residents based on population density: Low for 20.3 acres; intermediate-low for 13.5 acres; intermediate-high for 7.3 acres; high for 6.8 acres	U.S. Green Building Council	• Population Share	UGS per capita (m2)
16	Population located within a 1/2 miles or 10-min walk of public parkland: low for 70% and high for 85%	U.S. Green Building Council	• Green Space Catchment • Proximity	People living within 500 m of UGS (%) People living within1000 m of UGS (%)

Table 1. UGS access standards in the world (Hsu,et al.,2022,P4)

As the significance of UGS is recognised for the cities and citizens' health, emphasising UGS accessibility has increased in recent years by researchers and urban planners (Hsu et al., 2022). Previous studies adopted different approaches to measuring UGS accessibility (Dai, 2011; Ekkel & de Vries, 2017). As seen in table 1, Hsu et al. collected the most considered approaches in the world in this regard (Hsu et al., 2022). However, there is no national approach to addressing the fair distribution of green spaces in Australia.

While planning for UGS quantity has been emphasised in most cases, its equal distribution has been ignored (Wu et al., 2016). UGS is an essential urban infrastructure that affects the city's physical development (Zhang et al., 2020). Therefore, UGS is considered as an urban ecosystem service providing many social and ecological advantages for residents (Cilliers et al., 2013). However, equal spatial accessibility should be regarded in UGS planning concerning its advantages. Therefore, UGS's spatial equity and accessibility are vital to enhancing its benefits (Wolch et al., 2014). This paper aims to evaluate the accessibility of UGS through Adelaide Metropolitan Area using a Network Analyst in ArcGIS.

2. RESEARCH METHOD

2.1 Case Study

Greater Adelaide is the central part of South Australia, with a 3260 sqm. area with population of 1,295,649 (ABS, 2017). Adelaide is one of the primary international examples of the world's garden city and is well known as a livable city. This area's important strengths are planned structure and low-density suburbs (Kellett, 2010). "Adelaide takes a linear form, extending 90 km from north to south on the Adelaide Plains bounded by the Mount Lofty Ranges and the Gulf St Vincent" (Department of Infrastructure and Transportation, 2022). The population density in Adelaide was around 390 people per square kilometre in 2017 (Hsu et al., 2022), while its inner urban population density is 2148 people per km² (Hsu et al.).

2022). "About three-quarters of the population of South Australia lives in the Adelaide metropolitan area" (ABS, 2022). South Australia has 68 councils across the state, and 20 councils are located in Greater Adelaide (Local Government Association, 2022).

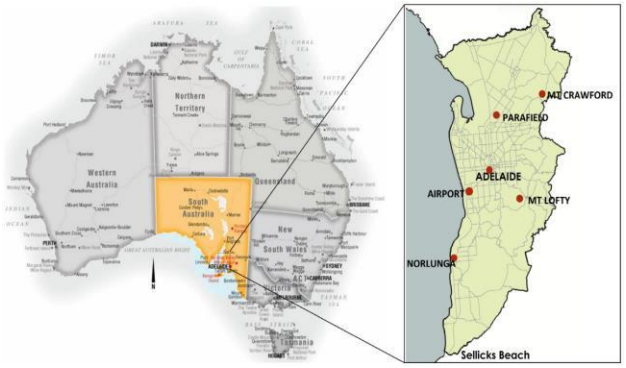

Figure 1. The case study area

Adelaide was the third most liveable city in the world in 2021. It has 30% open green space. Adelaide is Australia's first and the world's second globally recognised National Park City (Green Adelaide, 2022). Green space throughout Adelaide has a fragmented pattern around the central part of the mero, concentrating in the Adelaide Hills district, a cluster of national parks and reserves such as Belair National Park (Hsu et al., 2022).

Green spaces cover 10.81% of Greater Adelaide and provide 272.21 m² UGS per capita for all residents (Hsu et al., 2022).

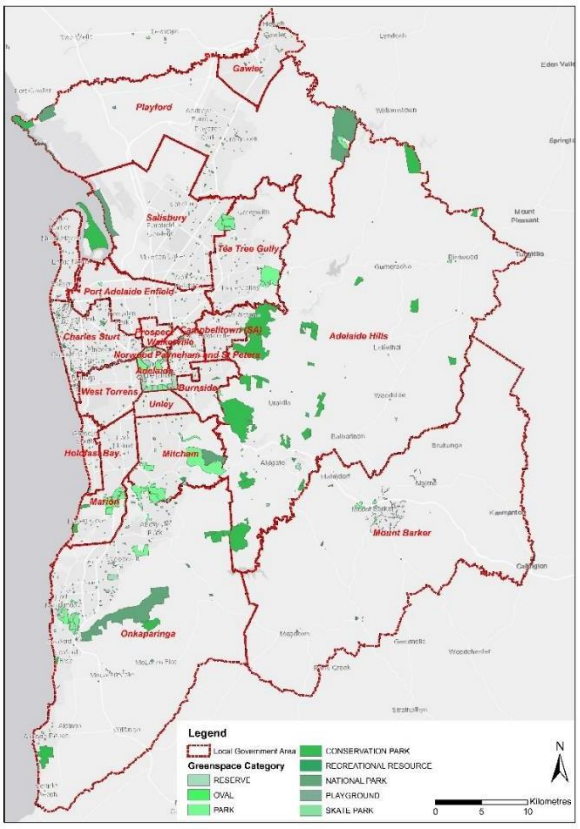

Figure 2. Public UGSs in Adelaide Metropolitan Area

2.2 The Method

In this study, the accessibility to UGS has been investigated using network analysis techniques in ArcGIS to address the aim of this research. Network analysis is the extensively used and most accurate method for calculating service areas (Zhu et al., 2022; Liu et al., 2016). To conduct the analyses, first, the locations of public UGSs at the scale of the Adelaide Metropolitan Area at the local government area level were Identified using the AURIN's dataset of 'PSMA – Transport & Topography – Greenspace (Polygon) August 2020'. AURIN which stands for Australian Urban Research Infrastructure Network, provides a portal in which researchers can access a vast range of datasets and computational tools for analysing, synthesising and visualising the urban and geographical data for all Australian cities (Bassiri Abyaneh et al., 2021).

Based on public accessibility, eight subcategories, namely recreational resource, playground, skate park, reserve, conservation park, national park, park and oval, were chosen as public green spaces to investigate the level of accessibility. Secondly, to analyse the level of accessibility of all green spaces, the Network Analyst toolkit of ArcMap 10.8 was used. According to Southworth (2005), local services, including public UGS, can be reached by up to 10-minute walking or up to approximately an 800-metre walk in cities. This study focuses on the accessibility of green space to nearby residential areas. Therefore, in this study, the network analysis was carried out on a roads dataset available from the Department of Infrastructure and Transport (2021), considering two service areas of 400 metres (5–10 minute walking) and 800 metres (10–20 minute walking) from each green spaces. Consequently, to understand and compare the proportion of each Local Government Area (LGA) with proper access to UGSs, a percentage analysis was conducted considering the 400-metre and 800-metre accessible green areas and the total areas of each LGA. Finally, by intersecting the accessible areas and the 2016 Mesh Block dataset provided by ABS (2017) using ArcMap 10.8, the number of people who reside in the 400-metre and 800-metre catchments from UGSs was determined.

3. RESULTS

This study explored the location and distribution of UGS and the spatial inequality within the Adelaide Metropolitan Area using GIS analyses. All green spaces that are accessible to the public are considered in this study (figure 2).

This research generally focuses on the public accessibility of UGS among the councils within the study area. Therefore, the service area within a 400 m² and 800 m² radius from the edge of green spaces was analysed. According to the network analysis, Norwood Payneham and St Peters council have the most walkable accessibility to UGSs, such that 71.11% of this council area has 400m accessibility, and 97.82% of its area have green spaces accessible within 800- meters. Council of Charles Sturt with 67.19% cover for 400-meters and 95.3% for 800-meter cover, and council of Adelaide City as CBD of the Metropolitan Area with 66.65% (400-meter) and 87.54% (800-meter) are in the second and third rank of walkable accessibility.

In contrast, the green spaces of the Council of Mount Barker only cover 2.37% of its area for 400-meter and 5.65% of its area for 800-meter accessibility. Also, Adelaide Hills and Playford councils are among the councils with less accessible green spaces (table 2).

No	Adelaide Metropolitan Area Councils	The Councils Areas	400M Accessibility Area	400M %	800M Accessibility Area	800M %
1	Adelaide	15578368.89	10383734.3	66.65	13637271.43	87.54
2	Adelaide Hills		24788084.4	3.12	79037900.07	9.95
3	Burnside	27527430.76	4382839.1	15.92	14734620.71	53.53
4	Campbelltown	24357092.99	6405410.09	26.3	19382615.18	79.58
5	Charles Sturt	54814833.14	36830807.7	67.19	52239230.23	95.3
6	Gawler	41148529.55	1725552.72	4.19	7393176.427	17.97
7	Holdfast Bay	13758779.03	3475746.83	25.26	9819006.73	71.37
8	Marion	55662541.26	8565851.64	15.39	25944486.31	46.61
9	Mitcham	75574796.62	14420218.7	19.08	37248097.79	49.29
10	Mount Barker	594716981.5	14115962.1	2.37	33753675.1	5.68
11	Norwood Payneham and St Peters	15108432.88	10743717.9	71.11	14779710.02	97.82
12	Onkaparinga	518334836.2	44402962.9	8.57	111877775.8	21.58
13	Playford	345318256.1	12359372.5	3.58	37932183.37	10.98
14	Port Adelaide Enfield	91796555.29	11464109.7	12.49	36965143.85	40.27
15	Prospect	7794847.128	1801153.06	23.11	5569027.802	71.45
16	Salisbury	159906846.6	10819628.3	6.77	38420131.22	24.03
17	Tea Tree Gully	95234178.03	9579825.07	10.06	32129868	33.74
18	Unley	14276218.28	2612660.75	18.3	7142993.614	50.03
19	Walkerville	3531114.605	1470352.94	41.64	3041088.091	86.12
20	West Torrens	37105199.48	4960849.44	13.37	15590506.21	42.02

Table 2. Council area and walking accessibility of 400m and 800m to UGS

The investigation reveals that around 50 per cent of the local councils have more than 10 minutes of walkable accessibility to UGS. Most of these areas are located in peripheral parts of the Adelaide Metropolitan area. Therefore, according to the network analysis carried out in this study (figure 4), neighbourhoods located in the councils closer to the central part of the metropolitan area known as "city" have better accessibility to UGS than other councils. In contrast, councils such as Adelaide Hills, Gawler, Mount Barker, Playford, and Salisbury, located further away from the city (CBD), have less walkable access to UGS. In addition, these councils with the extensive area have more private, natural and unplanned green spaces than public and planned green spaces. Thus, these areas have less accessible public green spaces compared to the councils closer to the city like Norwood Payneham and St Peters, Charles Sturt, Walkerville, and Campbelltown.

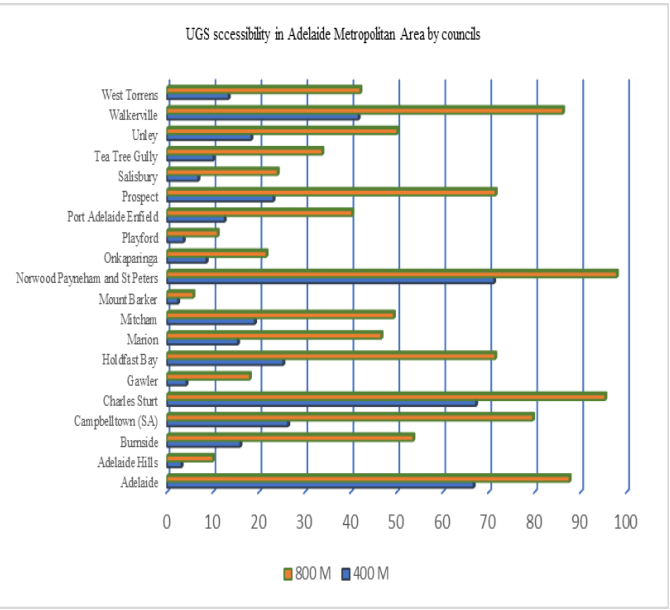

Figure 3. Walkable accessibility to UGS in Adelaide Metropolitan Area by councils

Therefore, as seen in figure 4, the first two councils, in terms of proper access to green space, are located in the vicinity of the central part of the metropolitan area, and the third council is the Central Business District (CBD) of Adelaide. Some councils located between the city and peripheral parts of the Adelaide Metropolitan Area have around 50 per cent walkable UGS, such as Marion, Unley, West Torrens, Port Adelaide, and Burnside. Therefore, it was evident that the councils' location in relation to the city (CBD) affects the UGS accessibility. In other words, the more the range of councils is far from the metropolitan centre, the less accessible green space is considered by the planners. It can be stated that existing of vast private, natural, and unplanned green areas in the peripheral councils may cause ignorance of planners about accessible public green spaces.

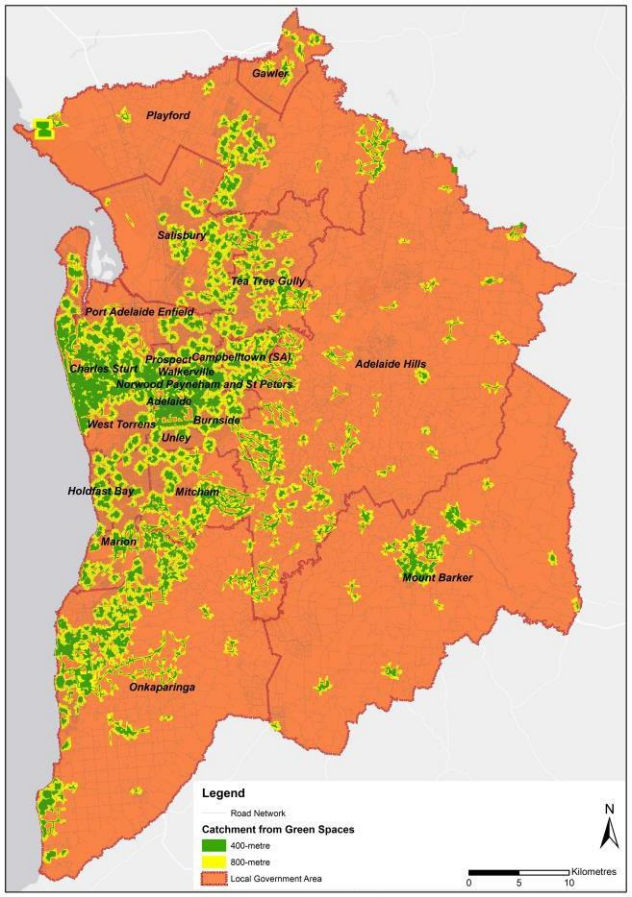

Figure 4. Walking accessibility of UGS in Adelaide Metropolitan Area

Regarding the analysis of this study, in general, 7.88% of the area of all Local Councils in Adelaide Metropolitan Area have 400-metre walkable access to urban public green spaces. Also, 20% of the councils benefit from 800-metre walking accessibility.

This analysis reveals that only residents living in one-fifth of the study area can reach green spaces within about 10-20 minutes of walking from their residential areas. However, the possibility of easy access for the people differs among the council areas.

The results of ArcMap analysis on the Mesh Block dataset (ABS, 2017) indicated that 9841 people live in the 400-metre and 15309 people live in 800-metre catchment from UGSs in their neighbourhoods (figure 5). Therefore, a small percentage of the Adelaide Metropolitan Area's population has about 800-metre or between 10 to 20 minutes of walking accessibility to green spaces.

Therefore, while previous studies show high per capita green space in Adelaide metropolitan area Hsu et al., 2022), access to UGS in different local government areas across the metro area varies to a large extent. The consequences of this disparity can affect the quality of life of people.

The findings demonstrate that the peripheral areas with low population and urban infrastructure density have fewer green spaces than councils located in the inner and middle parts of the metropolitan area.

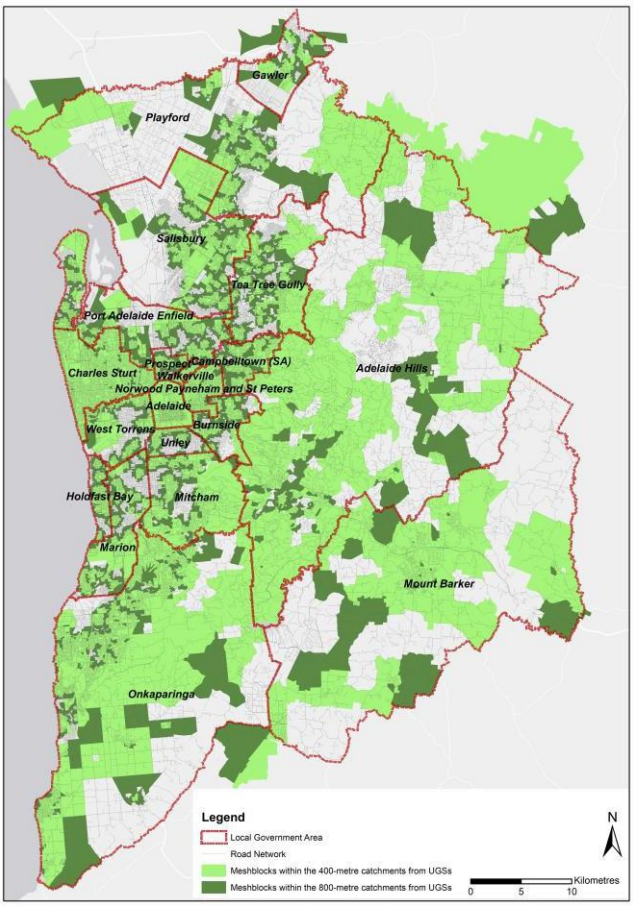

Figure 5. Mesh Blocks within the 400M and 800M catchment from UGSs in the Adelaide Metropolitan Area.

Therefore councils with high population density in the inner and middle parts of the Adelaide Metropolitan Area benefit more from available green spaces.

4. CONCLUSION

UGS accessibility essentially relieves social and ecological problems of urban life (Gutiérrez et al., 2021), and it has been identified as an effective method for evaluating urban sustainability (Du et al., 2020). Green space accessibility impacts climate mitigation in residential areas, air pollution purification, providing habitat for biodiversity, encouraging walking and cycling, improving human health and wellbeing, and promoting social interaction. Therefore, it can be viewed as a significant indicator of environmental justice (Hsu et al., 2022).

In this study, using Network Analyst in ArcGIS, all public green spaces that are useable by people have been analysed to determine the extent to which of Adelaide Metropolitan Area is accessible to public UGSs within 400m² and 800m² radius of green spaces. The results indicate that councils with active planning and housing programs closer to the central part of the metropolitan area generally have more accessible green spaces. However, extensive councils with more natural areas have more natural and private green spaces, such as private farms that are not accessible to the public. Therefore, the population density and housing positively impact the planning of accessible UGSs by councils in the Adelaide Metropolitan Area.

This study shows that UGS distribution throughout Adelaide Metropolitan Area is uneven. This Metropolitan Area faces a disparity in UGS, especially in the outer areas. Therefore, most peripheral parts of the Adelaide Metropolitan Area need more attention to planning and design of UGS, including the provision of new and additional UGS. State and local government support and community involvement should work towards the accessible, interactive and equitable provision of UGS in the metropolitan area.

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