The influence of urban densification on school provision in Cape Town

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ABSTRACT

Densification strategies have been part of the South African urban planning framework throughout its evolvement, including planning for social facilities. This is crucial as the demand for social facilities increase during densification due to an increase in population. One of these facilities is education facilities, which are impacted by densification efforts due to land being absorbed for purposes other than school development. Therefore, this research aims to evaluate how increased population densities impact the availability of adequate land for schooling provision within the City of Cape Town. To achieve this, the school backlogs of wards, land earmarked for development, and future growth areas were calculated to determine the land available for school development. These areas were evaluated to determine how many schools it can accommodate, which was transformed into an indication of the potential densification ability and index at ward, district, and study area level. The findings of the study indicated that individual wards generally showed higher levels of densification potential when school developable land in neighbouring wards were considered in calculations. However, large backlogs and low densification potentials were revealed – in some cases intersecting where the City of Cape Town's SDF (2012) earmarked areas of intensification. The results clearly indicate the need for a more quantified bases for identifying areas for future densification in spatial planning processes. The findings also show that an evaluation of neighbourhood life cycle changes within wards should inform the spatial planning for education facilities in advance.

Key words: densification; education facilities; spatial planning; SDF

OPSOMMING

Verdigtingstrategieë vorm deel van die ontwikkeling van Suid-Afrika se stedelike beplanningsraamwerk, insluitent die beplanning van sosiale fasiliteite. Hierdie is noodsaaklik waaneer die aanvraag op sosiale fasiliteite vermeerder tydens verdigting as gevolg van ‘n vermeerdering in bevolking. Een van hierdie fasiliteite is opvoedingsfasiliteite, wat beïnvloed word deur verdigtingspogings as gevolg van grond wat geabsorbeer word vir ander doeleindes as skole ontwikkeling. Daarom beoog hierdie navorsing om te evalueer hoe `n verhoging in bevolkingsdigthede die beskikbaarheid van genoegsame grond vir skole ontwikkeling in Stad Kaapstad beïnvloed. Om dit te bereik, is die skole agterstand, grond geoormerk vir ontwikkeling en toekomstige groei areas bereken om die hoeveelheid grond beskikbaar vir skole ontwikkeling te bepaal. Hierdie areas was ge-evalueer om te bepaal hoeveel skole daarin geakkommodeer kan word. Dít was omskep in waardes wat `n aanduiding gee van die potensiële verdigtingsvermoë en indeks op wyk, distrik en studie area vlak. Die bevindings van hierdie studie het aangedui dat individuele wyke in die algemeen hoër vlakke van verdigtingspotensiaal toon wanneer die ontwikkelbare grond vir skole in naburige wyke oorweeg word in berekeninge. Daar is egter hoë agterstande van skole en lae verdigtingspotensiaal wat geopenbaar is – in sommige gevalle in die areas waar die Stad Kaapstad se Ruimtelike Ontwikkelingsraamwerk (2012) areas geoormerk het vir intensivering. Die resultate toon duidelik die nood aan vir `n meer gekwantifiseerde basis om areas te identifiseer vir toekomstige verdigting in ruimtelike beplanningsprosesse. Die bevindings dui ook aan dat `n evaluasie van veranderinge in buurt-lewens-siklusse binne wyke die ruimtelike beplanning van opvoedingsfasiliteite vooruit moet inlig.

Sleutelwoorde: verdigting; opvoedingfasiliteite; ruimtelike beplanning; ROR

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CHAPTER 1 : INTRODUCTION

1.1. BACKGROUND

South African urban areas show consequences of the Apartheid era and have been known as ‘apartheid cities’, characterised by remnants of spatial segregation created by policies such as the Group Areas Act (Simon, 1989; Smith, 1992). During the post-Apartheid era, planners in South Africa have placed emphasis on planning towards compact form and densification in urban areas. The Spatial Planning and Land Use Management Act (SPLUMA) of 2013 contributes to this largely by promoting specific planning principles. SPLUMA informs the compilation of a Spatial Development Framework (SDF), which provides planning guidance and standards at provincial, regional, and municipal level. Municipalities compile an Integrated Development Plan (IDP) every five years which sets out a municipality’s vision, objectives, and development structure. High density urban areas of compact form are encouraged in South Africa as it promotes integration, social inclusion, and mixed land-use (Donaldson, 2001). It is also an important tool in renewing inner city regions.

Density measures, in the context of urban life, form, and function, refer to a specific quantity per unit area (Dovey & Pafka, 2014). The quantity can be a variable such as people, floor space, dwellings, or building volumes. Measures of density are used to compare different urban systems, in many cases to determine whether an urban system inhibits a high or low density of a particular variable, such as high population density or a low building density. The effects of a high or low density can be studied to determine which will lead to optimal and sustainable urban design and management. The challenge with using density as a measurable quantity in urban studies is that it can have different meanings and implications in different contexts. For instance, if dwellings are studied, the different types of built form will result in different categories of population density (Grosvenor & O'Neill, 2014). Therefore, when using a density measure, the specific variable, context, and spatial boundaries must be clearly defined and must remain constant to ensure that any comparisons made are scientifically sound.

Density, in the urban context, is linked to social, ecological, political, and economic dynamics (McFarlane, 2016). The idea of dense cities in many cases stirs ideas of overcrowding, pollution, and traffic congestion. But high density urban spaces are promoted as it is argued that it will limit urban sprawl, an urban trend that leads to increased government expenditure (Holcombe & Williams, 2008; Grosvenor & O'Neill, 2014; Libertun de Duren & Guerrero Compeán, 2016). Others such as Ladd (1992) argue the opposite through studies that reveal that high density leads to increased expenditures in the public sector and that high density can cause the quality of service provision to decrease. Lieske et al. (2012) produced results during a study that strongly suggest that urban form and neighbourhood characteristics have a large negative impact on government expenditure and local service provision.

One such service provision is education facilities. Schools are constructed and provided to serve the residents in its surrounding area. The area that a school serves can be referred to as its catchment area. For a school to function optimally it requires sufficient land space and effective access points through a transport network. The provision thereof is influenced by a neighbourhood's character and needs in terms of other social facilities provision that already make use of land in the area and the condition of infrastructure, such as roads and water access (McDonald, 2010). Current and projected demographic data also play a role in the design and siting of schools. In the South African context, the Council for Scientific and Industrial Research (CSIR) has produced guidelines and standards for the design and planning of human settlements and, more specifically, for social facility provision (CSIR, 2005; CSIR, 2015). These documents make detailed suggestions in terms of the appropriate location, access criteria, size and dimensions, and capacities and thresholds concerned with a variety of social facilities, including primary schools and high schools.

Guidelines for development, in the form of strategies, goals, and demarcated future development zones, are also provided in SDFs. Most of these publications are characterised by a shift towards encouraging and accommodating densification. The Cape Town SDF recognises the pressures of future development and densification, and specifies one of its intentions as "to balance competing land use demands" (City of Cape Town, 2012a). The SDF proposes strategies with a long-term urban vision for Cape Town in mind. Land use intensification is one of the primary strategies in promoting densification and sustainable development. Land use intensification areas are identified in SDFs to indicate which areas are targeted for residential, industrial, and commercial purposes. Such areas are referred to as mixed use areas where space is used to its full potential, both horizontally and vertically. Such areas are pockets of higher densities as a result of the heightened degree of land use and the increased spectrum of people these areas attract. The City of Cape Town SDF 2012-2017, for example, provides conceptual maps that indicate areas demarcated for land use intensification, especially along development corridors and other accessible transport axes. Some SDFs further identify infill sites where appropriate and feasible, which also encourages higher densities due to additional space being developed for various purposes. Both land use intensification areas and infill sites include residential development.

In urban areas, much of the land is already zoned for residential use. Concerning the remaining uses of land, land is used for purposes such as business, commercial, agricultural, and social service activities. Compared to these uses, education facilities consume large areas of space. This is due to the need for many class rooms, meeting halls, and sporting and recreational grounds. With the complex distribution of land uses in mind, any additional developments targeted for residential purposes suggest an increased need for various social facilities. Part of addressing these extended needs, is recognising areas that are already in need of social facilities as well as anticipating where future needs may be. Cape Town's SDF does this by identifying social priority action areas and indicating how many of each primary social facility is required within each area (City of Cape Town, 2012a).

1.2. PROBLEM STATEMENT

An increase in urban density implies an increase in population and demand for housing, government-funded infrastructure and social facility provision. To satisfy such demands and needs, sufficient vacant land, including land identified as possible brownfields development sites, must be allocated to different sectors as space on which to construct buildings that can serve the needs of a population. When population density continues to increase, available space becomes limited due to an increase in space being demanded and used for residential and other associated social facilities and purposes. City planners are then more urgently required to manage urban development carefully. Whether this is executed successfully, can be determined by a variety of factors such as how many people are homeless or struggling to find housing, the levels of traffic, number of patients being served at a single clinic, or the number of school children attending school in an area.

The available space and resources of an urban region determines at what point it has reached an optimum 'density threshold' which means that it has densified to such an extent that its quality of service and social facility provision is decreasing or not meeting the demands and needs of its population. In terms of school provision, it could mean that a region runs out of available space to provide schools for a growing population. Schools are an integral part of any society and for it to function it requires sufficient land for its development. Increased urban densities above a certain threshold could place the provision of schools according to acceptable spatial standards at risk when land is assigned to different competing land uses and social facilities other than that of education. It is thus necessary to systematically evaluate the potential impacts of increased population density on the provision of schooling facilities, to inform spatial plans and policies.

To further complicate matters neighbourhoods have different demographic profiles that change over time, which results in a change in the needs of the people in a neighbourhood. This relates to the Neighbourhood Life-Cycle Theory which describes the stages of neighbourhoods over time, referring to change in status, growth, decline, and renewal (Wiesel, 2012; Metzger, 2000). As the age profile of a neighbourhood's population changes over time, the need for educational facilities will change because as children grow up they transition from attending a crèche to attending a primary school and a few years later, they will attend a secondary school facility. The education need that is identified at different stages of a neighbourhood's life cycle can also influence the provision of education facilities in the area.

1.3. RESEARCH QUESTIONS

The research aims to answer the following research questions:

i. Is there sufficient land available in the study area to address the current backlogs of school facilities and the demand for school facilities associated with future urban growth?
ii. What will be the impact of different densification options in Cape Town on the availability of sufficient land or space for the provision of education facilities?
iii. What will be the optimum development density and/or densification threshold range in Cape Town from the perspective of existing available land and the need for land to provide education facilities?
iv. Does the City of Cape Town in its Spatial Development Framework consider the impact of densification on the future development of schooling facilities?

1.4. RESEARCH AIM

This research aims to determine the impact of increased population densities in the City of Cape Town on the availability of adequate land for schooling provision.

The specific objectives of the research are to:

i. determine potentially available land for social facility development in the study area, specifically education facilities,

ii. evaluate the land requirements and relative scarcity of land for education facilities associated with existing backlogs and projected future population growth, through the application of the CSIR social facility provision standards,

iii. determine the optimum development density and/or densification threshold range in Cape Town at ward level from the perspective of existing available land and the need for land to provide education facilities, and

iv. calculate the changes in school-going population of the study area from 1996 to 2011 at ward level and evaluate the implications thereof.

1.5. HYPOTHESIS

The hypothesis of the research is that the availability of land to provide social facilities such as schools implies an optimum density threshold range for development that, if exceeded, will impact negatively on the quality and sustainability of neighbourhoods.

In the following chapter, a literature review will be performed based on broad themes that provide background and a summary of knowledge related to the problem statement and research questions of this study. Thereafter, the data sourced, study area, and methodology is discussed and explained. Following that, is a chapter presenting the results and interpretation thereof. Finally, a conclusion to this research is provided which includes a summary of findings, a policy implication discussion, and remarks about limitations and recommendations related to the study.

CHAPTER 2 : LITERATURE REVIEW

2.1. SOUTH AFRICAN URBAN PLANNING FRAMEWORK

Following the end of the Apartheid era, the South African planning approach and system evolved into aiming for development and restoration in urban areas through working towards urban integration (Pieterse, 2004). This approach requires planning at different scales and the implementation of public participation. Planning now requires flexibility and the recognition of it being a process, instead of a simple blueprint (Pieterse, 2004). The legacy of Apartheid resulted in urban forms that were unsustainable and that generated an urgent need for compaction in cities (Dewar, 2000), requiring a crucial change in planning policies at the time. These new policies would also require changes such as increased local regulation by the state (Pieterse, 2004).

The Reconstruction and Development Programme (RDP) was initiated in 1994 and published a White Paper on Reconstruction and Development to present the foundational projects thereof and to align them according to the objectives of the RDP (South African Government, 1994). This publication urged the different levels of government to collaborate in future socio-economic growth of the country. One of its principles is Integration and Sustainability through which the government encouraged not only government bodies, but businesses and organisations to work within the RDP's framework. Another of its six principles, Meeting Basic Needs and Building the Infrastructure, describes the intention to create an "infrastructural programme that will provide access to modern and effective services such as electricity, water, telecommunications, transport, health, education and training for all our people" (Republic of South Africa, 1994). For this aim to be feasible within the planning and development domain, the government placed importance on addressing economic factors that obstruct this process.

By 1995, the government felt the need for more efficiency in the efforts towards land development. This led to the Development Facilitation Act No. 67 of 1995 which guided the establishment of Development and Planning Commissions and provincial development tribunals (Republic of South Africa, 1995). The commission was designed to advise the Minister responsible for the RDP's implementation on laws and policies relating to land development. The tribunals had a variety of functions such as the considerations of applications, suspension and removal of servitudes and restrictive conditions, and investigation and authorisation of non-statutory land development. The Act was published to ensure efficient land development, solve conflicts, and to be guide to any planning and development policies, laws, and general practices.

In 1997, the Department of Housing of the South African government released a document titled 'Urban Development Framework' (UDF). It details an urban vision, highlights the policy challenges of urban development at the time, and includes goals and strategies on how to implement the goals. The government had a vision to create urban settlements that are without racial and gender segregation and that are socio-economically and spatially integrated. The UDF set out urban densification as one of their goals under the urban vision in 1997, aimed at improving public transport effectivity, with the mission to achieve social and spatial integration. The vision included the creation of environmentally sustainable urban spaces.

The urban development envisioned in the UDF required city integration that consists of planning for higher density land-use and developments and a restructuring of the planning system which is described in the Development Facilitation Act (1995). The need to incorporate the city centres and existing peripheries at that time was stressed as an element of the process towards densification. Here the use of improving the transport system was also noted. Urban infrastructure and housing was further linked to densification projects in the UDF through the Department of Housing that set aside funding for densification projects, which encouraged mass housing delivery and integration between the state authorities and private sector construction companies.

The planning community further adapted the system to one that is favourable towards development of corridors, mixed land use, densification, and local planning methods that create urban opportunities at a pedestrian scale (Todes, 2000). Strategies to address these ideas and issues are made feasible at a city level through the IDPs that municipalities compile, as compelled by South African law. These planning documents sketch a clear process of implementing solutions and strategies to create the envisioned integrated urban environment in a way that is specific to a municipality, giving consideration to its unique background, planning obstacles, and future developments. The monitoring and evaluation tools lead to more successful and sustainable results. The contents of an IDP were described in The Local Government: Municipal Planning and Performance Management Regulations, published in 2001. The requirements of a municipality's SDF are also set out here. This publication further defined the performance management system that was expected from a municipality. At this point, the expectations from the planning system in South Africa grew to a detailed, local level.

By 2004, planning policies post-Apartheid have evolved over 10 years and the Reconstruction and Development Programme (RDP) was re-branded to the Breaking New Ground (BNG) initiative. The BNG approach aims to provide affordable housing through creating sustainable and integrated communities, while the RDP approach of planning only aimed to deliver houses to a population group that falls within the R0-R3500 income bracket. This shift towards creating lasting neighbourhoods through housing provision, was another transition in the South African planning framework towards developing maintainable high density spaces.

In the National Development Plan (NDP) 2030, released in 2012, the spatial legacy of Apartheid is addressed and it is noted that some post-1994 policies have led to further segregation, such as the development of some low-income housing in the urban edge (National Planning Commission, 2012). The 2030 vision urges densification to reduce commuting distances and to limit urban sprawl. At this time, the planning system of South Africa called for a national spatial framework – one that would improve coordination between the different government spheres, clarify the responsibilities of different bodies, and address the drawbacks of IDPs. Such a framework would provide an overview of principles that are to be employed at provincial and local levels of spatial planning.

Following the NDP 2030, came the publication of the Spatial Planning and Land Use Management Act (SPLUMA), 2013, introducing planning legislation and an overarching planning framework, applicable to the country as a whole, in urban and rural areas (Nel, 2016). This legislation serves as a replacement for the Development Facilitation Act. SPLUMA states that all bodies of government and other regulating bodies that are involved in spatial planning and the use, management, and development of land, are to perform their duties while applying these five development principles: spatial justice, spatial sustainability, efficiency, spatial resilience, and good administration (Republic of South Africa, 2013). The legislation further suggests integration between the three spheres of government (national, provincial, and local). Included in the requirements of SPLUMA, are IDPs, and SDFs as part thereof, from all municipalities. As per Section 21(f) of SPLUMA, the contents of an SDF are to include "estimates of the demand for housing units across different socio-economic categories and the planned location and density of future housing developments" (Republic of South Africa, 2013). This is an example of how SPLUMA and the policies for which it provides guidelines, speak to the future needs created by densification.

The Department of Cooperative Governance and Traditional Affairs (CoGTA) of South Africa published the latest Integrated Urban Development Framework (IUDF) in 2016. The IUDF aims to generate a mutual understanding between the government and society regarding urban planning and management. Two of the framework's nine policy levers link closely to the general shift towards densification. These two levers are 'Integrated urban planning and management' and 'Integrated transport and mobility'. The IUDF uses these nine levers as guidelines to reach the spatial transformation and urban restructuring aimed for in the NDP. One of the targets addressed through these guidelines is increased urban densities.

In 2016, the South African Cities Network released an updated State of South African Cities Report (SoCR), in which they stress again the need for densification of well-located areas to develop more sustainable cities, placing the pressure on the municipal sphere of government to develop and implement compact urban planning policies for their cities. An important element of integrated urban form is the location and function of community facilities. The SoCR of 2016 mentions poor facilities as one of the contributing factors that limit access to resources and minimise opportunities in communities. In cases where urban planning is lacking, it leads to prolonged spatial segregation and impacts negatively on the livelihoods of community members. This is typical in townships where there is little regulation of activities, housing of poor quality, and insufficient services (SACN, 2016). Townships that are well-established are amongst those that have substandard health and education facilities. This results in many school pupils from townships leaving to suburban schools on a daily basis. The trend is an urban inefficiency and comes at a great cost to households that have financial difficulties. The health, level of education, and access to services has an influence on a poorer person's ability to improve their circumstances and skills (SACN, 2016). This emphasizes the need for sustainable urban planning and policies, specifically to develop education facilities of quality, especially in townships as they are typically spatially segregated from the centre of cities that have undergone much integrated urban development since the end of the Apartheid era.

The urban policies developed after Apartheid broadly aim to generate and enable equal access to the opportunities that cities offer, through encouraging spatial proximity to livelihood opportunities, employment, and urban services (Harrison & Todes, 2015). However, the strategies of the policies and the level of success of implementation varies from city to city.

2.2. DENSITY AND DENSIFICATION IN SPATIAL PLANNING

According to Alexander (1993), the physical characteristics and objective of an environment, along with its users, are what influence and determine the perceived density experienced by individuals. These elements together create the physical density of a setting. But describing and determining population density is both a technical and moving target challenge, due to the challenge of creating a mathematical equation to define population density, and due to the changes that an urban system and its parts undergo continuously (Griffith & Wong, 2007). Goldewijk (2005) researched world population based on data for the years 1700 – 2000 and discovered a general increase in population density in large regions of Europe at the end of the 17th and 18th centuries, due to continued decline in mortality and increased birth rates. The population densities are recorded in the unit inhabitants per km^2. The differences found in the study when comparing population densities of continents or countries can be due to the different trends and rates in population growth over the centuries as a result of how habitable a region was and the locations of colonisation. The lack of historical context can be a limitation and source of uncertainty when comparing population densities at a global scale.

On a more local scale, Burton (2002) provides extensive research on measuring the compactness of a single city using categories such as ‘the high-density city’, ‘the mixed-use city’, and ‘the intensified city’ to provide a range of interpretations of compactness. Both Burton (2002) and Schwarz (2010) identify density as a main indicator to characterise urban form and compactness. Included in Burton’s (2002) measures for density are persons per hectare and persons per hectare in residential built-up area.

Methods to measure physical density include land use intensity, building height, coverage, spaciousness, and population and dwelling density calculations (Burton, 2002; Berghauser Pont & Haupt, 2009). The ratio between a measure of urban activity and the area on which it occurs, is an additional measure of density (Frenkel & Ashkenazi, 2008). In terms of population density, which is the number of people per unit area, also referred to as number of resident people per hectare (Turok, 2011), differentiation can be made between residential density, neighbourhood density, and city density. Residential density refers to the neighbourhood portion used by housing only, while neighbourhood density refers to the housing land use portion plus neighbourhood facilities (shopping centres and primary schools). City density covers neighbourhood density as well as additional general services such as hospitals and city halls (Berghauser Pont & Haupt, 2009).

Physical density can also be measured through the volume of buildings and the physical form thereof (Alexander, 1993; Dovey & Pafka, 2014). These measures include coverage, building height, and Floor Area Ratio (FAR). Coverage indicates allowable footprint of a building in relationship to the site area. Coverage regulations influence the urban patterns of neighbourhoods (Berghauser Pont & Haupt, 2009). Building height specifies the amount of storeys of a building.

This has an effect on how sites are developed to their full potential in order to reach a larger floor space for increased profits. FAR is the ratio between floor area of a building to the site area and is widely is used in planning and architecture. FAR enables variety in urban design, while placing a limit on development volume. This measure is appealing due to its close tie with profitability, as the amount of available floor space determines the potential income for the developer (Dovey & Pafka, 2014). These measures by themselves cannot determine or impact density, but when used in conjunction, they are useful particularly in building regulations concerning the maximum intensity of land use that is permitted, which influences population density, for example (Alexander, 1993; Berghauser Pont & Haupt, 2009; Dovey & Pafka, 2014).

However, despite the informative power of these indicators, it is crucial for any measure of urban density to define the boundary of the area from which variable data is collected, as this has a large influence on the outcome of the density measure and will minimise ambiguity (Alexander, 1993; Burton, 2002; Berghauser Pont & Haupt, 2009). The importance of density measures, such as population density, further lies in its use to "calculate development land requirements, estimate site capacities, and to control development on individual sites" for purposes such as retail, schools, transport, and transit expansion (Burton, 2002; Berghauser Pont & Haupt, 2009).

2.2.1. Urban renewal and regeneration

Physical density has an effect on the efficiency of an urban system. If the density of a city increases beyond what the city was designed to carry, it could lead to a variety of challenges for city planning and managing. High density could lead to problems such as traffic congestion and declining housing quality. These issues as well as social exclusion, low public space quality, poverty, and segregation are concerns that call for complex urban renewal policies (Kleinhans, 2004). When an urban environment is changing and shows signs of urban decay, urban renewal projects can be implemented to solve problems associated with the deterioration of urban form (Chan & Lee, 2008). The concept of sustainable urban design links closely to urban renewal because being cognitive of sustainable design objectives, informs urban designers about the unique values and needs of communities at different urban community scales (Macdonald, 2016). This is valuable knowledge in the renewal process, especially while planners must be aware of planning policies and regulations.

Infill and urban regeneration have become tools in the process of compaction and densification, especially in terms of the South African post-apartheid city context (Cape Town, 2012c; Todes, Weakley, & Harrison, 2017). Where densification is encouraged, regeneration often takes place in the form of subdivision and increase in office and commercial developments, usually designed and developed to accommodate higher densities (Cape Town, 2012c). This increases the types of employment opportunities and the market-range that people can choose from for residential purposes. With an increased population attracted to and accommodated for in the area, urban renewal is most likely to behave as a catalyst for densification.

Smart densification strategies can be implemented to contribute to sustainable urban design and development. This includes brownfield densification. 'Brownfield sites' can refer to commercial or industrial sites that are abandoned or not used to their full potential (Hayek et al., 2010). Such land is often environmentally contaminated as a result of previous industrial activity. Brownfield sites have been used in densification policies for new developments and promotion of infill projects (Schmidt-Thomé et al., 2013). These are approaches to improve an urban environment and to generate optimal land use. The implementation of brownfield densification is beneficial to surrounding sites as it minimises health risks, unpleasant smells, and noise, while it also generates development in areas that are near economic centres (SACN, 2016; Vermeer & Vermeulen, 2012), which is seldom the case for greenfield growth and developments. Greenfields are typically on the periphery of an urban area and are undeveloped agricultural land (De Sousa, 2002). Greenfields are appealing sites for new developments due to its accessibility, spaciousness, and lack of congestion. Such development can draw people away from the city and requires large sums of capital to develop the land and provide basic services.

The migration of people from the city to the urban periphery can be part of one of the neighbourhood life cycle phases. A change in phase is largely influenced by how the population density in a neighbourhood changes. The density of a neighbourhood changes, for example, when old detached houses are replaced with new flat buildings and over time more people can be accommodated in the neighbourhood, increasing the population density (Wiesel, 2012). Density decreases again later when overcrowding in the neighbourhood pressures some residents to move towards the urban periphery. This relates to how the need and demand for land and social facility provision changes. A more natural lifecycle of a neighbourhood is presented in Figure 2-1 (with Table 2-1 as the legend), which indicates how population changes over time, based on various factors within the neighbourhood. The changes in population creates a change in population densities over time, as well as differences in population densities between neighbourhoods depending on which lifecycle phase each neighbourhood is in at the time. During a change in lifecycle phase, a decrease in population density in one area, may be the cause of an increase in population density elsewhere.

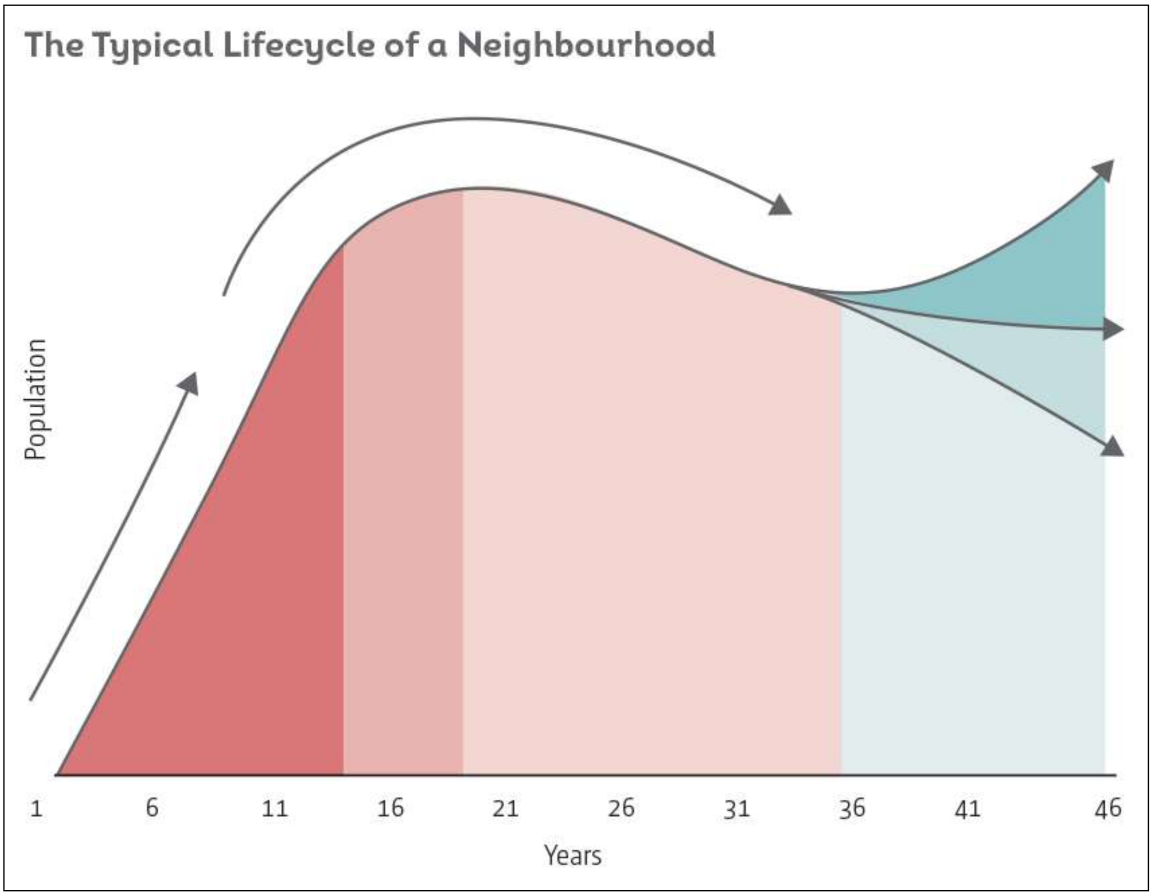

Figure 2-1 Lifecycle of a neighbourhood (Moran, 2015).

Table 2-1 Legend to Figure 2-1 (Moran, 2015).

	Development of vacant lands results in population increase, typically young families with young children.
	Neighbourhoods are completed and in-migration slows. The population continues to grow as families have children.
	The population declines as children grow up and leave home.
	Neighbourhoods may be revitalised, or become seen as a desirable place to live. Redevelopment and intensification increase available dwellings and attract new residents.
	New in –migration from young families occurs as older couples begin to leave the neighbourhood. A stable neighbourhood population is achieved.
	Undesirable economic and social conditions may make neighbourhoods unattractive, resulting in population losses

As density increases in a neighbourhood, it becomes characterised by overcrowding. There will be an increase in demand for housing. If there is no developable land available in the city, brownfield development could take place, the land use of property might be changed to residential, or greenfield development increases. However, with an increase in population density, it is not only additional housing that is required, but there is an increase in demand for social facilities such as schools and health clinics. With more land used for developing residential buildings, land quickly becomes limited for the development of the additional social facilities. Over time, the re-occurance of this struggle between different land uses for land availability leads to mixed land use, especially in the inner region of a city (Shi & Yang, 2015). Urban form that allows for mixed land use development accommodates a higher population density, has improved accessibility to public transport, and provides social facilities near residential buildings. These are characteristics of a compact city.

2.2.2. Arguments for and against densification

To describe a city as compact could mean different things for different cities, depending on factors such as cultural attitudes or the current level of density of the city (Burgess, 2000). Planning and development is a complex environment analysed by researchers, planners, and city decision-makers that continue to debate he benefits and drawbacks of high density urban form, be it intended densification or densification as a consequence of urban growth and change (Boyko & Cooper, 2011; Todes, 2011; Weakley & Harrison, 2017). The advantages and disadvantages, such as those discussed below, are not applicable in every case and should be considered within the context of the relevant urban system before making city-specific deductions.

Mobility and transport network improvement is one of the primary arguments for high density development in which easier access to facilities and community services is enabled (Todes, 2017). Efficient and more affordable public transport is feasible and promoted in compact urban settings (Churchman, 1999; Todes 2017). Due to mixed land use and the increased number of people being served in one area, the provision of public infrastructure incurs lower costs (Todes, 2017). The overall amount of energy consumed during the provision of transport and community services is also reduced (Turok & Parnell, 2009). In compact cities, people live in closer proximity to amenities, leading to a decreased number of vehicle trips made and fewer kilometres travelled per trip (Boyko & Cooper, 2011). However, there may be mobility issues in compact cities such as increased traffic congestion and limited parking availability (Todes, 2017; Churchman, 1999). With an increased population in the city, local services will begin to experience additional pressure (Turok, 2011). Another disadvantage about high density urban systems in terms of mobility is the pedestrian congestion and congestion experienced in public transport facilities (Ruback and Pandey, 1992 in Churchman, 1999). This congestion is exacerbated at street level, coupled with disruption, during times of building construction as part of high density development (Troy, 1996 in Churchman, 1999).

High density cities can have a positive influence on its local economy, such as promoting urban productivity and agglomeration economies (Turok, 2011). This leads to an efficient economy and simultaneously enables increased employment opportunities and easier access to employment (Alexander, 1993; Todes, 2017). Economic growth can be sustained over time with these benefits, which allows the city to deal more effectively with challenges in different sectors and makes the delivery of public services more cost-effective (Turok & Parnell, 2009). Furthermore, a larger resident population in a high density city increases the demand for a variety of services, while also contributing to optimal use of existing buildings and functions in a city, such as entertainment and arts venues (Boyko & Cooper, 2011; Turok, 2011). With the passing of time, detached dwellings located close to the urban centre will experience a rise in overall value due to the demand for the property and its close proximity to amenities and job opportunities (Boyko & Cooper, 2011; Todes 2017). Despite these advantages, the economy can suffer during the transition to a high density city, especially during the construction and maintenance of high density buildings and infrastructure (Alexander, 1993). These are said to be costlier than medium- or low density developments. The economy of the more rural areas surrounding the urban centre suffers as a result of the intense development within the city (Breheny, 1992 in Boyko & Cooper, 2011). The cost for land and cost of living, including goods, dwellings, and services costs, increase as a result of high densities (Boyko & Cooper, 2011). This relates to access to local undeveloped land becoming limited due to the increased value thereof (LSE, 2006 in Boyko & Cooper, 2011). Finally, more units have to be sold for each hectare of land in high density developments, which increases the time taken for overall land absorption for single high density developments (Preiser, 1992 in Churchman, 1999).

In addition to the disadvantages of high density cities create for the economy, the environment also suffers largely in terms of increased pollution within the urban area (Todes, 2017). Some have found this to be exacerbated by the decreased amount of available space for trees and other vegetation that work against pollution by cooling the area and purifying the air (Breheny, 1992 and De Roo & Miller, 2000, as cited in Churchman, 1999). Tied to this, is the decrease in public open space, which works against sustainability goals while also creating a limit in recreational opportunities (Cheshire & Sheppard, 2002). Another argument against high densities is the fact that the capacity to manage local waste and carry out recycling operations, is reduced (Troy, 1996 in Churchman, 1999). Todes (2017) further argues that where high densities are encouraged in middle- and low-income countries, slums and informal settlements develop worrisome environmental conditions. Despite these disadvantages, the environment and efforts towards sustainability benefit from high density developments in the sense that it promotes a reduced carbon footprint (Boyko & Cooper, 2011; Todes 2017). The environmental impact is decreased through, for example, transitioning from using private vehicles to public transport services and non-motorised transport. As a result of a limit to open spaces, the preservation thereof is encouraged, as well as preservation of fauna, flora, water, and clean air which promotes sustainability and a healthy environment (Kamal-Chaoui, & Robert, 2009). In other words, the decrease in availability of green open space emphasises the need to protect what is still available. Dave (2017) claims that high density neighbourhoods are planned carefully, which ensures that sufficient open spaces are innovatively designed and successfully maintained. This extends into the increased value that residents attach to the open spaces within a high density city, compared to regions outside the city (LSE, 2006 in Boyko & Cooper, 2011)

Linked to sustainability related benefits, are advantages of high densities in terms of resources and land availability such as a lower rate at which land with biodiversity, agricultural, and mineral potential, on the periphery, is consumed (Alexander & Tomalty, 2002; Turok, 2011). High density construction projects also require less natural resources. Existing infrastructure such as pavements, sewers, and roads, are used more efficiently which reduces unnecessary construction (Alexander, & Tomalty, 2002). Moreover, less water and energy is consumed compared to low density regions as a result of heating and cooling used by single-family homes and water being used in excess for gardening and cars (Alexander & Tomalty, 2002). The case for higher densities is also supported because urban agriculture reduces the travelling distances of food delivery and encourages local food suppliers to flourish (Boyko & Cooper, 2011). All of these advantages build on the fact that high density cities increase in efficiency due to the mix of land uses in a smaller urban space. Researchers do, however, point out the negative influence of high densities on a city's resources and land availability, such as that natural resources are under much more pressure (Todes, 2017) and there is increased energy consumption during construction of high rise buildings. When more land is used for solid surfaces and the amount of open and recreational space decreases, the area cannot absorb rainfall at the same capacity as previously (Troy, 1996 in Churchman, 1999). Another disadvantage in terms of land availability is that there are fewer options for how and where to place buildings on sites due to the increase in density and smaller sites being available for development (Hitchcock, 1994 in Boyko & Cooper, 2011). The process of absorbing land for high density developments is more timely than for low density developments, because for each hectare of land, more units are put on the market (Preiser, 1992 in Churchman, 1999).

In a different light, high densities have an influence on people's personal space and experiences, and their quality of life in both positive and negative ways. With amenities and efficient transport systems in place, people save time and petrol and live in neighbourhoods that are walking- and cycling-friendly, which also promotes healthy lifestyles and a safer environment due to more eyes on the streets (Turok, 2011). A variety of businesses experience a larger employee base and clientele in high density cities, which promotes mixed land use, which contributes to a higher quality of life (Alexander & Tomalty, 2002). Alexander and Tomalty (2002) also found that high density areas provide residents a wider variety of housing choices, allowing all residents to find a residential option that suits their financial situation. Researchers found that high densities decrease isolation and social segregation within neighbourhoods, and is likely to improve social capital, desired levels of privacy, social support, and attachment (Churchman, 1999; Boyko & Cooper; 2011, Turok, 2011). Nevertheless, there is a range of arguments against high densities in terms of the personal effects it may have, such as the development of overcrowding and rowdy apartments, as well as increased crime and nuisances from community members, and lack of privacy (De Roo & Miller, 2000; Turok, 2011). Baum and Paulus (1987) reported that a change to high density lifestyles can cause social withdrawal, loss of control, violations of personal space, cognitive overload, anxiety, psychological stress, physiological overstimulation. They also noted limits on freedom of choice and individual behaviour as a result of high densities. It has further been found that high densities may enhance social segregation and inequality (Rådberg, 1996 in Churchman, 1999), as well as damage the sense of community (Boyko and Cooper, 2011).

2.2.3. Planning for densification

The IUDF estimates in its 2016 publication that 71.3% of the country's population will be living in urban areas by 2030 (CoGTA, 2016). Urban areas in South Africa are densifying, while many city planners aim to densify urban spaces to create sustainable cities. In essence then, city managers are preparing and planning for densification. Without densification strategies and well-managed implementation schemes, cities run the risk of losing their character and of failing to maintain a healthy public domain (Byrne & Sipe, 2010).

The legislation passed (e.g. SPLUMA), policies implemented, frameworks released (e.g. UDF and IUDF), IDPs, SDFs, and an NDP published, each contribute to the promotion of densification in South African cities, towns, and neighbourhoods. These documents have shaped the urban planning framework of South Africa over time. They offer policy levers, strategies, and identified priority action areas and those that apply at a municipal level are updated and monitored. Despite these guidelines, additional national reports are also published that provide information about opportunities and viable methods to promote, enable, and manage densification. One such report is titled "Planning for Green Infrastructure: Options for South African Cities" which discusses the need for an intergovernmental planning approach towards the sustainable co-existence of the built and natural environment (Cilliers & Cilliers, 2016). The report highlights the importance of how high urban densities can impact the environment. In the IUDF report, nine policy levers are identified to guide and structure the needed policy actions. Reducing sprawl through increasing urban densities is one of the purposes of being directed by the nine policy levers (COGTA, 2016). The aim of densification, as described in the report, is to prevent any inefficient sprawl and to strive towards creating economic efficiency and decreasing social and environmental effects in areas with existing sprawl. The report also stresses the need for open and communal spaces in high density urban areas. The SoCR emphasizes the need for national and local government to collaborate in achieving high densities in well-located areas and it points out the responsibility of city governments to publish city densification policies (SACN, 2016).

Therefore, planning for densification ensures that urban spaces develop in stages at reasonable time intervals while promoting sustainability and efficiency. Planning documents that monitor and predict density changes assist in directing planners to where the optimal locations are in cities for densification and help to identify the signs to look out for that will indicate when a city has reach its densification capacity. In this regard, a density threshold could be useful to generate measurable outcomes of densification. This will assist in knowing in advance when a city will reach its full densification capacity to allow for long term planning and provision of alternative locations for development in the future. A density threshold index could be designed to make such a channel of future planning feasible.

2.3. PLANNING FOR SOCIAL FACILITIES

Despite the general lack of clarity in literature regarding what social sustainability means (Dempsey et al., 2009; Dave, 2011), Bramley et al. (2006) separated the concept into two components: equity of access and sustainability of community. Social equity refers to access to services and opportunities, while sustainability of community includes perceived quality of the local surroundings, safety within the community, and social interaction (Dave, 2011). Social sustainability challenges in the built environment may differ between developed and developing countries. Hence, developing countries face challenges such as alleviating poverty and ensuring socio-economic equity more intensely (Dave, 2011). Social equity can be promoted and increased through high density neighbourhoods, which is said to enable easier access to social facilities and services (Burton, 2000). Dempsey et al. (2009) identified a list of basic services that should be accessible to residents within a neighbourhood: doctor, post office, chemist, supermarket, bank, corner shop, primary school, restaurant or takeaway, pub, library, sports and recreation facility, community centre, children's facility, and public open space.

Planning and providing social services is not a straightforward task, as Cape Town's SDF for 2012-2017 points out that its sustainability is determined by its resilience. The City is constantly forced to balance schemes that improve social services and basic needs provision, against stimulation of the economy and environmental resource preservation, amidst the changes within the city (City of Cape Town, 2012a). This SDF further provides a matrix to indicate how social facilities and recreational spaces could potentially be clustered, thresholds of facilities and where they could potentially be located within the urban region, and a matrix identifying the potential multiple uses of selected social facilities (City of Cape Town, 2012a). Being aware of the capacities of social facilities, how they could be developed most efficiently, and how they can be used to their full potential, are essential to the planning of social facilities and their successful implementation.

In South Africa, the provision of social facilities shows a random pattern across settlements (CSIR, 2015). Due to previous and current unequal settlement development, it is crucial to plan carefully for the distribution and locations of social facilities, especially because settlements in South Africa have such a diverse range of physical and social characteristics. The Constitution of the Republic of South Africa, as well as Public Services Regulations, hold departments of the government responsible to improve, develop, and plan for access to social facilities and services (CSIR, 2015). The promotion of densification in planning guidelines and policies simultaneously acts as encouragement to developing efficient access to social facilities.

2.3.1. Education facilities

One of the key social infrastructure provisions required in communities to encourage and ensure integrated and sustainable urban spaces, is education facilities (COGTA, 2016). When planning for and designing education facilities, some locational factors should be considered: the site should be fairly level, the site should be within reasonable walking or busing distances, and the site should be suitable for recreation facilities, buildings, and landscaping, while also considering the safety of children (Chapin & Kaiser 1979). Planning for school provision concerns space requirements determination, which includes the steps of studying an existing school, estimating the future enrollments of a school, and developing a trial scheme of a school site, as suggested by Chapin & Kaiser (1979). The IUDF points out some benefits of increasing provision of and improving access to education facilities: it creates a link between urban and rural areas, involves the development of human capital, encourages migrant integration into society, and improves the chances of the unemployed to become employed. Access to education has social benefits such as nurturing common values across race, culture, language, class, and religion and promoting social cohesion (National Planning Commission, 2012). If schools are developed in line with the provided spatial guidelines, the required infrastructure and sports fields can be provided which will ensure a healthy learning environment and education of equal quality at all schools across the nation.

In their guidelines for social facility provision, the CSIR provides a range of criteria for a variety of education facility types, including secondary and primary schools (Table 2-2-2), with regards to provision guidelines. Both minimum and maximum population thresholds for primary and secondary schools has been identified. The minimum is stated as Settlement Type H, which refers to a village of 500-5000 people that is more than 20km away from the nearest settlement (CSIR, 2015). The criteria that is divided between small, medium, and large sized schools is based on what the National Department of Education proposed in 2008. These guidelines indicate the minimum and optimum site sizes for schools, ranging from 1.9 ha to 6.2 ha. Considering that 1 ha is about the size of a standard rugby field, it is evident that education facilities require large areas of land to provide adequate facilities to communities. Compared to 10 of the other social facilities included in the CSIR's guidelines (Table 2-2-3), primary and secondary schools demand a large portion of land allocated to social facilities in a neighbourhood. The site sizes noted in Table 2-2-3 may vary depending on population thresholds in different neighbourhoods. The demand for space from education facilities is high. This demand will change as population densities change in neighbourhoods.

Table 2-2-2 Primary and secondary school provision guidelines (adapted from CSIR, 2015).

	PRIMARY SCHOOL			SECONDARY SCHOOL		
	Small	Medium	Large	Small	Medium	Large
Population threshold range (optimal)	1000 people (Settlement Type H); 7000 people (large primary school)			2500 people (Settlement Type H); 12 500 people (large secondary school)		
Access distance	5km; 10km for Settlement Type H			5km; 10km for Settlement Type H		
School size	960 learners for a threshold of 7000 people			1000 learners		
Class size	20-30 learners for Grade R; 40 learners for other grades			40 learners		
Minimum capacity (no. of learners)	135	311	621	200	401	601

Maximum capacity (no. of learners)	310	620	930	400	600	1000
No. of classes per grade	1	2	3	2	4	5
Minimum site size (ha) - includes sports fields of 0.9 ha	1.9	2.8	3.5	2.6	3.2	4
Optimum site size (ha) - includes sports fields of 1.8 ha	3.2	4.4	6.2	3.9	4.6	5.5

Table 2-2-3 Site size guidelines for social facilities.

Social facility	Site size (ha)
Neighbourhood parks	0.04 - 2.0
Library	0.05 - 0.2
Police station	0.1 - 1.0
Worship centre	0.15 - 1.0
Primary health clinic	0.2 - 1.0
Fire station	0.3 - 1.2
Children's home	1.0
City hall	1.0 - 2.0
Prison and place of safety	2.0 - 5.0
Primary school	3.2 - 6.2
Secondary school	3.9 - 5.5
District hospital	5.0

Based on the optimal maximum population thresholds in Table 2-2-2, one could say that a neighbourhood's need for an additional primary school starts growing once the population increases beyond 7000 people. The same idea is true for secondary schools: a neighbourhood's need for an additional secondary school starts growing when the population increases beyond 12 500 people. This shows the importance of monitoring population density so that planners can be aware of when a settlement has reached its optimum population threshold for serving the community with its existing education facilities.

2.3.2. CSIR Space Planner

The demand for social facilities and the land requirements thereof, specific to a settlement, can be calculated using a free tool, available on the web, called Space Planner. The CSIR has developed this tool so that users can input criteria such as housing densities, land availability, and family sizes based on existing or future developments to generate outputs regarding land requirements for social facilities (CSIR, 2015). The tool is aimed at identifying social facility demand for a settlement, the required extent of land to accommodate a number of people and social facilities, and a measure of people that can be housed on a specific area of land. This means that the tool can be used to understand how many social facilities, education facilities specifically, are lacking, as well as how many additional educational facilities and associated hectares of land will be required based on future density estimates. Planning with social facility provision standards in mind, will lead to more equal and sustainable development across South African settlements.

2.4. SPATIAL PLANNING AND DENSIFICATION IN CAPE TOWN

Due to racial segregation during the Apartheid years, Cape Town was also one of the cities characterised by unequal opportunities and access to utilities for different racial groups. The legacy of the laws that created this urban environment remained long after 1994 and traces thereof can still be seen today in many neighbourhoods. The city was designed so that only the white population could have easy access to work opportunities and transport, while the coloured, black, and Indian population were pushed to the periphery where the quality of schooling was lower, job opportunities were scarce, and transport into the city came at a great cost (Selod & Zenou, 2001). The inequalities caused some areas to become more developed than other areas, while some were forgotten, which created a backlog of social facilities in many communities across the city (City of Cape Town, 2012b). The city was in urgent need of integration and equal social infrastructure provision. Over time the city experienced a high influx of people, from surrounding rural areas while densification took place even informally in the shape of backyard dwellings (Govender, Barnes & Pieper, 2011).

In its SDF 2012 publication, the City of Cape Town identifies three key strategies to ensure sustainable land use management that is in accordance with the City's spatial structure vision (City of Cape Town, 2012a). The first of these is to "plan for employment, and improve access to economic opportunities". One of the sub-strategies for this is the integration of land use, economic, and transport planning, which fosters two policies, one being to "encourage medium to higher-density forms of urban development to locate on or adjacent to activity routes, development routes and activity streets". The aim of this policy is to provide increased accessibility, improve land use mix and intensity, and promote economic activity within areas that are already economically established. The second main strategy revolves around facilitating urban growth through integrated planning and the promotion of higher densities as guided by local plans and the

Cape Town Densification Policy. Compact urban form is further encouraged through land use intensification. The types of densification that are planned for include 'incremental suburban', 'affordable housing', and 'spatial structuring elements', each with specific areas that are targeted. The third strategy addresses the need to transform settlements that are too densified, due to the influence of Apartheid policies. Integrated settlement patterns are further promoted in the third strategy in order to accommodate for new, well located, higher density residential developments. The SDF also discusses the role of improved public transport services and routes to accommodate mobility within high density regions. The route designations provided in the SDF direct appropriate activity development that supports mixed land use and intensification thereof.

In planning for social facilities, the SDF states the need to consider development corridors and accessibility to public transport to ensure that amenities are optimally located where residents can have easy access and make efficient use of services. It is also important to find a balance between dealings with backlogs and needs of new social facility projects. The SDF places an importance on clustering social facilities at intersections of activity routes to ensure highest accessibility. As previously discussed, draft standards and guidelines are provided in the SDF that are to be applied during planning for social facilities in the City of Cape Town.

In the 2016/2017 review of the City of Cape Town IDP, the shift towards densification is re-emphasised by its densification policy that aims to develop communities close to amenities and economic opportunities (City of Cape Town, 2012b). The report also confirms the goal to maintain the urban edge of the city in order to limit urban sprawl. There has been a large decrease in the city of land consumption since 2007, partly due to increased infill development which replaces greenfield development, and a change to cluster and apartment residential arrangements. These are signs of the implementation of densification policies. An example of how the City is planning for densification is its efforts to design long term capacity upgrades for water and sanitation infrastructure, which will be necessary for serving an increased population. The review report also mentions the successful link to the Wemmershoek pipeline that is complete, which will aide in future provision of bulk water for the City. Infrastructure, such as electricity networks, should be in place and available in appropriate locations and target areas, so that land use densification planning and implementation can take place, according to the review report. The City is planning for densification with transit-orientated development (TOD) in mind, which supports infill projects and efficient public transport typologies. The Built Environment Performance Plan is a programme used by the city to monitor developments and to evaluate progress made with densification within the city. These efforts allow the City to make informed decisions during its planning for the different stages of densification in different areas.

In 2012, the City of Cape Town released a Densification Policy. The policy was developed to address the challenges created by low density developments that threaten the City's long term sustainability (City of Cape Town, 2012c). The policy is to act as a decision making guide, consolidate literature into one policy framework, inform the City's SDF and other local plans, and to align densification strategies with land use management regulations and the capacity of the City's infrastructure.

The City of Cape Town continues to densify and experienced a population growth of 21.6% between 2003 and 2013 (SACN, 2016). Planning policies have largely shifted towards sustainable development to consider how improvements, growth, and expansion will affect the future Cape Town. City plans, frameworks, and reviews provide insight into the necessary guidelines for high density development and ensuring that social facilities are provided in accordance with the densification policies. This ensures that the city evolves into one high density and integrated urban system, instead of smaller inefficient, unsustainable, and disconnected communities.

CHAPTER 3 : METHODOLOGY & DATA

3.1. STUDY AREA

The study area for this research is the urban region of the City of Cape Town (CCT) municipal area (Figure 3-1) which is located in the south of the Western Cape province in South Africa. The metro is divided into 111 wards, of which 107 form part of the study area (Appendix A). These 107 wards were selected as these contain the bulk of the urban footprint of the CCT and hence the areas relevant to densification of the city. This metropolitan area had a population of 4 004 793 persons and 1 264 849 households in 2016 (Western Cape Government, 2016). The City of Cape Town covers an area of 243 996,71 ha and the study area covers an area of 137 755,51 ha, which is 56.45% of the total municipal region.

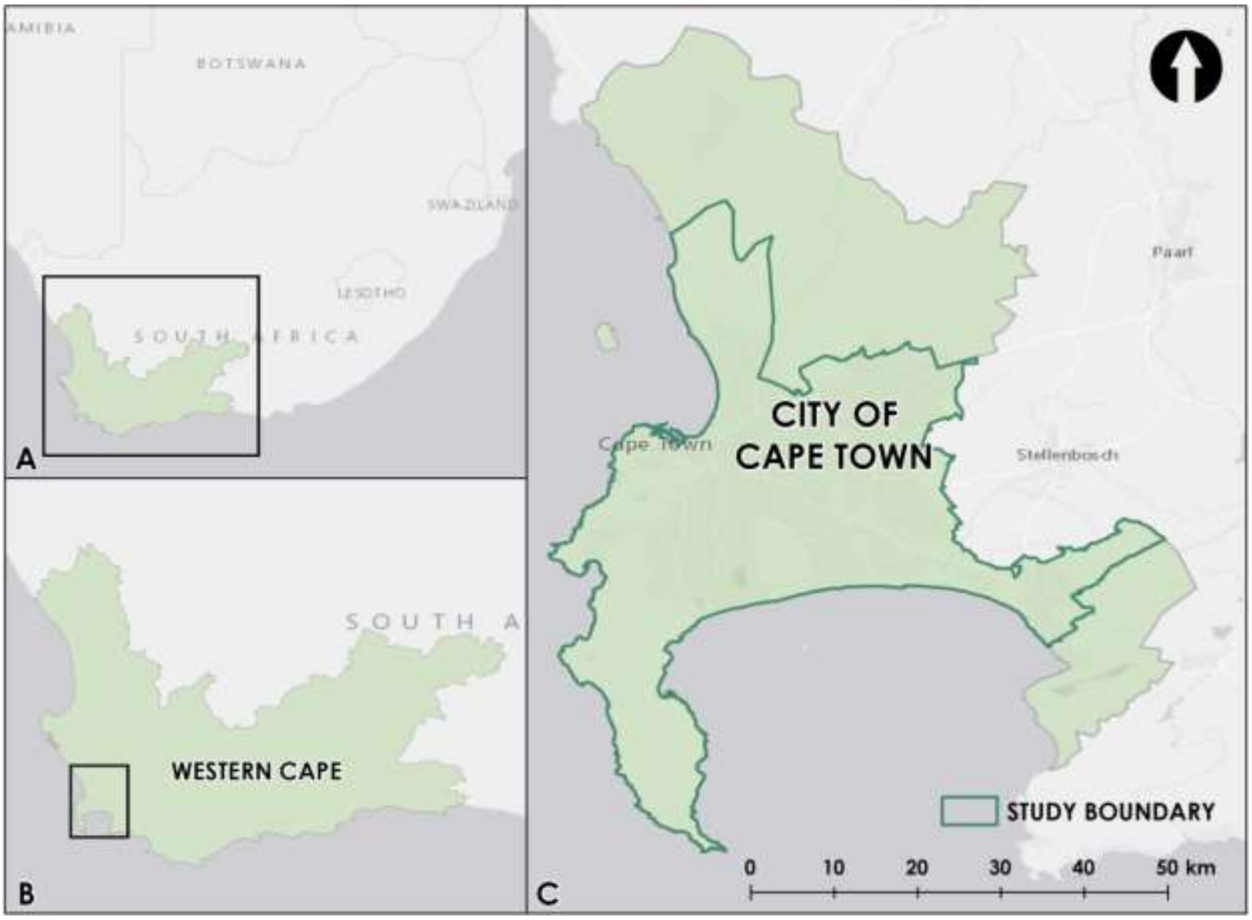

Figure 3-1 The study area (C) at provincial (B) and national (A) scale.

3.2. DATA SOURCED

The data that was used in this study is summarised in Table 3-1, which shows the source and date for each data set.

Table 3-1 Potential datasets for the study.

DATA	SOURCE	DATE
City of Cape Town census data per ward	City of Cape Town Data Portal	2011
City of Cape Town ward boundaries	City of Cape Town Data Portal	2011
City of Cape Town schools	Find-a-School (Education Management Information System); Western Cape Education Department	2017
Infill and mixed use intensification areas	Captured from City of Cape Town SDF District Plans	2017
Number of children in two school going age categories (age profiles)	Statistics South Africa	1996, 2001, & 2011
City of Cape Town residential footprint	CRUISE, Stellenbosch University	2010

The demographic data was obtained from censuses in the years 1996, 2001, and 2011. The results of the 2016 Community Survey could not be used since it is only available at municipal level. The data required is quantitative and includes information such as school geographic locations, boundaries of wards in Cape Town, and demographics such as number of households and population per ward.

3.3. METHODOLOGY

The methods for this research was divided into 5 broad components (Figure 3-2). The study analysed the current state of education facilities provision, identified land available for school development, and estimated potential population density increases based on the degree to which education facilities can potentially be provided. This quantitative analysis followed an empirical methodology. The steps of each component is discussed below, with each sub-step indicated in bold by the number and letter which identifies it in Figure 3-2.

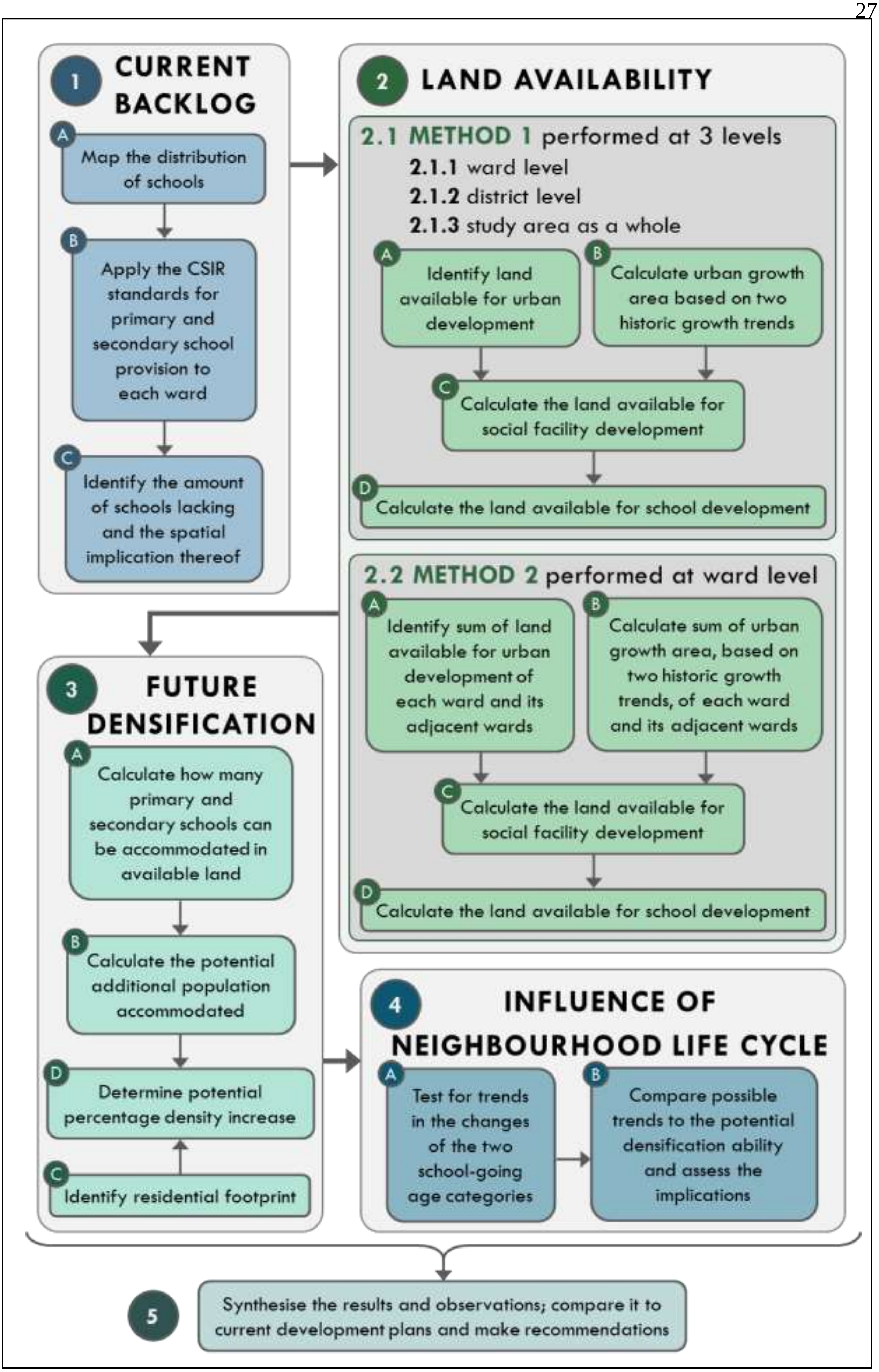

Figure 3-2 Methods used during analysis.

3.3.1. COMPONENT 1: School Backlog

(1-A) For the first component, all the primary and secondary schools registered before the 2011 census were extracted from the Find-a-School website, run by the Western Cape Education Department. Combined schools (schools that teach primary and secondary grades) and intermediate schools (schools that teach a selection of grades such as Gr R to Gr 9) were also extracted. For these two school types, the number of learners per grade were considered to decide if it would be classified as a primary or secondary school for analysis purposes. The CSIR recommends the optimum number of learners in a primary school as 620 learners, and 1 000 for a secondary school (CSIR, 2015). Therefore, for the combined and intermediate schools, where the primary school grades (Gr R to Gr 7) amounted to 620 or more learners, and the secondary school grades (Gr 8 to Gr 12) amounted to 1 000 or more learners, the school was counted as either a primary or secondary school. Using the co-ordinates of the schools, these primary and secondary schools were mapped in ArcMap, Version 10.4.1 (Esri, ArcGIS). They were then counted within each ward to produce a count value of primary schools and for secondary schools per ward.

(1-B) About 14% of a population is of primary school-going age and about 8% of a population is of secondary school-going age (CSIR, 2015). If the optimum number of learners is 620 and 1 000 in a primary and secondary school, respectively, then 14% of 4 428 is 620 and 8% of 12 500 is 1000. Therefore, the total population of each ward within the study area, as recorded in 2011, was divided by 4 428 to determine the current demand for primary schools in each ward. The total population values were also divided by 12 500 to determine the current demand for secondary schools in each ward. The current count of primary schools was subtracted from the current primary school demand to determine the theoretical backlog within each ward. A similar procedure was applied for secondary schools and these values are referred to as the backlog **(1-C)**. The minimum site size for a primary and secondary school is 2.8 ha and 4.0 ha, respectively (CSIR, 2015). The spatial implication of the school backlog was hence calculated by multiplying the backlog value with 4.0 for secondary schools and 2.8 for primary schools. The wards that had a surplus of primary and/or secondary schools, were assigned a backlog value of 0. This value represents the area of land needed to provide the backlog of primary schools and secondary schools, and were summed to determine the total area needed per ward to eradicate the existing backlog of schools (referred to as the ‘School Backlog Area’).

3.3.2. COMPONENT 2: Land Availability

The next component calculated the potential land available for the provision of school facilities. This was performed through two methods. Method 1 **(2.1)** was performed at three spatial levels: ward level, district level, and for the study area as a whole.

First, the eight district spatial development plans of the City of Cape Town (dated 2012) were geo-referenced to the study area in ArcMap and the areas identified for 'New Urban Infill' and 'Mixed Use Intensification' were calculated for each ward (2.1.1-A). The Technical Reports of the district spatial development plans refer to infill sites as some identified for industrial and urban development, while the remaining infill pockets across the districts are identified for residential purposes such as subsidised housing projects. Further, the Cape Town SDF does not specify the ratio between residential, commercial, and industrial purposes for the mixed-use intensification areas. Current research has not yet been able to suggest the ideal relationship between different land uses within such mixed-use areas (Du Plessis, 2015). Based on this background and the context of the study area, all the areas identified as urban infill in the district plans and 50% of the mixed-use intensification areas were used per ward to identify potential available land for new residential development and associated facilities. This represents the land that is available for potential future development of residential areas and associated social facilities in the study area, and is referred to as 'Developable Land'. The Developable Land within each ward was also calculated as a proportion of the total Developable Land within the study area.

t is assumed that the land requirements of the social facilities associated with future urban growth will be accommodated within the land areas identified for future urban growth. The future growth area of the City of Cape Town was estimated based on historic growth trends. Based on a 10-year historic growth rate of 216 ha per annum (Rabe, 2017), the city will grow 3 240 ha over the subsequent 15 years after 2016 used as the base year. In contrast, based on a 20-year historic urban growth rate of 525 ha of growth per annum it will imply a total growth of 7 875 ha over the 15-year period. A period of 15 years of city growth was chosen for this study because the demographic data that is available at a spatially disaggregated level is dated 2011. Adding 15 years to 2011 implies a planning horizon of 2026. This allows for at least two more IDP cycles subsequent to 2017 that can be informed by significant findings or suggestions that this research and related research may produce. Parts of the SDF are reviewed on a five-year basis, which also provides the opportunity for additional amendments in accordance with changes in the IDP and recommendations, from research, for policies. The 2012 SDF is currently under review as the 2017-2022 version is being finalised currently. The 2012 version of the SDF is used in this study because the data sourced is dated closer to 2012 and the 2017-2022 SDF was still open for comments from the public at the time of analysis.

The study area used for this research represents 56% of the total area of the City of Cape Town (a ratio of 0.56:1) although 95.59% of the total population of the City of Cape Town, lived within the study area at the time of the 2011 census (City of Cape Town, 2011). Based on the ratio of the study area to the whole metro, the area of estimated future urban growth to take place within the study area, was thus calculated as 56% of the total growth in the city for the next 15 years **(2.1.1-B)**. This translates into a land area of 1 829.2 ha using the 10-year average historical growth rate and 4 446.1 ha using the 20-year average historical growth rate and is referred to as 'Growth Area'. This area was then allocated proportionally to the various wards relative to the proportion of the total Developable Land located within each ward. **(2.1.1-C)** The proportion of the potentially available land available for the provision of schools and other social facilities resulting from densification of existing development was then calculated by subtracting the School Backlog Area (**1-C**) and the future Growth Area (**2.1.1-C**) from the Developable Land in each ward. The resulting remainder is thus referred to as 'Social Facilities Development Land'.

The primary purpose of this research is to determine the implications of densification for the provision of school facilities. The CSIR Space Planner was thus utilised to determine what proportion of the Social Facilities Development Land should be reserved for school development specifically. The calculation standard used in the tool was Fixed Housing, which indicated the area required for social facilities and housing in the output of the Space Planner tool, based on the developable land that was specified. The average density of 32.73 dwelling units/ha of the study area was specified as input. Roads and parking were specified to take up 15% of developable area, which is the median of the proportion range suggested by the Space Planner (10% - 20%). The CSIR's guidelines for social facility provision offers a hierarchy of settlement catchment types, each with its own optimum standards. There are eight types of catchments, A-H, of which type H is a remote village and type A is a metropolitan city. Table 3-2 lists the facilities chosen from the Type A Catchment facilities standard, which is appropriate for a metropolitan city such as the City of Cape Town (CSIR, 2015). The facilities were chosen based on the criteria of an average travelling distance of up to 15 km and a population threshold of up to 50 000 people which would roughly correspond to a municipal ward and all its neighbouring wards. These criteria were chosen based on the typical population of a ward in the study area and the estimated distance that people would travel to the nearest facility within a ward.

Table 3-2 Social facilities used in the Space Planner calculations.

Facility	Population served per facility	Hectares required per facility	Acceptable travel distance (km)
Community Health Centre	140000	1.5	within 5
Primary Health Clinic (multi-storey)	70000	0.7	within 5
Community Performing Arts Centre	50000	0	10 – 15
Branch Lbrary	70000	0.2	8 - 10
Community Hall - Medium/Small (Fringe Areas)	15000	0.5	15
ITC Access Point	10000	0.001	5
Post Office/ Agency with Post Offices	20000	0.03	5 – 10
SASSA (Social Service Office)	500000	0.1	15
Secondary School (large)	12500	4	5
Primary School (large) with Grade R	7000	3.5	5
Small Creche/ Early Childhood Development Centre	3000	0.09	2
ECD Resource Hub	20000	0.1	5
Urban Park	0	0.4	1
Local/ Neighbourhood Park (includes play Equipment)	15000	1.5	1
Home Affairs - small office	40000	0.02	15
Grassed Surface (2 football field equivalent)	15000	1.2	5

Three different sets of inputs were used in different runs of the Space Planner model, each time using a different developable area. These were firstly the Developable Land, secondly the Growth Area based on the 10-year historic growth rate, and thirdly the Growth Area based on a 20-year historical growth rate. The total areas required for different social facilities differed slightly under the various scenarios, but the combined proportion of land required for primary and secondary schools remained constant at 74.9% of the total land allocated to social facilities. **(2.1.1-D)** A total of 74.9% of the Social Facilities Development Land per ward was thus calculated as the School Development Land for each ward.

The steps followed above to determine the School Development Land is referred to as Method 1. Using the outlines of the districts from the eight district spatial development plans, wards were merged in ArcMap to create eight district regions (Appendix B). The steps of Method 1 were applied to these districts as applied during ward level analysis. However, the values used for each step was each respective district's total Developable Land **(2.1.2-A)**, total Growth Area **(2.1.2-B)**, total Social Facilities Development Land **(2.1.2-C)**, and total School Development Land **(2.1.2-D)**. The same Method 1 analysis steps were thereafter applied to the study area as a whole (a combination of the 107 wards), in which the total values for the study area were used in calculations.

Following Method 1, a different set of steps, which included adjacent wards in calculations, were applied. These steps are referred to as Method 2 **(2.2),** which was performed only at ward level to test if the available development land and growth area in a ward, together with its neighbouring wards, would make a difference to its ability to potentially densify. This rests on the assumption that it is likely for children from one ward to attend a school in a neighbouring or nearby ward. In that sense, some wards may have schools that serve students that reside in a different ward. For Method 2, the variables Developable Land **(2.2-A)**, Growth Area **(2.2-B)**, and School Backlog Area **(1-C)** for each ward was assigned the sum of its own value together with the values of its neighbouring wards' values. Figure 3-3 depicts how Method 2 is applied using Developable Land values as an example. All wards neighbouring Ward X are coloured in various shades of green. A in Figure 3-3 displays the Developable Land area for each ward individually. B in Figure 3-3 indicates the summed area for Developable Land (Ward X's value plus the neighbouring wards' values) which is assigned to Ward X and used in the calculations. The approach for Method 2 was used to overcome the modifiable areal unit problem (MAUP), which can distort visualisation of data as a result of different spatial scales being used during analysis. This is known as the scaling effect.

Figure 3-3 (A) Developable Land of the ward and its adjacent wards. (B) Sum of Developable Land of a ward and its adjacent wards assigned to the ward.

Using the resulting Social Facilities Development Land for each ward **(2.2-C)**, the School Development Land was again calculated as 74.94% thereof **(2.2-D)** for every ward.

3.3.3. COMPONENT 3: Potential for future densification

The third component calculated how much potential densification would theoretically be possible within each ward whilst still maintaining sustainable neighbourhoods with sufficient space to provide for school and other social facilities to cater for this increased population density at acceptable provision standards. A secondary school, of minimum site size 4.0 ha, serves a population of 12 500 people. As a primary school, of minimum site size 2.8 ha, serves 4 428 people, 12 500 was divided by 4 428 to determine how many primary schools should be provided for the population served by each secondary school. This amounted to 2.8 primary schools for every secondary school. One secondary school (4.0 ha) and 2.8 primary schools (2.8 x 2.8 ha) represent a land requirement of 11.84 ha (Figure 3-4).

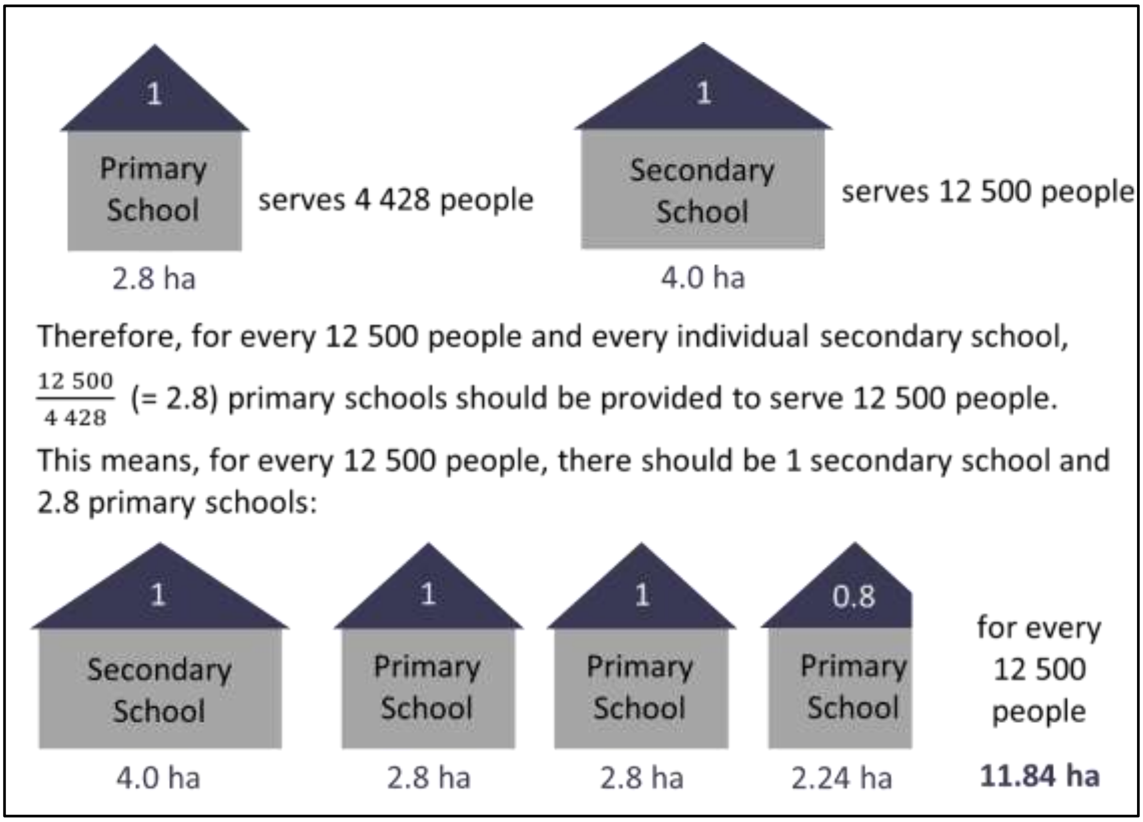

Figure 3-4 Reasoning used for Component 3-A and 3-B.

The School Development Land of every ward was hence divided by 11.84 to determine how many secondary schools can be accommodated within the School Development Land, and this figure was then multiplied by 2.8 to determine how many primary schools can be accommodated within the same area **(3-A)**. As a further step the number of secondary schools that can be accommodated within each ward was multiplied by 12 500 to calculate how many additional people can be served within that ward (after allowing for land to address current backlogs and anticipated 15-year future urban growth) as a result of densification policies. **(3-B)**. The result is referred to as 'Densification Additional Population' and provides an indication of the extent to which each ward can densify in future based on the assumption of providing sufficient social facilities to maintain sustainable human settlements (after allowing for land to address current backlogs and anticipated 15-year future urban growth).

The current population (from the 2011 census) of each ward was added to the Densification Additional Population and divided by the respective residential footprint **(3-C)** per ward, which provided a potential population density (population per residential hectare) for each ward. The difference between the 2011 population density and the calculated potential population density, was then used in a final step to calculate the potential increase in population density from 2011 to what it could potentially be within the next 15 years **(3-D)**. These values are referred to as 'Potential Population Density Increase'.

3.3.4. COMPONENT 4: Influence of Neighbourhood Life Cycle

Neighbourhood life cycles consist of phases based on demographic changes within the neighbourhood. The age-profile of a neighbourhood is slightly different for every consecutive life cycle phase and this typically determines the type of social facilities, such as schools, required by the community. For the fourth component, the general distribution of the school-going population, across the wards within the study area, were visualised. The population from the age-categories 5-12 years and 13-17 years were used for this operation, based on census data from the years 1996, 2001, and 2011. The percentage population increase between 1996 and 2001, and 2001 and 2011, was then determined for these two age categories at ward level. The wards from either or both of the age categories, that continued to increase or decrease in population over these two time periods, were identified **(4-A)**. Thereafter, wards that continued to increase in school-going population over the years, but based on Component 3, do not have the land capacity to provide the required education facilities to a potentially densifying population, were identified **(4-B)**.

The final component consisted of synthesising the findings and comparing the observations to spatial planning policies that are currently in place for the region that includes the study area. From here, recommendations could be made for possible adjustments to the policies to ensure sustainable future densification within the study area.

CHAPTER 4 : RESULTS AND DISCUSSION

4.1. COMPONENT 1: School Backlog

The primary and secondary school backlog that was calculated (**1-C**) indicated that there are no backlogs in wards clustered around the CBD within the study area for either primary or secondary schools (Figure 4-1). For the primary schools (box A), the backlog generally increased towards the urban edge of the region with the highest backlogs (10.8 and 11.3 schools) found in two coastal wards within the Khayelitsha / Mitchells Plain district. In terms of secondary schools (box B), the majority of wards had a backlog of 0 to 2 schools, while there were 14 wards with a backlog between 2 and 4. The highest backlog in secondary schools was 3.7 which was the backlog of the ward that also had the highest backlog (11.3) in primary schools. Generally, there were higher numbers of primary schools lacking than secondary schools at ward level.

The School Backlog Area that was calculated to represent the spatial implication of the backlogs **(1-C)** is presented in Appendix D. The School Backlog Areas at ward level, excluding wards with a surplus of schools, range from just below 1 ha to 46.44 ha. This implies that in order to provide the school facilities, there are wards that will require more than 40 ha of land for school development. The total land required within the study area to eradicate the backlog is estimated at 1265,93 ha. This represents at least 302 primary schools and 104 secondary schools that were still required to serve the 2011 population, according to CSIR standards. The City of Cape Town's 2012 SDF explains the partial purpose of its densification policy as providing increased accessibility in high-density urban developments, which supports the idea of improving access to social facilities. The review of the City's IDP for 2016/2017 emphasises the need to cluster social facilities so that members of communities are close to a variety of amenities, including schools. Improving access to schools will ensure that existing school facilities are being used optimally and that new schools are built in locations with easy access

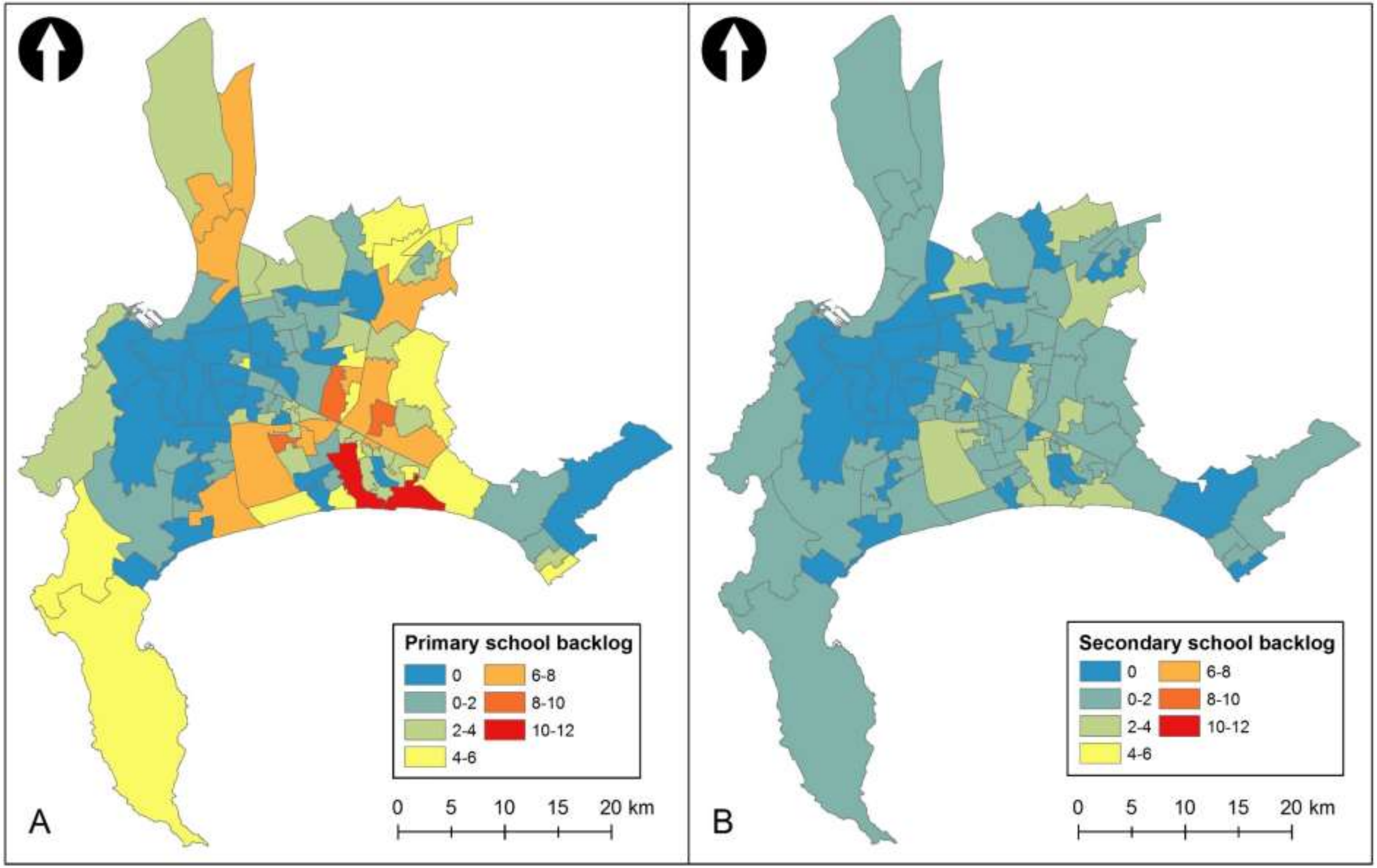

Figure 4-1 Distribution of primary (A) and secondary (B) school backlog at ward level.

4.2. COMPONENT 2: Land Availability

The Developable Land areas that were calculated are illustrated in Appendix C. The map in Appendix C shows small pockets of land identified for urban infill across the study area. The areas identified for mixed use intensification are generally along major transport routes. There are large portions of urban infill identified towards the northern urban edge of the study area (Wards 8, 23, 101, 103, 104, and 107). The only significant region identified for mixed use intensification, despite the areas along transport routes, is in the south-east, in ward 15.

The School Development Land calculated in Component 2 for the eight districts (**2.1.2-C**) and the study area as a whole (**2.1.3-C**) are displayed in Table 4-1. The Blaauwberg District has significantly larger School Development Land compared to the other districts, while the Cape Flats District is at the lowest end of the range. The school backlog area, which decreases the amount of land available for new school development, also explains the significant difference: Blaauwberg District has a School Backlog Area of only 95.91 ha, while that of Cape Flats District is 174.83 ha.

Table 4-1 School Developable Land of the districts and the study area.

SPATIAL REGION	Method 1: 10-year growth trend	Method 1: 20-year growth trend
Cape Flats district	169.6	61.2
Helderberg district	263.0	152.7
Southern district	297.0	173.9
Tygerberg district	347.4	170.8
Table Bay district	355.9	214.7
Khayelitsha / Mitchells Plain district	456.5	155.7
Northern district	521.2	295.6
Blaauwberg district	2076.0	1301.0
Study area	4486.6	2525.6

Compared to the 10-year historic growth trend, using the 20-year historic growth trend produced larger areas of growth required for 15 years of growth and development within the study area. This resulted in a decrease in the land available for social facility development across all spatial levels that were evaluated in Component 2's calculations.

The School Developable Land calculated at ward level is presented in Figure 4-2, showing both the results for Method 1 and Method 2 with the 20-year growth trend applied. Using Method 2 yielded much larger areas of School Developable Land. This is due to the fact that during this operation each ward was assumed to be able to make use of available land in all adjacent wards for the purposes of social facility development.

4.3. COMPONENT 3: Potential for future Densification

The Potential Population Density Increase calculated at district and study area level, using the 10-year growth rate, is presented in Table 4-2. The Blaauwberg District and Cape Flats District were at the higher and lower ends of the value ranges again, respectively. In some cases, the potential additional population of a ward may have been large, but its densification ability lower than a district that had a small potential additional population, such as with the Khayelitsha / Mitchells Plain District and Tygerberg District. This was due to the potential densification ability that was calculated as percentage increase from its current (2011) population density. The densification ability is therefore relative to the demographic profile of each district.

The ward level results of the steps in Component 3 are presented in Appendix E (Method 1) and Appendix F (Method 2). These results show that there are wards that cannot accommodate any additional schools according to both Method 1 and 2, at either of the two historic growth rates. Therefore, these wards also cannot accommodate a larger population or increased density and thus have a zero potential percentage density increase ability. Using Method 1 calculations, there are 32 and 42 of these wards when applying the 10-year and 20-year historic growth trend, respectively.

Table 4-2 Component 3 results at district and study area level, using a 10-year historic growth trend.

SPATIAL REGION	Method 1: 10-year growth trend		
	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Population Density Increase (%)
Cape Flats district	14.3	40.1	28.6
Khayelitsha / Mitchells Plain district	38.6	107.9	44.6
Tygerberg district	29.3	82.1	53.1
Southern district	25.1	70.2	114.8
Helderberg district	22.2	62.2	149.6
Table Bay district	30.1	84.2	158.7
Northern district	44.0	123.3	195.5
Blaauwberg district	175.3	490.9	1152.5
Study area	378.9	1061.0	132.8

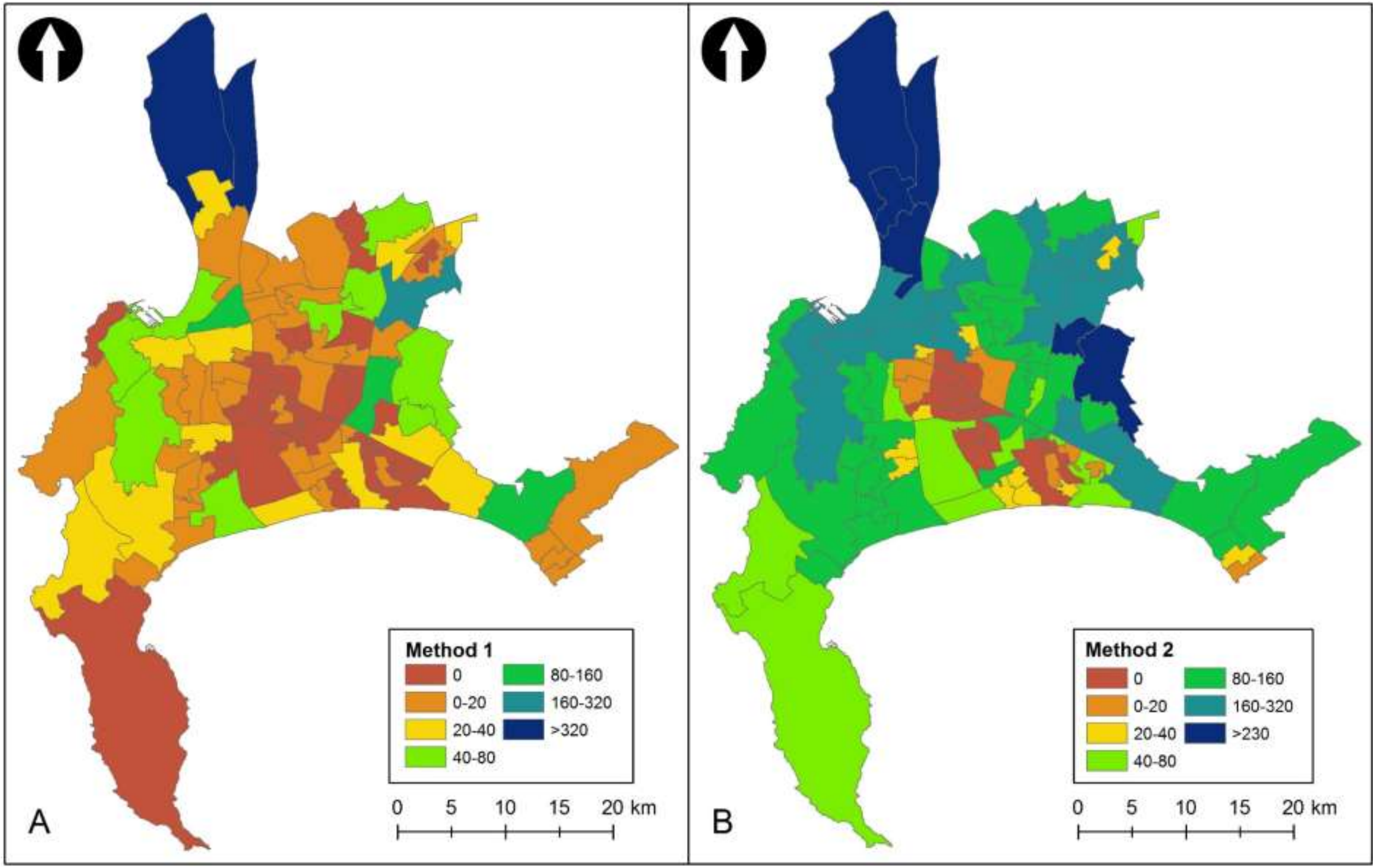

Figure 4-2 School Developable Land using a 20-year historic growth trend for Method 1 (A) and Method 2 (B)

The differences between the results of the two historic growth trends for both methods used, are visualised in Figure 4-3 and Figure 4-4. The closer the colour of the ward is to blue, the higher its population density increase potential. The wards that are coloured red, have no densification potential based on current social facility provision standards. In Figure 4-3(A), the red wards are centrally located within the study area and are clustered in some cases such as in the north of the Cape Flats district. In box B, many of these wards remain red and some of the wards neighbouring these are also red with the 20-year growth trend applied in calculations, indicating a decrease in densification ability within the central wards of the study area. Wards with very high potential percentage density increase abilities, such as above 200% (dark and light blue wards), are mostly located closer to the urban edge.

The distribution of potential densification ability produced by Method 2, is presented in Figure 4-4 by using a potential densification index based on the results of Component 3. The results were normalised to a scale of 0 to 100 and not as absolute values based on land areas because and not as absolute values based on land as the index provided gives an indication of the overall effect when a ward's developable land is considered jointly with that of its neighbours. Wards in Figure 4-4 with an index of 0 are located in the centre of the study area. These wards are more or less surrounded by wards with an index of up to 5. The index generally increases outwards, resulting in wards with indexes of up to 20 on the edges, and up to 100 on the far outskirts. Only three wards have an index above 50, which are located in a cluster in the top north region of the study area. Comparing the results in box A to box B, the most noticeable change is the central wards that undergo a decrease in index from the category 5 to 10, to the category 0 to 5. On the outer edges, the application of the 20-year growth trend did not make a large difference. However, the wards that are on the western, northern, and eastern edges of the study area, generally have an index above 10. Overall, there appears to be a circular pattern of increasing potential densification index value from the central and south eastern parts of the study area to the outer edge of the study area.

In Figure 4-5, intensification areas that were identified in a conceptual development framework of the 2012 SDF of the City of Cape Town was overlaid on the Potential Densification Index produced (Figure 4-4). This framework provides a flexible, general 50-year growth vision for the municipal region of Cape Town. Both boxes in Figure 4-5 show that the intensification areas intersect sections of some wards that have a Potential Densification Index of 0, such as those in the Cape Flats and Khayelitsha / Mitchells Plain districts. Some intensification areas also cross wards that have an index of 0 to 5, especially in box B, which shows the results from applying the

20-year growth trend. This implies that the City has a long-term vision to densify and intensify in some areas that cannot realistically accommodate any densification due to lack of available land to provide sufficient school facilities. However, there are also many portions of the intensification areas that intersect with wards that have a Potential Densification Index above 10, such as those east and south of the CBD. These results clearly indicate the need for a more nuanced and quantified bases for identifying areas for future densification in spatial planning processes.

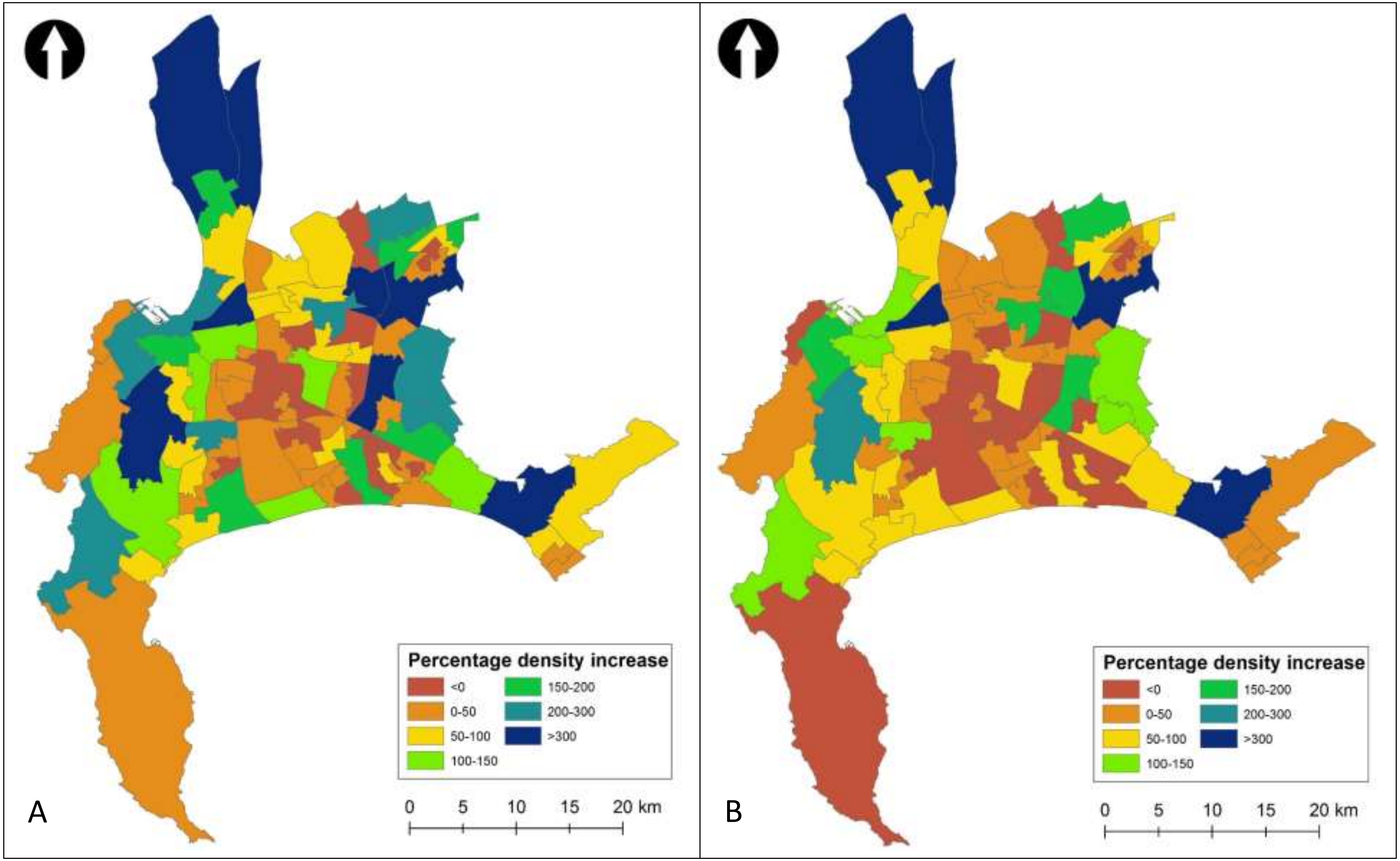

Figure 4-3 Potential Percentage Density Increase using Method 1 with a 10-year growth trend (A) and a 20-year growth trend (B).

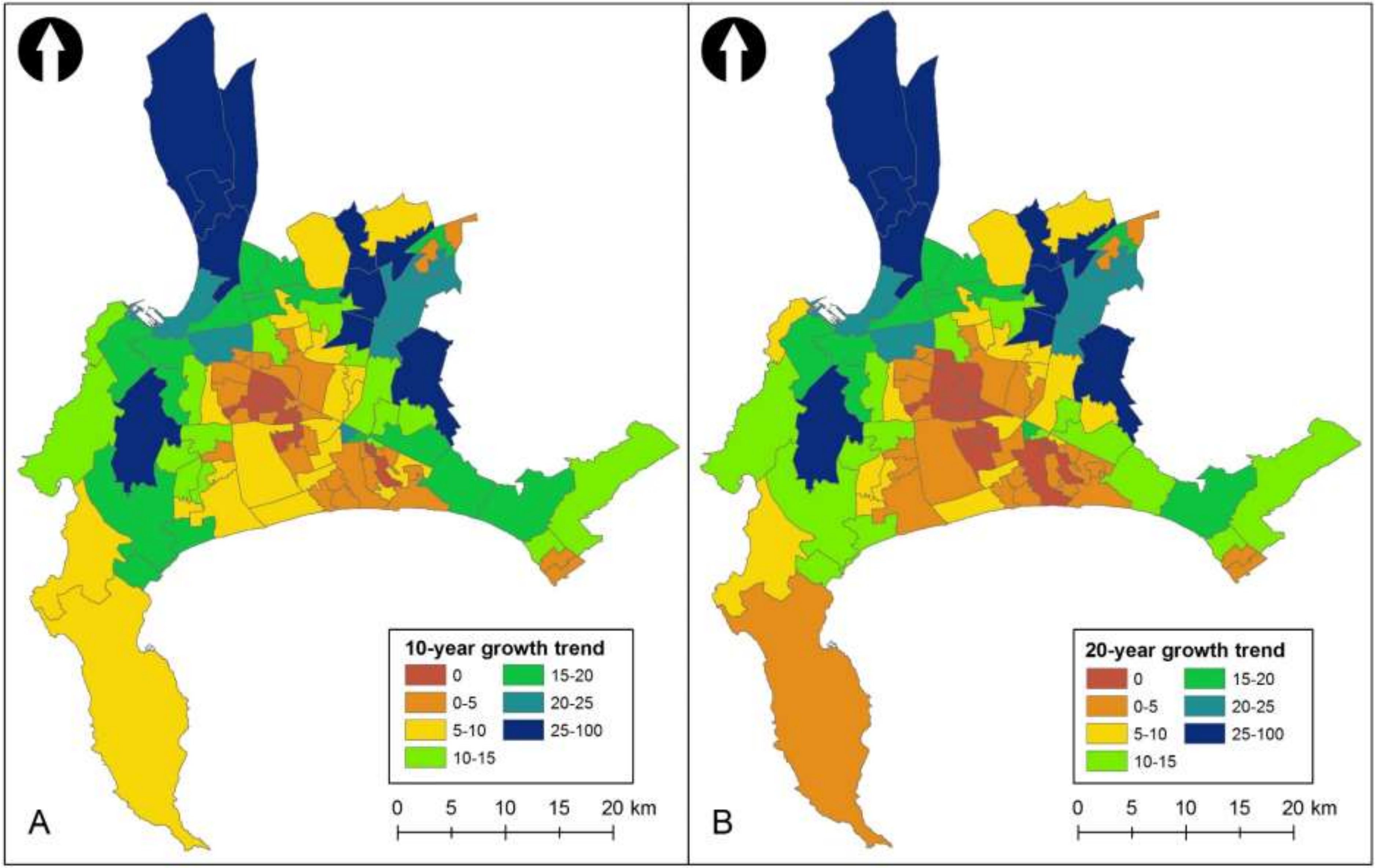

Figure 4-4 Potential Densification Index based on Method 2 with a 10-year growth trend (A) and a 20-year growth trend (B).

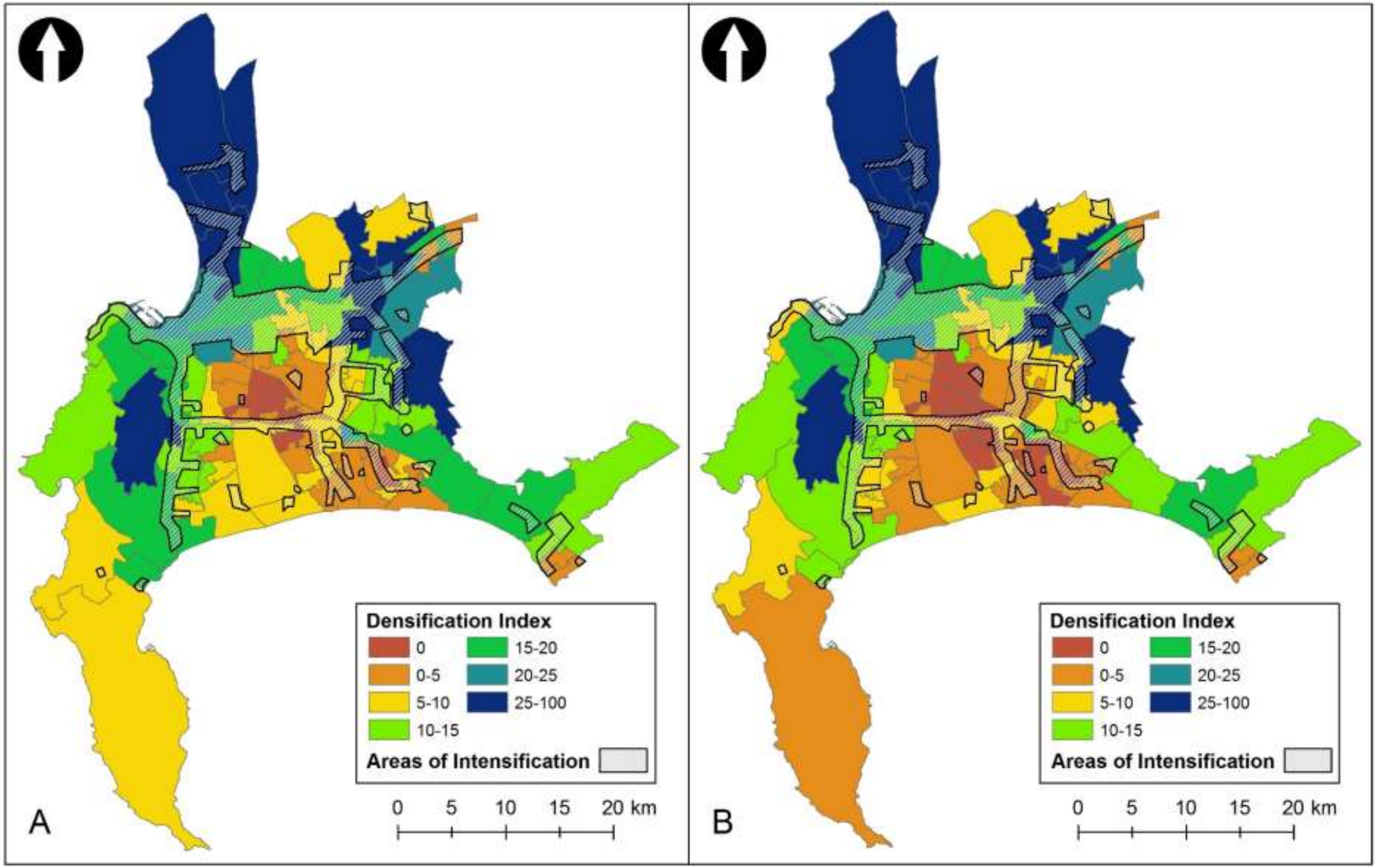

Figure 4-5 Potential Densification Index of wards using Method 2, based on the (A) 10-year growth trend and (B) 20-year growth trend, overlaid with identified densification areas. Refer to Figure 4-4.

4.4. COMPONENT 4: Influence of Neighbourhood Life Cycle

The percentage population increases of the age category 5-12 years (primary school going age) and 13-17 years (secondary school going age) are presented in Figure 4-6 and Figure 4-7, respectively. For each of the two figures, box A shows the percentage increase between 1996 and 2001, and box B shows the percentage increase between 2001 and 2011. For both time periods, the primary school-going age population had a decrease in numbers in most wards. From 1996 to 2001, the wards with a decreasing primary school population are fairly dispersed in the central region of the study area, while for the period 2001 to 2011 in box B, the wards with a decreasing population are located more towards the south. In the case of the secondary school-going age population, there were few wards with a decreasing population over the first time period, but many wards with a decreasing population over the second time period. From 1996 to 2001, these wards are located close to the CBD, while from 2001 to 2011 these wards are more dispersed across the study area, towards the south, north, and east.

Figure 4-8 shows which wards had the same trends in their school-going population from 1996 to 2011. Box B of Figure 4-8 indicates the wards that experienced an increase in its primary school-going population from 1996 to 2001, as well as from 2001 to 2011. Box C shows the opposite thereof: the identified wards experienced a continuous decrease in this population over the same time periods. Box D and box E show the same increasing and decreasing trends, respectively, over the same time periods, but for the secondary school-going population. It is clear that the wards with an overall increasing population for these age categories are generally located closer to the urban edge of the city. Those with a decreasing population are more centrally located. This observation can be related to the tendency of families with young children to move to neighbourhoods that are further away from the city centre, which may form part of urban sprawl (Turok, 2011).

When these trends were compared to the densification ability of the wards **(4-B)**, some wards were identified that had an overall increasing school-going population, but had no potential density increase ability. These wards are presented in Figure 4-9, using Method 1. Box B and C refer to the primary school-going age category and box D and E refer to the secondary school-going age category. Box B and D present the results from calculations using the 10-year growth trend, while box C and E present the results from calculations using the 20-year growth trend. Generally, the wards that displayed an increasing school-going population trend, while having no or limited potential densification ability, are located within the Tygerberg, Cape Flats, and Khayelitsha /

Mitchells Plain districts, mostly adjacent to each other. For both age categories, the wards that displayed this increasing population phenomenon when using the 10-year growth trend, were also identified among the wards that exhibited the phenomenon when applying the 20-year growth trend. This is due to the fact that with the 20-year growth trend, less land is available for development, which decreases the ability to potentially densify.

When the young population of a neighbourhood increases, it is a sign of a neighbourhood entering its first two phases of the life cycle (Figure 2-1 and Table 2-1), which can last around 20 years. This means that over those 20 years, schooling facilities will be in higher demand than before while the opposite will be true for areas where the population in these age categories are decreasing. It is therefore crucial that trends in school-going populations are evaluated together with the land development requirements to predict which neighbourhoods may experience the highest demand for schools in future. In Figure 4-1, the wards with higher backlog values are generally located on the eastern edge of the study area, which intersects with the wards in Figure 4-8 that have an increasing school-going population. One could infer that this increasing population was not predicted and planned for, resulting in a larger backlog in the corresponding wards and hence a lower potential densification ability in some cases. For the wards that experienced a decrease in their school-going population, it would be worthwhile to plan ahead in terms of school facilities for the next life cycle of these wards when young families might move to these neighbourhoods. This may be especially true for the wards near the city centre where urban infill and densification is focussed.

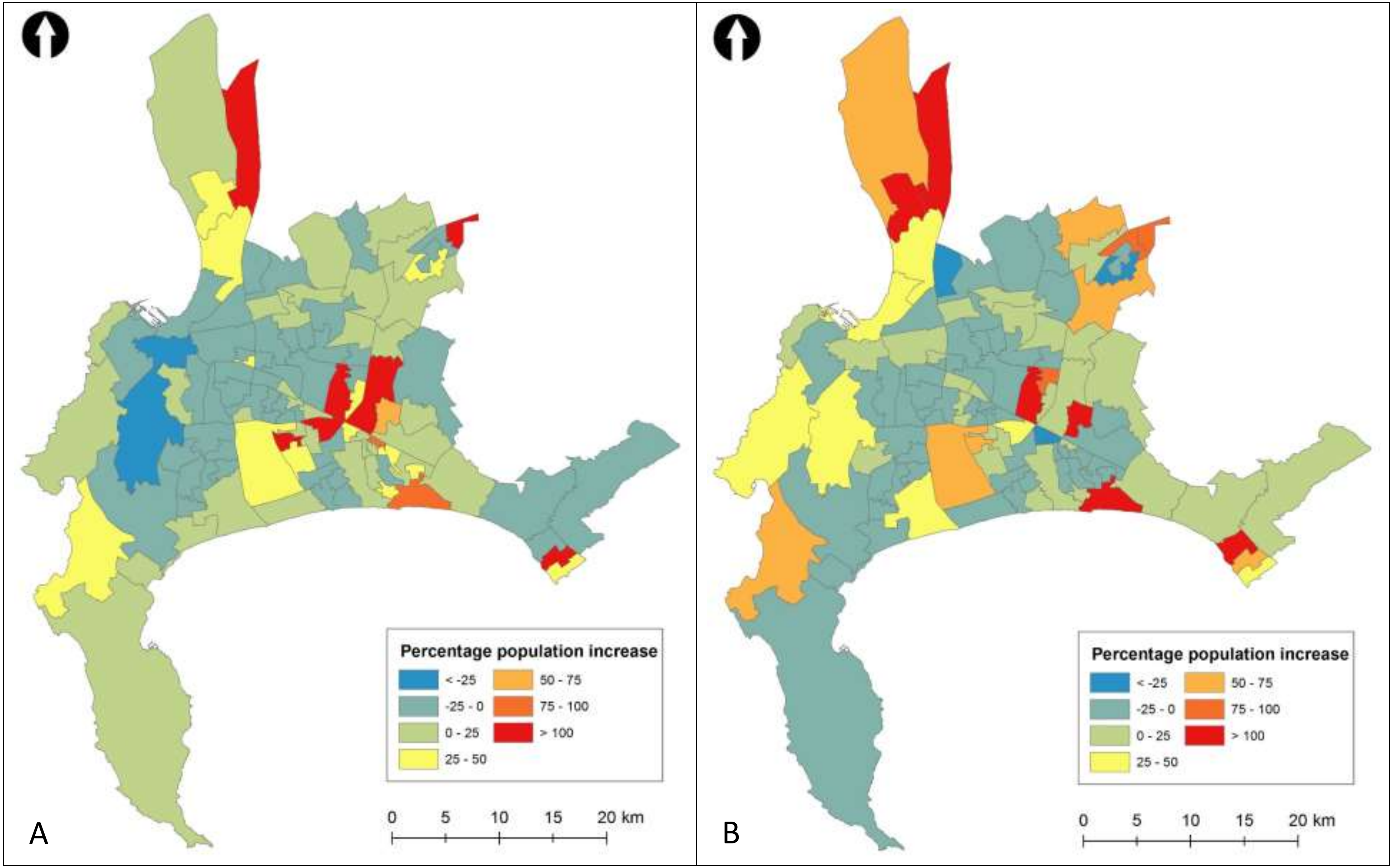

Figure 4-6 Percentage population increase per ward in the age category 5-12 years, from 1996 to 2001 (A) and 2001 to 2011 (B).

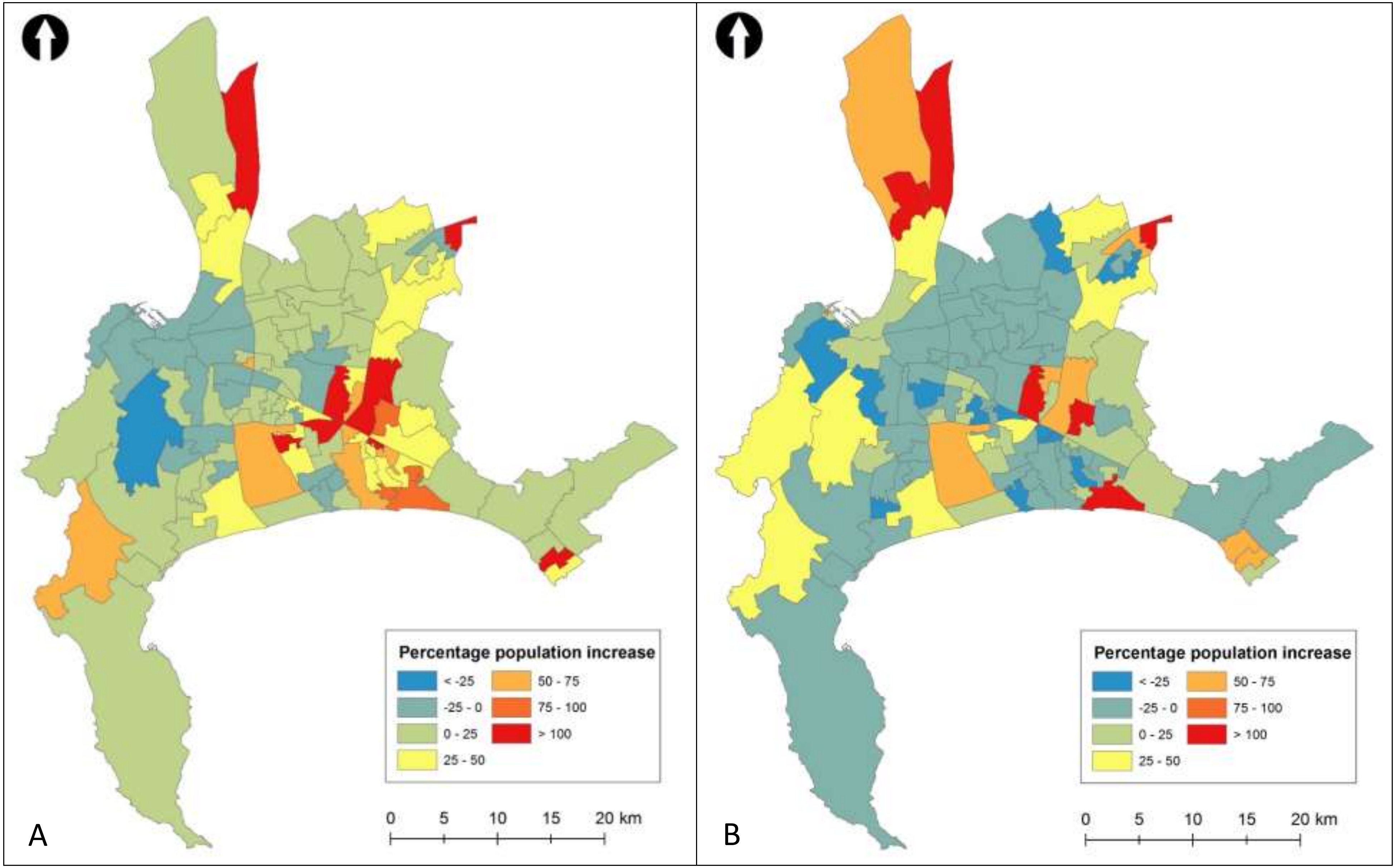

Figure 4-7 Percentage population increase per ward in the age category 13-17 years, from 1996 to 2001 (A) and 2001 to 2011 (B).

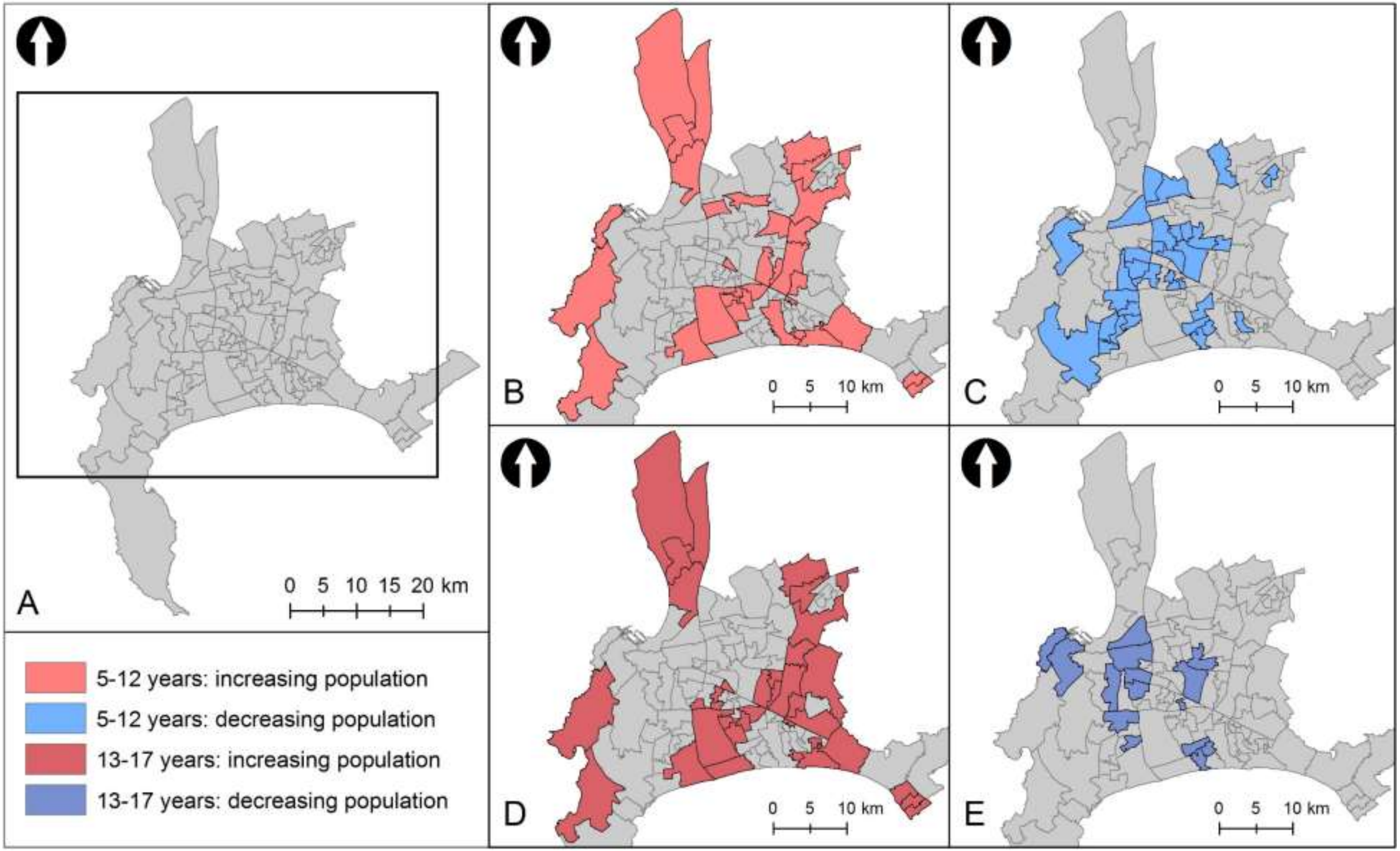

Figure 4-8 Wards that had an increasing population (B and D) and a decreasing population (C and E) in the two school-going age categories, from 1996 to 2011.

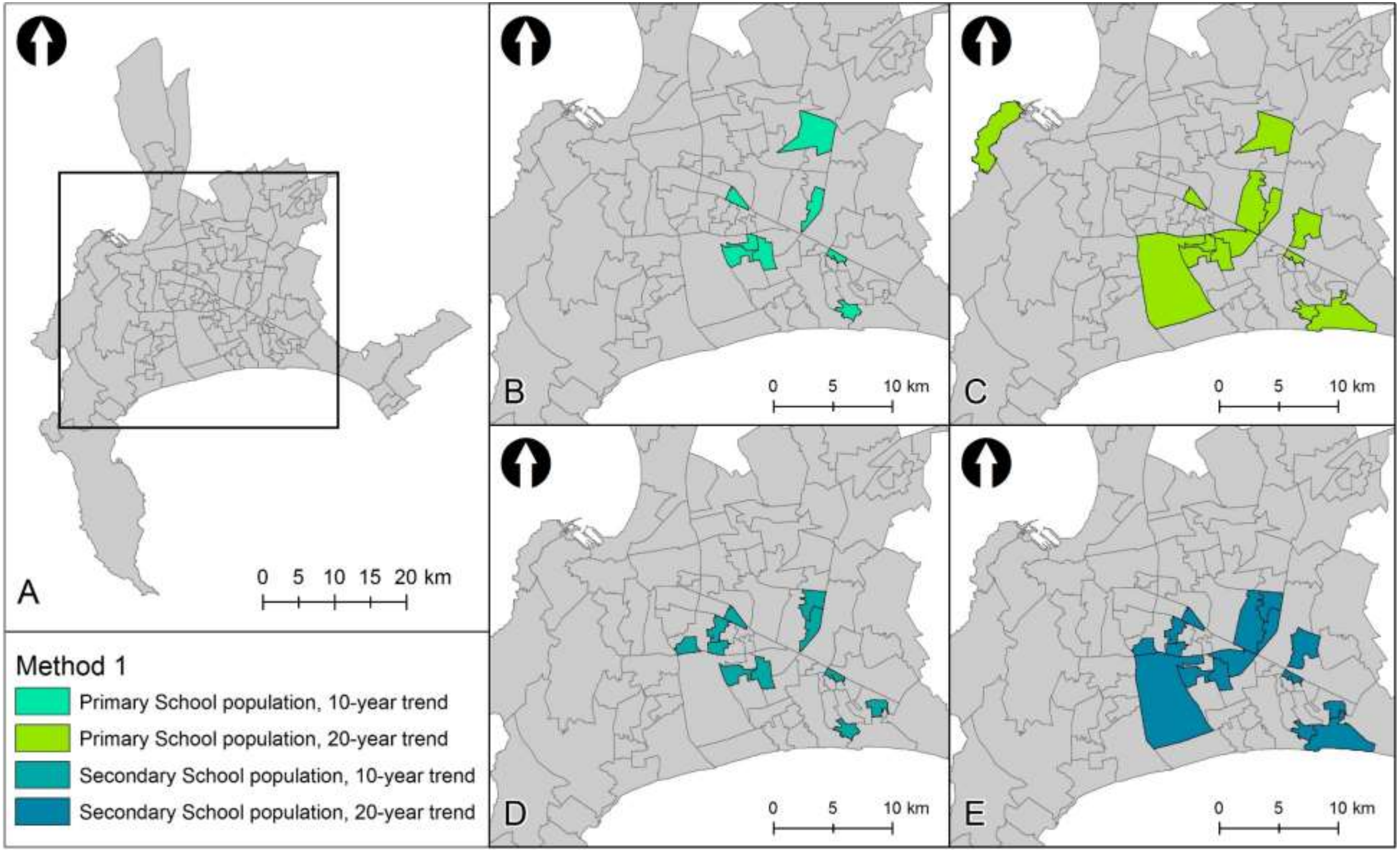

Figure 4-9 Wards with an increasing school-going population from 1996 to 2011, but with 0% potential ability to increase in density when using Method 1.

4.5. COMPONENT 5: Synthesis

The results discussed in the previous sections of this chapter reveal that there is a variety of school backlogs across the wards within the study are and that this, combined with the distribution of identified developable land, influences how much land is available within the wards to eradicate the school backlog and to provide school facilities demanded by future urban growth. Some wards, especially those on the urban fringe, have much more land available for this purpose, while some wards have theoretically no available land. The urban growth that plays a role in determining land availability, was calculated in minimum and maximum amounts, based on a 10-year and 20-year historical growth trend. The latter growth trend decreased available land noticeably which reduced the land available for future education facility provision. However, by considering school developable land in neighbouring wards which takes a somewhat broader view on the provision of social facilities not constrained within ward boundaries, individual wards generally showed higher levels of densification potential.

Using Method 1 while applying the 20-year growth trend, the optimum development density ranged from 30.4 to 7 029.2 people/residential ha. In contrast, the 10-year growth trend combined with Method 2 produced optimum development densities from 123.6 to 28 723.7 people/residential ha. Considering all methods and growth trends applied, the potential percentage population density increases ranged from a minimum of 0 to 2 317.3 and a maximum of 0 to 6 181.9. These levels of densification accommodate the school backlogs and future education facility needs. In some instances, the results revealed large backlogs and low densification potential. This requires urgent attention from planning authorities and policies, such as those described in the City of Cape Town SDF. The 2012 SDF of the municipality discusses schools as facilities that should be included among those that require easy access as part of high-density development promotion. However, the SDF does not evaluate the state of education facilities, specifically. Schools are broadly included in social facilities that should be planned for with high-density development in mind. Based on the results and discussion above, it is crucial that a spatial planning document such as the SDF more specifically considers how densification will influence future schooling facility provision, so that other social facilities are planned for appropriately and that the education facility demand is met.

CHAPTER 5 : CONCLUSION AND RECOMMENDATIONS

5.1. Summary of findings

The overarching aim of this research was to determine the impact of increased population densities in the City of Cape Town on the availability of adequate land for schooling provision.

The first objective was to determine potentially available land for social facility development in the study area, specifically education facilities. The social facility land that was calculated, was used to determine how much land is available for schooling facility provision at ward, district, and study area level. The results revealed limited to no land available in the central wards of the study area, with larger portions of developable land towards the edge of the study area, specifically the northern most wards. Applying two growth-trends revealed that the 20-year growth trend limits the amount of available land due to a higher historical rate of urban growth over this period. The two Methods used during calculations suggested that the second method, which considers available land in neighbouring wards, increases the densification potential of wards. The largest area of School Development Land calculated using Method 2, at a 20-year growth rate, was 1 253.5 ha.

The second objective stated for this study was to evaluate the land requirements and relative scarcity of land for education facilities associated with existing backlogs and projected future population growth, through the application of the CSIR social facility provision standards. The backlog of primary and secondary schools was based on optimal CSIR school class size and site size standards which indicated which wards had a backlog of schooling facilities and to what degree. The largest backlog calculated is in the same ward, located on the coast of the Khayelitsha / Mitchells Plain district. Some wards had a zero backlog due to a surplus in schools. Calculations involving the spatial implication of the backlogs, school developable land, and growth areas, provided an estimate of the potential future population growth, based on the available land to provide education facilities. Some wards cannot accommodate further population growth due to lack of available developable land and the degree of school backlog. The results showed that substantial densification of the study area is indeed possible from the social facility provision perspective, but not always at ideal locations as envisaged by the SDF and in many cases in areas closer to the urban edge.

The third objective was to determine the optimum development density and/or densification threshold range in Cape Town at ward level from the perspective of existing available land and the need for land to provide education facilities. The optimum range was identified by determining a minimum and maximum density increase and densification threshold range. For the threshold, the minimum and maximum percentage density increase was 0 to 2 317.3, and 0 to 6181.9, respectively. The optimum densities ranged from 30.4 to 7 029.2 people/residential ha as a minimum and 123.6 to 28 723.7 people/residential ha as a maximum. Using these results, an index was created to provide a practical measure of a ward's densification ability in relation to the wards of the study area. On a scale of 0 to 100, most of the wards had an index below 20. The results of the index operation were compared with a conceptual development framework which indicates areas earmarked for future intensification. These revealed areas that cannot densify further, but intersect with intensification areas. Many intensification areas, however, do align with wards that have higher potential densification index values in relation to other wards, especially those towards the edge of the study area. These results clearly indicate the need for a more nuanced and quantified bases for identifying areas for future densification in spatial planning processes.

The fourth objective was to calculate the changes in school-going population of the study area from 1996 to 2011 at ward level and evaluate the implications thereof. The school-going population data was evaluated to discover trends across the three census years. The wards that had an increasing and decreasing trend across the years were identified for both primary school-going ages and secondary school-going ages. The results showed that generally, the school-going populations are increasing in the wards that are located towards the urban edge of the study area. There are central wards in the study area, close to the CBD, that have been experiencing a decrease in its school-going population. The wards that have increasing populations, but cannot densify further, were identify in order to emphasize that improved planning is required in these areas for education facility provision to address the current backlog, as well as the future need that is likely to arise. This was linked to the changing phases of the neighbourhood life cycle and how an evaluation of such changes within wards should inform the spatial planning for education facilities in advance.

Based on the discussion above, the study was successful in achieving its aim and objectives. The implications of the results are further discussed below.

5.2. Policy Implications

The urban planning framework of South Africa has adopted a vision for densification since the first post-Apartheid planning policy publications. However, to find the most effective strategies for densification, stakeholders and authorities adapt policies and plans accordingly. However, due to changing circumstances and the constant changes in population profiles, it is important to plan ahead for the population of the city at every stage of densification. The neighbourhood life cycle is one starting point that could give insight into the current and future needs and demands of a community. The sustainability of a densifying city becomes threatened when social facilities are not adequately planned for. Education facilities were used in this study as an example of densification potential being limited by backlogs in facility provision and possible lack of planning in advance for the future demands of neighbourhoods. Consequently, the disadvantages of densification could begin to outweigh the advantages thereof. It also implies that a more nuanced and quantified approach is required for identifying areas for future densification in spatial planning processes.

Planning policies such as Cape Town SDF and Densification Policy, both released in 2012, do not clearly make provision for specific and informed social facility planning, specifically education facilities, with future densification impacts in mind. Social facilities are treated as one entity that require planning to ensure efficient and sustainable high-density urban systems. But, as this study shows, more specific planning, guidelines, and standards are required in these policy document to ensure a working and healthy urban system as it densifies. Addressing the different requirements of different types of social facilities would be beneficial to the formation of social facility clusters which are already promoted in policy documents. The pace of urban renewal and regeneration should also be evaluated in relation to the rate at which social facilities provision is feasible.

5.3. Potential shortcomings and future research

The lack of data availability proved to be one of the biggest limitations during this research. Age profile data from censuses were only available for three census years, which allowed a fairly short time series from which to evaluate trends. The latest census data that were available was dated 2011. More recent data would have been ideal, such as the 2016 Community survey. Unfortunately, the Community survey data set is only available at municipal level, which is not appropriate for the spatial level of analysis used in this study. Comparing spatial data from different years is challenging due to the changing spatial boundaries in South Africa. Due to a lack in literature, an assumption was made regarding the proportion of mixed-use intensification areas to use in calculations as residential land use. The modifiable areal unit problem (MAUP) as a limitation in this study. By using different spatial levels during the presentation of the results, the scaling effect can cause the interpretation of the results to be different, even if the same analysis was performed.

In future, related research could potentially evaluate additional social facilities and use more recent census data to determine measures of potential densification more true to the current situation and level of development. Alternative standards for social facility provision, provided by the CSIR, could be explored, as well as the possible amendments made to the 2012 version of the City of Cape Town SDF.

5.4. Value and contributions of this research

This research did not aim to identify optimal school locations, but to use schooling facilities as an indication of the potential densification ability within the study area. The methods used here allow for estimated minimum and maximum measures of density and can be adapted to different types of settlements based on the CSIR standards for social facility provision. This study proved the importance of including a detailed evaluation of the impact of densification on social facility provision in planning policies and provides a feasible methodology with which to perform such evaluations at different spatial scales.

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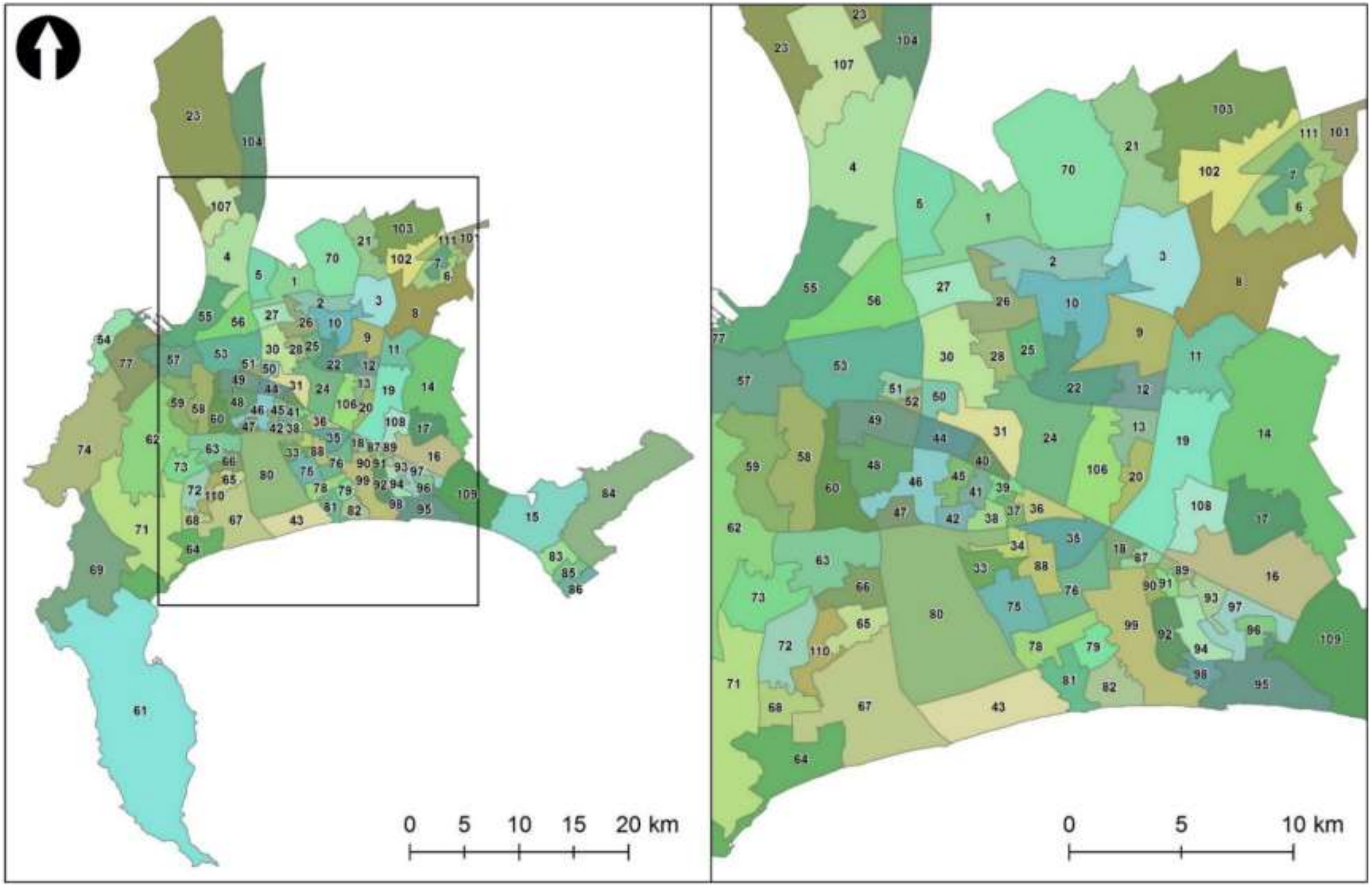
APPENDICES

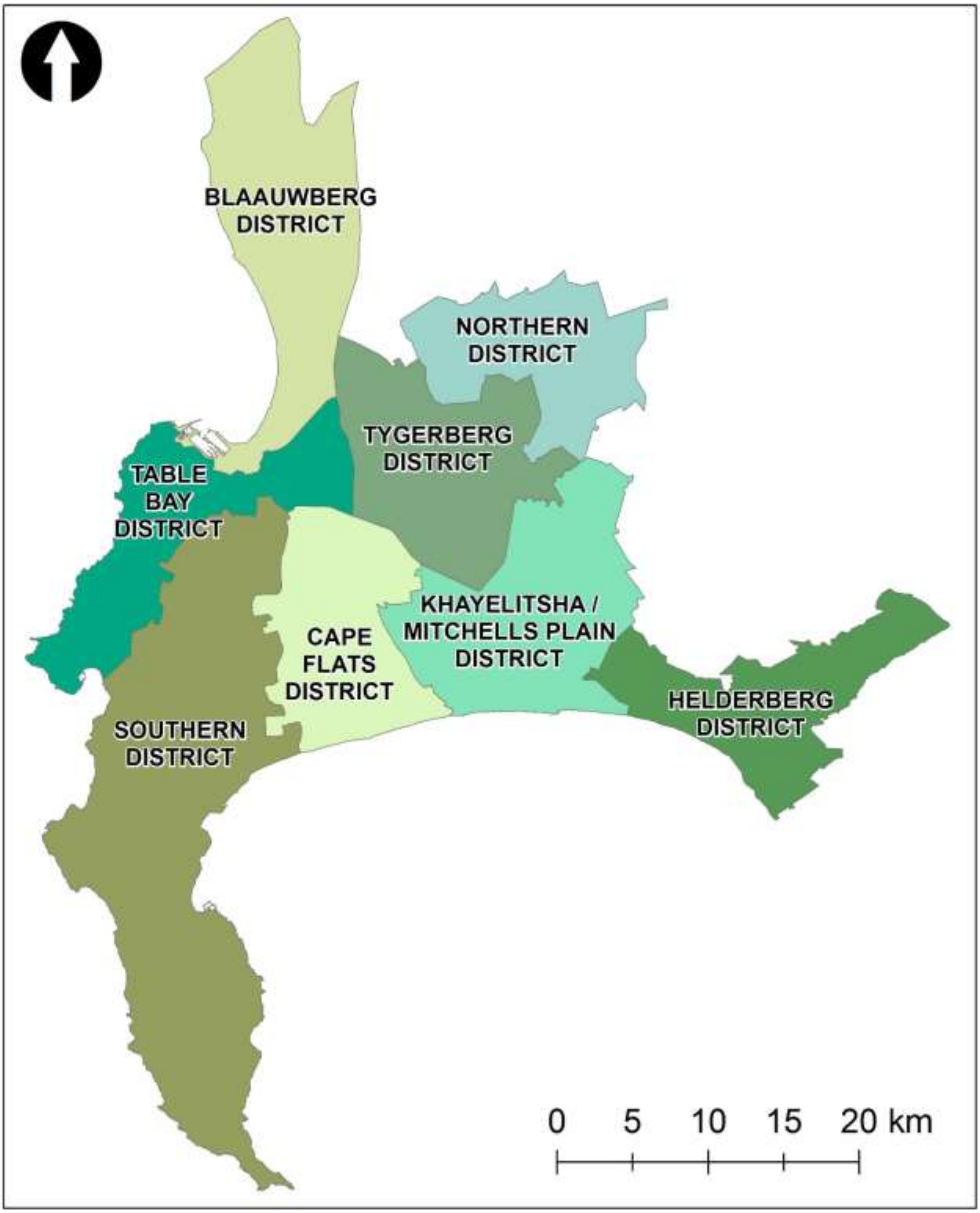
Appendix A

Wards within the study area with their unique ward number.



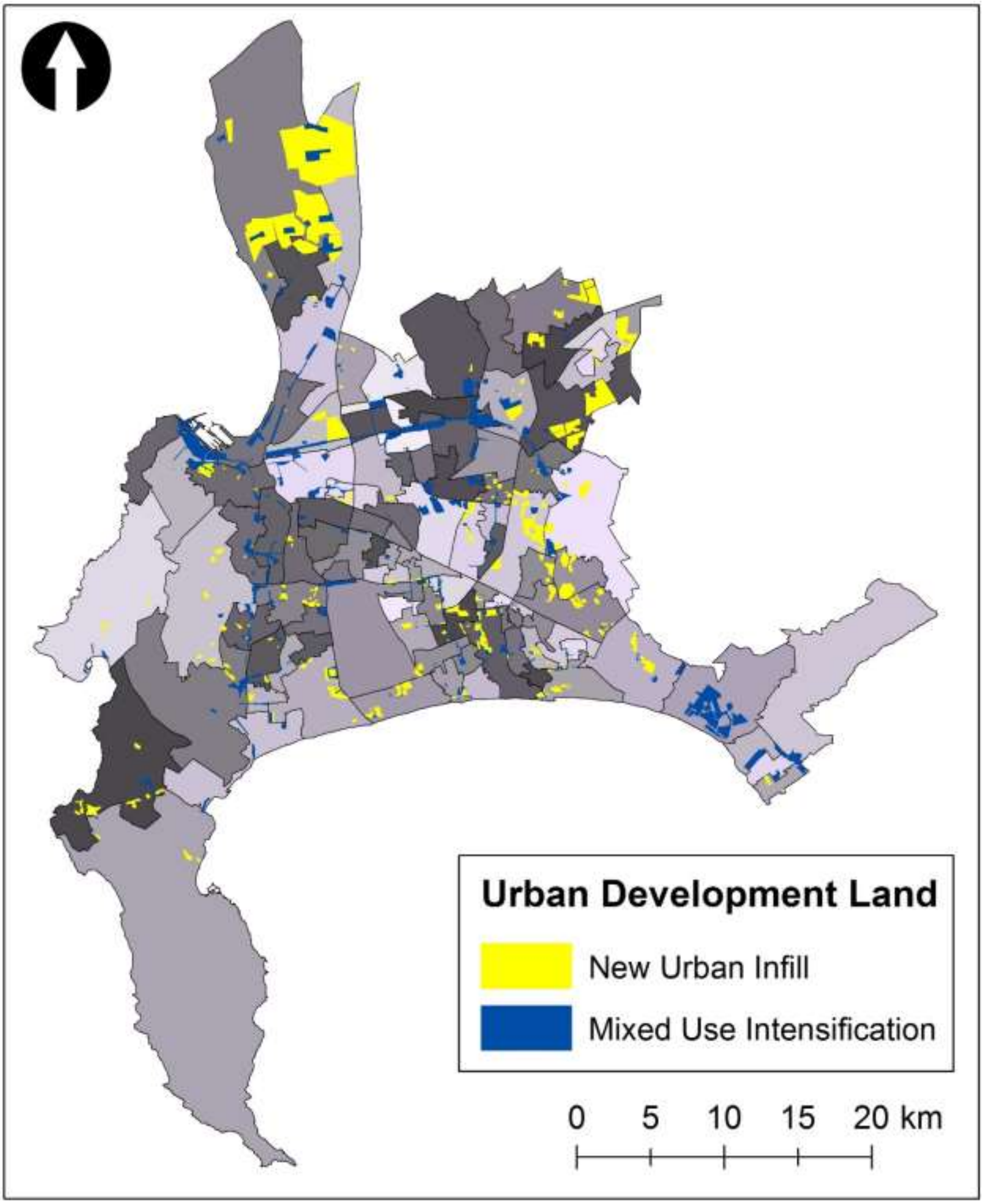
Appendix B

Eight districts made up of wards that correlate roughly with the eight district spatial development plans.



Appendix C

New Urban Infill and Mixed Use Intensification (Developable Land) areas as captured from the City of Cape Town District SDFs (2012)



Appendix D

Primary and secondary school backlog and spatial implication thereof.

Ward name	Primary school backlog	Primary school backlog area (ha)	Secondary school backlog	Secondary school backlog area (ha)	Combined primary & secondary school backlog area (ha)
1	3.1	8.6	2.2	8.6	17.2
2	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.6	2.2	2.2
4	6.2	17.5	0.3	1.1	18.6
5	2.6	7.2	0.0	0.0	7.2
6	2.3	6.4	0.0	0.0	6.4
7	1.0	2.7	1.5	5.9	8.5
8	6.5	18.3	3.0	12.1	30.3
9	2.6	7.3	0.3	1.4	8.7
10	0.9	2.5	1.4	5.8	8.3
11	2.4	6.8	0.3	1.3	8.1
12	5.0	14.0	1.8	7.3	21.3
13	6.3	17.7	1.7	6.6	24.4
14	4.8	13.4	1.5	5.9	19.2
15	1.1	3.1	0.0	0.0	3.1
16	6.7	18.9	1.4	5.8	24.7
17	3.3	9.2	0.3	1.1	10.3
18	2.0	5.7	0.0	0.0	5.7
19	7.3	20.5	1.4	5.4	25.9
20	4.4	12.4	1.3	5.4	17.8
21	1.9	5.2	0.0	0.0	5.2
22	0.0	0.0	0.0	0.0	0.0
23	3.6	10.0	1.7	6.7	16.7
24	1.3	3.5	1.2	4.9	8.4
25	1.1	3.0	0.2	0.9	3.9
26	0.9	2.6	1.5	5.8	8.5

Ward name	Primary school backlog	Primary school backlog area (ha)	Secondary school backlog	Secondary school backlog area (ha)	Combined primary & secondary school backlog area (ha)
27	1.3	3.8	0.0	0.0	3.8
28	1.0	2.7	0.5	1.9	4.6
30	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.8	3.3	3.3
33	8.9	24.8	2.5	10.0	34.8
34	3.8	10.5	1.8	7.0	17.6
35	6.0	16.9	1.2	4.8	21.8
36	2.7	7.6	0.7	2.9	10.5
37	2.0	5.6	0.8	3.1	8.7
38	0.0	0.0	0.7	2.6	2.6
39	3.5	9.9	2.0	7.8	17.7
40	1.4	4.0	2.3	9.1	13.1
41	0.7	2.1	0.0	0.0	2.1
42	3.3	9.4	0.2	1.0	10.3
43	4.1	11.5	1.2	4.9	16.5
44	0.8	2.2	0.8	3.0	5.2
45	0.9	2.4	0.8	3.1	5.5
46	0.0	0.0	1.7	6.8	6.8
47	3.8	10.7	1.8	7.1	17.8
48	0.0	0.0	0.0	0.0	0.0
49	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.6	2.6	2.6
51	1.3	3.5	0.0	0.0	3.5
52	5.6	15.6	1.0	3.9	19.5
53	0.0	0.0	0.0	0.0	0.0
54	2.3	6.4	0.2	0.9	7.4

Ward name	Primary school backlog	Primary school backlog area (ha)	Secondary school backlog	Secondary school backlog area (ha)	Combined primary & secondary school backlog area (ha)
55	1.0	2.9	1.8	7.4	10.2
56	0.0	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	0.0	0.0
58	0.0	0.0	0.0	0.0	0.0
59	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0
61	5.2	14.6	1.6	6.2	20.8
62	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0
64	0.0	0.0	0.0	0.0	0.0
65	0.3	1.0	1.2	5.0	6.0
66	0.5	1.4	1.3	5.2	6.7
67	7.0	19.5	1.9	7.6	27.1
68	1.2	3.3	0.5	2.2	5.5
69	5.4	15.1	2.0	7.9	23.0
70	2.6	7.4	2.0	8.0	15.3
71	0.3	0.9	0.2	0.9	1.8
72	0.0	0.0	0.0	0.1	0.1
73	1.5	4.2	0.9	3.8	7.9
74	3.3	9.3	1.9	7.8	17.1
75	3.5	9.8	0.0	0.1	9.9
76	1.3	3.5	1.3	5.1	8.6
77	0.0	0.0	0.0	0.0	0.0
78	0.0	0.0	1.2	4.8	4.8
79	2.0	5.6	0.8	3.3	8.9
80	6.7	18.9	2.5	9.8	28.7
81	0.0	0.0	0.0	0.0	0.0
82	4.3	12.2	2.3	9.2	21.4

Ward name	Primary school backlog	Primary school backlog area (ha)	Secondary school backlog	Secondary school backlog area (ha)	Combined primary & secondary school backlog area (ha)
83	1.6	4.5	1.0	3.9	8.5
84	0.0	0.0	0.0	0.1	0.1
85	3.5	9.9	0.7	2.7	12.6
86	4.8	13.6	0.0	0.0	13.6
87	3.7	10.4	2.4	9.5	19.8
88	6.2	17.5	1.3	5.1	22.6
89	6.2	17.5	1.2	4.8	22.3
90	4.5	12.5	2.3	9.1	21.6
91	2.9	8.2	1.5	5.8	14.0
92	2.8	7.9	0.0	0.0	7.9
93	3.0	8.5	2.5	10.0	18.5
94	0.0	0.0	0.0	0.0	0.0
95	11.3	31.6	3.7	14.8	46.4
96	4.1	11.4	0.1	0.6	12.0
97	2.4	6.8	0.3	1.1	8.0
98	3.5	9.9	0.3	1.3	11.2
99	10.8	30.2	3.2	12.7	42.9
101	4.4	12.2	1.0	3.9	16.1
102	4.1	11.5	0.2	0.7	12.2
103	5.3	14.9	3.3	13.2	28.1
104	6.3	17.8	2.0	7.8	25.6
106	9.6	26.8	3.2	12.6	39.4
107	6.8	19.0	1.5	5.9	24.8
108	8.1	22.7	2.3	9.1	31.8
109	5.1	14.3	1.2	4.9	19.2
110	0.0	0.0	0.0	0.0	0.0
111	4.5	12.5	1.0	4.0	16.5
Total	302.8	847.7	104.5	418.2	1265.9

Appendix E

Future densification calculation outputs (Component 3) including the potential population density increases, at ward level for Method 1 at the 10-year and 20-year growth rates.

Ward Name	Method 1: 10-year growth trend				Method 1: 20-year growth trend			
	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)
1	1.5	4.1	18277.7	68.0	0.5	1.5	6772.3	25.2
2	1.5	4.1	18268.9	71.4	0.9	2.6	11677.5	45.6
3	8.0	22.4	99994.8	313.0	5.1	14.2	63282.6	198.1
4	3.3	9.1	40811.4	99.7	1.7	4.7	20787.1	50.8
5	0.6	1.8	7870.8	31.9	0.2	0.7	2977.1	12.1
6	0.2	0.7	2939.1	12.5	0.0	0.0	39.6	0.2
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	22.7	63.5	283395.3	750.8	13.8	38.6	172484.8	457.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	6.3	17.8	79277.5	259.7	3.9	10.8	48314.5	158.3
11	1.4	4.0	17844.2	42.8	0.7	2.0	9092.2	21.8
12	1.9	5.2	23204.1	65.6	0.7	2.0	8750.5	24.7
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	7.7	21.5	95989.7	221.7	4.5	12.5	55869.1	129.1
15	13.4	37.5	167564.2	741.2	8.5	23.8	106224.2	469.9
16	6.1	17.1	76245.3	176.9	3.3	9.3	41698.0	96.7
17	7.1	20.0	89076.3	216.9	4.3	12.1	53992.2	131.4
18	0.3	0.9	3965.4	17.8	0.1	0.2	906.6	4.1
19	14.1	39.4	175918.6	322.7	8.4	23.5	105049.5	192.7
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Ward Name	Method 1: 10-year growth trend				Method 1: 20-year growth trend			
	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	1.9	5.2	23280.6	75.5	1.2	3.3	14881.0	48.2
23	97.6	273.3	1220042.1	3647.6	62.0	173.6	775100.8	2317.3
24	2.8	7.9	35180.1	126.9	1.6	4.5	20087.0	72.4
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	1.9	5.2	23121.0	75.2	1.0	2.8	12359.5	40.2
27	1.4	3.9	17522.9	62.3	0.8	2.3	10121.8	36.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.9	2.6	11569.1	32.4	0.6	1.7	7395.0	20.7
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.4	1.0	4555.0	11.4	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.4	1.2	5451.2	26.4	0.2	0.6	2741.5	13.3
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.2	0.5	2024.1	9.6	0.1	0.2	699.4	3.3
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	4.5	12.5	55910.4	138.4	2.5	7.0	31034.6	76.8
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Ward Name	Method 1: 10-year growth trend				Method 1: 20-year growth trend			
	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)
47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.3	0.9	4187.1	14.1	0.2	0.6	2676.4	9.0
49	0.3	0.8	3666.3	9.8	0.2	0.5	2343.5	6.3
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.2	0.6	2826.6	12.1	0.1	0.2	799.9	3.4
52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	3.0	8.5	37967.8	130.8	1.9	5.4	24269.2	83.6
54	0.0	0.1	318.7	1.1	0.0	0.0	0.0	0.0
55	6.7	18.6	83156.1	234.0	4.0	11.3	50230.2	141.4
56	14.8	41.4	184610.9	546.3	9.4	26.4	118003.9	349.2
57	4.9	13.8	61422.7	185.7	3.1	8.8	39261.6	118.7
58	2.4	6.6	29502.4	103.1	1.5	4.2	18858.0	65.9
59	1.9	5.2	23400.0	98.6	1.2	3.4	14957.4	63.0
60	0.7	1.9	8523.7	26.9	0.4	1.2	5448.4	17.2
61	0.6	1.6	7298.5	22.9	0.0	0.0	0.0	0.0
62	5.5	15.3	68296.3	378.5	3.5	9.8	43655.2	241.9
63	5.2	14.5	64806.1	232.5	3.3	9.3	41424.3	148.6
64	1.6	4.3	19380.6	79.1	1.0	2.8	12388.2	50.6
65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	0.2	0.6	2771.6	9.6	0.0	0.0	0.0	0.0
67	6.3	17.7	78953.2	162.4	3.4	9.6	42732.5	87.9
68	1.0	2.7	11924.5	37.5	0.5	1.4	6047.9	19.0
69	6.0	16.9	75308.0	202.6	3.3	9.3	41571.6	111.8
70	1.6	4.4	19691.1	79.0	0.7	1.8	8206.1	32.9

Ward Name	Method 1: 10-year growth trend				Method 1: 20-year growth trend			
	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)
71	3.1	8.8	39347.3	140.8	2.0	5.5	24633.9	88.2
72	1.6	4.4	19747.6	78.4	1.0	2.8	12605.5	50.0
73	1.6	4.3	19370.5	79.8	0.8	2.3	10118.7	41.7
74	0.8	2.2	9828.9	26.7	0.1	0.3	1410.8	3.8
75	0.9	2.6	11723.1	31.1	0.4	1.0	4667.1	12.4
76	2.8	7.9	35373.7	86.4	1.6	4.5	20152.5	49.2
77	6.4	17.8	79569.5	281.6	4.1	11.4	50861.1	180.0
78	0.6	1.8	8095.1	20.2	0.3	0.9	3797.8	9.5
79	0.0	0.1	341.5	1.0	0.0	0.0	0.0	0.0
80	0.7	2.1	9199.3	21.3	0.0	0.0	0.0	0.0
81	1.0	2.7	12070.5	37.5	0.6	1.7	7715.5	24.0
82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
83	1.6	4.5	19979.5	80.4	0.8	2.3	10356.6	41.7
84	1.1	3.1	13793.4	54.5	0.7	2.0	8789.9	34.8
85	0.7	1.9	8546.6	25.6	0.2	0.4	1872.9	5.6
86	0.8	2.2	9883.3	25.2	0.2	0.5	2442.9	6.2
87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
91	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
94	1.8	5.0	22103.6	88.5	1.1	3.2	14128.7	56.6

Ward Name	Method 1: 10-year growth trend				Method 1: 20-year growth trend			
	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)	Number of Potential Additional Primary Schools	Number of Potential Additional Secondary Schools	Potential Densification Additional Population	Potential Population Density Increase (%)
95	0.4	1.2	5471.8	9.3	0.0	0.0	0.0	0.0
96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97	0.1	0.1	637.4	2.2	0.0	0.0	0.0	0.0
98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99	6.3	17.6	78414.5	150.2	3.0	8.5	37870.1	72.5
101	5.0	14.0	62453.7	168.4	2.8	7.9	35320.1	95.2
102	3.3	9.1	40715.8	150.6	1.8	5.1	22557.3	83.4
103	9.3	26.1	116519.5	282.1	5.3	14.9	66447.2	160.9
104	62.0	173.6	775003.0	2096.1	39.0	109.3	488073.7	1320.1
106	1.3	3.7	16666.8	25.8	0.0	0.0	0.0	0.0
107	5.8	16.3	72693.0	167.9	3.2	8.8	39376.8	90.9
108	0.8	2.2	9858.9	18.4	0.0	0.0	0.0	0.0
109	4.6	13.0	57906.8	143.6	2.5	7.1	31530.7	78.2
110	0.2	0.6	2885.7	10.4	0.1	0.4	1844.6	6.6
111	2.4	6.8	30218.3	80.6	1.2	3.3	14603.6	38.9
Total	398.1	1114.6	4975730.6	14569.5	237.3	664.5	2966390.7	8746.9

Appendix F

Potential Densification Index (Component 3), at ward level for Method 2 at the 10-year and 20-year growth rates.

Ward Name	10-year growth	20-year growth
1	17.4	16.2
2	16.4	15.1
3	27.1	25.6
4	46.0	45.2
5	16.5	15.5
6	24.5	22.6
7	3.8	2.8
8	24.2	22.4
9	28.9	27.4
10	12.7	12.2
11	23.0	21.4
12	11.0	8.5
13	7.0	5.0
14	30.1	27.7
15	18.6	17.8
16	17.3	14.1
17	10.7	9.3
18	21.8	16.7
19	11.2	7.5
20	6.8	5.0
21	41.7	39.1
22	9.1	7.1
23	100.0	100.0
24	3.6	1.3
25	6.4	5.9
26	8.8	7.8
27	16.9	16.3
28	3.6	3.1
30	14.0	13.5
31	0.7	0.0
33	0.0	0.0
34	0.0	0.0
35	8.6	5.8
36	1.5	0.0
37	0.0	0.0
38	0.0	0.0
39	0.4	0.0
40	0.0	0.0
41	0.0	0.0
42	0.2	0.0
43	6.6	5.3
44	0.0	0.0
45	0.0	0.0
46	0.0	0.0
47	3.2	2.1
48	0.5	0.2
49	1.9	1.3
50	0.5	0.0
51	3.4	2.7
52	2.5	1.6
53	24.5	23.9
54	10.0	9.3
55	22.2	21.8
56	19.2	18.3
57	18.7	18.8
58	12.8	12.9
59	16.9	17.1
60	7.3	6.2
61	5.2	4.2
62	32.8	32.2
63	13.8	12.3
64	15.3	13.2
65	5.2	3.5
66	4.2	3.3
67	5.8	4.6
68	8.8	8.1
69	6.6	5.4
70	9.9	8.8
71	15.2	14.0
72	10.2	9.9
73	14.1	14.0
74	12.0	11.2
75	1.6	0.0
76	5.6	3.6
77	17.3	16.7
78	8.5	6.4
79	4.2	2.6
80	6.7	3.4
81	3.5	2.4
82	3.3	2.0
83	13.7	13.2
84	14.1	13.2
85	2.5	1.8
86	1.3	0.9
87	15.7	11.9
88	0.5	0.0
89	10.5	6.8
90	1.0	0.0
91	0.0	0.0
92	2.8	0.8
93	3.0	1.0
94	0.0	0.0
95	4.1	2.4
96	3.4	1.1
97	7.9	4.7
98	5.2	2.6
99	2.5	0.0
101	4.0	3.5
102	34.0	31.5
103	6.0	5.3
104	92.3	91.9
106	6.4	4.5
107	78.8	78.5
108	13.5	12.2
109	15.9	13.7
110	10.3	9.3
111	18.0	16.5
Total	1317.9	1188.5