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Using GIS and satellite data to assess access of green area for children living in growing cities

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Using GIS and satellite data to assess access of green area for children living in growing cities.

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1 ABSTRACT

Urban green space (UGS) refers to open spaces within an urban context that are filled with greenery and nature. These can range from very small vegetation to expansive park areas. The common denominator is that they have proven to be beneficial for human health and well-being. Access to green spaces is also important for children. Research suggests that time spent in green spaces supports the behavioral, intellectual, and physical development of children.

When cities are growing, it is often associated with a loss of UGS due to the current concept of densification which is achieved by infill, repurposing land, and adding height to existing buildings. The loss of UGS can negatively affect access to green spaces for the inhabitants of an urbanized city. It is supported by previous research that access is not equal, and oftentimes those with lower socio-economic standing are negatively affected by the loss of UGS.

Given the above, this study set out to examine how changes to a city influences UGS and access to green space in urban areas using the city of Malmö as a case study. A rapidly growing urban area, it is the fastest growing city in Sweden. While the city reports diminishing UGS within the urban context, the municipality has aimed to expand Malmö through densification - mostly through the refurbishing of industrial areas according to official documents regarding city development. This study uses the official greenery guidelines for Malmö, to assess how access to UGS corresponds to official aims. It focuses on the relation to children's daytime access to UGS by examining the accessibility from school environment, using pre- and compulsory schools as the base for analysis. This study also examines how this varied depending on socio-economic background.

To assess the extent of UGS access, GIS is used to develop a methodology using open access satellite-, demographic- and socioeconomic data. By creating a landcover map of Malmö. using a satellite image and maximum-likelihood classification, the UGS was mapped for the studied year. Statistical analysis using SPSS was used to examine correlations to socioeconomic variables, making it possible to analyze how access to green space varies depending on socio-economic properties.

The study concludes that UGS access in Malmö does not correspond to official aims. It is also concluded that there are strong correlations between the access to UGS from schools and built-up environment and the socio-economic variables income, educational level, employment rate and heritage.

Keywords: Geography, GIS, Geographical Information System, Urban green space, children, school, Malmö.

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2 LIST OF ABBREVATIONS

GIS	Geographical Information System
NDVI	Normalized difference vegetation index
PIQ	Performance Intelligence Quotient
SCB	Statistics Sweden
TIQ	Total Intelligence Quotient
UGS	Urban Green Space
UN	United Nations
WHO	World Health Organization

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4 INTRODUCTION

Urban green spaces (UGS) are open spaces filled with greenery, within an urban context. Parks, playgrounds, and vegetation are all types of UGS (World Health Organization, 2017). Benefits from utilizing green spaces are proven to be many, amongst them better air quality (Givoni, 1991), incentive for physical movement (Richardson et al, 2013), promotion of social activities (Mohd Hisyam Rasidi et al, 2012; Zhou & Rana, 2010) and the stress reducing effect of nature (Yang et al, 2020)– leading to better mental health as well as physical health (Hartig et al, 2014).

In addition to the positive effects on mental and physical health mentioned above, cognitive development and academic results of children have been found to correlate to the access to green space. The effects differ somewhat between age groups, but effects all point toward a positive development of children (Dockx et al., 2022; Flouri et al., 2014; Bijnens et al., 2020)

The utilization of and access to UGS (Urban Green Space) has shown correlation with socioeconomic factors. Studies have found that those of lesser socio-economic status have more limited access to UGS (Nesbitt et. al., 2019; Wüstemann et. al, 2017).

Many studies point towards a negative correlation with densification. As cities grow denser, urban green space areas in cities tend to lessen. While efforts to counteract this effect by applying planning policies accounting for the maintenance and creation of UGS has had a positive effect, there are many instances where it is not implemented in the planning process (Haaland & Konijnendijk van den Bosch, 2015; Lin et. al., 2015).
Urban green space will in the context of this study be defined as consecutive green area within city limits. Green space will be detected using remote sensing from Landsat 7 and 8, with a spatial resolution of 30 m and a temporal resolution of 16 days. The access of a long-time sequence in combination with a high temporal resolution temporal resolution allows for up-to-date maps for years of interest. The spatial resolution fulfils the required balance of having enough detail to track changes in time, and yet not consider areas that are too small to be classified as green spaces for utilization purposes applicable here.

Using GIS, it is possible to create maps of land use over a set period. The data can then be used to detect patterns in land use and using demographic and socioeconomical data, patterns can be linked to the residents of a geographical area. The quantitative nature of GIS also allows for distance and accessibility analysis that cannot be answered with qualitative methods.

Open data is easily available today. The term open data is used for public sector data allowing free access, reuse and sharing. It allows anyone to legally access, interpret, and combine datasets. However, not all data can be published freely. Data containing personal and sensitive information is regulated by the Data Protection Directives within the EU. Studies show that open data benefits both public and private organizations, mainly in effectivization and efficiency in operations and services. While open data should not contain personal information, anonymized data still runs the risk of being linkable to individuals (Borgesius et al, 2015; Welle Donker, F., & van Loenen, B., 2018; Kulk & van Loenen, 2012).

For children, access to green space is an important factor in both physical and mental development. Studies have shown that greenness in and around schools has a positive effect on memory, attentiveness, academic results, stress levels and social activities. Greenery close to or within school grounds had an increasing effect on positive effects (Davand et al., 2015; Wu et al.,2014; Chawla et al, 2014).

Unfortunately, children are rarely able to voice their opinion in urban planning. Often, the children are at the center of impact during densification, where a loss of open, green space is often occurring. While it is recommended to take the child's perspective into consideration in the planning process, the municipalities of Sweden have a public planning monopoly and thus there is no guarantee nor demand that children are involved (Boverket, 2020).

Access to UGS is motivated by positive effects on physical and mental health. However, access to and utilization of UGS has been proven to be unequal. A study of 10 cities in the USA concluded that there was a clear inequity related to access to UGS, based on income, education and race. Unequal access was associated to socioeconomic variables in many cases. A similar study in Germany showed the same relationship between access and socioeconomic variables such as income, education and age (Nesbitt et. al., 2019; Wüstemann et. al, 2017).

4.1 AIM

The aim of this project is to highlight the access to urban green space in the year 2019, and to examine how the changes of Malmö may have influenced the access to green space for children. A methodology using open access satellite-, demographic- and socioeconomic data in a GIS will be developed, applied, and evaluated. The aim is to propose a method where knowledge about children´s access to green areas from schools may be given a larger role in future city planning. The method will also make it possible to analyze if access to green space varies depending on socio-economic properties. If this method performs well, it could easily be applied to any city that is that is subjected to expansion and/or densifications, just by using open access data, commonly applied GIS-tools and descriptive statistics.

The importance of UGS in relation to children's daytime activities highlights the need to examine the accessibility nearby the school environment, using pre- and compulsory schools as the base for analysis. In addition, a spatial analysis will be performed, that investigates if access varies depending on socioeconomic background. As many of the old million-project housing areas are built near nature, the access correlated to socioeconomic background might differ from predictions made using background material from studies conducted elsewhere.

This study investigates people's access to UGS in Malmö in general, and for children in particular, after change in the discourse of densification planning ideals, in order to incorporate children's needs to access green space, would create changes in the physical shape of the city. The aim is sorted into the following parts:

1. *Could open midspace-resolution satellite data be used to detect and monitor green areas in an urbanized city? Is the source data (resolutions in time and space) and classification method sound and appropriate?*
2. *How may GIS be used to detect to what extent the residents have access to green space in terms of distance from their built-up environment? Could GIS tools be used to reveal spatial patterns linking access to socioeconomic factors?*
3. *How may GIS be used to detect access between green space and pre- and compulsory schools? Could GIS-tools be used to detect variations of access due to socioeconomic factors?*

4. *How do the future plans for new developments in densification purposes in Malmö City relate to people´s access to green space? How could the proposed method using satellite data and GIS be used to find out how they agree with the intentions of Malmö strategic plan in terms of greenery guidelines?*

This study will use a GIS and geo-spatial analysis tool, statistic measures (correlations, regressions, Hot spot analysis and Moran's I), and open data to answer research questions 1-3. By using the methods described further below, urban green space and its availability will be examined using remote sensing- and demographic data. Spatial analyses, such as supervised classifications based on reflectance signature to analyze land cover and create land use maps and to identify green areas according to the guidelines of Malmö city, as well as performing spatial overlays and producing visualizations (maps) will be done in ArcGIS Pro, while statistical analyses will be performed in Excel and SPSS. Research question 3 will be answered by a literature review and the results of research question 1.

The study uses only open data. As data becomes increasingly available, methods to handle data and to perform analysis using open data can be of use for anyone. By establishing a method to assess accessibility and spatial patterns using open, non-personal data, it is possible to present a method to be used in any research and project concerned with land cover. The method of the study also presents ways to look for patterns of distribution based on open socioeconomic data. As the socioeconomic data used is non-personal, it is possible to republish and share the results without intruding on privacy which is useful for non-public organizations, public organizations, and private citizens alike. The method presented is easily applicable to other countries and cities. It can be scaled up as well as down to fit both more and less detailed datasets.

4.2 EXPECTED RESULTS

As green space is shrinking in many cities across the world, consequences are expected for everyone's access. For children, where these green areas have proven to be important in many aspects of health and development, the loss of UGS is expected to have changed the access to areas of recreation during and after school hours.

However, the demographics and physical environment of Swedish urban areas must be considered when forming a hypothesis. While it holds true that disadvantaged socio-economic groups often feel the effects of green inequality the hardest in studies presented, most of the Swedish vulnerable areas were built quite close to nature. This could mean that it is instead the inner-city areas and schools within them, often constituting affluent neighborhoods, that will be influenced by the effects of densification the strongest. Still, as densification can be used to connect areas together there is a risk of loss of green space in adjacency to vulnerable areas as well, which would still mean a loss of UGS for children in these areas.

Whilst it is expected that many will be affected by changes in UGS, the main expectation is that it is administrative areas and schools of high- and middle-class socioeconomic standing that, contrary to many other studies in UGS loss, will experience the smallest access to green areas due to the geography of vulnerable areas in Sweden.

Therefore, a null hypothesis can be presented:

The change presented by Malmö city has not limited the access to UGS for residents and school grounds in administrative regions with a low rate of foreign heritage, high income, employment rate and share of residents with higher education due to densification and infill development of central city areas.

5 BACKGROUND

Here, current and relevant prior research and findings are presented to give a background for this study area.

5.1 URBAN GREEN SPACE

5.1.1 Environmental benefits of urban green space

There are many benefits of UGS, for the environment as well as human health.

UGS can support biodiversity depending on the structure, studies have found. This can be done by enhancing already existing habitat quality. Size of UGS has proven to increase avian richness in one study. This is true for both informal and maintained UGS (Silorski et al, 2021; Aida et al, 2016; Muluneh & Worku, 2022).

The urban heat island effect refers to the elevated temperatures often present in cities. The cause of this is complex, but studies have shown that UGS has a cooling effect of the city, both in the direct area and the surrounding area combating the urban heat island effect (Oake, 1992; Aram et.al., 2019; Fletcher et. al, 2021). Size and vegetation type plays an important role in the cooling effect. Urban parks of greater size have proven to have a larger cooling effect than smaller UGS to some extent (Aram et.al., 2019; Bowler et al., 2010).

On the note of climatic benefits, UGS also has a positive effect on air pollution. Studies show that urban greenery has the potential to reduce air pollution to varying extents (Nowak et al., 2006; Jaung et al., 2006). Further, not all plants and greenery showcase the same response to air pollutants. Therefore, it can be of advantage to consider plant species in relation to pollution type and levels (Kaur & Nagpal, 2017).

5.1.2 Children and urban green space

While health benefits of UGS can be seen throughout all ages, this study focuses on children. Therefore, this part will present the findings in studies of health benefits in children. Briefly introduced in the introduction, benefits for children have been proven cognitive, physical, and emotional.

Dockx et al. (2022) found in a study of 459 children ages 4-6, that closeness to green space has a positive effect on motor accuracy, increased visual memory and reducing hyperactivity. The strongest finding in the study was that between hyperactivity behavior and close access to urban green space, starting to show correlations at green spaces 100 m from the residential area of the child. Dexterity also showed positive correlation to proximity to green areas from the housing quarters of the child. Working memory was tested using short-term recognition exercises, where an increased access to green space resulted in fewer errors.

The findings of the previously cited study are supported by Flouri et al. (2014) where the development of 6348 children in the analytic sample and 1458 in a non-analytic sample was measured at age 3, 5, and 7. The results showed that hyperactivity and other behavioral problems were reduced in children that frequented parks and those with access to a garden. Further, access to green space proved to have a positive effect on emotional resilience on children of poor background in ages 3-5. Bijnens et al. (2020) also indicated a positive effect on behavioral problems in children that had access to urban green space, in externalized problem behavior as well as total problem behavior.

Bijnens et al. also (2020) found that intelligence of children living in an urban environment had a positive correlation to surrounding green space, an effect that was not present in children living in rural and suburban areas. The type of IQ that registered a positive effect was based upon the distance to green space from the residential area of the child. Within the 1000 m and 5000 m buffer zone, TIQ and PIQ had a significant correlation whilst the effect on verbal IQ was present in the 2000 m to 5000 m buffer. Further, children living in an area with less green space were more likely (4,2% of the sample) to have an IQ below 80 in the study. 11,2% of the children in highly green areas scored in the high range IQ of 125 and over. In the low green areas, this number was 4,2%. Almeida et al. (2022) also showed the significance of urban green space on intelligence of children, but to a lesser extent.

Urban green space has also shown physical benefits to children's well-being. Children living in greener residential areas have been shown to be less likely to increase their BMI in a study over 2 years (Bell et al., 2008). The effect on BMI is already present at a 500 m interval to the closest park. However, variables such as traffic density, total road length and number of X intersections that had a negative effect on walkability also diminished the effect of the correlation (Wolch et al., 2011).

Important to note is that studies have shown that while proximity to parks do entice use, the size of urban green spaces also matter. Larger parks have more of the features that attract visitors, and size is quoted as a factor in finding a park likeable. The park area has shown to have a positive correlation to average frequency of walking, relaxing, and exercise. However, for social activities, small-sized UGS was frequently chosen. Interacting with smaller UGS has also been shown to improve health (Giles-Corti et al., 2005; Kaczynski et. al., 2008; Gozalo et al, 2019; Lee et al, 2019, Cohen et al, 2010; Sugiyama et al., 2010).

The results shown in Epstein et al. (2006) reveal that a decrease of sedentary activity is reached when reducing access to for example television, when children turned to urban green space instead. Here, the park area played an important role and larger parks were shown to attract children more due to the ranging potential activities offered. While the study did show that access to parks influences physical activity in children, it also showed that the effect is greater when an effort to minimize sedentary behavior is taking place.

While no specific size is provided in the above cited studies, a study of urban forest landscapes suggests that urban woodland should be at least 2 ha in size and within a 5-10 min walk from the residency (Coles & Bussey, 2000).

5.1.3 Green space proximity to schools and effects on children

Children spend many hours in pre-school and school. Often, children attend schools and daycare activities close to home. While there is a free choice of schools in Sweden, “Närhetsprincipen” (cf. “Proximity principle”) gives children the right to attend schools close to their residence. Should more children apply to a school than the school has capacity for, the child living closest has the right of admission (Skolverket, n.d.).

Studies have shown that the benefits of UGS close to schools are many. Among them is better academic performance. A long-term study found that distance to NDVI-values classified as “green” significantly correlated to the academic performance of children in 3rd grade. The study also suggests that larger buffer zones are important to include in a study of UGS and its effect on school-aged children. As children often attend school close to home, a 2000-m buffer would include greenness encountered outside of school hours (Leung et al., 2019; Wu et al., 2014).

Access to natural landscapes has also proven to reduce stress and anger, as well as other behavioral problems while supporting positive moods and attention. Positive effects are also present on memory function, with an increase in working memory and superior working memory measured to 5% and 6% respectively over a 12-month observation period. After spending recess in natural settings, children were also found to be more attentive (Dadvand et al, 2015; Amicone et al., 2018; Chawla, 2014).

Access to UGS from schools has also been linked to pro-environmental behavior. Field work in green space not only fostered positive attitudes regarding environmental preservation, but successful excursions in or close to the school grounds were found to be an incitement for excursions further away. In these cases, the proximity of UGS was a favorable factor for fieldwork in other locations further away from the school (Wolsink, 2016; Liu & Chen, 2021).

5.1.4 Concerns with prior research on benefits of UGS

Although there are great findings that proclaim the benefits of UGS for both adults and children, the question of causation is present. Studies report finding that those with better socioeconomic status have greater access to UGS. This would also present the possibility that the proximity to UGS that is reported to increase both physical and mental health as well as cognitive functioning and intelligence not only be due to the UGS itself, but also an access to other resources not available to those with a lower socioeconomic status that could benefit the studied cases. This is especially true for studies conducted in countries that have a large gap in socioeconomic demographics. Having access to better healthcare, extracurricular activities, and tutoring, in addition to living close to UGS, could influence the results of studies. Those with stronger economic status might also have better means to transport themselves to UGS of varying sizes. Furthermore, the ones to frequent parks and nature might also be those who are already very healthy, which also would influence results on studies on health.

It is hard to deny that proximity to UGS should support frequenting green spaces, as proximity shortens travel time and logistics issues. However, the way in which conclusions have been drawn in research articles oftentimes do not take this paradox into account, giving full credit of benefits to only the proximity of UGS.

5.2 CHILD PERSPECTIVE AND THE CHILDREN'S PERSPECTIVE

As follows the Planning and Building act in Sweden, detailed development plans and comprehensive plans need to be put up for consultation before being adopted. This allows for all concerned parties to voice their opinions on the plan (PBL 2010:900; Boverket 2022a). Giving the affected parties a chance to voice opinions is, however, not the same as a citizen dialogue. The citizen dialogue is intended to involve the residents of a city at an early stage, before the planning process, utilizing their unique insight into an area.

At the same time, a citizen dialogue will allow more space for the Convention on the Rights of the Child which was adopted in Sweden in 2020. The law states that children (up to 18 years of age) have the right to take part in and influence all issues that concern them. Further, the national goal for all government decisions and efforts is that all youth (13-25 years of age) should have the power to shape their life and influence the community development (Boverket, 2022b).

When speaking about children and the perspective concerning them, there are often two viewpoints that are spoken of – the child perspective and the children's perspective. While the child perspective is used to denote an adult-created outside-perspective aimed at recreating children's perspectives, the children's perspective focuses on representing the child's own perspective as a subject in their own world. It represents children's experiences and understanding in their life (Sommer et. al., 2010).

Arnstein's (1969) "Ladder of Participation" came to change how citizen participation is seen. This ladder was adapted by Hart (1992) into a ladder of participation for youth and entails how participation can range from tokenism to different degrees of participation. Involving children in projects does, however, not allow for guaranteed participation. The development of youth and children determine to what degree they can participate, and it is not always necessary that children's participation is at the top step of the ladder. The presented model of genuine participation has four stipulations: understanding the project, why they were included and by whom the decision was made, the children are given a meaningful role and that they participate willingly after the project is presented to them (Hart, 1992).

5.2.1 Comprehensive plans

The comprehensive plan proposes the future direction of development for Malmö. It is comprised of long-term planning strategies for land and water, in addition to all built-up environment for the next 20 years. While all municipalities in Sweden need to have one, it is not legally binding (Malmö stad, 2018a).

The newest comprehensive plan was adopted in 2018. However, there are older comprehensive plans that have paved the way for the direction of development in Malmö during the study period.

5.3 GROWING CITIES, DENSIFICATION AND URBAN GREEN SPACE

Urbanization is a continuing trend. At the beginning of the 20th century, only 16 cities worldwide had a population of 1 million or more. The same number had changed to 449 cities by the year of 2010. While 50% of the total world population lived in an urban settlement of 500 000 or more inhabitants in 2010, this share is expected to fall to around 42% by the year 2025. Instead, cities with a population of 1-5 million and megacities with over 5 million inhabitants are expected to expand their share (UN, 2013).

As the share of people living in larger cities expands, they need somewhere to dwell. As seen in the case of Malmö city, the fastest growing city with 3800 new inhabitants only during the year 2021, densification while maintaining and expanding greenery is one of the main objectives in the comprehensive plans of the city since the comprehensive plan of 2000. The objective is an in-fill development located at old dock- and industrial areas, and thus not to exploit green areas and parks to this end (Malmö stad, n.d. a; Malmö stad, 2018; Malmö stad. 2000; Malmö stad, 2005).

During the last decades, the urban planning ideal in Sweden has shifted from the goal seen in the Million Programme in Sweden during the 60's and 70´s (Boverket, 2015). Today, densification is on the agenda for Swedish cities, after a period of urban sprawl during the Million Programme when suburbs were built in proximity to both nature and city-life (Tunström, 2009). As much as the ideal is for cities to make use of land within city borders and halt the expansion into the periphery, there is another factor to take into consideration –green space in the urban area (Malmö Stad, 2021a). While the Million Programme did create green areas within residential areas, as well as playgrounds and other open space facilities, the housing policy has garnered critique. The Million Programme residential areas are blamed for initiating a pattern of socio-economic segregation (Hall, T. & Vidén, S., 2005; Grundström, K. & Molina, I., 2016).

Malmö city (2021a) reports a consistent loss of UGS since the year 2005. In 2005, the UGS per capita measured 154 m^2 in the city center. In 2015, the same measurement showed a decline to 111 m^2 per capita. For the municipality of Malmö, which is examined in this study, the city reports the per capita green space at 174m^2 in 2015 and 137 m^2 in 2020.

Densification is a current, fundamental concept in urban development. There are different ways to achieve a denser city, such as by infill, repurposing land, and building higher on existing buildings (Haaland & van der Bosch, 2015). While the benefits of UGS are clear, studies show that densification often occurs at the cost of green infrastructure (Naess et al., 2020; Lin et al., 2015; Haaland & van der Bosch, 2015).

Infill development has proven to lead to a decrease of existing USG. Further, creating new UGS is one concern within a densifying city, also present in a suburban context (Haaland & van der Bosch, 2015).

5.4 MALMÖ CITY AND ITS INHABITANTS

Malmö is the fastest growing city in Sweden today, with 351 749 inhabitants as of December 31st 2021 (Malmö stad, n.d. a). Table 1 presents the demographic development of Malmö.

Table 1 Demography of Malmö (Malmö stad, n.d. a)

Year	0-5 years	6-15 years	16-19 years	20-64 years	65-79 years	80+ years	Total population
2007	19700	27308	12981	175189	29985	15638	280801
2008	21142	27157	13321	179195	30192	15528	286535
2009	22659	27210	13408	184385	30848	15399	293909
2010	24062	27328	13224	187799	31162	15388	298963
2011	25165	27577	13070	189937	31834	15252	302835
2012	26203	28417	12588	192836	32755	14959	307758
2013	27068	29573	12447	195561	33621	14724	312994
2014	27687	30898	12136	198463	34438	14485	318107
2015	28050	32469	11839	200540	35246	14430	322574
2016	28242	34271	11966	203682	35975	14358	328494
2017	28390	35919	12170	206288	36618	14248	333633
2018	28376	37738	12529	209160	37222	14288	339313
2019	28135	39102	12762	211988	37835	14344	344166
2020	27595	40243	13110	214369	38426	14206	347949
2021	27329	40998	13514	216706	39017	14185	351749

While the population of the city has grown around 25% since the year 2007, the demographic development shows that the share of children aged 0-15 in Malmö has increased since 2007, in comparison to other age groups according to Figure 1.

The increase can be seen in the age group 0-5 and 6-15, but it is primarily the share of older children that is increasing. Between 2007-2021, the number of children aged 0-5 had increased by 7 629 or 39%. For children aged 6-15, an increase of 13690 children or 50% has occurred. It is important to note the larger age span for the group of compulsory school children. As it spans 10 years instead of 6, the increase is not disproportionate to the youngest children.

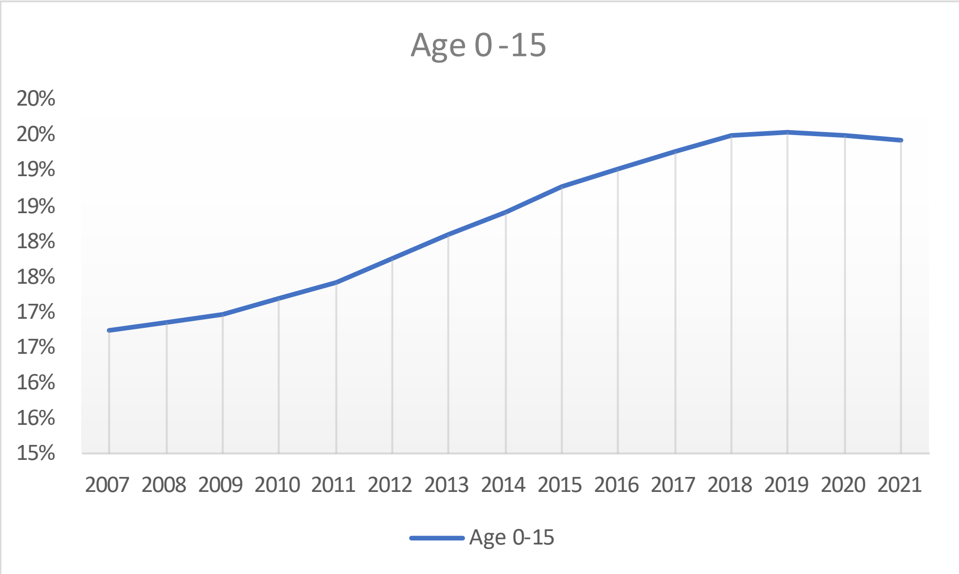

Figure 1 Share of children aged 0-15 years old in Malmö city

The older population (80+) is steadily declining, while the other age groups are also increasing over time. The increase in the share of children can therefore be explained by a growing number of residents of the age 0-16. This decline is not large enough to explain the rising share of children especially with the decrease in children aged 0-5 between 2017-2021.

5.5 Segregation in Malmö

According to Segregationsbarometern (n.d.), 20,2% of the inhabitants of Malmö live in areas with great socioeconomic issues. Further, 8,8% of the population lives in areas with moderate socioeconomic issues. Thus, 29% of the population live in areas with segregation issues. This contrasts with the 4,8% of the population that lives in areas with great socioeconomic conditions. However, most of the residents live in areas with good socioeconomic conditions, counting for 41,7% of the population.

In a report on segregation from Malmö city (Salonen, Grander & Rasmusson, 2018), the western parts of the city are noted as high income whereas the eastern parts are lower income households. The most financially segregated areas are in “Södra innerstaden” and “Rosengård”. The ethnical segregation follows the same pattern. There is also segregation in forms of tenure. People with high income and Swedish heritage are more likely to own their residence. Although large differences in socioeconomic backgrounds exist, the poorest and richest neighborhoods are no more than a 20-minute bike ride away.

Malmö is divided into different administrative levels. Used for this study are the 136 statistical areas, named "delområden". The neighborhoods of Malmö display a diverse composition of socioeconomic variables. As this study will focus on income, heritage, level of education, employment rate, and need for economic aid, the most current statistical measures will be presented in this section. Some areas are mainly industrial or commercial and have no, or fewer than 5 individuals living within the administrative boundaries. Therefore, Malmö does not maintain some of the data in these areas (Malmö stad, n.d. c).

The correlation of the socioeconomic variables presented in Table 2 shows that the four different socioeconomic variables strongly relate to one another. Income, heritage and employment show a relationship where an increase in one variable is followed by an increase in the other. Where the share of inhabitants with a foreign background (born outside of Sweden, or with both parents born outside of Sweden) increases, the other markers of socio-economic status decreases.

Table 2 Correlations between socioeconomic variables

Correlations of socioeconomic variables

		Education	Heritage	Income	Employment
Education	Pearson Correlation	1	-,716**	,664**	,684**
	Sig. (2-tailed)		<,001	<,001	<,001
	N	108	108	108	108
Heritage	Pearson Correlation	-,716**	1	-,677**	-,835**
	Sig. (2-tailed)	<,001		<,001	<,001
	N	108	108	108	108
Income	Pearson Correlation	,664**	-,677**	1	,631**
	Sig. (2-tailed)	<,001	<,001		<,001
	N	108	108	108	108
Employment	Pearson Correlation	,684**	-,835**	,631**	1
	Sig. (2-tailed)	<,001	<,001	<,001	
	N	108	108	108	108

**. Correlation is significant at the 0.01 level (2-tailed).

Figures 2, 3 and 4 below illustrate the dispersion of classes based upon percentiles, up to 50th percentile and at/above 50th percentile, of the four selected socioeconomic variables income, education, employment rate and foreign heritage. As per table 2, all socioeconomic variables have statistically significant correlations. The maps present the correlations to foreign heritage, as this variable has an inverted correlation to the others. For a thorough look at the socioeconomic variables per administrative region, refer to table 25 in appendix A.

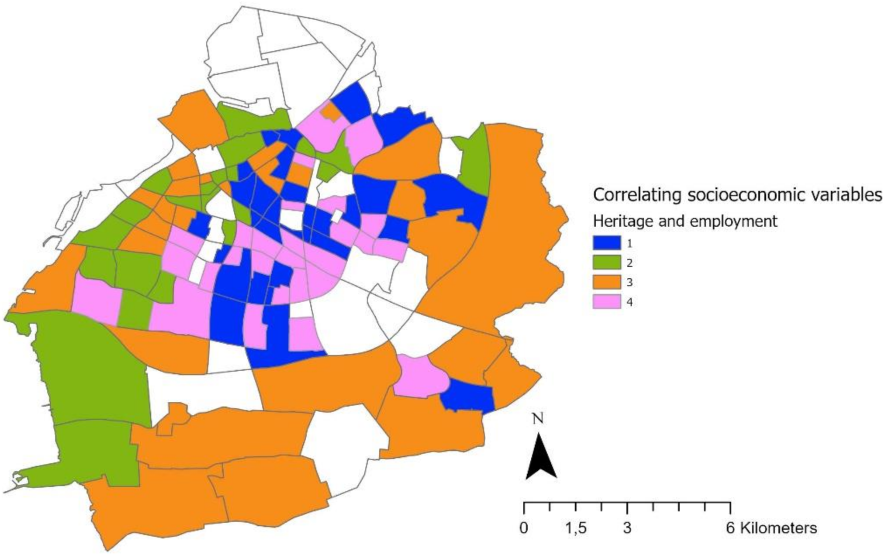

Figure 3 Correlation between foreign heritage and employment based upon percentile classes. Class 1: employment > 50th percentile, heritage >50th percentile. Class 2: employment < 50th percentile, heritage <50th percentile. Class 3: employment > 50th percentile, heritage <50th percentile. Class 4: employment < 50th percentile, heritage >50th percentile.

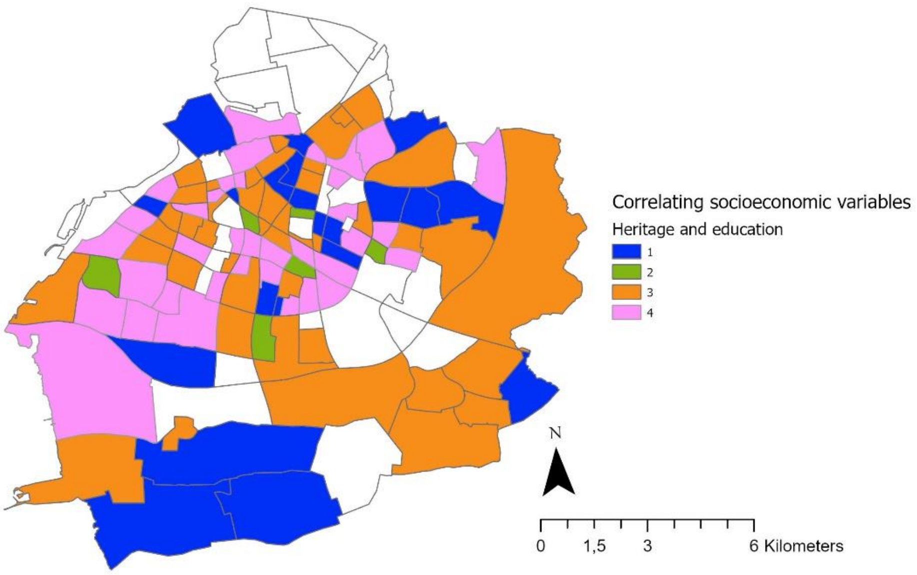

Figure 2 Correlation between foreign heritage and education based upon percentile classes. Class 1: education > 50th percentile, heritage >50th percentile. Class 2: education < 50th percentile, heritage <50th percentile. Class 3: education > 50th percentile, heritage <50th percentile. Class 4: income < 50th percentile, heritage >50th percentile.

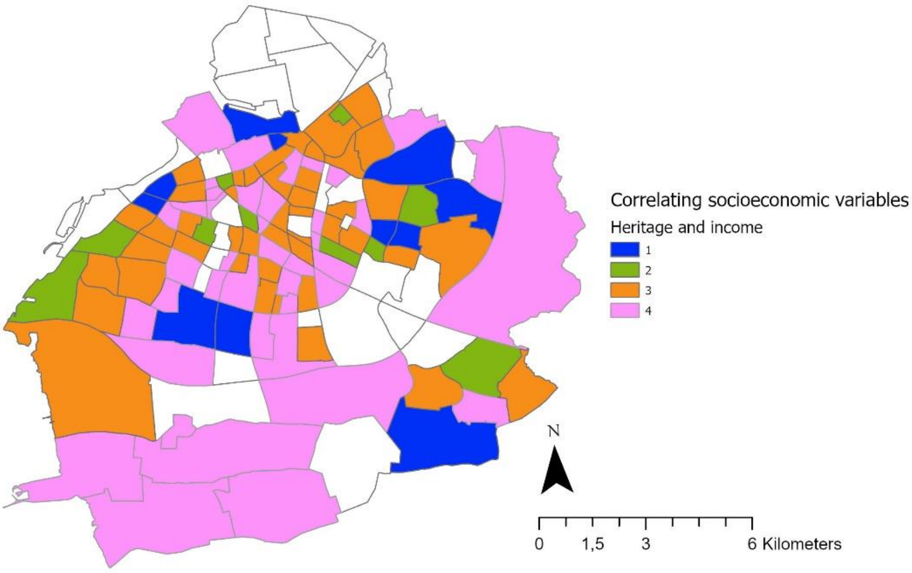

Figure 4 Correlation between foreign heritage and income based upon percentile classes. Class 1: income > 50th percentile, heritage >50th percentile. Class 2: income < 50th percentile, heritage <50th percentile. Class 3: income > 50th percentile, heritage <50th percentile. Class 4: income < 50th percentile, heritage >50th percentile.

The mean income in Malmö city for the year 2019 was 408 928 SEK per year before tax. While most neighborhoods display an income around the average level, there are some parts of Malmö that are below this rate: Heleneholm, Flensburg, Södervärn, Södra Sofielund, Augustenborg, Lönngården, Norra Sofielund, Annelund, Törnrosen, Örtagården, Apelgården, Kryddgården and Katrinelund (Malmö stad, n.d. c). Several of the areas with a below average income coincide with the need for economic aid. The average share of individuals that are born outside of Sweden, or have two parents who are, were 46,7% in Malmö for the year 2019 (Malmö stad, n.d. c).

Areas with a high level of education, income and employment rate are Tygelsjö, Västra Klagstorp, Klagshamn, Skumarp, Djupadal, Elinelund, Rosenvång, Annetorp, Rönneholm and Ribersborg. Most residents in these areas have studied at university level, regardless of length and the residents are primarily of Swedish heritage (Malmö stad, n.d. c).

5.6 GREEN URBAN SPACE AND CHILDREN IN LITERATURE

Plans to maintain and expand green areas are not necessarily a guarantee, as planning policies revolving around densification often have a reverse effect on UGS. It is therefore of importance to examine to which degree residents of urban areas are affected by inaccessibility and if there could be a socioeconomic pattern.

Studies on UGS regarding children's development, adults' health, and the environment, in addition to social injustice are easy to locate. However, there has been little research on the effects on accessibility for children of different socioeconomic background in Sweden. A report was published by Statistics Sweden (SCB, 2018), where they found that available open space close to compulsory school grounds (within 300 m) is getting smaller and fewer. However, this study was on a city level and only examined accessibility to UGS very close to the school. This study will examine UGS of different sizes and distance, as well as examine if a link to socioeconomic status can be found.

5.7 DEFINITIONS

5.7.1 Urban green space (UGS)

In the context of this study, urban green space will be defined as consecutive green area within city limits.

5.7.2 Buildings

Buildings in the study are the areas that are classified as built-up areas in the land cover maps. Thus, no difference is made based on the type of building.

5.7.3 Available and accessible UGS

This study differentiates between the available UGS and the accessible UGS. Accessibility is measured as UGS of a certain size within a set distance from a building.

The available UGS is a measure of total UGS, unrelated to distance and within an administrative border (Malmö stad or delområde).

5.7.4 Children

All children between ages 0-15 identified in the census year of 2019.

5.7.5 Pre and compulsory Schools

All pre- and compulsory schools from the register of Skolverket and SCB.

6 METHOD

Here, the methods used will be divided into steps to reach the aim and conclusion of the study. Consisting of a literature analysis and statistical analysis using GIS and statistical software, the study will use a combination of qualitative and quantitative methods to reach its conclusions.

By establishing a method to assess accessibility and spatial patterns of UGS using open, non-personal data, it is applicable in any urban environment. It can be scaled up as well as down to fit both more and less detailed datasets.

6.1 AIM 1: TO DETECT URBAN GREEN AREAS USING RS-DATA

Tool: ArcGIS

Material: Landsat 7 (earlier years of study period) and 8 (later years of study period) satellite data

Using the Landsat satellite images, NDVI and land cover classifications can be conducted using a supervised classification. Accuracy evaluation was done using visual assessment of random points.

The products of the land cover analysis were used to capture green space size. As the most important part for this analysis is the difference in urban green areas over time, a proposed classification is the four classes that follows:

1: Urban and built-up area

2: Green area

3: Water area

4: Soil/agricultural

Further, the area of the green urban space was assessed and classified by the guidelines of green space size from Malmö City presented in figure 5. The aim of this step is to find the areas of green space within the city that adhere to the guidelines of UGS so that distance calculations can be conducted.

The land cover map creation is an important step, as this will be used in consecutive analyses. Landsat products have a resolution of 30 m. This means that smaller patches of urban green area will be hard to detect. This study uses the guidelines from Malmö city (fig. 2) to classify the land cover, where small patches of green areas should be disregarded and therefore not meant to be captured. In such aspect, the spatial resolution of 30 m should be good.

Figure 5 Greenery guidelines of Malmö (Malmö stad, 2021b)

Class 1:
- Within 300 m from residency: 0,2 ha and 30 m wide

Class 2:
- Within 500 m from residency: 1 ha and 50 m wide

Class 3:
- Within 1000 m from residency: 5 ha and 100 m wide

Class 4:
- Within 2000 m from residency: 10 ha and 200 m wide

Class 5
- Within 3000 m from residency: 35 ha and 300 m wide

For this thesis, the land cover map was created using a supervised classification with the maximum likelihood method. Training samples (25 for each class), using known points were collected, and signature files were collected for each class, followed by the maximum likelihood classification as it has been proven to give satisfactory results in other studies using remote sensing data. The maximum likelihood classification assigns each cell in a raster to the class represented in the signature file, based on which one it most closely resembles (Afify, 2011).

6.2 Post-classification

6.2.1 Accuracy assessment

2000 random points were generated in ArcGIS. Water was underrepresented in relation to the other class sample points, so the large number of points were required to retrieve enough points within all classes. As 50 points per class is recommended to avoid biased sampling, the first 50 points per class was selected out of the 2000 points generated. The point layers were exported to Google Earth as KML-files and a visual accuracy assessment was done for the points (Congalton & Green, 2019).

The user accuracy expresses the probability of a randomly chosen point on the map belonging to the same class in real life,

Producer accuracy instead measures the probability of a point chosen on the ground having the same class on the map.

Kappa accuracy expresses the agreement of two datasets, compared to the agreement of chance. The resulting score tells what level the map agrees to a map created by chance. A result of 0 means no better than chance and a positive value means that the agreement is better than chance. 1 means that the evaluation of the classified map totally agrees with the reference (considered as the truth) (Lund university, 2004).

6.2.2 UGS classification using the greenery guidelines

The UGS was extracted from the land cover map and vectorized and converted into polygons. The polygons were further sorted into 5 classes according to the guideline from the greenery plan of Malmö (Figure 5).

6.2.2.1 Implications on accuracy

The spatial resolution is adequate for the study, where greenness of at least 30 m width and 0,2 ha needs to be detected.

When producing land cover maps, the issue of accuracy arises. The study does not have access to any validation points or training points from previous years. This means the accuracy will be assessed for the studied year 2019 using high-resolution Google Earth imagery. This means that any validation points used will not be collected in the field as the dates studied are in the past.

However, studies have shown that this is a good way to validate LULC maps (Rwanga & Ndambuki, 2017; Tilahun & Teferie, 2015). Google Earth has a high positional accuracy, with a difference of a few meters which would be acceptable in this study mainly focused on the green land cover (Zomrawi et al, 2013).

50 sample points were collected for each of the classes, using randomized points in ArcGIS and exported to Google Earth as a KML-file. Then, a visual analysis of the land use was conducted resulting in the below accuracy.

The classification of UGS also needs to be raised. This study makes no difference between private and public UGS. Thus, what might be classified as accessible UGS might only be accessible to a limited number of specific persons. It also does not make a difference between the different forms of UGS. Thus, the green space identified could be a playground, a cemetery or someone's backyard. While not inaccurate per definition, this does have implications on the intended user and activity of activity the green space.

It is also hard to separate green agricultural areas from UGS. When creating the training samples, samples were collected of different kinds of NDVI values from agricultural fields. By establishing many training points, representing a large range of NDVI values, accuracy can improve. While the accuracy assessment done for this study resulted in a high accuracy, there is still a risk of misrepresentation between class 2 and 4 which is hard to avoid due to the similar NDVI value range of green fields and UGS.

6.3 AIM 2: SPATIAL GIS-TOOLS FOR ACCESSIBILITY ANALYSES

Tools: ArcGIS

Measurements of accessibility: Buffer zones

Material: Maps produced in step two

Accessibility by distance analysis will be conducted in this initial stage. WHO (2016) details several different indicators of UGS characteristics, such as size, land cover type and recreational type. Further, a minimum of 9m^2 of green space per capita within 15 minutes walking distance has been proposed (Pafi et.al., 2016). Although the possibility to fulfill this differs on a city-per-city basis, square meter of UGS per capita is a measurement which can be used to quantify the space available in relation to residents (Badiu et. al, 2016). A review of studies on green spaces' relationship with mental health found that several studies (21 out of 50 studies) relate the number of UGS available to residents (Houlden et al, 2018). As already mentioned, the size of UGS influences the use of it.

In this study, the measurement will be available urban green space per capita in m^2 for residents of Malmö as this measurement takes demographic makeup into consideration. Another measurement of accessibility is available and accessible UGS from the administrative area and from the school environment, both in number of UGS and area of accessible UGS. As the size of urban green spaces have been shown to play an important part in attracting utilization, this is an appropriate measure.

Figure 6 on the next page helps visualize the data handling. As seen in the figure, buffer zones were created around the green spaces due to the importance of distance when assessing availability to UGS. By creating buffer zones around the green spaces, the UGS of different classes that are accessible from schools as well as for buildings can be detected according to the distance from the green space. For example, all schools that fall within 300 meters of a class 1 urban green space can be detected this way. In short, the “reach” of the urban green space is measured.

Many of the buildings within an administrative area have access to the same UGS. Any doubles where access to an UGS was already accounted for within an administrative area was therefore cleaned up using “Delete identical” in ArcGIS. This created a data layer with all unique and available UGS (based upon the feature ID and administrative region) per administrative area. This ensured that there was no misrepresentation due to the same UGS area being detected more than once for a certain administrative area.

When UGS are shared across administrative borders, the accessible and available UGS is shared with a larger number of residents. This implies that certain UGS have the potential to be overcrowded, which mostly is a risk of larger UGS that serve a larger extent when the classification of UGS is based on size and distance. As the UGS per capita in this study will only be examined for all of Malmö, while available and accessible UGS will be measured in total area and number of UGS, this does not concern the results. However, it is important to point out that the space presented might also be shared with a larger number of residents than those within the administrative areas.

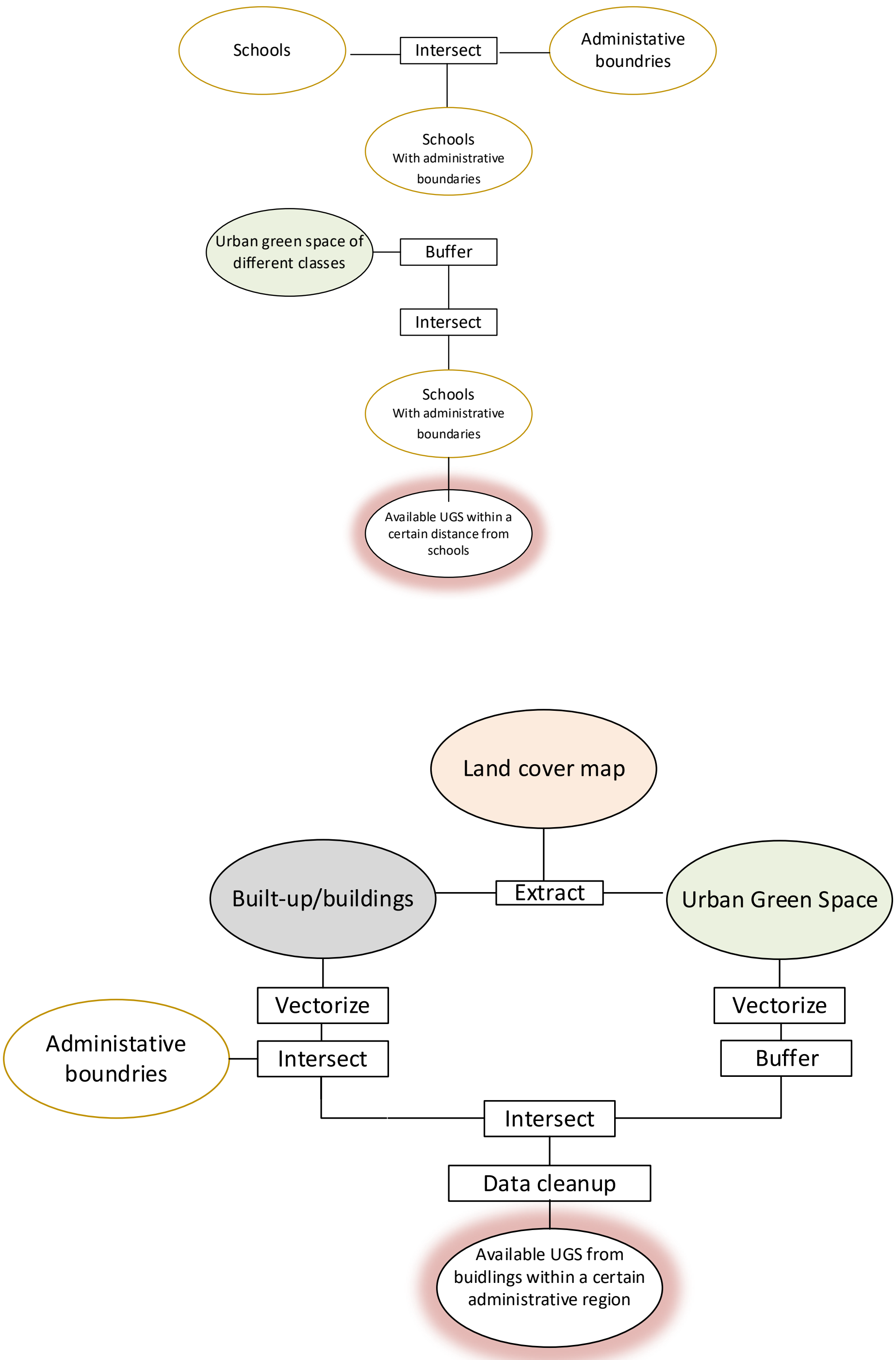

Figure 6 Post classification data handling

6.3.1 Implications on accuracy

While studies have shown that a road network analysis is more precise than using Euclidian distance over farther distances, Euclidean distances are often more accurate in an urban area with a larger street network density (Apparicio et. al., 2008; La Rosa, 2014; Moseley, 2013).

6.4 AIM 2-3: SPATIAL AND STATISTICAL ANALYSES OF SOCIOECONOMIC ISSUES

Tool: ArcGIS

Material: Statistical data from Malmö City

To answer research question 2 and 3, variables of socioeconomic status will be correlated to the access of UGS. In this stage the aim is to be able to answer the question "*Could GIS tools be used to detect a pattern of access that is linked to socioeconomic factors?* The variables of socioeconomic status in this study are income, disposable income, education, national background, and the need for economic aid. Not all variables are available for all areas, during all study years.

Thereafter, a regression and correlation analysis were conducted of the variables relating to socioeconomic status of the children.

A regression analysis explores the casual relationship of a dependent variable and one or more independent variables and is expected to reveal if there is any statistically significant relationship of green urban space and the socioeconomic variables (Rogerson, 2001).

A correlation analysis will instead explore linear association between two variables, but not necessarily a causal one (Rogerson, 2001). The study will use Pearson's coefficient.

Correlation and regression were examined using SPSS.

6.4.1 Statistical measurements

Spatial autocorrelation was calculated in ArcGIS. Moran's I is one of the most common statistical measures of spatial autocorrelation. Using this measure, one can correlate variables.

to their spatial distribution. Thus, resulting in how different values are clustered in space (Rogerson, 2001). Examining the autocorrelation of the UGS is expected to show if there is a spatial pattern to the distribution. Moran's I was calculated in ArcGIS. Figure 7 presents the formula for calculating Moran's I.

$$I = \frac{n \sum_{i}^{n} \sum_{j}^{n} w_{ij} (y_i - \bar{y})(y_j - \bar{y})}{\left(\sum_{i}^{n} \sum_{j}^{n} w_{ij}\right) \sum_{i}^{n} (y_i - \bar{y})^2}$$

Figure 7 Moran's I (Rogerson, 2001)

Featured in Figure 8, the hot spot analysis calculates the Getis-Ord Gi* statistic which shows where features cluster spatially, both low values of a feature (cold) and high (hot). The operation returns a z-score and a map of the spatial distribution of the clustering (ESRI, n.d.).

6.5 AIM 4: LITERATURE ANALYSIS

The literature analysis used the comprehensive plans of Malmö, dating back to 2000 and ending with the current one from 2019.

The Getis-Ord local statistic is given as:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \quad (1)$$

where x_j is the attribute value for feature j, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\bar{X}\right)^2} \quad (3)$$

The G_i^* statistic is a z-score so no further calculations are required.

Figure 8 Getis-Ord formula, ESRI (n.d.)

The search terms were green space (grönyta), parks (parker), children (barn), schools (skolor) and playgrounds (lekplatser). This enables finding results relating to children and UGS.

7 DATA

While more detailed data might be available from city offices, the study uses only open data. The reasoning behind this is that as data becomes increasingly available, methods to handle data and to perform analysis using open data can be of use for anyone, anywhere. With benefits such as innovation, transparency, knowledge enhancement and equal access, open data also gives users the possibility to confirm any assumptions and conclusions drawn from the outcome. As the socioeconomic data used is non-personal, it is possible to publish and share the results without intruding on privacy which is useful for non-public organizations, public organizations, and private citizens alike.

7.1 SOCIOECONOMIC VARIABLES

The socioeconomic variables that are used in the study are based on statistical data published by Malmö city. The variables used are demographic distributions (details), income, employment rate, heritage and educational level.

Data for the relevant years was extracted and joined with spatial properties in a Geodatabase in ArcGIS for further analyses and map making.

Correlations to UGS are conducted using SPSS.

7.1.1 Implications on accuracy

Not all socioeconomic variables are measured for all areas or years. Areas with less than 5 residents are excluded in Malmö city's statistical presentation. To be able to do a paired analysis, it is necessary to have the same sample size. Thus, statistical analysis is done on areas where all variables are available.

7.2 LANDSAT SATELLITE IMAGES

Landsat data is available at a 30 m resolution in WGS 1984 UTM Zone 33N using the Transverse Mercator projection. Landsat data was used to produce land cover maps. Images from the summer month of July (17^{th}) for the year 2019 were used to ensure that greenness could be detected when at a peak level.

7.3 SCHOOLS

Pre-school data is available as a Geopackage-file from SCB. The data is in SWEREF99 and was projected to WGS1984.

The compulsory school shapefile was retrieved from Lantmäteriet and is based on data from Skolverkets school registry. All data from Lantmäteriet is in SWEREF99 and was projected to WGS1984.

7.4 ADMINISTRATIVE BOUNDARIES

The administrative boundaries are available in vector data from Malmö city, in both EPSG:3008 and EPSG:4326. The administrative level of 136 districts will be used for analysis.

7.5 COMPREHENSIVE PLANS

The comprehensive plans will be accessed from Malmö city and used in the literature overview and analysis. On the website, historical comprehensive plans are also published and will be used in the analysis. The comprehensive plans used are from the year 2000 (revised in 2005), 2014, and 2018.

8 RESULTS

8.1 AIM 1 - URBAN GREEN SPACE WITHIN MALMÖ

The error matrix (Table 3) expresses the number of pixels identified in each class, for both the ground truth and on the land cover map produced for this study. The resulting accuracy of the land cover map can be seen in Table 4. The results point to good agreement for all classes. While water has a high accuracy through the years, the classification of built-up areas is a little lower. Overall accuracy is good, and thus the maps are adequately accurate to conduct further analysis. However, it is important to keep in mind that all data is a representation of reality, irrespective of the accuracy results. There is always a level of uncertainty when representing the truth. Therefore, all consecutive analyses also have a level of uncertainty.

A comparison between the points on the ground, using Google Earth imagery is seen in Figure 9 which relates to the same area on the land cover map produced by satellite image in Figure 10.

Figure 9 Snippet of accuracy assessment points in Google Earth (Google Earth, 2022)

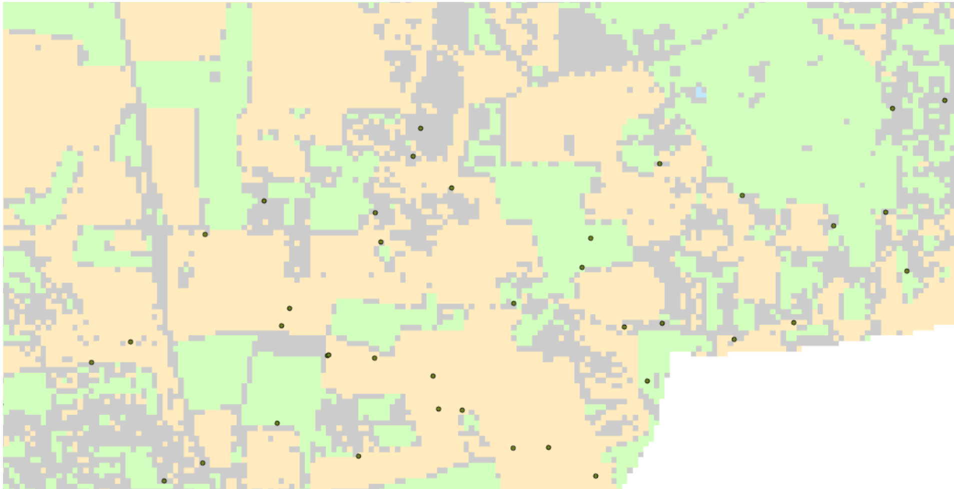

Figure 10 Snippet of accuracy assessment points over land cover in ArcGIS

The maximum likelihood classification will use both the covariance and means of the class signatures collected in the signature file to classify a pixel on the map. It is exemplified in Figure 11, where a point on the map is present and the same class on the ground truth.

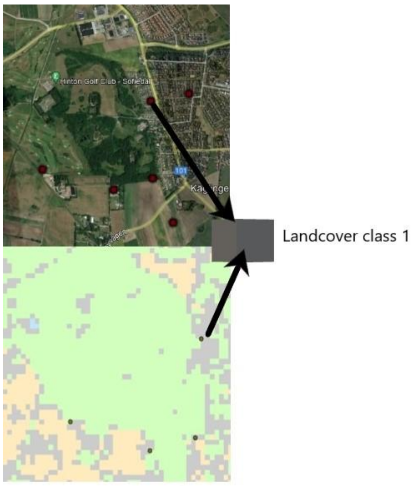

Figure 11 Simplification of the Maximum likelihood classification

Table 3 Error matrix for the Maximum likelihood classification

Ground truth						
Map data	Class	**UGS**	**Agriculture**	**Built-up**	**Water**	**Total**
	UGS	42	5	3	0	50
	Agriculture	3	42	4	1	50
	Built-up	3	2	45	0	50
	Water	0	1	3	46	50
	Total	48	50	55	47	200

Table 4 Accuracy assessment table

Class	User accuracy		Producer accuracy	
	Pixels	%	Pixels	%
UGS	42/48	88%	42/50	84%
Agriculture	42/50	84%	42/50	84%
Built-up	45/55	81%	45/50	90%
Water	46/47	98%	46/50	92%

8.1.1 Available UGS

The land cover map created in ArcGIS is presented in Figure 12. The map contains the land cover data used in consecutive analysis.

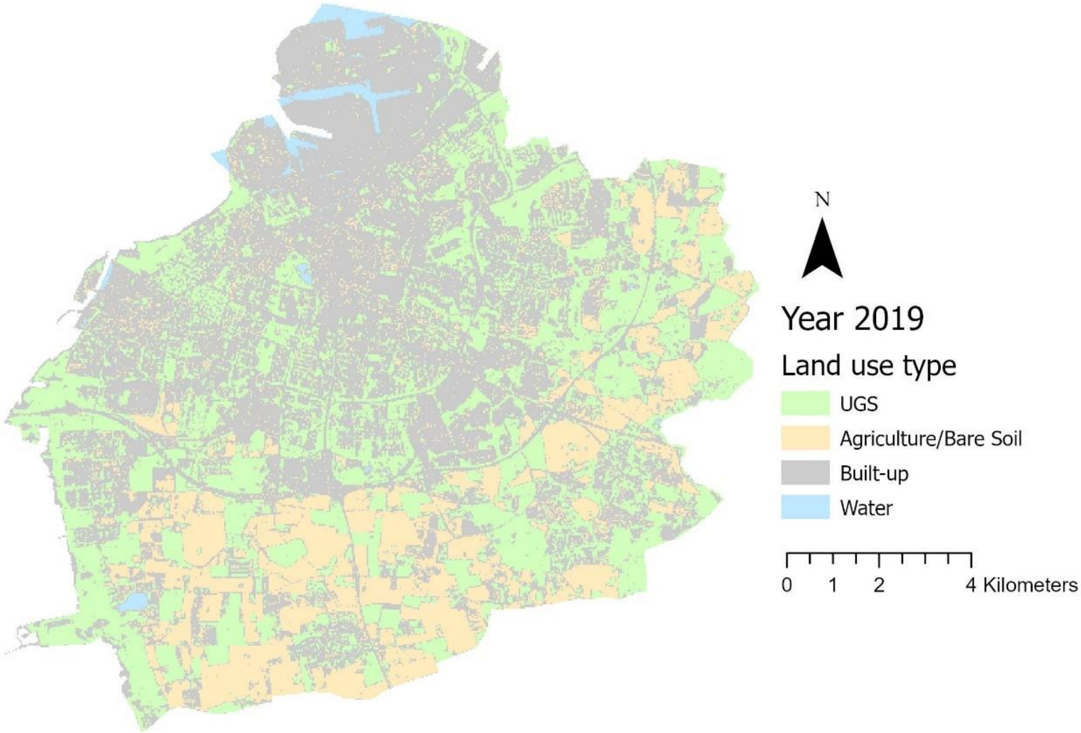

Figure 12 Land cover map

Table 5 illustrates the share of the different land covers of Malmö based on the results of the land cover map. The largest part is the built-up environment, followed by green space.

Table 5 Land cover statistics for 2019 in km²

Land cover in km²	
UGS	50
Agriculture	30
Built-up	76
Water	2

A breakdown of the UGS per capita and class is provided in Table 6, where class 3 offers the smallest amount of green space per capita, and class 5 the largest.

Table 6 UGS per capita for 2019, separated by class.

UGS per capita and class				
Class 1	Class 2	Class 3	Class 4	Class 5
7 m^2	14 m^2	6 m^2	26 m^2	89 m^2

With a decrease in UGS for the city of Malmö since 2005, combined with a steady increase in population, there is also less available UGS per capita reported from Malmö city (2021a, Table 7). The result of the study falls close to the reported UGS per capita for the municipality, as presented by Malmö city.

Table 7 Square meter per capita comparison

Source	Year	Sqm/capita
Malmö City (Malmö stad)	2015	174
Malmö City (Malmö stad)	2020	137
Malmö city (Results from study)	2019	142

As per Table 8, there are two administrative areas where lack of access to UGS of class 2 has been established. For class 3, there are 28 areas and for all other classes, the access to UGS is fulfilled.

Table 8 Lack of access to UGS per class

Number of administrative areas lacking access to UGS				
Class 1	Class 2	Class 3	Class 4	Class 5
0	2	28	0	0

8.2 Aim 2 – Detecting UGS from built-up environment

Correlation based on accessible UGS area

Correlations were examined using the four variables of educational level, income in SEK, employment rate and rate of foreign heritage in the administrative region, presented in Table 9. Some regions have less than five residents and are therefore excluded from the statistics. Data was available for 108 administrative regions.

Table 9 Correlation to total accessible UGS area

		Area	Education	Heritage	Income	Employment
Area	Pearson Correlation	1	-,539**	,388**	-,309**	-,310**
	Sig. (2-tailed)		<,001	<,001	,001	,001

**. Correlation is significant at the 0.01 level (2-tailed). N=108

There are statistically significant correlations for all socioeconomic variables based on accessible area. For education, income and employment, the correlation is inverted. This is implied by the negative Pearson index. As UGS increases in area, these variables decline.

The regression model output provided in Table 10presented that the distribution of UGS could be explained to some extent by the socioeconomic variables, but that other factors are at large.

Table 10 Regression analysis

Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,554[a]	,307	,281	4142693,3

a. Predictors: (Constant), Employment, Income, Education, Heritage

The correlation to number of UGS, presented in Table 11, did not yield any significant correlations, and the regression analysis highlighted by Table 12 indicates that as little as 2,6% of the accessible number of UGS can be explained by the socioeconomic variables in the dataset.

Table 11 Correlation to the total number of UGS per administrative area

Correlation based on number of UGS

		Number_of_UGS	Education	Heritage	Income	Employment
Number_of_UGS	Pearson Correlation	1	-,036	-,060	,063	,006
	Sig. (2-tailed)		,711	,539	,519	,950

**. Correlation is significant at the 0.01 level (2-tailed). N=108.

Table 12 Regression model using total number of accessible UGS and the four selected variables

Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,160[a]	,026	-,012	14,53189

a. Predictors: (Constant), Employment, Income, Education, Heritage

As figure 13 illustrates, the number of UGS appears somewhat dispersed across the municipality. The area of accessible UGS is concentrated in a quite clear clustering, with low values centered around the northwest part of Malmö and high values in the south-central areas.

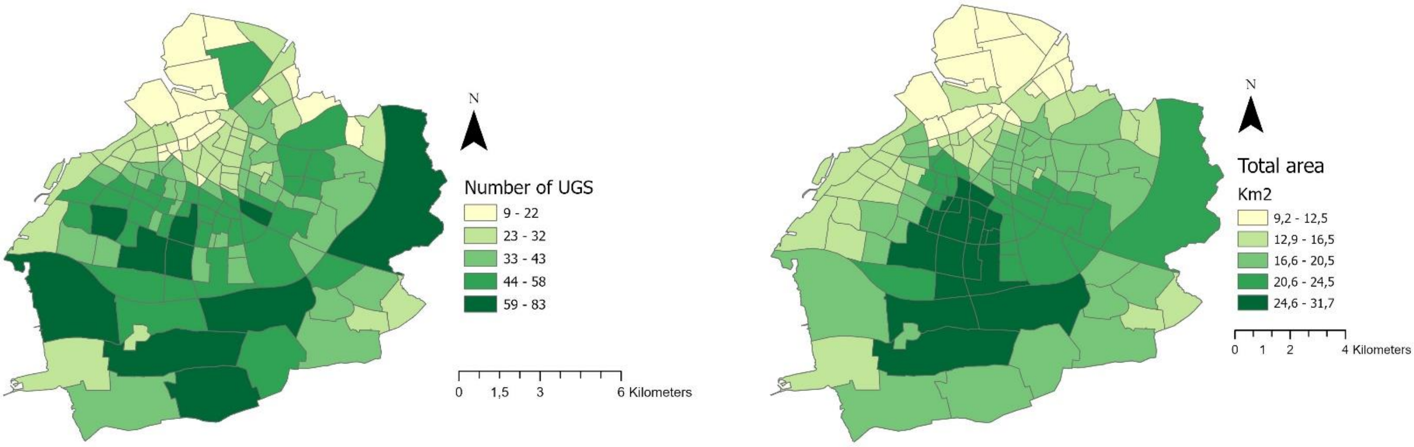

Figure 13 Maps of total UGS across all classes, per administrative region

8.3 AIM 3 CHILDREN'S ACCESS FROM PRE- AND COMPULSORY SCHOOLS

Examining children's access to UGS from school grounds both in total area of UGS and number of UGS gives indicators for future development of green space. Pre- and compulsory schools are overlayed on the total area of UGS accessible from the schools in different administrative

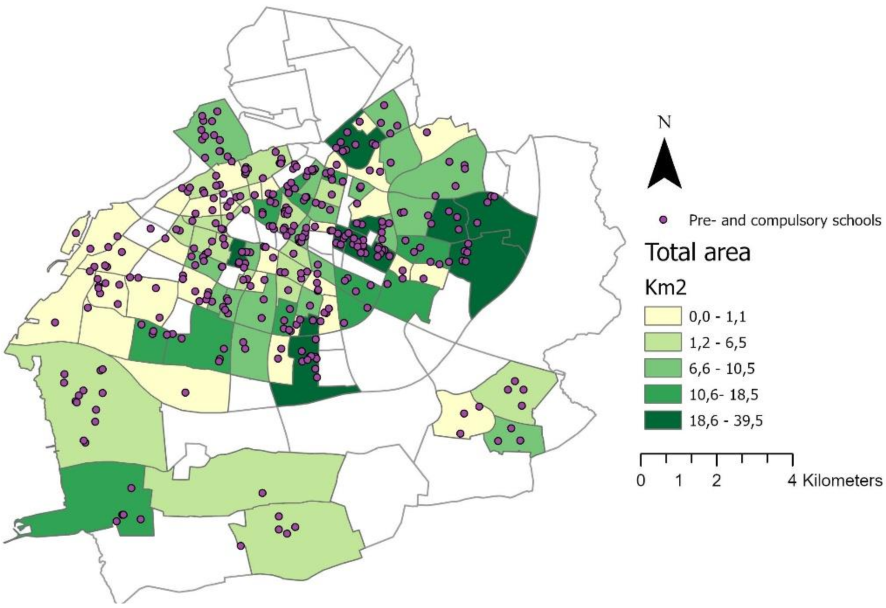

Figure 14 The area of accessible UGS from pre- and compulsory schools per administrative area

areas in Figure 14, while Table 13 presents the total amount of green spaces that are accessible from schools, divided into each class of UGS.

Table 13 Number of accessible UGS from pre- and compulsory schools

Number of accessible UGS from pre- and compulsory school				
Class 1	Class 2	Class 3	Class 4	Class 5
504	355	120	383	569

Figure 15 illustrates the number of UGS that are within reach for schools in each of the administrative areas. Important to note is that the green space itself could be located outside of the administrative borders, especially those of larger classes. The number of UGS within each class is presented in Table 13. There are more accessible UGS in class 5 (within 3000 m from school grounds and over 35 ha in size) and 1 than all other classes. The smallest number of UGS can be found in class 3 (within 1000 meters from school grounds and over 5 ha in size). As seen in Appendix A, table 26 and 27, there is an uneven distribution of access across the administrative regions. Some areas lack access to small UGS but have access to larger ones, and the inverse relationship is also present. 40 of the administrative areas' pre- and/or compulsory schools have access to UGS in all classes.

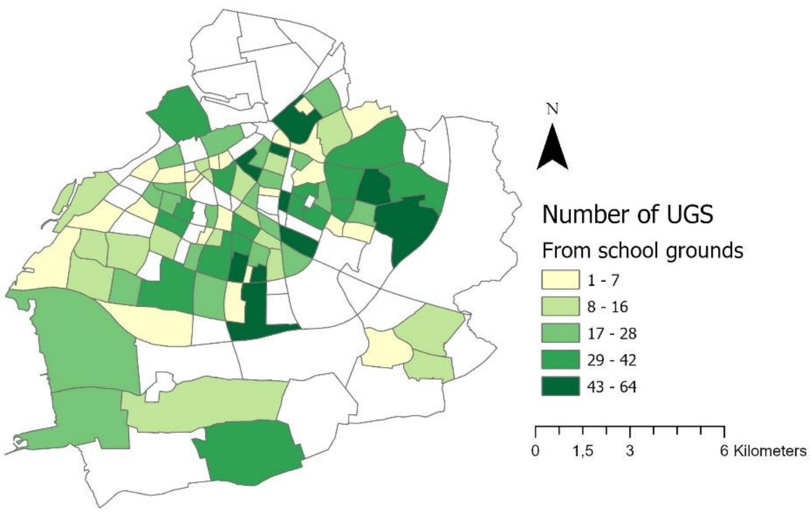

Figure 15 The number of accessible UGS from pre- and compulsory schools per administrative area

As per Table 14, many school grounds lack access class 3 UGS (UGS of 5 ha within 1000 meters). Only 7 administrative areas are lacking access to UGS in class 1, sized 0,2 ha or 30 m wide, within 300 meters from the school grounds.

Table 14 Administrative areas lacking access to UGS of different classes.

Number of areas with no accessible UGS				
Class 1	Class 2	Class 3	Class 4	Class 5
6	13	40	23	25

To examine if there is a spatial pattern to the distribution of UGS, a Moran's I analysis was done for the accessible UGS area in year 2019. The results in Table 15 indicate a significant autocorrelation, with a significance level of 0,042. This suggests a less than 5% chance that the spatial distribution of accessible sqm of UGS is random.

Table 15 ArcGIS (2022)

Moran's Index:	0,057424
Expected Index:	-0,007407
Variance:	0,001019
z-score:	2,031194
p-value:	0,042235

The hot spot analysis used the accessible area of UGS to examine spatial patterns of distribution related to both low (cold) and high (hot) values. Figure 16 shows cold values clustered around the northwestern part of Malmö, a dense environment with higher socioeconomic status. The higher values are located quite centrally in Malmö, possibly due to accessibility to UGS in all directions.

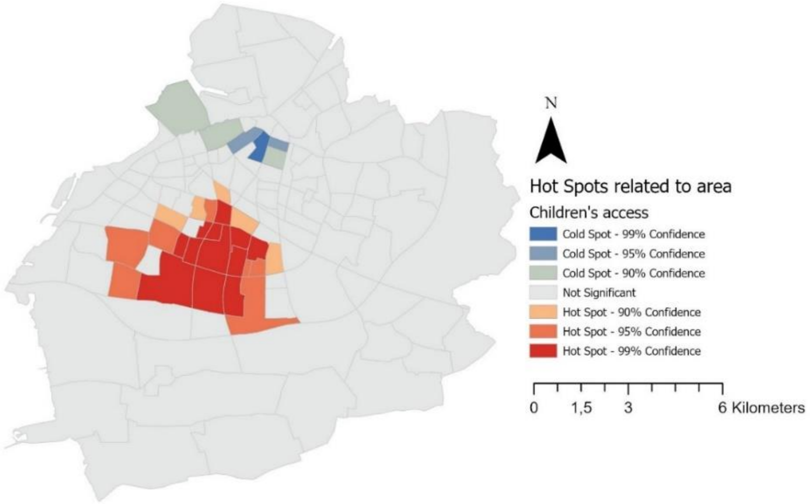

Figure 16 Hot spot analysis map

8.3.1 Correlation to socioeconomic variables

As young children often attend school close to their home, studying correlations to socioeconomic variables can give insight to accessibility patterns relating to the socioeconomic factors of an administrative area. The 87 administrative areas where pre- and compulsory schools are located were correlated to the socioeconomic variables educational level, income, employment rate and rate of foreign heritage and the results are presented in Table 16.

Table 16 Correlation of number of UGS per administrative area and the selected socioeconomic variables

Correlation in relation to school grounds – number of UGS

		Number_of_UGS	Education	Heritage	Income	Employment
Number_of_UGS	Pearson Correlation	1	-,290**	,312**	-,264*	-,227*
	Sig. (2-tailed)		,007	,003	,013	,035

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

N=87

The number of UGS is shown to correlate to all variables at a statistically significant level. When rejecting the null hypothesis that there would be no effect on accessible UGS based on advantageous socioeconomic variables, it can be done with a high degree of confidence. This indicates a strong correlation with the mentioned variables.

The correlation is inverted in all cases except foreign heritage. This indicates that where education, income and employment is higher, there are less accessible numbers of UGS. For heritage, the relationship is the reverse – when the number of UGS increases, there are more people with foreign heritage.

Further, the regression analysis in Table 17 indicates that 11% of the number of accessible UGS can be explained by the selected socioeconomic variables.

Table 17 Regression analysis of number of UGS and the selected socioeconomic variables

Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,332[a]	,110	,067	15,58715

a. Predictors: (Constant), Employment, Education, Income, Heritage

The accessible area has significant correlations to all studied variables, in the same pattern as number of UGS according to the results in Table 18.

Table 18 Correlation of total accessible UGS area per administrative area and the selected socioeconomic variables

Correlation in relation to school grounds - total area of UGS

		Area	Education	Heritage	Income	Employment
Area	Pearson Correlation	1	-,335**	,336**	-,289**	-,243*
	Sig. (2-tailed)		,002	,001	,007	,023
	N	87	87	87	87	87

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

N=87

The regression model provided in Table 19 indicates that 13.5% of the accessibility of UGS can be explained by the selected socioeconomic variables.

Table 19 Regression analysis of total area of UGS and the selected socioeconomic variables

Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,367[a]	,135	,093	7,5

a. Predictors: (Constant), Employment, Education, Income, Heritage

8.4 Aim 4 – Children and UGS within the urban planning of Malmö

8.4.1.1 Children and UGS in the Current comprehensive plan

Closeness to UGS, both large and small, is a high priority in the development of Malmö. While Malmö aims for a green and dense city, they note difficulties navigating green areas and qualities in a city with a growing population. This is due to the risks of qualities such as peace and solitude being threatened when larger crowds have more residents. Pre -and compulsory schools should have open space within their grounds. The green space on school grounds should also be a part of the public space, available for use on holidays, weekends, and after-school hours (Malmö stad, 2018b).

The comprehensive plan mentions children in different contexts of the city. The positive effects of green space on children's cognitive, social, and physical development are mentioned in the comprehensive plan. The vision of the city includes children growing up in stimulating environments that are close to parks and green space. Green environments close to schools and pre-schools should be designed to fulfill the needs of those not able to travel long distances (Malmö stad, 2018b).

Further, safe and sustainable travel routes are also part of the identified child-centered needs. As such, the comprehensive plan asserts the need for children to not only have access to green space, but also safe routes to and from activities and school/pre-school. The need to analyze all urban development in different perspectives, amongst them the child's perspective, is also part of the comprehensive plan of 2018 – taking both children's views and the child perspective into account (Malmö stad, 2018b). It has been established that citizen participation is important, and the comprehensive plan does mention the importance of participation on social sustainability. It is also mentioned as an aspect of densification. There is also specific mention of children's participation in the urban planning and goals of developing forms for this (Malmö stad, 2018b).

According to the comprehensive plan, the city of Malmö should offer an environment for children and families that enables them to continue living in the urban setting. This includes urban green areas, but also other outdoor areas that give incentive for play and physical activity. The city identifies areas with high childhood poverty and overcrowding as areas where it is especially important to offer a rich local environment. This should act as a means of compensation for the lack of space in living arrangements (Malmö stad, 2018b).

There is a specific document relating to free space at schools where the aim of $30m^2$ of free space at pre-schools and $15m^2$ in proximity of compulsory schools is presented. There is also an aim of $2000m^2$ of total free space located by pre-schools (Malmö stad, 2021). Free space is not synonymous with green space, as it could be open areas of other kinds.

8.4.1.2 Aims relating to UGS and children in Earlier comprehensive plans

The predecessor to the current comprehensive plan is from the year 2014 and shares many similarities with the one from year 2018. The discourse on children in the comprehensive plan is the same, and it highlights the need for areas that entice and enable children to play and move. The 2014 comprehensive plan puts a somewhat larger focus on the negative changes of the range of free space for children to roam without adult company. There is also a lack of discussion on the child's perspective in the older comprehensive plan, which has been incorporated into the current one. Goals include pre- and compulsory school access to high quality outdoor environment, with closeness to parks, playgrounds, and nature within the city (Malmö, 2014).

The 2014 comprehensive plan mentions access to a mixture of small and large parks, nature areas and squares with strategic placing in the city. The city also acknowledges the need for quality, access, and closeness. A neighborhood park or larger should be accessible within 1 km from all living quarters. Smaller open spaces, like squares and smaller parks, should be accessible within 300 m of the residence. The need to localize larger parks in growing cities is also acknowledged. The city claims it has gotten greener by creating or restoring green spaces, and small parks/UGS (Malmö, 2014).

The difference in planning principle becomes more apparent in the older comprehensive plan from 2000 (revised in 2005). There is mention on how "new research" has proven that children benefit from nature-imitating play areas, the importance of creating environments for play and physical movement in the comprehensive plan from 2000.

The overall mention of green space within the urban environment shows an intent to maintain and develop parks, small UGS and larger recreational areas on a detailed level. Green space itself is given a large role for city development in this comprehensive plan, with clear distance indicators (Malmö stad, 2000). The plan also presents new UGS to be created within the city. The plan also presents the lack of public green structure. The regions presented as suffering the most from this are the eastern parts of the city center, from Värnhem to Sofielund and Tygelsjö and ideas to implement green space are presented.

The development of a green city has held high priority in the comprehensive plan throughout the years, but the inclusion of a dedicated headline for how to develop the city in a way that benefits children started with the comprehensive plans of 2018 and 2014. The plan from 2000, revised in 2005, makes no mention of children and their place in the city.

There is no mention of how to include children in the planning processes and thus, all comprehensive plans hold a top-down take on the role of children in city planning.

9 DISCUSSION/ANALYSIS

9.1 RESEARCH QUESTION 1

9.1.1 Could open midspace-resolution satellite data be used to detect and monitor green areas of in an urbanized city? Is the source data (resolutions in time and space) and classification method sound and appropriate?

While land cover maps often are a representation of reality, a map with high accuracy can lend important data to a study. By using remote sensing data to create land cover maps and examining the land use, distribution of UGS was determined for 2019 with adequate accuracy as per fig. 6.

One of the main purposes of this study was to examine the UGS of different scales using open, mid-resolution remote sensing data. By using GIS tools, a classification of different sized UGS in accordance with city guidelines could be established.

The maps can be used to detect patterns of spatial distribution of access and availability, as illustrated in the results. As the city greenery guidelines determine UGS of at least 2000m^2 or 30 m width of interest, mid-resolution satellite data could be used for the land cover mapping.

The method presented allows for mapping UGS of different sizes within smaller administrative areas. This can give detailed information, even in countries and situations where access to high-resolution or finished products is unavailable.

There was a very slight difference between the results of this study and those from SCB for the year 2020. It is possible that UGS is somewhat overestimated in the study, but it could also be due to further losses of UGS. The differences can also be due to variations in methods of data handling and land cover mapping. As the city of Malmö has access to further information regarding the different types of green space, it could also be due to differences in classification of green space, such as private and public space or type of UGS.

The method used in this study relies on visual assessment both during the creation of training samples and the accuracy assessment, which puts some responsibility of the result of accuracy on the producer. Further, for smaller UGS higher resolutions would be necessary to adequately capture UGS under 30 m width or 2000m^2 area or for a higher level of detail regarding land cover types.

However, this method allows for general studies on UGS (or other land cover types) done using accessible, open remote sensing data of mid-resolution by using simple methods and analysis available in most GIS-software, both licensed and open. The resulting data can be used for further statistical analysis, for example in correlation to socioeconomic variables such as in this study.

The results of the study show that open data can be used to conduct accessibility analysis, at an administrative level. To go onto a finer scale, the data could prove too undetailed.

9.2 Research Question 2

9.2.1 How may GIS be used to detect to what extent the residents have access to green space in terms of distance from their built-up environment? Could GIS tools be used to reveal spatial patterns linking access to socioeconomic factors?

Using buffer zones around built-up areas, the UGS of a certain class that falls within a buffer zone according to the guideline was determined. Using this method, it was possible to find out the extent, number, and class of UGS accessible to residents of an administrative region.

No administrative areas lacked UGS of class 1, which indicates that UGS are close to the built environment in the city. It is however noticeable that class 3 offers the smallest amount of UGS per capita (Appendix A, Table 28 & 29). As UGS of different sizes are used for different activities, this could potentially limit some activities for residents that are lacking access to UGS of this size.

There are also clear correlations between the area of UGS and all socioeconomic variables. For education levels above high-school, income and employment rate, the correlation is negative. As accessible UGS gets larger, these variables get smaller. For foreign heritage, the opposite trend was discovered. Where accessible UGS is larger in total size, there are more residents with foreign heritage. Correlation to the number of UGS did not show any significant correlations. However, the regression analysis showed that 30,7% of the area of UGS could be explained by the regression model. While this indicates that the socioeconomic variables do offer some predictability to the number of UGS, there are many more unknown factors which also do. This is to be expected, as planning policies, economy and many other things steering the development of a city.

The result of the correlation supports the initial hypothesis that it would be high- and medium-income residential areas with a higher employment rate, where residents with higher education and mostly non-foreign heritage resides experiencing limited access to UGS. This contradicts previous research from other western countries where the opposite is often acknowledged. However, considering the background of Swedish building principles, it is likely an observation that can be made in other Swedish cities of larger size.

9.3 RESEARCH QUESTION 3

9.3.1 How may GIS be used to detect access between green space and pre- and compulsory schools? Could GIS-tools be used to detect variations of access due to socioeconomic factors?

The loss of UGS in Malmö has a negative effect on accessibility for schools. Different administrative regions are affected by UGS availability in different variations.

6 school grounds lack access to green space within 300 meters from the school. The lack of free space in proximity to compulsory school grounds were already acknowledged in the published report from SCB (2018), but this study can conclude more specifically that Elinelund, Fridhem, Gamla Limhamn, Kristineberg, Kronborg, and Södra Sofielund was shown to lack access to class 1 UGS. Thus, the aim of 15-30 m^2 of free space per child adjacent to school grounds is not met in these areas. Limhamn has been pointed out as one of the fastest developing administrative areas by Malmö stad (Malmö stad, 2021b).

For the larger classes, even more pre- and compulsory schools lacked access to green spaces. Larger UGS are mostly located in the outer parts of Malmö, which makes these areas less accessible to inner-city children. While it is less probable that children often visit these larger UGS during school hours, previous research links access to larger UGS important to school age children. It also acts as an incentive for excursions, as studies have shown that successful excursions to smaller UGS often led to visits to larger green spaces during school hours.

Both amount and the total size of accessible UGS correlated significantly with the socioeconomic variables employment rate, higher educational level, heritage, and disposable income. For all variables except heritage, the correlation is inverted. Thus, as UGS gets larger in size and number, the socioeconomic variables show more disadvantageous conditions. This supports the hypothesis that it is primarily administrative regions with a higher socioeconomic profile that lack access to UGS.

Figures 17-24 in Appendix B illustrate classes of the socioeconomic variables based upon the percentiles of the variables in Table 20, seen below.

Table 20 Percentiles of the four socioeconomic variables

	Education (% of population with higher education)	Income (sek)	Employment rate (% of population)	Rate of foreign heritage (% of population)
25th percentile	0,313544489	317700	0,643695732	0,238618524
50th percentile	0,452173913	374610	0,734939759	0,380595149
75th percentile	0,573351477	425932	0,76792147	0,56305359
90th percentile	0,637931949	494592	0,797340493	0,776998962

From these variables, the classes were created as per table 21.

Table 21 Classes based on the percentiles of socioeconomic variables.

Class 1	< 25th percentile
Class 2	<50th percentile
Class 3	<75th percentile
Class 4	< 90th percentile
Class 5	>= 90th percentile

When examining figures 17-24 in Appendix B, as well as Table 21, it also becomes visually apparent that many of the administrative regions with a high share of residents with foreign background belong to lower income, education and employment rate classes. This further confirms the results of the correlation analysis.

The regression analysis resulted in weak models, where only a small percentage of the accessible UGS could be predicted using the variables. Once again, this is not strange considering cities rarely plan based solely on socioeconomic factors. As such, a simple linear regression model is inadequate in explaining the accessibility of UGS and cannot be used to predict accessibility solely based on these variables.

When developing cities with land fill, research shows that UGS is often at loss. For areas that already primarily consist of buildings, this development could have a negative impact on residents which makes strategic planning allowing for access to UGS even more important. While the loss of UGS cannot be established to be a direct cause of densification, green space has been lost within Malmö as the city has consistently grown over the years.

9.4 RESEARCH QUESTION 4

9.4.1 How do the future plans for new developments in densification purposes in Malmö City relate to people´s access to green space? How could the proposed method using satellite data and GIS be used to find out how they agree with the intentions of Malmö strategic plan in terms of greenery guidelines**?**

Table 22 provides an overview of what this study had an interest in exploring and explaining using open-source satellite data.

Table 22 Useability of GIS results when following up comprehensive plans.

Goals	Analyzed using GIS
Accessability	X
Green environments close to school	X
Availability on non-school hours	-
Child's perspective	-
Citizen participation	-
Rich local environment in low income & crowded areas	X
Useability	-

It has been established that citizen participation is important, and the comprehensive plan does mention the importance of participation on social sustainability (Malmö stad, 2018). It is also mentioned as an aspect of densification (Malmö Stad, 2018). The comprehensive plan mentions access to UGS in looser terms. While both blue and green space is of high importance, and has been for many years, there is no mention of the greenery guidelines set by the city.

There is no mention of greenery in and around schools, nor access to it for children of pre- or compulsory school age within the older comprehensive plans. In the newest comprehensive plan, Malmö city indicates the need for access to UGS in school for children that cannot travel to green space when at home. There are also mentions of free space in supplementary documents from 2021.

The comprehensive plan mentions the need for green, varied, and eventful local environments. One could argue that as children spend much of their day in daycare and school, this is also part of their local environment and should be included in the guidelines or have other greenery guidelines to assure a beneficial local environment during the daytime hours.

The result of this study indicates that there is a lack of access to class 3 UGS for all residents, and to all classes from pre- and compulsory schools. While UGS of class 1 can be noted as the most accessible of all classes, access to greenery of class 3 is lacking in 28 administrative areas. As mentioned before, the importance of access to larger green spaces should not be overlooked and in this regard Malmö city does not live up to their own guidelines. This is true for the residents of Malmö at large, but also for pre- and compulsory schools for all classes of UGS. The aim of greenery close to schools for children not able to travel long distances could possibly be filled by the UGS that does exist, but this cannot be answered by a study of this scale. The result of the study instead indicates that there is not enough green space close to places where children dwell during the daytime which is a large issue for children that might not have the means to transport to other UGS outside of school hours.

Further, having had greenness as a high priority in comprehensive planning for the past couple of decades, the presented decline of UGS by Malmö city does indicate that the city prioritizes building and city development in a way that affects the total size of UGS. The reality of development shows a step away from the compulsory plans.

There is mention of the children’s perspective in the comprehensive plan, but the scale of the study makes it hard to assess how it affects children and their access to UGS. While children might still be involved in some part in detailed development planning, it could also be an overall aim in the comprehensive plan.

While green space holds many benefits, the useability of it is also important. Access to UGS allows for easier utilization, but it does not promise utilization. By letting children be heard, and planning community spaces with children, could enhance the attractivity of UGS. The clear aim of citizen participation, although described very loosely, indicates an initiative towards this.

Clear definition and plannings could put more pressure on execution of citizen participation and define what type of participation is expected. As mentioned in both ladders of participation, there are different ways to involve citizens in urban planning – with varying feelings of inclusion.

By analyzing the current situation and comparing it to the goals relating to UGS, GIS can be a useful tool to assess the development of accessibility. By conducting a literature analysis of the comprehensive plans, it is possible to identify soft and hard goals of the city. These can then be compared to the results of the GIS analysis. While GIS is proven to be useful for answering the hard goals, it is less effective in answering the soft aims of the city (Table 22).

10 CONCLUSION

Urban green space is important for human health, children's development and the environment. This study set out to examine the accessibility of UGS from build-up environment and school grounds, correlated with income, education level, employment rate and foreign heritage which are the most common socioeconomic indicators, using only open data.

While a land cover analysis is a representation of the world, and cannot depict the world with 100% accuracy, it is still a good tool to be used in detecting the geographic makeup of an area. Thus, the method of this study can give a clear indication of the trends of UGS, both in availability and accessibility.

When revisiting the null hypothesis for this study, it becomes clear that it can be rejected, as the results show that it is areas with high income, employment rate and educational level that have the least access to UGS. While the building ideals of Sweden during the Million program did prioritize adjacent green areas to living quarters, and many of these areas are experiencing worse socioeconomic conditions than other parts of the cities, they do have an advantage in UGS accessibility.

As mentioned previously, the housing policy during the era of Folkhemmet where the Million Programme was implemented did advocate green living. As such, the idea of 'houses in park´ was realized in many locations across Sweden. This also included building parks and recreational areas within these new neighborhoods. Part of the idea was the local services the neighborhood should offer, and therefore many of the facilities were within walking distance of the residential area. Simultaneously, the Million Programme is often blamed for the pattern of socio-economic segregation that is present in many cities all over Sweden (Hall, T. & Vidén, S., 2005; Grundström, K. & Molina, I., 2016; Mack, J., 2021). The result of this study contradicts previous studies. However, taking the above into account the pattern found in Malmö could also be explained by socio-economic reasoning. The residential areas of the Million Programme exhibit socio-economic difficulties, often being described as "vulnerable areas". These areas were built upon a planning policy promoting green and open spaces. Therefore, those that belong to a lower socio-economic category would often live in areas with proximity to greenery. It can therefore be concluded that the reason for the seemingly inverted pattern of accessibility in Malmö compared to other examined countries could be the issues with segregation in combination with housing policies of the 60-70s.

The results show that there are many areas of Malmö that are lacking in accessible UGS of primarily size 3, but that accessibility from the built-up environment is good overall for the residents. For school grounds, no administrative area lacks access to all classes but many of the areas lack access to UGS of some class (Appendix A, table 26 & 27). The access to UGS is thus limited to and from the school grounds in Malmö.

Correlations between accessible UGS and socioeconomic variables show statistically significant correlations, as per Table 23. Whilst the access from pre- and compulsory school correlates both to the number and total area of UGS, the municipality of Malmö correlates to all variables regarding the size of UGS. A relationship with socioeconomic variables has been established in previous studies, where access to UGS showed correlation to socioeconomic variables. This study however shows an inverted relationship from previously mentioned studies, where disadvantageous areas had the least access to UGS.

Table 23 A summary of correlations

Area of correlation	Education	Heritage	Income	Employment
UGS Area - Malmö City	-0,54	0,39	-0,31	-0,31
Significance	<,001	<,001	0,001	0,001
Number of UGS - Malmö City	-0,036	-0,06	0,063	0,01
Significance	0,711	0,539	0,519	0,95
UGS Area - Schools	-0,34	0,34	-0,29	-0,24
Significance	0,002	0,001	0,007	0,023
Number of UGS - Schools	-0,29	0,31	-0,26	-0,23
Significance	0,007	0,003	0,013	0,035

It can also be concluded that while the regression models did explain the accessibility to UGS to varying degrees, it is not possible to use the regression model to predict accessible UGS based on these socioeconomic variables. This becomes evident from Table 24.

Area	R^2
UGS Area - Malmö City	0,307
Number of UGS - Malmö City	0,026
UGS Area - Schools	0,11
Number of UGS - Schools	0,135

Table 24 Regression results

11 FUTURE RESEARCH

This thesis has a top-down perspective, analyzing the access that children have to UGS using quantitative measures. While access to UGS near the residency has been shown to encourage utilization of the same, this paper does not consider how the inhabitants of Malmö use the areas, nor the number of visits to areas. Considering certain UGS areas have proven more attractive than others in other research, it is probable that the residents of Malmö might also travel some distance to UGS.

Further, the changes can be studied at a closer level by assessing the UGS change per capita for each of the administrative areas. For this study, the focus was changes in accessible and available areas per administrative level. The accessible and available UGS might be shared between residents between several administrative areas, either because of location or attractivity.

The study also does not discuss children's actual use of UGS, nor the views of the children on UGS. Contemplating participation, further research that includes the children's perspective on their access to and quality of accessible urban green areas would be interesting.

Further, the pattern of access correlated to socio-economic variables should be further examined. Studies on access to UGS conducted in other countries show positive correlations to health, accomplishments in school and mental health. A greater insight to how closeness to green spaces in larger cities in Sweden affect wellbeing could yield interesting results due to the differing socioeconomic makeup of the urban areas with greater access to green space. It could also strengthen the results of previous studies if the same pattern of health and academic performance is found where socio-economic status is lower.

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13 APPENDIX A TABLES

Table 25 Socioeconomic statistics per administrative area

	Socioeconomic variables 2019			
Region	Share of higher education	Foreign heritage	Employment rate	Average income
ALLMÄNNA SJUKHUSET	65,3%	34,5%	75,7%	318 511
ALMGÅRDEN	20,2%	43,1%	70,0%	307 413
ALMHÖG	30,5%	77,7%	58,0%	298 466
ALMVIK	30,4%	69,3%	59,4%	318 041
ANNELUND	51,9%	49,4%	68,6%	299 378
ANNETORP	52,3%	23,6%	78,9%	440 402
APELGÅRDEN	24,1%	86,3%	58,0%	296 854
AUGUSTENBORG	28,5%	76,7%	49,1%	273 987
BELLEVUE	72,5%	21,3%	72,8%	936 154
BELLEVUEGÅRDEN	33,0%	61,8%	57,7%	317 526
BORGMÄSTAREGÅRDEN	57,0%	35,2%	78,9%	384 483
BULLTOFTA	45,2%	45,4%	73,4%	408 395
BUNKEFLOSTRAND	52,1%	34,1%	74,0%	453 969
DAMMFRI	58,5%	27,8%	76,5%	364 769
DAVIDSHALL	64,8%	27,1%	74,7%	426 173
DJUPADAL	72,1%	13,4%	84,5%	526 595
ELINELUND	52,3%	37,4%	78,9%	387 089
ELISEDAL	0,0%		55,6%	
ELLSTORP	57,5%	32,5%	76,5%	322 274
EMILSTORP	0,0%			
ERIKSFÄLT	44,8%	47,7%	76,3%	387 167
FLENSBURG	42,7%	60,9%	48,1%	284 634
FORTUNA HEMGÅRDEN	36,8%	0,0%	76,8%	415 639
FOSIEBY	0,0%	0,0%		
FOSIEBY INDUSTRIOMRÅDE	0,0%	0,0%	47,8%	
FREDRIKSBERG	0,0%			
FRIDHEM	65,9%	24,2%	75,8%	569 058
FRIHAMNEN				
FÅGELBACKEN	61,7%	27,1%	76,9%	372 099
GAMLA LIMHAMN	53,1%	21,2%	76,0%	456 429
GAMLA STADEN	60,8%	35,0%	74,5%	428 495
GLOSTORP	36,8%	0,0%	79,4%	
GRÖNDAL	41,5%	42,4%	70,8%	350 825
GULLVIK	34,1%	64,1%	70,2%	371 887
GULLVIKSBORG	27,1%	79,9%	51,8%	287 916
HELENEHOLM	31,3%	78,6%	54,7%	276 230
HERMODSDAL	24,1%	84,1%	49,1%	262 187
HERRGÅRDEN	17,5%	94,9%	36,4%	252 756
HINDBY	37,6%	64,2%	66,1%	334 551
HOLMA	28,6%	82,6%	47,5%	285 531
HYLLIEBY	63,9%	16,7%	77,5%	528 419
HYLLIEVÅNG	49,7%	59,7%	62,9%	360 552
HÅKANSTORP	45,2%	34,0%	76,5%	375 026
HÄSTHAGEN	71,8%	17,9%	78,9%	447 951
HÖJA	33,3%	50,7%	74,5%	348 113
INRE HAMNEN	56,0%	0,0%	73,5%	427 030
JOHANNESLUST	63,3%	23,9%	83,7%	422 183
JÄGERSRO	0,0%			
JÄGERSRO VILLASTAD	43,4%	56,2%	73,4%	385 530
KALKBROTTET	46,6%	44,8%	67,2%	397 690
KASTANJEGÅRDEN	42,2%	74,9%	67,4%	342 270
KATRINELUND	58,0%	52,7%	49,2%	247 268
KIRSEBERGSSTADEN	46,3%	43,7%	67,9%	322 733
KLAGSHAMN	61,7%	22,4%	82,6%	500 374
KRISTINEBERG	35,8%	49,7%	64,0%	362 844
KROKSBÄCK	36,9%	63,8%	57,3%	357 980
KROKSBÄCKSPARKEN				
KRONBORG	61,4%	32,6%	76,6%	382 933
KRONPRINSEN	47,8%	30,7%	77,8%	376 286
KRYDDGÅRDEN	29,5%	88,3%	44,1%	238 879
KULLADAL	46,1%	42,6%	77,5%	382 059
KUNGSHÖG	0,0%			
KVARNBY	40,7%	31,1%	75,2%	395 185
KÄGLINGE	38,3%	35,7%	76,1%	417 632
LIMHAMNS HAMNOMRÅDE	58,8%	32,7%	76,8%	453 763
LINDEBORG	38,1%	47,2%	70,5%	361 085
LINDÄNGEN	27,7%	79,0%	54,5%	288 327
LOCKARP	22,4%	0,0%	75,7%	359 454

Socioeconomic variables 2019				
Region	Share of higher education	Foreign heritage	Employment rate	Average income
LORENSBORG	36,6%	56,7%	59,1%	317 586
LUGNET	58,0%	40,9%	72,3%	397 148
LÖNNGÅRDEN	44,2%	52,3%	65,7%	287 511
MALMÖHUS				
MELLANHEDEN	54,3%	29,8%	72,3%	374 540
MELLERSTA HAMN				
MÖLLEVÅNGEN	57,3%	48,0%	66,8%	316 874
NAFFENTORP	0,0%	0,0%		
NORRA HAMNEN				
NORRA SOFIELUND	57,1%	43,5%	65,1%	303 462
NORRA SORGENFRI	46,4%	0,0%	66,7%	344 902
NYA BELLEVUE	73,9%	18,5%	73,7%	672 949
NYDALA	27,2%	77,7%	55,8%	295 529
OLJEHAMNEN				
OXIE KYRKBY	35,1%	37,5%	75,2%	374 679
OXIEVÅNG	31,0%	54,6%	65,5%	345 220
PERSBORG	24,1%	81,6%	47,6%	269 048
PILDAMMSPARKEN				
RIBERSBORG	66,0%	16,7%	81,9%	425 208
RIBERSBORGSSTRANDEN				
RISEBERGA	50,6%	32,8%	79,7%	431 915
ROSENGÅRD CENTRUM				
ROSENVÅNG	75,4%	13,9%	81,2%	609 295
ROSTORP	46,5%	37,3%	75,0%	359 835
RÅDMANSVÅNGEN	62,7%	39,9%	70,8%	378 561
RÖNNEHOLM	61,0%	21,1%	79,7%	382 659
RÖRSJÖSTADEN	71,1%	26,7%	78,3%	393 564
SEGE INDUSTRIOMRÅDE	0,0%			
SEGEMÖLLA	0,0%			
SEGEVÅNG	34,1%	58,9%	63,9%	315 146
SIBBARP	54,6%	22,0%	76,3%	478 677
SKUMPARP	62,3%	0,0%	83,3%	476 410
SLUSSEN	61,0%	38,3%	76,1%	378 653
SOFIELUND INDUSTRIOMR	0,0%		50,0%	
SOLBACKEN	61,1%	28,8%	76,5%	494 928
SPILLEPENGEN				
STADION				
STENKÄLLAN	39,6%	50,1%	74,3%	386 314
SVÅGERTORP				
SÖDERTORP	45,6%	40,1%	75,8%	366 371
SÖDERVÄRN	52,6%	46,9%	66,7%	286 488
SÖDRA SALLERUP	38,1%	28,4%	75,7%	394 749
SÖDRA SOFIELUND	38,4%	66,1%	55,2%	274 582
TEATERN	63,8%	0,0%	79,7%	548 613
TOARP	58,1%	0,0%	74,0%	427 956
TOFTANÄS	0,0%	0,0%	52,9%	
TYGELSJÖ BY	52,0%	17,9%	68,6%	477 704
TYGELSJÖ VÅNG	45,2%	0,0%	84,6%	475 481
TÖRNROSEN	19,8%	93,6%	79,1%	253 225
VALDEMARSRO	45,4%	46,6%	43,3%	406 264
VIDEDAL	49,2%	43,3%	64,7%	402 209
VINTRIE	59,0%	30,1%	78,9%	494 555
VIRENTOFTA	45,6%	36,0%	77,0%	404 251
VÄRNHEM	52,9%	53,4%	79,3%	339 126
VÄSTERVÅNG	78,6%	0,0%	68,6%	635 252
VÄSTRA HAMNEN	67,5%	33,7%	82,1%	475 336
VÄSTRA KATTARP	37,2%	67,0%	74,9%	347 485
VÄSTRA KLAGSTORP	54,5%	0,0%	65,8%	477 355
VÄSTRA SORGENFRI	66,8%	30,7%	82,2%	348 996
VÄSTRA SÖDERKULLA	31,6%	65,3%	74,8%	328 308
ÄRTHOLMEN			68,1%	
ÖRTAGÅRDEN	19,2%	91,8%		262 843
ÖSTERVÄRN	55,9%	49,2%	43,1%	329 047
ÖSTRA HAMNEN	0,0%		71,1%	
ÖSTRA KYRKOGÅRDEN				
ÖSTRA SKRÄVLINGE	44,6%	38,1%		414 636
ÖSTRA SORGENFRI	53,5%	48,0%	84,1%	310 381
ÖSTRA SÖDERKULLA	32,5%	65,5%	69,0%	327 797
MALMÖ AVERAGE	48,0%	46,7%	68,6%	378774

Table 26 Number of UGS available from school grounds

Admnitrative region	Class 1	Class 2	Class 3	Class 4	Class 5
ALMGÅRDEN	2	1	0	0	1
ALMHÖG	6	2	0	0	0
ALMVIK	2	0	1	1	0
ANNELUND	1	0	0	0	0
ANNETORP	7	4	0	0	0
APELGÅRDEN	10	2	2	4	14
AUGUSTENBORG	4	4	1	4	8
BELLEVUEGÅRDEN	9	6	3	7	8
BORGMÄSTAREGÅRDEN	1	6	0	7	8
BULLTOFTA	3	2	1	2	5
BUNKEFLOSTRAND	17	4	1	3	3
DAMMFRI	7	3	2	5	4
DAVIDSHALL	2	0	0	0	0
DJUPADAL	11	5	0	0	0
ELINELUND	0	5	2	8	9
ELLSTORP	1	1	0	0	0
ERIKSFÄLT	16	1	3	7	7
FLENSBURG	3	1	0	0	0
FRIDHEM	0	2	0	0	0
FÅGELBACKEN	1	0	0	0	0
GAMLA LIMHAMN	0	1	0	0	0
GAMLA STADEN	3	5	0	2	10
GRÖNDAL	7	1	0	0	0
GULLVIK	2	5	2	9	8
GULLVIKSBORG	8	3	0	0	0
HELENEHOLM	11	4	2	7	5
HERMODSDAL	4	4	4	16	18
HERRGÅRDEN	3	10	6	8	14
HINDBY	15	12	3	6	9
HOLMA	8	1	3	8	7
HYLLIEVÅNG	7	3	3	13	10
HÅKANSTORP	18	0	1	2	6
HÄSTHAGEN	2	2	0	3	4
HÖJA	9	10	4	2	9
JOHANNESLUST	1	1	0	1	0
JÄGERSRO VILLASTAD	2	2	2	0	0
KALKBROTTET	1	5	1	0	1
KATRINELUND	17	14	0	6	15
KIRSEBERGSSTADEN	13	10	2	7	15
KLAGSHAMN	6	2	1	8	6
KRISTINEBERG	0	4	0	2	0
KROKSBÄCK	9	5	1	1	0
KRONBORG	0	0	0	4	3
KRYDDGÅRDEN	1	4	5	2	6
KULLADAL	12	5	2	8	7
KVARNBY	13	10	0	10	29
LIMHAMNS HAMNOMRÅDE	8	1	0	0	0
LINDEBORG	4	2	1	9	8
LINDÄNGEN	3	8	3	30	20
LORENSBORG	14	3	1	7	6
LUGNET	1	0	0	0	0
MELLANHEDEN	6	3	2	6	4
MÖLLEVÅNGEN	1	1	0	2	5
NORRA SOFIELUND	3	4	0	4	12
NORRA SORGENFRI	3	3	0	1	5
NYA BELLEVUE	2	4	0	0	0
NYDALA	3	3	3	7	8
OXIE KYRKBY	5	5	2	2	2
OXIEVÅNG	3	0	0	3	5
RIBERSBORG	7	5	2	4	6
RISEBERGA	10	5	3	5	6
ROSTORP	2	2	0	0	0
RÅDMANSVÅNGEN	4	0	0	8	20
RÖNNEHOLM	2	0	0	0	0
SEGEVÅNG	5	7	2	4	4
SIBBARP	2	1	0	0	0
SOLBACKEN	4	4	2	7	5
STENKÄLLAN	6	6	3	4	9
SÖDERTORP	2	0	0	0	0
SÖDRA SOFIELUND	0	2	0	5	6
TEATERN	3	0	0	3	5
TYGELSJÖ BY	11	7	0	10	4
TÖRNROSEN	18	6	2	6	14
VALDEMARSRO	1	1	0	0	0
VIDEDAL	9	6	4	3	7
VINTRIE	1	1	1	2	1
VIRENTOFTA	21	14	4	5	15
VÄRNHEM	1	8	0	2	12
VÄSTRA HAMNEN	10	8	0	4	12
VÄSTRA KLAGSTORP	2	2	3	2	2
VÄSTRA SORGENFRI	4	18	0	4	24
VÄSTRA SÖDERKULLA	10	7	7	15	16
ÖRTAGÅRDEN	4	2	4	6	16
ÖSTRA KYRKOGÅRDEN	1	0	0	0	0
ÖSTRA SKRÄVLINGE	5	6	3	9	19
ÖSTRA SORGENFRI	9	6	0	1	6
ÖSTRA SÖDERKULLA	3	0	1	0	0

Table 27 Area of UGS accessible from school grounds (m^2)

Administrative region	Class 1	Class 2	Class 3	Class 4	Class 5
ALMGÅRDEN	11806	275295	0	0	623690
ALMHÖG	25151	19300	0	0	0
ALMVIK	7945	0	70868	124124	0
ANNELUND	5909	0	0	0	0
ANNETORP	37359	28189	0	0	0
APELGÅRDEN	53511	30274	136794	764170	19143314
AUGUSTENBORG	15430	121982	51497	825450	8582872
BELLEVUEGÅRDEN	43867	20505	211857	1413430	5654498
BORGMÄSTAREGÅRDEN	5081	20970	0	1439696	5556381
BULLTOFTA	16979	15964	54822	382085	7664300
BUNKEFLOSTRAND	72048	12203	83297	390180	2213395
DAMMFRI	30502	16728	147145	1168383	2538644
DAVIDSHALL	18267	0	0	0	0
DJUPADAL	39527	293506	0	0	0
ELINELUND	0	13157	131886	1318005	11171132
ELLSTORP	5388	48648	0	0	0
ERIKSFÄLT	82287	5602	178694	1281807	4876926
FLENSBURG	11219	3031	0	0	0
FRIDHEM	0	7612	0	0	0
FÅGELBACKEN	7206	0	0	0	0
GAMLA LIMHAMN	0	106369	0	0	0
GAMLA STADEN	9015	39559	0	420252	5354476
GRÖNDAL	32081	3732	0	0	0
GULLVIK	11511	32400	143189	1423353	10577713
GULLVIKSBORG	25296	35686	0	0	0
HELENEHOLM	56949	53130	107826	1281807	3476905
HERMODSDAL	9642	37656	244730	2814816	18592692
HERRGÅRDEN	8319	60054	369400	1435432	18986330
HINDBY	77093	46713	188291	989659	10446633
HOLMA	20577	4490	212132	1478540	5266858
HYLLIEVÅNG	29101	15979	246894	2348689	11187666
HÅKANSTORP	61892	0	54822	382085	8123468
HÄSTHAGEN	17119	5510	0	831733	2548038
HÖJA	43147	149158	250429	238029	10898745
JOHANNESLUST	5226	7179	0	261199	0
JÄGERSRO	16488	11204	217813	717716	12540623
JÄGERSRO VILLASTAD	10349	4160	116303	0	0
KALKBROTTET	2128	10400	50114	0	1077540
KATRINELUND	79299	146294	0	1146255	11521104
KIRSEBERGSSTADEN	68236	136533	129384	1489754	23000510
KLAGSHAMN	20877	20311	87370	2088762	13548777
KRISTINEBERG	0	37601	0	250936	0
KROKSBÄCK	35748	75680	65674	307910	0
KROKSBÄCKSPARKEN	16654	15422	221477	1654537	6348336
KRONBORG	0	0	0	1044259	1924348
KRYDDGÅRDEN	2413	8488	306585	382085	9112489
KULLADAL	58219	45382	127197	1405437	4918838
KVARNBY	51624	100428	0	1602679	37705009
LIMHAMNS HAMNOMRÅDE	32758	7179	0	0	0
LINDEBORG	19408	19834	70868	1627736	5253096
LINDÄNGEN	11382	61686	192327	5197500	16383818
LORENSBORG	59661	12206	65674	1503849	4481133
LUGNET	4714	0	0	0	0
MALMÖHUS	12632	0	0	0	0
MELLANHEDEN	41063	18189	147145	1338783	2538644
MÖLLEVÅNGEN	2413	4631	0	523823	2364247
NORRA SOFIELUND	6321	11438	0	930606	7838192
NORRA SORGENFRI	11293	12726	0	120886	3840368
NYA BELLEVUE	9095	13604	0	0	0
NYDALA	7917	16806	178694	1305415	8926406
OXIE KYRKBY	32078	196603	147140	379440	1701772
OXIEVÅNG	16806	0	0	564706	6064777
RIBERSBORG	23033	37599	162942	1036072	3848696
RISEBERGA	34983	51437	218618	0	9692720
ROSTORP	11550	10044	0	887200	0
RÅDMANSVÅNGEN	12134	0	0	1908119	12267850
RÖNNEHOLM	7171	0	0	0	0
SEGEVÅNG	17669	111858	129384	1069083	7212742
SIBBARP	7680	4809	0	0	0
SOLBACKEN	21610	14368	147145	1462907	3032944
STADION	46987	319714	178332	5245446	21302214
STENKÄLLAN	22162	40379	183366	622046	12211652
SÖDERTORP	6527	0	0	1045506	3919096
SÖDRA SOFIELUND	0	0	46134	831733	2999596
TEATERN	21627	0	0	0	0
TYGELSJÖ BY	56637	176183	0	1636112	2116762
TÖRNROSEN	90314	61362	136794	1032090	19143314
VALDEMARSRO	5795	2107	0	0	0
VIDEDAL	34104	34121	235286	678498	9243906
VINTRIE	7415	33348	67174	282049	494300
VIRENTOFTA	77626	36490	264493	1060583	18990813
VÄRNHEM	4604	41309	0	420252	8456016
VÄSTRA HAMNEN	53195	68111	0	840504	7697392
VÄSTRA KLAGSTORP	4520	4214	185649	638777	2233914
VÄSTRA SORGENFRI	15892	92447	413717	840504	16912032
VÄSTRA SÖDERKULLA	53842	50354	0	2665607	10546380
ÖRTAGÅRDEN	24075	32935	252242	1032090	19904666
ÖSTRA KYRKOGÅRDEN	2773	0	0	0	0
ÖSTRA SKRÄVLINGE	30806	51928	215364	1533898	25591902
ÖSTRA SORGENFRI	39571	55494	0	120886	8123468
ÖSTRA SÖDERKULLA	7917	0	51497	0	0

Table 28 Number of accessible UGS, Malmö stad

Administrative region	Class 1	Class 2	Class 3	Class 4	Class 5
ALLMÄNNA SJUKHUSET	6	4	0	6	1
ALMGÅRDEN	5	10	5	5	6
ALMHÖG	16	9	2	8	1
ALMVIK	8	3	3	15	15
ANNELUND	7	5	1	4	2
ANNETORP	15	14	1	5	4
APELGÅRDEN	8	7	5	3	2
AUGUSTENBORG	17	10	2	7	1
BELLEVUE	13	7	2	6	33
BELLEVUEGÅRDEN	18	10	4	8	9
BORGMÄSTAREGÅRDEN	11	5	1	7	2
BULLTOFTA	8	6	3	4	12
BUNKEFLOSTRAND	32	9	3	12	143
DAMMFRI	16	6	2	6	1
DAVIDSHALL	5	2	0	2	1
DJUPADAL	25	17	4	11	19
ELINELUND	4	11	4	12	35
ELISEDAL	12	7	3	10	48
ELLSTORP	10	6	0	2	1
EMILSTORP	18	9	2	2	1
ERIKSFÄLT	23	7	3	7	1
FLENSBURG	16	6	2	9	3
FORTUNA HEMGÅRDEN	5	7	2	6	39
FOSIEBY	6	4	3	11	6
FOSIEBY INDUSTRIOMRÅDE	12	9	6	13	5
FREDRIKSBERG	7	4	3	10	11
FRIDHEM	12	5	1	4	8
FRIHAMNEN	2	0	0	1	1
FÅGELBACKEN	3	1	1	4	1
GAMLA LIMHAMN	22	12	1	5	4
GAMLA STADEN	4	5	0	1	2
GLOSTORP	8	14	1	13	162
GRÖNDAL	18	7	3	9	4
GULLVIK	19	13	2	7	5
GULLVIKSBORG	17	8	2	10	11
HELENEHOLM	16	5	2	8	1
HERMODSDAL	8	6	3	10	2
HERRGÅRDEN	5	12	4	5	6
HINDBY	26	14	4	7	3
HOLMA	16	5	4	11	4
HYLLIEBY	14	8	4	11	3
HYLLIEVÅNG	21	14	3	15	15
HÅKANSTORP	12	4	1	2	4
HÄSTHAGEN	6	2	0	3	1
HÖJA	12	15	4	5	3
INRE HAMNEN	8	4	0	2	2
JOHANNESLUST	16	8	3	2	7
JÄGERSRO	13	12	5	9	16
JÄGERSRO VILLASTAD	10	9	5	5	15
KALKBROTTET	8	15	2	6	18
KASTANJEGÅRDEN	8	4	4	12	13
KATRINELUND	6	9	0	3	1
KIRSEBERGSSTADEN	18	12	2	3	11
KLAGSHAMN	11	1	2	9	132
KRISTINEBERG	8	5	1	8	65
KROKSBÄCK	21	10	4	9	2
KROKSBÄCKSPARKEN	10	7	4	11	4
KRONBORG	14	4	2	5	1
KRONPRINSEN	4	2	1	3	1
KRYDDGÅRDEN	7	9	5	5	4
KULLADAL	43	11	4	11	12
KUNGSHÖG	15	8	4	9	40
KVARNBY	12	9	3	9	74
KÅGLINGE	11	12	1	8	136
LIMHAMNS HAMNOMRÅDE	16	5	0	3	19
LINDEBORG	20	6	3	17	20
LINDÄNGEN	14	5	6	16	32
LOCKARP	18	10	6	23	191
LORENSBORG	17	8	2	8	2

LUGNET	3	3	0	2	1
LÖNNGÅRDEN	8	6	2	4	1
MALMÖHUS	12	3	0	3	13
MELLANHEDEN	14	8	2	7	5
MELLERSTA HAMNEN	6	0	0	3	4
MÖLLEVÅNGEN	2	5	0	5	1
NAFFENTORP	11	4	5	22	118
NORRA HAMNEN	6	1	0	1	4
NORRA SOFIELUND	3	6	0	5	2
NORRA SORGENFRI	13	8	0	3	1
NYA BELLEVUE	18	12	3	7	34
NYDALA	22	8	3	9	2
OLJEHAMNEN	12	3	0	1	2
OXIE KYRKBY	14	8	3	7	61
OXIEVÅNG	7	5	0	6	28
PERSBORG	11	8	2	4	2
PILDAMMSPARKEN	12	4	2	5	27
RIBERSBORG	11	5	1	3	6
RIBERSBORGSSTRANDEN	10	4	1	3	20
RISEBERGA	23	8	5	5	34
ROSENGÅRD CENTRUM	4	5	4	3	1
ROSENVÅNG	22	14	4	7	8
ROSTORP	6	5	1	3	13
RÅDMANSVÅNGEN	6	3	0	5	2
RÖNNEHOLM	14	5	2	5	3
RÖRSJÖSTADEN	3	8	0	2	2
SEGE INDUSTRIOMRÅDE	9	13	1	2	3
SEGEMÖLLA	5	10	1	3	10
SEGEVÅNG	13	14	1	3	25
SIBBARP	15	8	1	4	24
SKUMPARP	8	1	1	12	25
SLUSSEN	1	5	0	1	1
SOFIELUNDS INDUSTRIOMR.	10	6	1	4	1
SOLBACKEN	15	7	2	7	2
SPILLEPENGEN	11	10	1	2	21
STADION	9	7	2	8	1
STENKÄLLAN	13	13	4	7	2
SVÅGERTORP	12	3	0	16	1
SÖDERTORP	11	6	1	9	2
SÖDERVÄRN	3	2	0	5	1
SÖDRA SALLERUP	30	20	4	14	476
SÖDRA SOFIELUND	7	6	2	7	1
TEATERN	6	1	0	4	2
TOARP	8	8	3	6	49
TOFTANÄS	5	3	2	5	6
TYGELSJÖ BY	26	13	4	14	124
TYGELSJÖ VÅNG	12	8	3	12	148
TÖRNROSEN	14	5	1	3	2
VALDEMARSRO	3	4	4	6	19
VIDEDAL	20	17	6	4	8
VINTRIE	8	12	3	15	41
VIRENTOFTA	24	15	5	5	5
VÅRNHEM	8	10	0	3	1
VÄSTERVÅNG	11	6	2	6	8
VÄSTRA HAMNEN	11	5	0	1	9
VÄSTRA KATTARP	17	11	5	5	10
VÄSTRA KLAGSTORP	19	13	5	22	187
VÄSTRA SORGENFRI	4	8	0	2	2
VÄSTRA SÖDERKULLA	18	6	3	10	1
ÄRTHOLMEN	12	8	4	10	10
ÖRTAGÅRDEN	14	8	2	5	3
ÖSTERVÄRN	10	6	0	3	1
ÖSTRA HAMNEN	23	17	1	2	5
ÖSTRA KYRKOGÅRDEN	18	3	4	2	9
ÖSTRA SKRÄVLINGE	16	11	2	8	45
ÖSTRA SORGENFRI	10	8	1	2	1
ÖSTRA SÖDERKULLA	5	4	3	10	1

Table 29 Area of accessible UGS, Malmö stad

Area of accessible UGS areas in 2019 in (m2)					
Administrative region	Class 1	Class 2	Class 3	Class 4	Class 5
ALLMÄNNA SJUKHUSET	21917	122724	0	1319989	21421877
ALMGÅRDEN	28662	174453	343455	865599	19169113
ALMHÖG	70997	169138	107826	1517941	19862659
ALMVIK	36873	46637	178694	2866046	24840780
ANNELUND	34658	125138	68397	796315	16801483
ANNETORP	67276	252070	50114	867248	13737731
APELGÅRDEN	36775	174226	306585	625638	17134976
AUGUSTENBORG	69551	206914	119894	1306594	19862659
BELLEVUE	54910	96979	147145	1338783	14082209
BELLEVUEGÅRDEN	89917	163031	302948	1582614	14894340
BORGMÄSTAREGÅRDEN	50552	138855	56329	1439696	21421877
BULLTOFTA	33322	124224	186577	1021997	14948840
BUNKEFLOSTRAND	150674	181838	200585	2352293	14107671
DAMMFRI	71146	173551	147145	1293723	16388161
DAVIDSHALL	28695	79542	0	523823	12931158
DJUPADAL	111081	318355	271591	1875533	15182919
ELINELUND	25739	231136	273091	2204730	14107671
ELISEDAL	59529	118624	247658	1667195	19169113
ELLSTORP	52691	121661	0	382085	11911813
EMILSTORP	80389	222100	123219	382085	16631975
ERIKSFÄLT	108616	144270	178694	1281807	25261976
FLENSBURG	74030	169720	107826	1799843	23948137
FORTUNA HEMGÅRDEN	20621	180486	145203	1349780	14371882
FOSIEBY	20289	57966	172956	1891113	21528573
FOSIEBY INDUSTRIOMRÅDE	58085	151724	425399	2150487	21234736
FREDRIKSBERG	43130	55566	257878	1648302	19954838
FRIDHEM	56583	142019	81471	957073	13858798
FRIHAMNEN	5839	0	0	210126	9588648
FÅGELBACKEN	20558	44563	81471	1044259	15722559
GAMLA LIMHAMN	87915	205099	81471	1128657	13006961
GAMLA STADEN	20341	125281	0	210126	12145433
GLOSTORP	45448	361577	82746	2259583	16258707
GRÖNDAL	74817	159663	178694	1713347	23948137
GULLVIK	83388	198538	143189	1070076	20884928
GULLVIKSBORG	58446	126416	122365	1629843	20797803
HELENEHOLM	76012	116657	107826	1491933	24078753
HERMODSDAL	21485	98472	178694	1629843	26484707
HERRGÅRDEN	19751	221135	251763	869322	20956774
HINDBY	124762	244321	269310	1088969	22699916
HOLMA	64138	113059	277806	1922737	23165596
HYLLIEBY	58949	160624	288651	1875533	15182919
HYLLIEVÅNG	92442	270398	222977	2782510	22723405
HÅKANSTORP	46024	85247	0	382085	16520680
HÄSTHAGEN	38872	79542	54822	831733	14114381
HÖJA	51858	301705	0	978915	18448723
INRE HAMNEN	31392	118814	251763	471325	12145433
JOHANNESLUST	62727	184119	186577	382085	16520680
JÄGERSRO	69046	188009	374634	1390986	21234736
JÄGERSRO VILLASTAD	47878	132289	343455	865599	19169113
KALKBROTTET	38558	317415	117288	981849	14107671
KASTANJEGÅRDEN	32265	58061	254836	2011982	20063393
KATRINELUND	29394	194536	0	592211	12875202
KIRSEBERGSSTADEN	86118	232376	119514	725584	13491419
KLAGSHAMN	37983	10658	170667	1722233	12183323
KRISTINEBERG	30455	83182	67944	1302756	18267754
KROKSBÄCK	90038	162078	302948	1654537	15625110
KROKSBÄCKSPARKEN	42079	129885	277806	1922737	22815146
KRONBORG	72474	122836	147145	1168383	20671261
KRONPRINSEN	20893	93211	81471	831733	9831281
KRYDDGÅRDEN	24744	207071	306585	978915	18836363
KULLADAL	201509	241561	269785	1997106	25029357
KUNGSHÖG	76169	153147	313326	1548359	18267754
KVARNBY	53288	233551	183366	1737445	17845705
KÄGLINGE	58356	274819	0	1509881	15164086
LIMHAMNS HAMNOMRÅDE	75354	91541	82746	602434	13006961
LINDEBORG	90258	115326	218288	3233129	23165596
LINDÄNGEN	68917	86930	362662	2993179	28187198
LOCKARP	87776	201654	397258	4027513	26798376
LORENSBORG	81934	181289	147145	1582614	21041201

LUGNET	15481	92998	0	523823	12931158
LÖNNGÅRDEN	28731	155613	0	829742	17837025
MALMÖHUS	57987	124105	119894	831733	9831281
MELLANHEDEN	69549	197694	147145	1462907	14524400
MELLERSTA HAMNEN	34674	0	0	814824	9588648
MÖLLEVÅNGEN	7127	108217	0	1012079	13311834
NAFFENTORP	50147	121546	325312	3993349	23387259
NORRA HAMNEN	34021	39392	0	343499	9588648
NORRA SOFIELUND	6521	136680	211857	1043106	16873636
NORRA SORGENFRI	55435	154579	178694	592211	16015758
NYA BELLEVUE	80214	196273	205888	1462907	14524400
NYDALA	87416	151673	119894	1619934	25753937
OLJEHAMNEN	64778	85896	0	343499	9137090
OXIE KYRKBY	71971	160062	147145	1195082	17773454
OXIEVÅNG	32617	113423	0	1092029	14669786
PERSBORG	52143	189412	81471	752179	17171423
PILDAMMSPARKEN	51780	122724	81471	1168383	21051937
RIBERSBORG	48172	171889	325667	831733	15722559
RIBERSBORGSSTRANDEN	45145	97456	251763	643376	13858798
RISEBERGA	82844	123289	302948	887200	17161179
ROSENGÅRD CENTRUM	12449	119894	64692	625638	15443140
ROSENVÅNG	74108	220310	147145	1372488	14082209
ROSTORP	30060	84312	64692	725584	9127325
RÅDMANSVÅNGEN	33679	71851	0	1168383	13311834
RÖNNEHOLM	62266	155021	64692	1169599	15722559
RÖRSJÖSTADEN	11425	180735	0	471325	12145433
SEGE INDUSTRIOMRÅDE	41577	298415	64692	604698	9127325
SEGEMÖLLA	20477	249348	50114	725584	9703074
SEGEVÅNG	54325	320886	72489	725584	10090714
SIBBARP	74537	146459	68397	708829	13737731
SKUMPARP	33939	21552	147145	2538426	15519201
SLUSSEN	2107	82153	0	210126	11531137
SOFIELUNDS INDUSTRIOMR.	43635	148424	64692	829742	17171423
SOLBACKEN	72590	150671	122003	1462907	14524400
SPILLEPENGEN	56834	258327	251763	604698	8051940
STADION	37951	164248	56329	1565036	21421877
STENKÄLLAN	59534	264420	304130	1423211	18448723
SVÅGERTORP	54060	61829	0	2715069	24398589
SÖDERTORP	43796	154980	107826	1595134	23948137
SÖDERVÄRN	11219	46735	0	1012079	16873636
SÖDRA SALLERUP	134268	473433	205888	2636940	18709945
SÖDRA SOFIELUND	26229	158133	145203	1372226	17837025
TEATERN	36171	30894	0	1044259	14114381
TOARP	43982	172844	258138	1092029	13467874
TOFTANÄS	27048	86492	230460	1041609	14371882
TYGELSJÖ BY	120182	280451	68397	2637913	15932670
TYGELSJÖ VÅNG	49820	122674	264717	2549455	15060033
TÖRNROSEN	71409	125138	378373	516045	17171423
VALDEMARSRO	13220	68707	208379	1230699	13233711
VIDEDAL	70181	317233	309976	795641	17161179
VINTRIE	38436	254135	147145	2591854	17816615
VIRENTOFTA	87425	288998	327889	902010	18448723
VÄRNHEM	34644	215621	0	592211	12526109
VÄSTERVÅNG	57481	122324	345508	1338783	14524400
VÄSTRA HAMNEN	48868	133212	0	210126	9045556
VÄSTRA KATTARP	85161	232735	178694	869322	22034314
VÄSTRA KLAGSTORP	68907	272355	277806	4177988	22828987
VÄSTRA SORGENFRI	20162	166818	0	331012	13311834
VÄSTRA SÖDERKULLA	81063	97536	126121	1743564	25029357
ÄRTHOLMEN	47712	174205	64692	1857850	21421877
ÖRTAGÅRDEN	72329	201864	248861	869322	18290641
ÖSTERVÄRN	45524	130958	0	592211	11531137
ÖSTRA HAMNEN	109225	420816	138851	604698	11036837
ÖSTRA KYRKOGÅRDEN	67138	67108	68397	382085	16520680
ÖSTRA SKRÄVLINGE	71439	249379	178694	1587809	17495255
ÖSTRA SORGENFRI	48884	192840	0	331012	16801483
ÖSTRA SÖDERKULLA	21122	72855	0	1739316	26484707

Table 30 Classes of socioeconomic variables per administrative region

Administrative region	Income Class	Education Class	Employment Class	Heritage Class
ALMGÅRDEN	1	1	2	3
ALMHÖG	1	1	1	5
ALMVIK	2	1	1	4
ANNELUND	1	3	2	3
ANNETORP	4	3	4	2
APELGÅRDEN	1	1	1	5
AUGUSTENBORG	1	1	1	4
BELLEVUEGÅRDEN	1	2	1	4
BORGMÄSTAREGÅRDEN	3	4	4	2
BULLTOFTA	3	3	3	3
BUNKEFLOSTRAND	4	3	3	2
DAMMFRI	2	4	3	2
DAVIDSHALL	4	5	3	2
DJUPADAL	5	5	5	1
ELINELUND	3	3	4	2
ELLSTORP	2	4	4	2
ERIKSFÄLT	3	3	3	3
FLENSBURG	1	2	1	4
FRIDHEM	5	5	3	2
FÅGELBACKEN	2	4	4	2
GAMLA LIMHAMN	4	3	3	1
GAMLA STADEN	4	4	3	2
GRÖNDAL	2	2	2	3
GULLVIK	2	2	2	4
GULLVIKSBORG	1	1	1	5
HELENEHOLM	1	2	1	5
HERMODSDAL	1	1	1	5
HERRGÅRDEN	1	1	1	5
HINDBY	2	2	2	4
HOLMA	1	1	1	5
HYLLIEVÅNG	2	3	1	4
HÅKANSTORP	3	3	3	2
HÄSTHAGEN	4	5	4	1
HÖJA	2	2	3	3
JOHANNESLUST	3	4	5	2
JÄGERSRO VILLASTAD	3	2	3	4
KALKBROTTET	3	3	2	3
KATRINELUND	1	4	1	3
KIRSEBERGSSTADEN	2	3	2	3
KLAGSHAMN	5	4	5	1
KRISTINEBERG	2	2	2	3
KROKSBÄCK	2	2	1	4
KRONBORG	3	4	4	2
KRYDDGÅRDEN	1	1	1	5
KULLADAL	3	3	4	3
KVARNBY	3	2	3	2
LIMHAMNS HAMNOMRÅDE	4	4	4	2
LINDEBORG	2	2	2	3
LINDÄNGEN	1	1	1	5
LORENSBORG	1	2	1	4

LUGNET	3	4	2	3
MELLANHEDEN	2	3	2	2
MÖLLEVÅNGEN	1	4	2	3
NORRA SOFIELUND	1	4	2	3
NORRA SORGENFRI	2	3	2	1
NYA BELLEVUE	5	5	3	1
NYDALA	1	1	1	5
OXIE KYRKBY	3	2	3	2
OXIEVÅNG	2	2	2	3
RIBERSBORG	3	5	5	1
RISEBERGA	4	3	5	2
ROSTORP	2	3	3	2
RÅDMANSVÅNGEN	3	4	2	3
RÖNNEHOLM	3	4	5	1
SEGEVÅNG	1	2	2	4
SIBBARP	4	3	3	1
SOLBACKEN	5	4	3	2
STENKÄLLAN	3	2	3	3
SÖDERTORP	2	3	3	3
SÖDRA SOFIELUND	1	2	1	4
TEATERN	5	5	5	1
TYGELSJÖ BY	4	3	5	1
TÖRNROSEN	1	1	1	5
VALDEMARSRO	3	3	2	3
VIDEDAL	3	3	4	3
VINTRIE	4	4	4	2
VIRENTOFTA	3	3	4	2
VÄRNHEM	2	3	2	3
VÄSTRA HAMNEN	4	5	3	2
VÄSTRA KLAGSTORP	4	3	5	1
VÄSTRA SORGENFRI	2	5	3	2
VÄSTRA SÖDERKULLA	2	2	2	4
ÖRTAGÅRDEN	1	1	1	5
ÖSTRA KYRKOGÅRDEN	2	3	2	3
ÖSTRA SKRÄVLINGE	3	3	5	3
ÖSTRA SORGENFRI	1	3	2	3
ÖSTRA SÖDERKULLA	2	2	2	4

14 Appendix B Maps

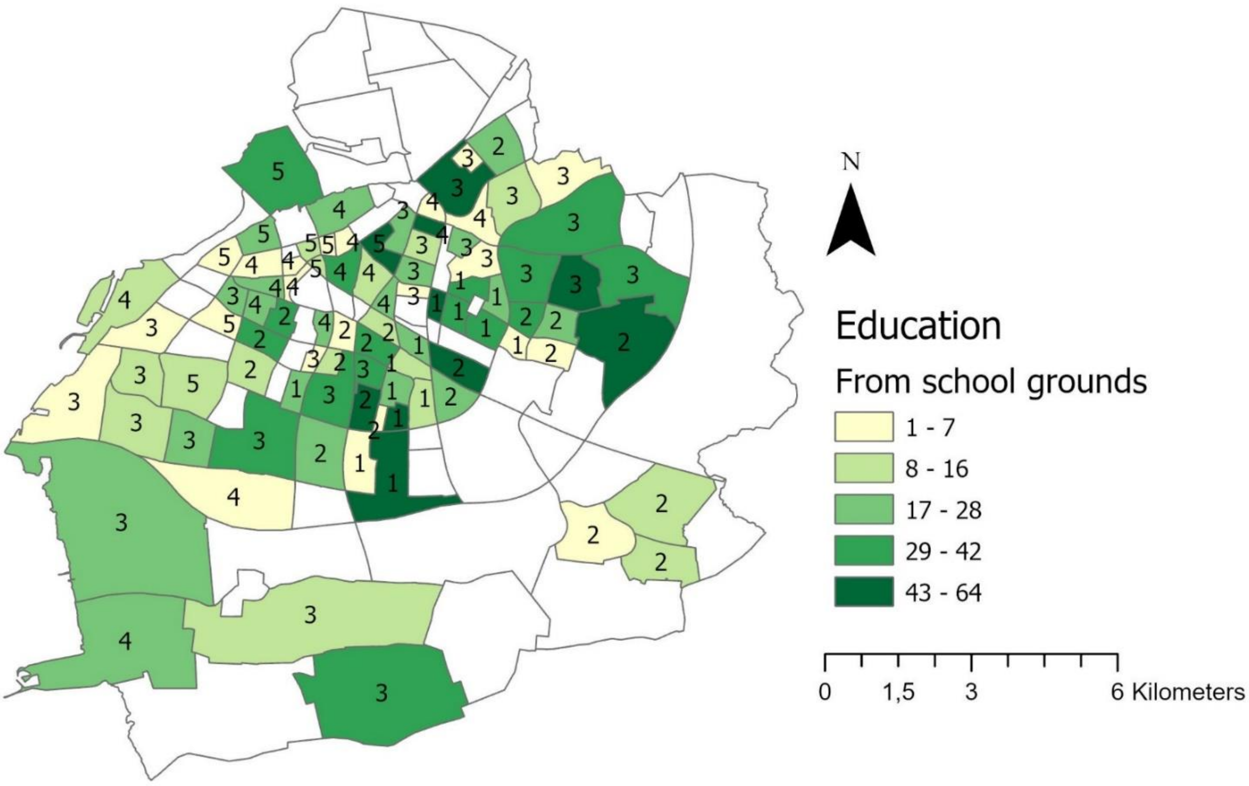

Figure 17 Number of UGS that can be accessed from school grounds and the educational level class in the administrative area

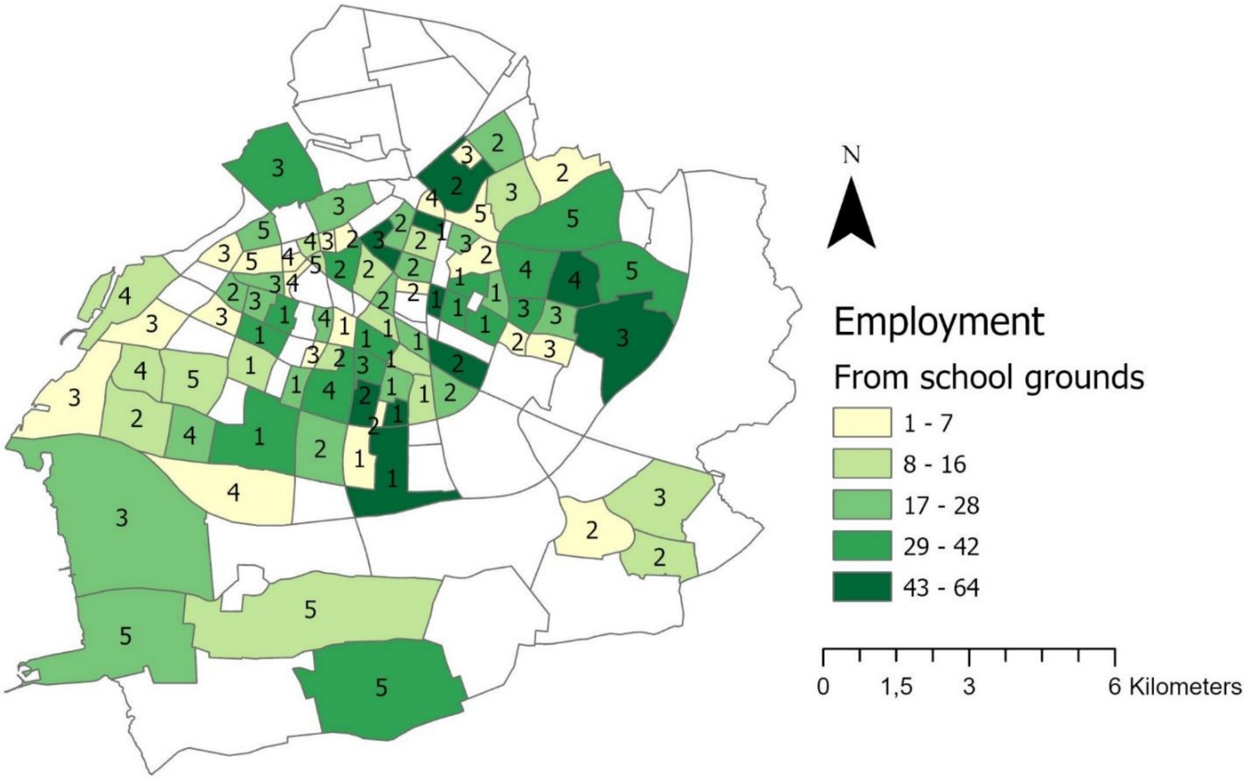

Figure 18 Number of UGS that can be accessed from school grounds and the employment rate class in the administrative area

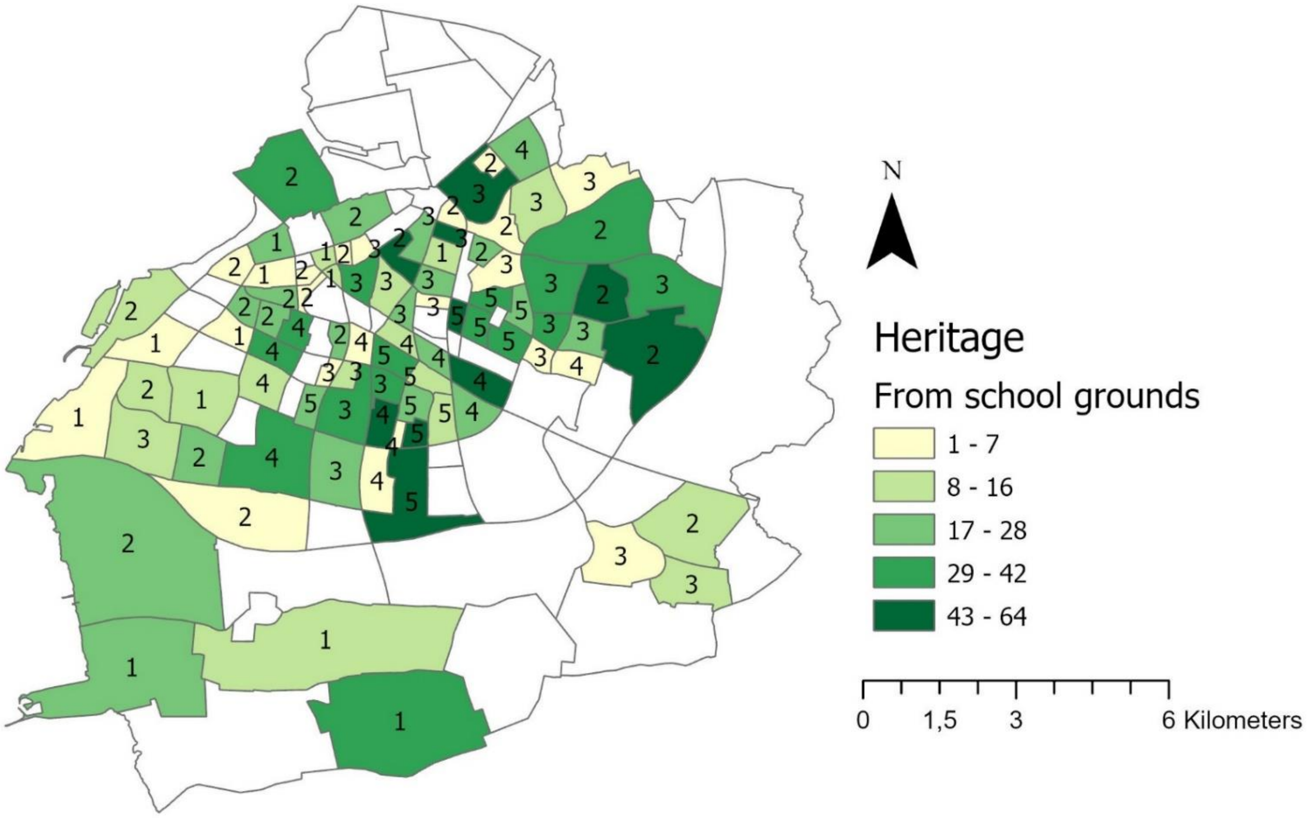

Figure 19 Number of UGS that can be accessed from school grounds and the foreign heritage class in the administrative area

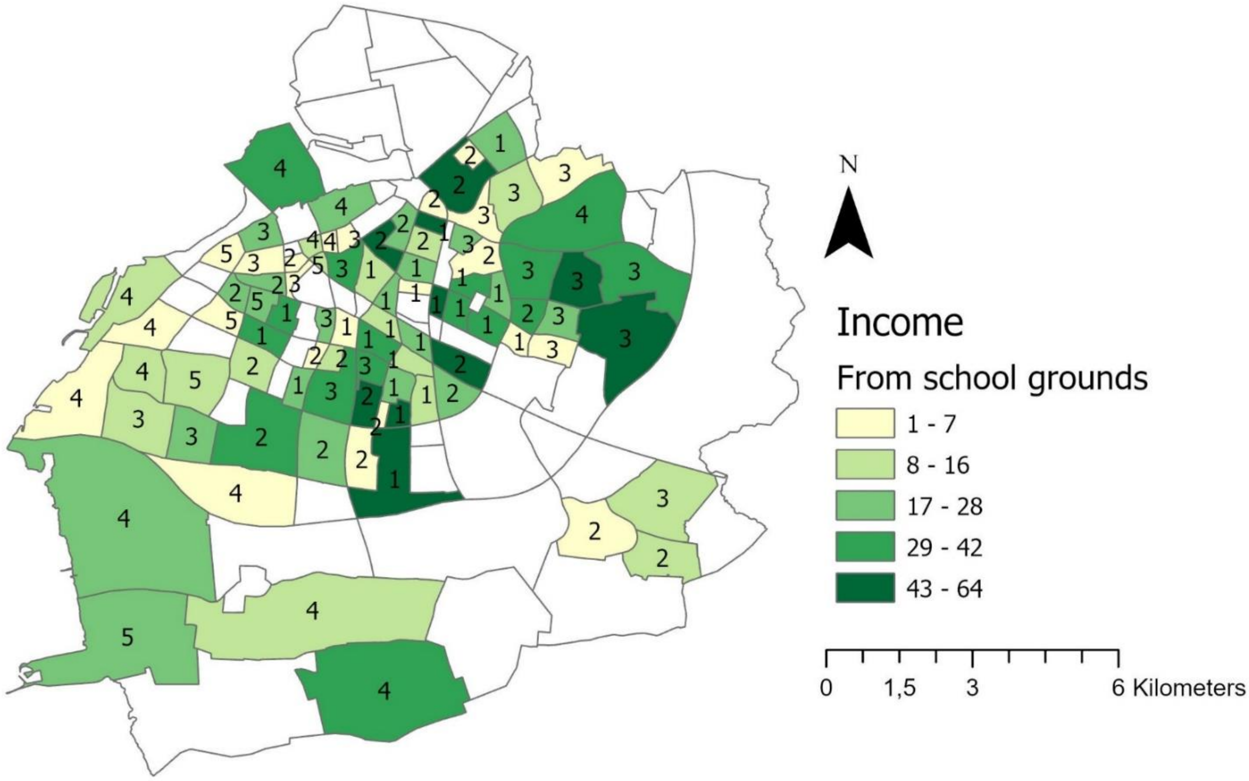

Figure 20 Number of UGS that can be accessed from school grounds and the income class in the administrative area

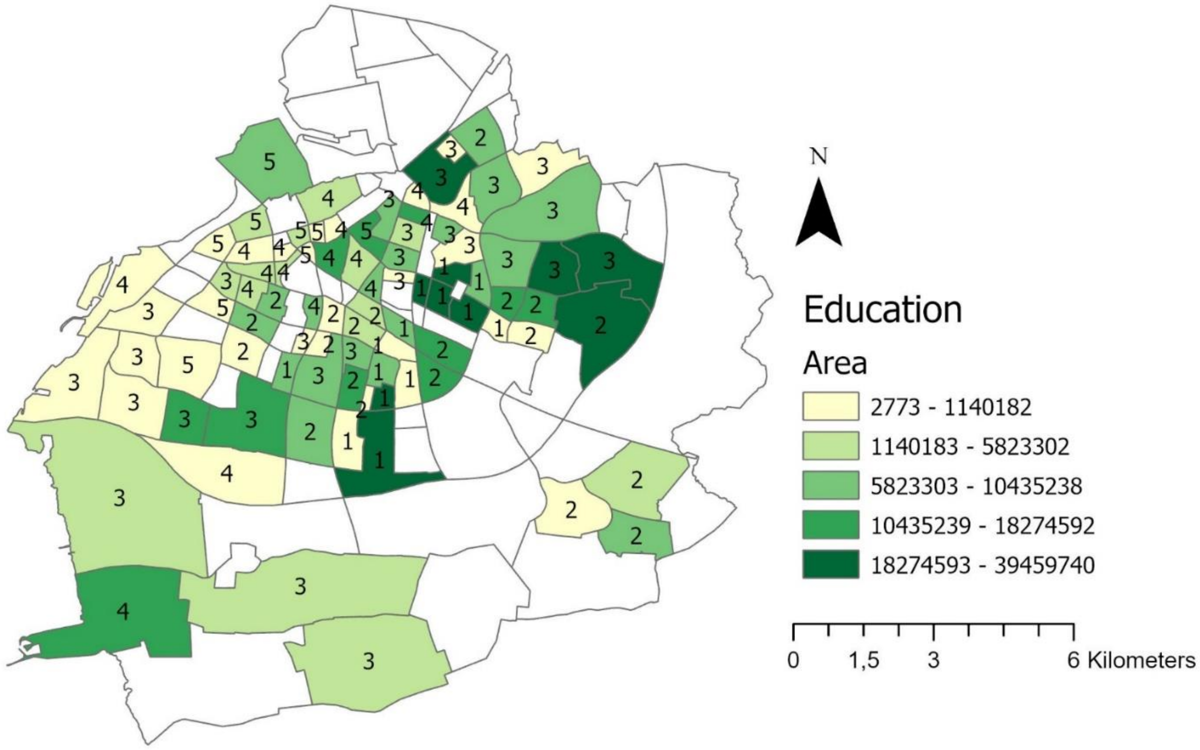

Figure 21 Total area of accessible UGS from school grounds and the educational level class in the administrative area

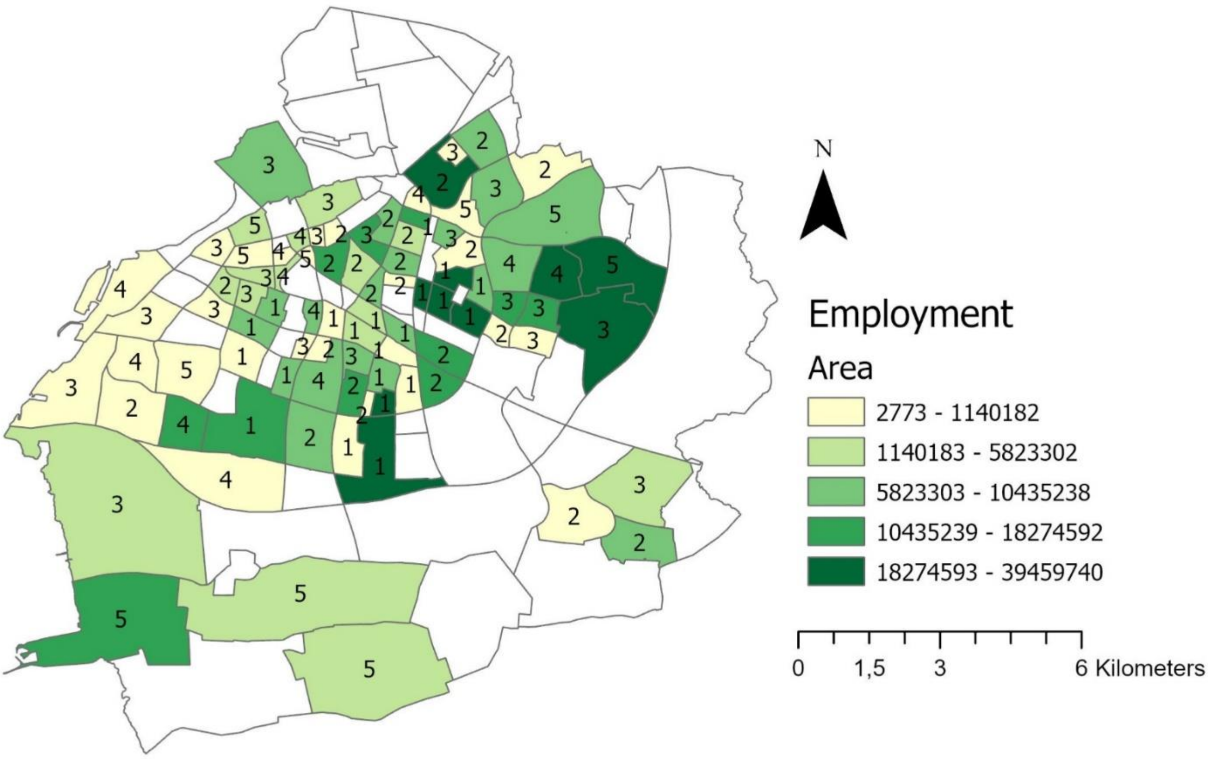

Figure 22 Total area of accessible UGS from school grounds and the employment rate class in the administrative area

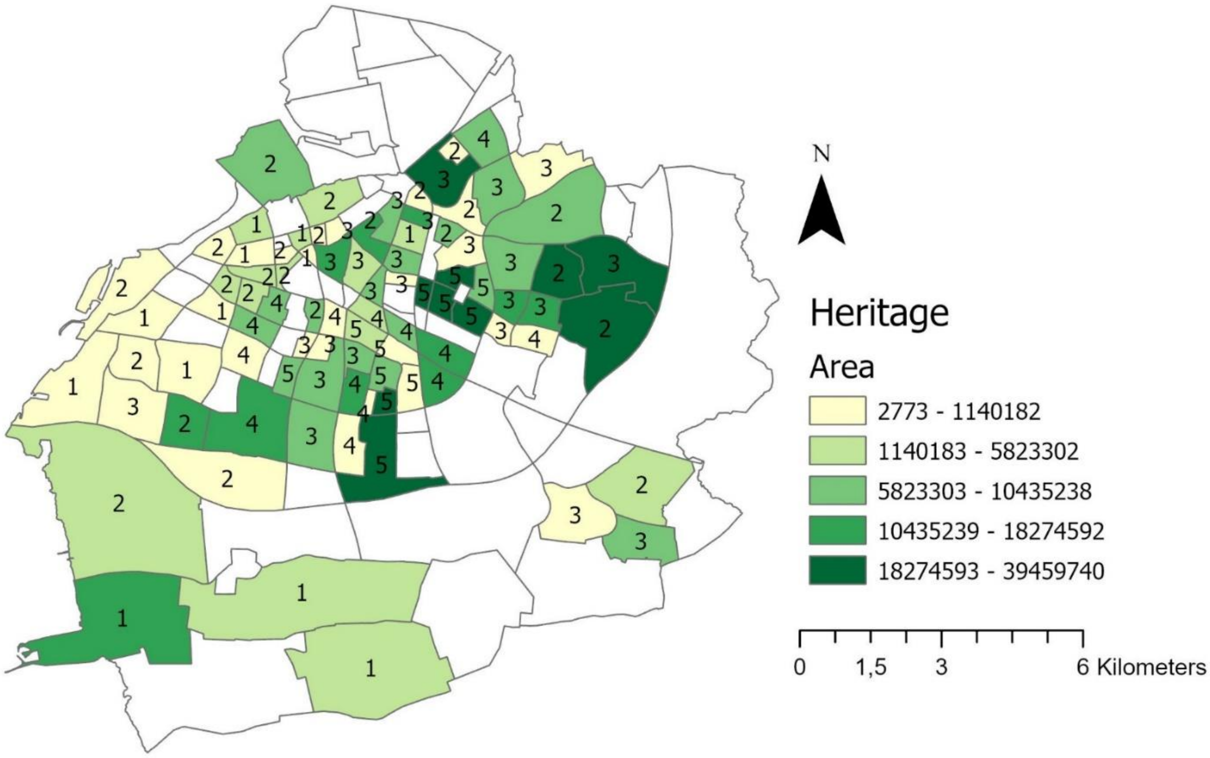

Figure 23 Total area of accessible UGS from school grounds and the foreign heritage rate class in the administrative area

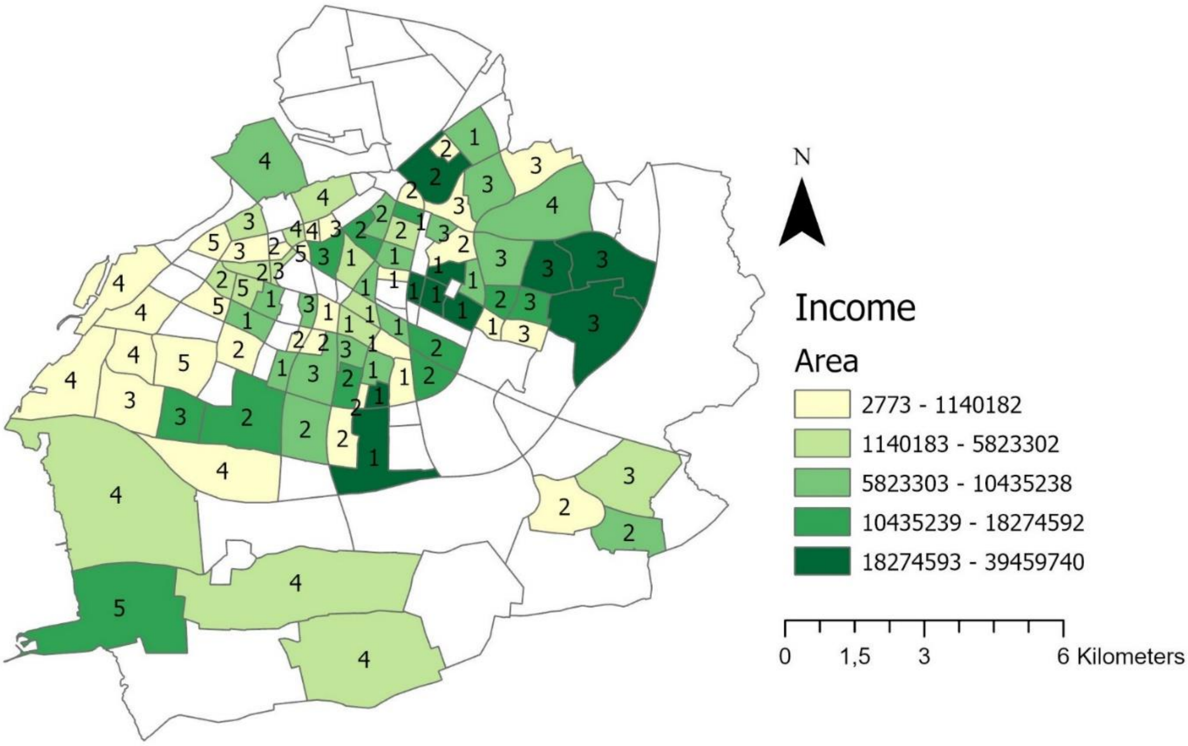

Figure 24 Total area of accessible UGS from school grounds and the income class in the administrative area

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