A WAY TO USE GIS (INCL. GEOMASKING) TO UNDERSTAND HOMELESSNESS: A FOCUS ON THE SPATIAL CHARACTERISTICS OF AND AROUND SLEEPING LOCATIONS OF THE HOMELESS IN CAPE TOWN CITY BOWL

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DEDICATION

Dedication of this research study is to wide-spectrum of homeless individuals and groups. That is, those who sleep/rest in public spaces, abundant buildings, storm-water systems, informal settlement, inadequate housing, squatting setups, crowded households and so forth. The message (also to those experiencing various setbacks in life) is that in hindsight all is clear. Nonetheless, in due course, appropriate and relevant measure(s) will be at your doorstep. Patience cooks a stone, although it is often easier said than done.

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ABSTRACT

Background: The homeless individuals/groups are the most vulnerable and less dignified member of the society. The evidences lie in the nature of their sleeping locations in the urban spaces, amongst other aspects. An internationally unique and integrated approach (GIS/socio-spatial) is utilized to enhance the knowledge and understanding of homelessness through analyzing the spatial characteristics of and around the sleeping locations of the homeless community in the urban public spaces, Cape Town City Bowl (South Africa) case study.

Data Source and Method: Through the quantitative approach, the individual sleeping locations of The Homeless, including their surrounding characteristics, are observed daily for two weeks, 13-26 Oct. 2018 (total of all locations: n = 9515, daily average, n = 680) between 06:00 am and 08:30am. The analyses entail sequential application of eight analytical methods; spatial distribution, attribute analysis, proximity analysis, weather analysis, and obfuscation/geographic masking

Results: (a) The daily individual sleeping locations of the homeless individuals and groups increase over time but their geographic distributions are similar or display insignificant/little variations. (b) Majority of these locations are situated in marginalized urban spaces that deny The Homeless personal privacy/security, human dignity and perpetuate stigmatization and social isolation. (c) The sleeping locations of The Homeless are far from the sources of basic needs to enhance their livelihoods (e.g., water resources). (d) Although more data is needed, however, the limited data in this research show that weather conditions are (in)directly related to the changes in the numbers of sleeping locations. (d) The voronoi masking and weight rand perturbation are best presenting the sleeping location of The Homeless without compromising the spatial confidence of The Homeless, and the spatial distributions/patterns of these locations.

Conclusion: GIS (geographic information system) is capable of enhancing the knowledge and understanding of homelessness, and therefore, it can inform establishments and improvements of initiatives/measures that seek to reduce the vulnerability of the homeless community and/or integrate them with the public community, especial in the urban spaces.

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CHAPTER 1: INTRODUCTION

1.1 CONTEXT

Due to the complex nature of and multitudes of definitions for homelessness, it remains difficult to combat it. The global statistics estimates were between 100 million and 1 billion in 2005 (United Nation CHR, 2005). There is a wide spectrum of causations of homelessness, ranging from socioeconomic though health and ecological to political aspects (Dachner and Tarasuk, 2002; Du Toit (2010); Ferguson et al. (2016); Finch, 2013; Jocoy and Del Casino, 2010; Nzula, 2016; Rahimian, Wolch and Koegel (1992); Tipple and Speak, 2005; Wolch et al., 1993; and United Nation CHR, 2005).

For instance; the Homeless Policy of the City of Tshwane states that some of the root-causes of homelessness include; the inability to afford daily cost for commuting between home and place of work; lack family or have family problems; drugs and substance abuse; peer pressure; retrenchment; lack of employment; and migration (Kekana, 2013).

The present lack of adequate and integrated knowledge and understanding of homelessness do not only yield the unpreparedness to reactively and proactively address this concern. It also perpetuates the harsh categorization of the homeless individuals and groups as "others in the eyes of the public" as well as set a spotlight for these community to be "seen as underserving of help" (Legoigne, 2015 in WPI, 2018) and that they are "incapable of making good decisions for themselves (Mitchell, 1985 also in WPI, 2018).

Jocoy and Del Casino (2010) stress the point that there is a need for intra- and inter-disciplinary research in order to better understand the socioeconomic relations, spatial characteristics and homelessness in an urban context. Furthermore; Cloke, May and Johnsen (2008) add that the spatial aspect to homelessness research is essential as it provides more knowledge about 'rationalities' and 'irrationalities', i.e., how The Homeless understand, what they make of and their negotiation or resistance tactics for the urban spaces. In that light, this research attempts to contribute to the knowledge and understanding of homelessness, through integration of geographic information system (GIS).

1.2 AIM

The aim of this research study is to provide a guide, a way on how to use GIS to enhance the knowledge and understanding of The Homeless (i.e., the homeless individuals and groups) in the public places - as per the City of Cape Town's by-law relating to the streets, public places and the prevention of noise nuisances (2007). Thus, this study attempts to promote and highlight the importance of incorporating the spatial characteristics when addressing homelessness. Through analyzing the spatial characteristics of and around the sleeping locations of the homeless individuals and groups in public places of Cape Town City Center.

1.3 OBJECTIVES

There are six primary objectives:

- The first objective is to observe and record sleeping locations of The Homeless and their surroundings in public places at early hours of the morning within Cape Town City Bowl.
- Secondly, the objective is to assess the daily and weekly variations of sleeping locations of The Homeless.
- The third objective is to assess the surrounding nature of and around sleeping locations of The Homeless
- The fourth objective is to investigate the proximity distances between the sleeping locations and water resources (i.e., privately and publicly accessible human basic need example)
- The fifth objective is to explore the relationship between various weather elements (i.e., temperature, rainfall, cloud cover and wind speed) and the daily numbers of sleeping locations
- The sixth objective is to highlight the geographical masking or obfuscation methods that are most appropriate for visualization of (low scale) The Homeless (sleeping) locations.

1.4 RESEARCH QUESTION

What are the spatial characteristics of and around, as well as the weather conditions related to the numbers of observed public places, where The Homeless sleep/rest in the early hours of the morning?

1.5 PREMISES

There are five premises or hypotheses and these include the following:

- Geographic distributions of the sleeping locations are similar or display insignificant or negligible variations throughout the study period.
- Majority of the sleeping locations of The Homeless are in marginalized urban spaces that deny them personal privacy/security, human dignity and perpetuate stigmatization and social isolation, therefore, they are highly vulnerable (members of the society).
- The Homeless seek sleeping locations nearer to sources of basic needs, esp. those that are accessible by the public, to enhance their livelihood activities.
- Weather conditions are (in)directly related to the changes in the numbers of sleeping locations.
- The sleeping locations of the homeless can be presented without compromising the spatial confidence of The Homeless, and the spatial distribution/patterns of the sleeping locations.

1.6 SCOPE

The scope of this research is limited to the following. (a) Observing The Homeless' sleeping locations without interviewing The Homeless themselves or anyone living around or encountered near the homeless people's sleeping locations – details are below in subsection 1.7.1. (b) Observing the sleeping locations on a daily bases for duration of two weeks (from 13-26 October 2018), in the early hours of the morning (6:00 – 8:30 am) – the impacts of the date/time are discussed in subsection 1.7.2 below. (c) Focusing only on the sleeping locations that are in public spaces and only those that do not exhibit profited behavior as per the City of Cape Town's by-law relating to the streets, public places and the prevention of noise nuisances (2007) – the weakness are discussed below in subsection 1.7.3. (d) Strictly collecting datasets (i.e. sleeping locations and surrounding characteristics) that are within the boundary of study area and at the set study period.

1.7. LIMITATIONS

There are seven key limitations in this research and they are as follow.

1.7.1 Research Approach

The first limitation is introduced by the sole adoption of the quantitative approach. That is, the primary datasets are only observations of the sleeping locations of The Homeless. There is neither usage of the surveillance footages near the locations nor conducting of the interviews with The Homeless or any member of the public (e.g., residents near, by-passer, law officials). Unfortunately, there is no mitigation measure in place for excluding qualitative and only using quantitative approach. Consequently, this research is limited for the following reasons. (a) It assumes that the sleeping locations observed in the morning are used the whole night, and these locations are chosen based on the social, weather and other conditions of the previous day/night. (b) There is a lack of personal information of The Homeless (e.g., demographics, gender, background, reason for being homeless), which can serve more insight on the homelessness, the social and spatial distributions/patterns.

On that note; others may (further) argue that this research somewhat treats The Homeless as objects. Thus, it separates them from both their human (i.e., education, skill and ability to generate income) and social context (which comprises of behavior, belief, attitude and both relationship amongst each other and the public). Although the latter comprises some degree of merits; however, Collin and Hussey (1997) argue that it is possible that quantitative approach can reveal qualitative data and vice versa. Furthermore, Mojtabi (2005) discredits the qualitative approach on the ground that the information provided by the homeless people remains to be key limitation, especial if there is no objective measure of the information these people provide.

1.7.2 Data Collection Period

The second limitation is triggered by the selection of the date period and daily time slot for the data collection process. The date period is two weeks (from 13th to 26th, October 2018), i.e., the last part of the month of October. Consequently, this research is only limited to and present the analyses of the trends from mid to end of the month. As such, there is no analyses for the early to the mid-month patterns. As well as there no bi-weekly, monthly, quarterly and/or seasonally analysis of the sleeping. Furthermore, there is no mitigation measure for the above limitation (i.e., additional types of analyses).

On the other hand, the daily time slot for the two weeks data collections is 06:00am to 08:30am. The associated and unmitigated limitation is the omission of other possible sleeping locations of The Homeless on the day of observations/data collection. For example, some of The Homeless may be awake, packed-up their belongings and/or moved away from their sleeping locations before the time of data collection (i.e., 6am) - for some social, spiritual and/or economic reasons (e.g., accompanying a friend somewhere, attending for a prayer session, and going to conduct labor work). Another possibility associated with this time frame is that some of the homeless people may prefer or happen to start arranging to sleep and actually sleeping after 08:30 – for instance, those who worked night shifts (if they had a job).

On the same note, the City of Cape Town state the security concerns pertaining the data collection of The Homeless (the Street People, as referred) especially at night (or before sunrise). Although the City Official conduct the data collection process before sunrise, i.e., around 3am, they do so in the presence of armed Law Enforcement officials (Finch, 2013). Perhaps the usage of some form of surveillance footage and interviews of anyone (incl. The Homeless) about the sleeping locations can serve as mitigation measure for this study's daily time slot. Nonetheless; this study follows Hashimah et al. (2016) who found out that majority of The Homeless sleep in early hours of the morning covering this study's time slot, the scholars state that The Homeless walk around the city until midnight when most shops and restaurants close and the city is quiet and inductive for resting. This implies that even though other homeless individuals, their locations, are not recorded during the time slot of the set date period; however, the observations of this study carry the optimum/predominant numbers of the sleeping locations.

1.7.3 Definition of Homelessness

This research's homeless definition raises the forth limitation, which cannot be mitigated. Because it only focuses on the subset of the homeless people sleep/rest in the public places, i.e. those in the public places but do not exhibit prohibited behavior - as per City of Cape Town's by-law relating to streets, public places and the prevention of noise nuisances (2007). This implies exclusion of all the other sleeping locations, which do not match this research's definition. Regardless of the insight provided by the literature (e.g., United Nation CHR, 2005), that is, the homeless people do not only choose and use the public places, such as public parks, under the bridge and street pavements. They also sleep/rest in available closed spaces at times, if not all the time. Examples of the closed spaces include: aban-

doned buildings; underground tunnel systems; shady passages; and Cal-de-sac streets that seemed dark and deserted.

1.7.5 Inaccurate/Missing Spatial Datasets

The fifth and unmitigated limitation comes with inaccurate and missing secondary (or third party) spatial datasets, when assuming there are no errors associated with the primary datasets (i.e., the sleeping locations of The Homeless). Although the records of weather elements (temperature, rainfall, cloud cover and wind speed) are obtained from two different sources (namely; South African Weather Service (SAWS) and World Weather Online), sanity (accuracy and errorless) checks are not done, more especially on rainfall and cloud cover where the records from SAWS show null values.

On the other hand: all of the secondary spatial (vector and raster) datasets come from the City of Cape Town's GIS department and these datasets serve as reference for the geocoding (i.e., process of assigning XY coordinate of sleeping location using both QGIS and ArcGIS (ESRI) software). Zandbergen and colleagues (2012) note that one of the main sources of positional errors associated with geocoding is the use of inaccurate reference data as a result of inaccurately captured reference features (i.e., parcels, building footprints, imagery).

In addition, the missing of (updated) datasets lead to incorrect results (e.g., in proximity analysis) or entirely limit further multivariable analyzes. For instance; Faraji, Ridgeway and Wu (2018) debate that establishment of shelters during winter in the City of Vancouver (Canada) increase the property crime by 56% within a distance of 100 meters and yet a decrease in breaking activities of commercial property, i.e. 34% lower when shelters are established in the same 100m distance.

1.7.6 Diurnal Data Collection

The sixth unmitigated limitation results from lack of observations of the same spatial locations of The Homeless during the day, but instead, only at night or rather early hours of the morning. The diurnal observations for each of sleeping locations can possibly provide additional insights about the homeless community, i.e., their livelihood activities and the spatial surroundings. For instance, these diurnal information (about the spatial locations of The Homeless) may possibly answer some of the questions such as: do all the homeless people pack away all their belongings during the day? If they do, where do they store them? If not, who stays with them at the site (i.e., spatial locations for sleeping), whilst they are searching for means to maintain their livelihoods (e.g., food, drinks, and water)? Or perhaps, does someone else bring them food, water, drinks and so forth to main their livelihoods?

1.7.7 Ethical Concerns

The institution (University of Cape Town) is very concerned and strict when it comes to ethical matters, in this instance, Engineering and Built Environment (EBE) faculty hold key responsibility. The ethical

clearance in this research is given based on the following conditions. (a) The spatial privacy is upheld and no geographically unmasked sleeping locations of The Homeless are shared in the publication or with the public; and (b) the personal information of the homeless individuals and groups are used and this caters for the usage of (un)censored photographs of the individuals, the sleeping locations and surrounding area.

That said; limitation is implied that cannot be mitigated, particularly when it comes to displaying the actual and exploring the spatial distribution patterns of the sleeping locations. For instance; in proximity analysis (which evaluate a number sleeping locations with a specified distance radius from a particular feature, e.g., clinic, restaurant, public toilet, taxi rank), only two feature types are used (namely; water resources, which include the waterbodies and open water courses, and land/ ownership limited to public and private classifications). In general, the display of the sleeping locations are aggregated output instead of the actual XY coordinates locations of where the homeless individuals and groups sleep/rest.

1.8 CASE STUDY

The case study region (also referred as study area or region of interest) is the Cape Town City Center/Bowl (refers to figure 1, below), which is located in the City of Cape Town. At a larger scale, the study area is located in the City of Cape Town, Western Cape Province, i.e., at the Southwestern tip of South Africa.

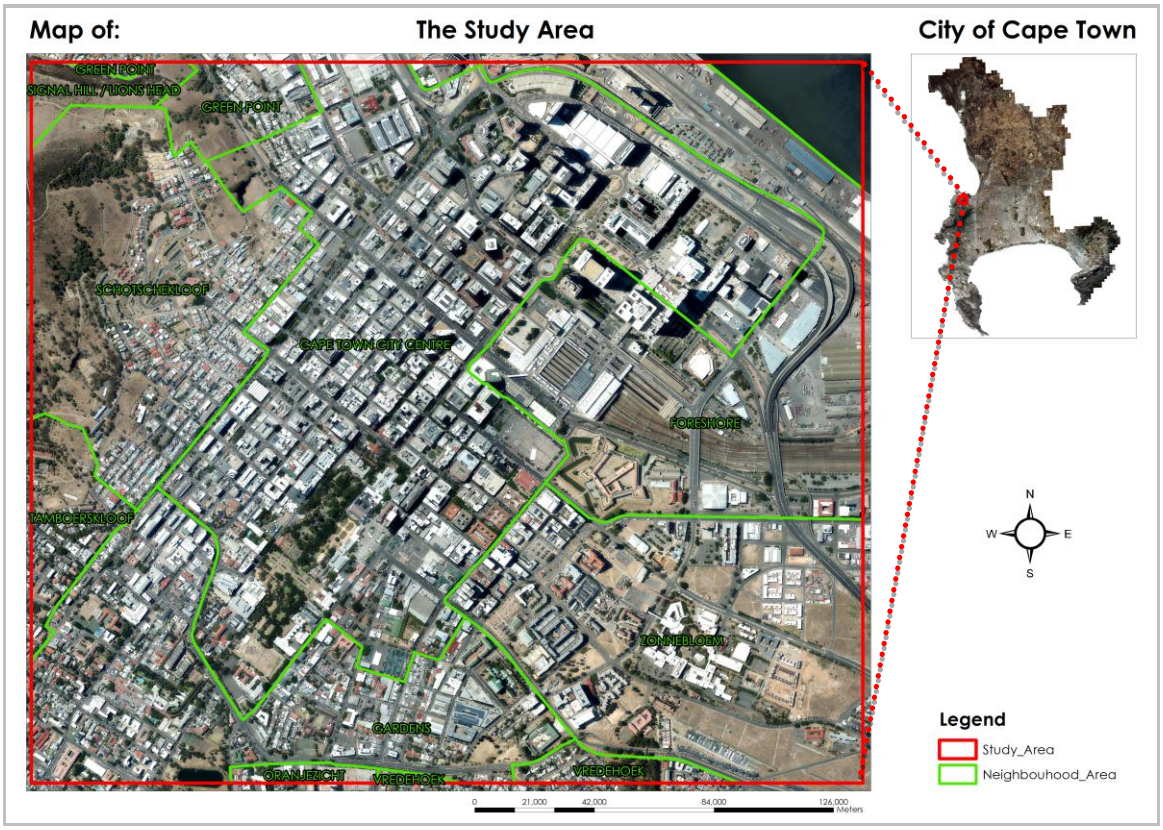


Figure 1: The spatial boundaries display of the case study, Cape Town City Center/Bowl - (Western Cape Province)

The entire area of the case study is 7.1 km^2 and it covers 10 neighborhood areas (refers to figure 1 above). These neighborhoods and their percentile contributions to the overall 7.1 km^2 geographic area are as follow. Cape Town Central (35,07%); Foreshore (16,97%); Zonnebloem (15,25%); Gardens (13,34%); Schotchekloof (12,56%); Tamboerskloof (2,22%); Green point (1,99%); Signal Hill/Lions Head (1,11%); Vredehoek (1,03%); and Orangjezicht Lower (0,45%) – refers to figure 2 below for range representation. The main aim is to adequately capture Cape Town CBD (i.e. Central Business District), but instead, an extended boundary is chosen to eliminate/avoid questions associated with defined spatial land boundaries, which some consider it (i.e., spatial land boundaries) to be a burning issue in the country (and all over the world).

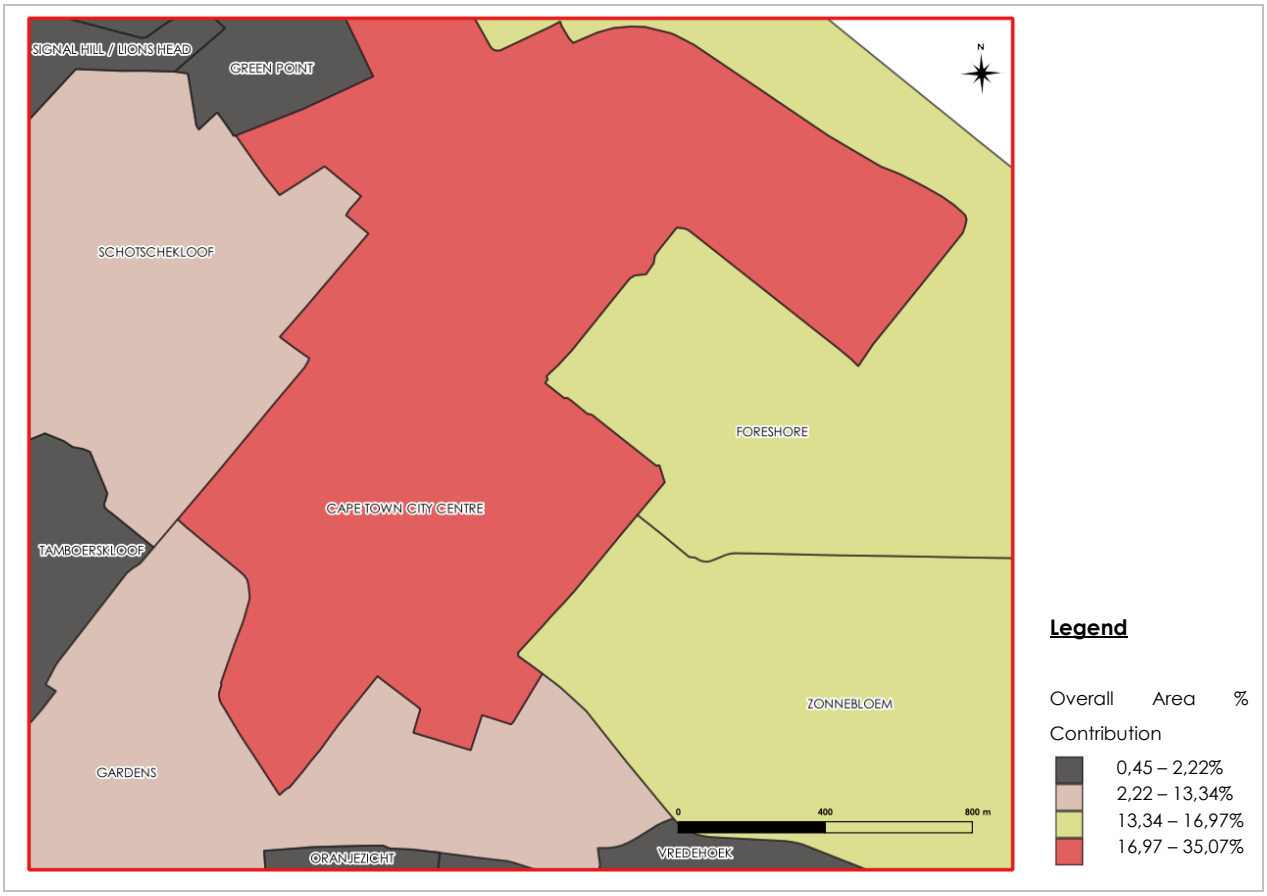


Figure 2: Map of neighborhoods within the case study region and their percentile contributions to the overall 7.1 km2 areas of the case study region.

The 10 neighborhoods are classified into residential, commercial, industrial and agricultural neighborhood types. However; these neighborhood classification types are not necessarily based on the general classification, for example, by the Valuations Department of the City. Instead, in this research, they (i.e., neighborhood classification types) are based on the predominant percentile of the existing property type (or rather property use/purpose) within the neighborhood area in relation to the coverage of the study area boundary.

Greenpoint, for example, in its fullest extent, comprises the industrial and residential property types/uses (refers to table 1 below). Since the large proportion/percentile of property counts are residential, it (Greenpoint) is classified as residential. However, in this research study, Greenpoint area is denoted as

industrial, and it is based on its high amount of industrial property counts appearing in the portion of the study area.

Furthermore; in terms of counts, the dominant neighborhood types, in this study, are residential (composed of 8 of 10 neighborhood areas), refers to table 1 below. On the other hand, in terms of geographic extend (i.e., unit area) of the study region, the dominant neighborhood type is commercial (3309835.225 meters sq., 60.2% of the study area). While others types are as follow: agricultural (109731.3426 meters sq., 2.0%); industrial (1036773.202 meters sq., 18.9% of the study area); and residential (2380719.998 meters sq., 60.2% of the study area).

City of Cape Town is: the only metropolitan municipality in the Western Cape Province; and one of the eight metropolitan municipalities or 1 of the 278 local municipalities in the country (SA Local Government Handbook, 2016). Chapter 7 (titled: Local Government) of the Constitution of the Republic of South Africa states three categories of municipalities (i.e., category A, B, and C). The first Category (A) refers to all metropolitan municipalities, i.e., "A municipality that has exclusive municipal executive and legislative authority in its area" (section 115). As opposed to other categories that share their executive and legislative authority (i.e., category B and C). In terms of language; English, Xhosa and Afrikaans are the local official languages in the City (or Province) as encouraged by sub-section 6 of chapter one of the Constitution.

1.8.1 Case Study Methodology

According to Yin (2012), the case study is a commonly used methodology, empirical inquiry, to answer the "how" or "why" questions in various research fields (from social science through nursing and community planning to economics). Particularly when the primary focus is on real-life, contemporary phenomenon that the author has little or no control over. The availability of rooms to make real-life observations and make interviews, form part of the advantages. There is a misconception that generalization cannot be made from one study/investigation. The truth is that the theoretical generalizations can be made, but not about the universe or populations.

Yin (2012) also highlights that one of the key challenges solemnly associated with this methodology is that there are more variable to consider other than the points of interests and acquiring/adding them require tactic skill. Since, the real-life events require finicky, meaningful and holistic capturing. In addition, the case study requires rigorous, systematic procedures throughout the investigation and research, and the findings and conclusions must not be bias or equivocal. Unlike other methodologies, the systematic procedures are to be defined by the investigator. Currently, there is relatively little, to almost no texts/guides covering the case study methodologies and this is the key source of prejudices against it over the years. Moreover, there is a very thin line between the context and phenomenon in the case study research.

1.8.2 Case Study Motivation

The Cape Town City Bowl is chosen as the study case for a number of reasons, of which, the key ones are as follow. (a) It is conveniently located in terms of travelling around, to and from (the availability of public transport; 71% in 2013, 83% in 2014 and 82% in 2015, according to CCID Annual Report (2015)). (b) There is reasonable security at the street level (i.e., safety at the street level: 77% in 2014 and 83% in 2015, CCID Annual Report (2015)). (c) It is complex with reference to the socio-economic, political, cultural, religious and ecological aspects (further details in the preceding subsection 1.8.3 – 1.8.8). (d) There is the potential to expand in the light that this era (i.e. 21st century) is still declared as a period in which large number of people migrate from the rural to urban areas with the hope to better their livelihood activities (CCID Annual Report, 2015; CoT Research Report 2015; and United Nation CHR, 2005).

1.8.3 Economy

The case study, according to the State of Cape Town Report (2015), is predominantly commercial (southern or bottom part) and industrial (northern or top part), refers to figure 1 above. The neighborhood areas (mentioned earlier in the introduction of this section 1.8) are classified as part of the middle to high value/income areas in the City of Cape Town, refers to table 1 below. The (legal) economic activities taking place within the research region of interest can be summed up and described in terms of the following: street vendors; retails; supermarkets; rental accommodations; restaurants, clubs/taverns; transport services; educational services; manufacturing/technological services and beauty services.

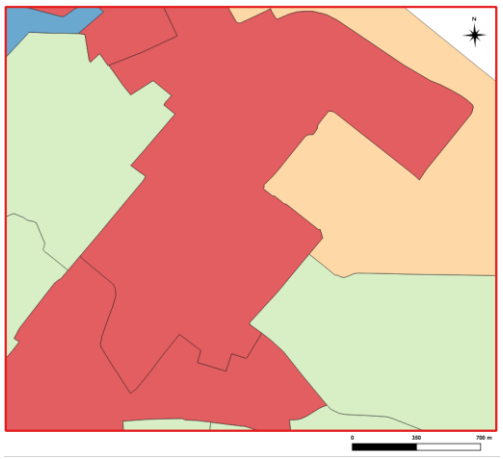
Table 1, below, is a South African Census 2011 and 2014 summary presented by the City of Cape Town GIS department. The economic indicators (i.e., columns) highlight interesting aspects for various neighborhood areas falling within the research study area. For example, the column called "commercial growth" indicates that the neighborhood areas with the lowest commercial growth are in the range R0 - R16,041,240 (e.g., Orangjezicht), while the highest areas fall within this range R218,003,430 - R646,466,653 (i.e., Cape Town Center & Foreshore). In addition, all the neighborhoods are applicable in the commercial growth category. Thus, each of the neighborhood areas within the study region is included and highlighted using an actual value or range, instead of no value. In terms of 'public service growth' economic indicator; there are only two neighborhoods that are applicable (i.e., Cape Town Center and Vredehoek) and both are in the range R10,000 - R990,450.

1.8.4 Social Factors/Processes

The social aspects within the study area are described in terms of local society, tourists and the available resources. Whereby the local society is used to simply denote all the individuals who update their locations/residential addresses to Cape Town (on social media, credit accounts and so forth) and/or reside in Cape Town for over a period of 3 months (since, at least, South African Credit Regulators deem a residential address over 3 months invalid).

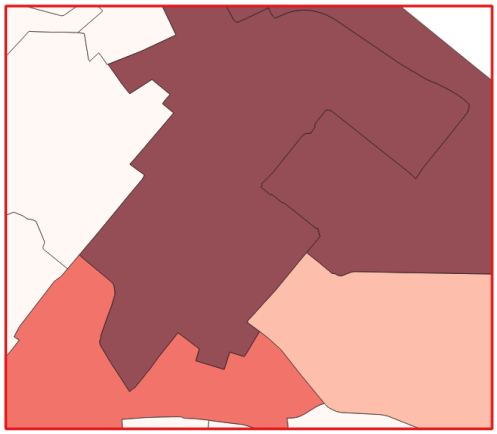
Moreover, the local society, within the study region, is broken down into two groups, namely. (a) The residents (i.e. people who owns/rent an apartment, squad/share a room, are recorded on population census, and/or sleep in available open/closed spaces). (b) The workers (i.e. individuals who do not necessarily reside within the study areas but conduct some sort of work in the study region at a particular time of the day/night, e.g. school, (in)formal job).

Table 1: Neighborhood areas and some of their economic indicators in the study area. South African Census 2011 and 2014 summary, by City of Cape Town GIS department



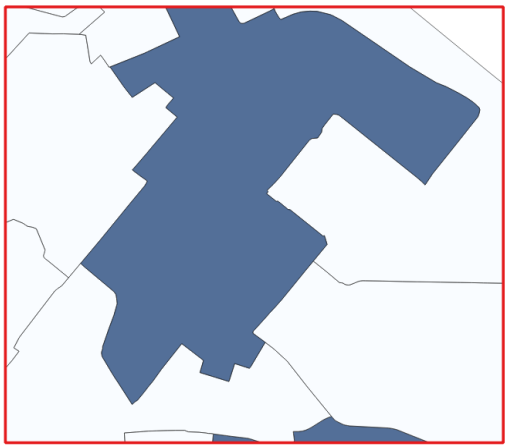
Neighbourhood Property Type/Use

Commercial
Industrial
Residential
Agricultural



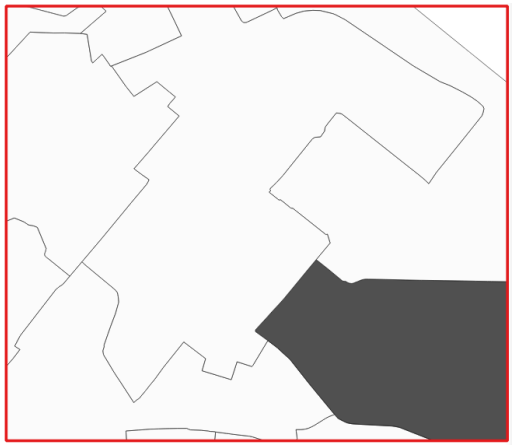
Commercial Growth Jan2011 – Dec2014

R0 – R16 041 240
R16 041 240 – R40 054 684
R40 054 684 – R218 003 430
R218 003 430– R646 466 653



Public Service Growth Jan2011 – Dec2014

R0 – R10 000
R10 000 – R990 450



Industrial Growth Jan2011 – Dec2014

R0 – R10 000
R10 000 – R990 450

As for tourists, these are defined as individuals/groups who visit for duration ranging from minutes/hours to days/weeks for some form of knowledge exchange (e.g. in business, entertainment and/or other lifestyle activities) within the study region. That said; the South Africa Tourism (2016) describes Cape Town (and Cape Peninsula) as the number one tourist attraction on their website under the theme

"Popular South African Attractions" for its presence and/or access to: "scenic beauty; celebrity beaches; Table Mountain; whale-watching; world-class shopping, nightlife, food & wine; and a laid-back atmosphere".

Apart from the above mentioned tourists' attractions elements and phenomena; there are other platforms that offer entertainment, relaxation, uplift and other overwhelming experiences. Examples include: public gardens; religious buildings/arenas; restaurants offering local food; local traditional/cultural/religious entertainments; local clothes/shoes and other products; as well as general experience to engage with local society in (in)formal setting such as theatre-play, traveling and public concerts/performances. The latter is possible as a result of different sorts of resources available, from the spatial infrastructures through governing laws-regulators to living organisms' capacities (e.g., people, horses, penguins, plants).

1.8.5 Environmental Aspect

Both State of Cape Town Report (2012), and Mukheibir and Ziervogel (2007) highlight that the case study region (or rather Cape Town as a whole) is vulnerable to the emerging and anticipated impacts of climate change. Ranging from the sea level rise through rainfall variability and water scarcity to poor air quality and landscape modification. The environmental aspect together with the cultural and heritage diversity of the case study area forms part of the key base of the City's economy (CoCT ERM, 2009). As a result, the above richness is integrated into the spatial planning and 60% is conserved (State of Cape Town Report, 2012). Where some of the vegetation types include fynbos, renosterveld, and southern afrotemperate forest (CoCT ERM, 2009). CoCT ERM (2009) displays the estimates of indigenous species in the City and these include: 3000 plants; 83 mammals; 361 birds; 57 reptiles; 27 amphibians; and 6 fresh water fish.

The indigenous species, amongst others, are unfortunately under severe ongoing and anticipated threats and these threats are predominantly anthropogenic in nature. A few examples of the environmental threats are as follow: urbanization; agriculture; inappropriate fires; mowing; over-exploitation; pollution; hydrology; and crime (CoCT ERM, 2009; State of Cape Town Report, 2012; and State of Cape Town Report, 2012). For instance. urbanization is in progress and it dates back decades, as a result of induced population density amongst other aspects. A good example of urbanization is housing development. State of Cape Town Report (2015) notes that between 1996 and 2001 housing growth was: 16% for formal dwelling; 50% for informal dwelling in backyard; 6.4% informal dwelling in settlement; and 29.2% for others.

1.8.6 Atmospheric Conditions

According to CCID Annual Report (2015); in Cape Town, the average weather conditions are as follow: 17 degrees Celsius (temperature); 580 mm (annual rainfall); 48.33 mm (month rainfall); 12 hours and 36 minutes (length of a day) and 8 hours and 12 minutes (daily sunlight). During winter season (i.e., June-

August) the wind blows from north west and south east during summer season, i.e., December-March (Wilkinson, 2000). To an ordinary citizen; Cape Town weather conditions are generally "odd", thus, the changes occur over a short period of time. For instance; two or more distinct weather conditions can be experienced in one day (i.e., 24 hours cycle). Consequently; these rapid changes in weather conditions are sources of exaggerations in causal or normal day-to-day local communications/dialogues regarding local weather conditions. Especially with reference to the three indicators, namely; rainfall/precipitation, wind magnitude and temperature.

The latter can be linked to climate change to some degree. The climate change impacts, for example, include extreme weather events such as drought, floods, and heat waves (Mukheibir and Ziervogel, 2007; and State of Cape Town Report, 2012). In addition, the gradual changes in both temperature and rainfall in the City are emerging and likely to continue changing in the future (Mukheibir and Ziervogel, 2007).

Generally, the Cape Town weather is distinguished from other parts of the country/region (i.e., northern parts of South Africa) in terms of the spatial atmospheric and oceanic circulation systems. According to Wündsch et al. (2016), the study region lies in what is known-as winter-rainfall zone (WRZ). The implication of WRZ is that maximum rainfall is experienced during the winter season (i.e., from the months of June - August) and the opposite is true for the summer season (i.e., December - February). Consequently, this leaves the intermediate seasons (i.e., spring, September – November, and autumn, March - May) with titles 'transition seasons' between winter and summer. The existence of the rainfall zones or rather changes in Cape Town weather conditions are influenced by various dynamics and interactions of atmospheric and oceanic circulations (to be precise; cold Benguela current, in the Atlantic Ocean, as well as the Westerlies). Furthermore, the presence of Table Mountain (rising approximately 1080 meters above mean sea level) also play a key role in the atmospheric circulation, and thus, the local weather conditions (Wilkinson, 2000).

Temperature, wind and rainfall are the common key weather indicators. However, scientifically, there are other weather indicators include air pollution concentration, air/atmospheric pressure, humidity and so forth. For example, an easily, seldom and/or periodical detectable change in air pollution concentration in Cape Town is visible in the form of what is known to be "brown haze". Brown haze is brown visible colored smog that is common during winter season or between May and September in Cape Town's lower class suburbs or Cape Flat region (e.g., Athlone, Khayelitsha and Mitchell's Plain). Trends of brown haze (or rather air pollution in general) remain to be challenging issues in Cape Town due to the nature of their occurrence, i.e., seasonal and localized (State of Cape Town, 2012).

Furthermore, brown haze does not only pose visibility challenges but also unpleasant odor and health threats such as TB, lungs infections and other respiratory illnesses. According to van Tienhoven and Scholes (2003); the brown haze results from various gaseous and particulate pollutants emitted in the atmosphere and the primary component is particulate matters - especially those with diameter size less than two and half microns (i.e., $PM_{2.5}$). The emission sources of particulate matters include the burning

of fossil fuels (e.g., wood, diesel) and dust generated and carried by wind and other similar activities (e.g. industrial processes, transport on unpaved roads), State of Cape Town (2015).

1.8.7 Legislations and Policies

Another reason for conducting this research is the existing gap in the government system to address homelessness (Du Toit, 2010; and United Nation CHR, 2005), as it holds relatively more power as per the supreme framework guiding all legislations and policies in the country, the Bill of Human Rights or Constitution of the Republic of South Africa (1996). Various legislations related to homelessness exist at and for various levels of government and private organisations. Key examples relating to this case study on The Homeless include: Housing Act (Act 107 of 1997); Republic of South Africa. 1998. Housing Consumers Protection Measures (Act 95 of 1998); Prevention of Illegal Eviction from Unlawful Occupation of Land Act (Act 19 of 1998); Advisory Board on Social Development Act (Act 3 of 2001); White Paper on Social Welfare. 1997; Mental Health Care Act (Act 17 of 2002); National Development Plan: vision 2030; City of Cape Town Street People Policy (2013); and City of Cape Town By-law relating to Streets, Public Places and the Prevention of Noise Nuisances (2007). Some of the intended and unintended impacts resulting from policies and legislations plan and implementations are discussed in chapter 2, subsection 1.4.1 below.

At present, the homelessness preventative framework highly depends on the government departments, and unfortunately, the required effective collaboration and coordination are lacking (Naidoo, 2010). Studies (e.g., CoT Research Report, 2015; Du Toit; 2005; Elliot and Krivo, 1991; Hoch, 2000; Lee et al., 2001; Mojtabi, 2005; Naidoo, 2010; and United Nation CHR, 2005) show that the mitigating/eliminating measures of the social welfare and housing are not adequate to capture the complexity nature of homelessness. Few examples of this inadequacy include the lack an official definition of The Homeless in South Africa (SA) and growing statistics of people without (adequate) homes. The presence of and growing homeless community also challenge the effectiveness, efficiency and dignity of service deliver to the citizens/public by the state and its organs.

1.8.8 Miscellaneous

Four additional triggers to conduct this study include the following.

(a) Randomly and interesting spatial locations (seemingly preferred by homeless to sleep or rest) observed prior to the study at various times and dates in and around the City of Cape Town (as well as other part of the country). Whereby some of the homeless community are isolated from the active public social dynamics (such as public walk-paths, hubs and centers). Of which, to some extent, these public setups exacerbate the difficulties to reach out to these homeless individuals and groups. Possibly a sign to seek (special and new) approach to ensure that The Homeless are integrated into the public spaces, community.

(b) Third party assistances are commonly targeting those with specific human and/or social capitals. For example, Western Cape Government (2015, 5) comprises the norms and standards for providing "… particular relevance for those that will access shelter services, [and this to satisfy] the organizations providing the services, the funders of these services, government and the various stakeholder that have a role to play". When of The Homeless' human and/or social capitals do not match the outlined criteria, consequently, the 'non-qualifying' homeless individuals forfeit the opportunity to benefit from these services/products.

(c) Inspiration and questions that are triggered by some of the clauses in the South African's Bill of Rights - which serves as a cornerstone for the human dignity, equality, freedom and other democratic values (or human rights) for everyone in South Africa.

- On human dignity, subsection 11 - "[everyone] has inherent dignity and the right to have their dignity respected and protected". For homeless couples, for instance, do the set-up or spatial locations for sleeping/resting also provide a room to spent exclusive quality time and romantically connect with appropriate level of dignity, respect and protection from their children, fellows and/or the public? If so, how and when? If not, how is it done given that some women fall pregnant whilst reside in non-housing set-ups?

- On freedom and security of the person, subsection 12, no. 1 states the follow. "Everyone has the right to freedom and security of the person, which includes the right: (a) not to be deprived of freedom arbitrarily or without just cause; (b) not to be tortured in any way; (c) to be free from all forms of violence form either public or private sources; and (e) not to be treated or punished in a cruel, inhuman or degrading way". NLCHP (2014), on the topic of criminalization of The Homeless, debates that sometimes some of The Homeless experience public and private unreasonable and (un)lawful intrusions or disturbances (such as shouting/verbal harassments/degrading statements and invasions of privacy) and tenure insecurities. In that light, are the "offenders" aware of their unlawful/injustice acts that suppress the human rights of the fellow citizens, the homeless individuals and groups? Or rather, are the homeless people aware of and exercise their democratic human rights when the public or private/official members temper with them in an unjust manner or unlawfully? If not, why and how can they be encouraged/empowered to act or protected legally? If so, how far are their cases or concerns attended to by the justice department or civil societies?

(d) Majority of the society are facing housing challenges due to affordability and unavailable land, which somewhat come forth as feedbacks from other scenarios (e.g. unemployment, mortgage or financial policies, land and ownership polices. Whereby, in the country, the housing affordability index determined by National Association of Realtors is used to indicate whether an individual or a family qualify for a mortgage loan of a specific house based on their income (NAR, 2016).

1.9 RESEARCH STUDY MOTIVATION

"*Gae ke moo motho a lahlang hlogo gona*"

A Pedi phrase that loosely translates "home is any place where one lays down his/her head to sleep or rest". Pedi, also known as Sepedi or Northern Sotho, is one of the eleven official languages in South Africa (predominantly, in the northern part of the country, Limpopo Province) and partially the mother tongue of the author (Mr. Dime Kekana). At present, this phrase holds minimal or almost no practicality, as resting in some of the places is considered unlawful, thereof, there is a cultural/social shift.

To the author, the cultural shift became more vivid primarily after Rustenburg Anglo Platinum Mines Bursary termination at end of the academic year 2010, on the ground of poor performance of his undergraduate studies (BSc Geology degree) at the alma mater, University of Cape Town (UCT). Leading him to experience homelessness for the first time, which was in the beginning of the academic year 2011, for a period of five weeks. Although it occurred during the senior stage of his studies; at the time, Dime had not fully adjusted to new town, city lifestyle, being in world prestigious university with diverse community and a learning environment of solemnly English as medium of communication.

The homeless experience primarily comprised social instabilities, economic poverty and food insecurity. In addition, the author had an exposure to increased weather vulnerabilities and structural risks, because of various attempts to navigate security measures in private properties and secure warm and safe environments to sleep each night (e.g., lecture theatres, passages and public parks).

Nonetheless, today, the experience is a blessing in disguise as it bred more insight to making difficult decision-making, appreciation of key aspects in life and the spirit of hard work and dedication of duties at hands, in the midst of harsh reality. Furthermore, the author had the chance to do a thorough self-introspection and use the given opportunity to search and focus on the most desired career route, research in the field of Geographic Information Science (GISc), of which, this serves as part of the outcomes.

1.10 RESEARCH STRUCTURE

This research study comprises seven chapters. Chapter 1, **Introduction**: provides the context of the homelessness from statistics, causes and challenges to studies linked with this research, as well as the research aim, objectives, research question, premises, scope, limitations, case study, research motivation and research structure. Chapter 2, **Literature Review**: presents theory on homelessness (i.e. definition, cause, challenges and various interventions in place) extracted from other testimonies and stud-

ies; spatial (homelessness) literature; and the linkages with this research and gaps in literature, including those this research attempted to fill. Chapter 3, **Analytical Methods**: highlights the approaches for collecting, manipulating and analyzing the datasets (i.e. the spatial locations of and around where the homeless people sleep/rest). Chapter 4, **Discussion**: provides summary of the findings and related brief discussions. Chapter 5, **Conclusion**: is summary of the overall research, how the findings match with and support the research aim.

CHAPTER 2: LITERATURE REVIEW

This is an interdisciplinary study, composed of two different fields, namely; homelessness (i.e., homeless individuals and groups) and GISc (geographic information science). Likewise, the literature review entails both fields, respectively. Such type of interdisciplinary study is also known as socio-spatial study within GISc discipline. To be more specific, in this study, GISc tool (i.e., GIS - geographic information system), is used to (re-)emphasize the presence, need to reveal and potential of salient information embedded in the spatial data.

Contextually, the use of GIS is to enhance the knowledge and understanding of the homelessness within (Cape Town) City Center. In which the focus is solemnly on individual spatial locations chosen and used by homeless individuals and/or groups to sleep or rest at night/early hours of the morning. In essence; the study attempts to draw attention to spatial characteristics of and around the sleeping locations of the homeless individuals/groups (i.e., salient information, which qualitative and other studies often miss) and thereof, reveal powerful insight for initiatives that focus on/are interested in improving the livelihoods of the homeless community located in such and/or similar setups.

2.1 HOMELESSNESS THEORY

2.1.1 The Homeless Definition

Defining homelessness is crucial when conducting a research study, as there are numerous viewpoints and classifications (Springer, 2000). As such, a definition provides clarity as to whom out of the society is the target (i.e., relative object or subject of the research study). Consequently; the study outcomes define the relevant and precise homelessness knowledge and understanding, which can accurately inform the social, policy, budgetary (CoT Research Report, 2015) and/or other interventions focusing on/relating to the livelihoods improvement or (sustainable) development of the societal members in question (Toro, 2007).

At present, there are multitudes of homeless definitions worldwide; some of the examples are listed below in table 2. However, in this research, the definition of The Homeless (i.e., the homeless individuals and groups) is as follow. All the individuals observed preparing to sleep, sleeping or waking up, at a particular point and time of the early hours of the morning, in public places (e.g. streets, pavements, under the bridge, in public parks), without exhibiting prohibited behavior as per the City of Cape Town's by-law relating to streets, public places and the prevention of noise nuisances (2007), regardless of their background and/or intentions to be at that specific location in time.

Toro (2007) admits that defining homelessness seems easy but it is not. Since homelessness is a multifaceted and complex phenomenon (Gloger et al., 2004; HSRC, 2015; and United Nation CHR, 2005). HSRC (2015) defines the complexity of homelessness in terms of various types of 'continuum' and 'patterns'.

Whereby the 'continuum' of homelessness is composed of primary (i.e., rootlessness, rough or absolute homelessness), secondary (i.e., temporary housing at a shelter or with friends or family) and tertiary (i.e., some form of housing such as shacks, marginalized house and trailer). The 'patterns' of homelessness comprise temporary (i.e., in transition, once-in-a-lifetime); episodic (i.e. in and out homelessness over short time intervals); and chronic (i.e., permanent homelessness or homeless over longer time period).

Table 2: Various definitions of The Homeless by different authors /organizations around the world.

Organization/Author	Definition of The Homeless
Australia Bureau of Statistics (ABS, 2012)	"[Individuals who do not] have suitable accommodation… [and] their current living arrangement: is in a dwelling that is inadequate; has no tenure or if their initial tenure is short and not extendable; or does not allow them to have control of, and access to space for social relations".
Caplow et al. (1968, in du Toit, 2010:, 2)	"[Individuals in] a condition of detachment from society characterized by the absence or attenuation of the affiliate bonds that link settled persons to a network of interconnected social structures"
City of Cape Town Street People Policy (Finch, 2013)	"[P]eople, who for any reason use the outdoors as a place of abode for a lengthy period of time…[and they are referred as street people, where the term 'street'] includes all areas open spaces and river banks "
City of Cape Town Street People Report (Hendricks et al., 2016, 37)	"[T]hose who are living and sleeping on the street, including those staying in shelters, within the City of Cape Town"
City of Tshwane (adopted Cross et al. 2010:18, in CoT Research Report, 2015)	"[Individuals who] are the proverbial skeletons at the feast, the excluded poorest who enter unobserved and stand by, gaunt ad starved, terrifying to the invited guest but deprived of any capacity to the party."
India Census (Jha, 2013)	"[Individuals who] do no live in buildings but stay in open, roadside, railway platforms, under flyovers, etc."
Layton (2000, in Ismail and Turiman, 2016)	"[Individuals] without any shelter at night [and also] live in spaces that do not meet basic health and safety standards."
Link et al. (1994 in Ismail and Turiman, 2016)	"[Individuals] sleeping in shelters, abandoned buildings, bus station etc."
Link et al. (1994, in Ismail and Turiman, 2016)	"[Individuals] sleeping in shelters, abandoned building, bus station, etc."
United Nation Habitat (United Nation CHR, 2005, 6)	"[Individuals who are a state that] carries implications of belonging nowhere rather than simply having nowhere to sleep"
United Nations Statistics Division of the Department of Economic and Social Affairs (United Nation CHR, 2015, 7)	"[Individuals from] households without a shelter that would fall within the scope of living quarters"

Whilst on the complexity of homelessness, Gloger et al. (2004) argue that the politically controversial aspect of the subject (i.e., defining homelessness) also introduces some difficulties. There are three complicating factors, according Toro (2007, 2), and these include. Firstly, the duration an individual is homeless (i.e., whether to include those who are homeless only for night or not). Secondly, the nature of the dwelling or shelter (i.e., whether to include those living in slums, informal settlement or substandard houses). Third and lastly, the relationships existing in the household (i.e., whether to include those who are squatting/sharing with their relatives/friends or not).

Fazel, Geddes and Kushel (2014) note that although the European Union (EU) does not have an official definition of homelessness. However, out of each of the definitions used, there is, at least, an element of 'sleeping rough' (or unsheltered), squatting with relatives or transitional accommodation. According to United Nation CHR (2005), most developing countries substitute the social exclusion aspects in their

definitions of homelessness. Du Toit (2010) mentions that most literatures in South Africa cite the definition of Caplow et al. (1968, refers to table 2 above). Despite the fact that the definition is only limited to the socio-psychological aspect and excludes other aspects such as the housing and geography.

In addition, Du Toit (2010) makes an example about South Africa Alliance to Shack/Slum Dwellers International (i.e., SDI (2016)) that they refers to people who reside in the informal settlements as 'homeless'. Although the informal settlements offer a better livelihood standing as oppose to those who sleep on the streets. For instance, informal settlement offers: retreat places that are somehow recognized in the urban spatial planning records; somewhat stronger social relation structures; and better position to raise service delivery issues.

In contrast, other scholars such as Depres (1991) provide the definition of The Homeless through the lens of 'home', i.e., homeless is not having a 'home'. Where a 'home' is defined as a physical environment that caters, at least, the following behavioral interpretations. (a) security and control; (b) reflections of one's ideas and values; (c) acting upon and modifying one's dwelling; (d) permanence and continuity; (e) relationships with family and friends; and (f) center of activities; (h) refuge from the outside world; (i) indicator of personal status; (k) material structure; (l) place to own.

That being the case; the definition of homelessness must not be limited or narrowed down to lack of roof, shelter and home (HSRC, 2015; and United Nation CHR, 2005), which is what most researchers in United States (and other parts of the world) settle for and refers to it as 'literally homeless' (Toro, 2007). Toro (2007) also states that different homelessness advocates and policy makers prefer different definitions. Consequently, these preferences have significant impacts on the resistant, growing and complexity of the homeless community. Because the preferred or chosen, narrow definition excludes others within the full spectrum of the homeless community (HSRC, 2015; and United Nation CHR, 2005).

2.1.2 Causes of Homelessness

Despite the multitude of literature on the homelessness, especially in the developed countries (Tipple and Speak, 2005; Toro, 2007; and United Nation CHR, 2005); the Special Rapporteur of United Nation CHR (2005) says that the causation of homelessness remains unclear and difficult to identity. However, it is now evident that the roots of homelessness run beyond social exclusion and the transition from home to homelessness is complex and not instantaneous. Furthermore; studies (e.g., Cheng and Yang, 2010); Wolch et al., 1993) often make differentiations of homelessness causations based on two notes: individual (what reflects on individual, e.g., mental illness, alcohol and substance abuse, work ethics) and structure (a wider socioeconomic, political and structural changes such as unemployment, poverty, policies, housing arena and so forth). The causations of homelessness trace down to violation of human rights (e.g. denied access to water, land), and marginalization or discrimination based on a number of factors such as race, gender, nationality, social origin, and birth (CoT Research Report, 2015; du Toit; 2005; Elliot and Krivo, 1991; Hoch, 2000; Lee et al., 2001; Mojtabi, 2005; and United Nation CHR, 2005).

Figure 3 (below) is a summary by Cheng and Yang (2010) illustrating that although there are multiple roots to homeless (e.g., family disruption, job insecurity, mental health problems and social issues), however, there is somewhat a similar trajectory to homelessness. That is, prior-unique story, root or causation (either individual, structural or both), followed by unstable living conditions, sleeping on the street, transfer in and out of shelters, back to sleeping in the street and the loop between streets and in/out of shelter. In which, the various aspects (discussed below, i.e., subsection 1.2.1-1.2.4) shape or stimulate the various transitions in the "life expectancy of becoming homeless" model.

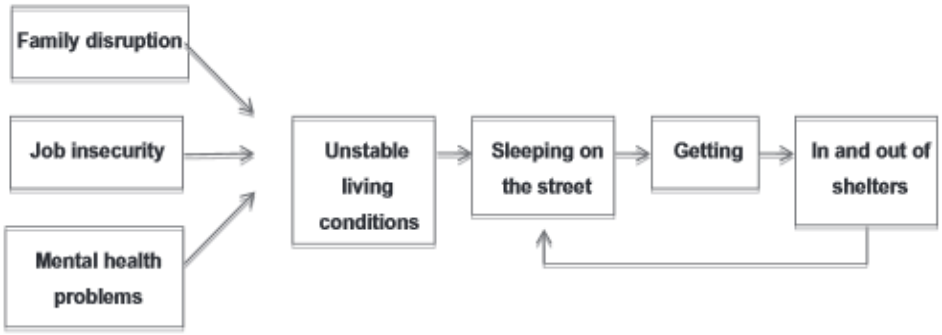


Figure 3: Illustration of "Life expectancy of becoming homeless". Source: Cheng and Yang (2010)

2.1.2.1 Social, Cultural and Religious Aspects

Literature indicates that social, cultural and religious aspects play significant roles in an individual's attitude, belief and behavior (OCED, 2007). As noted by (Mojtabi, 2005), one way the above aspects can be linked to homelessness is through interpersonal issues/challenges in the form of domestic violence. CoCT Metro Police (2016: 2) defines domestic violence as "[a] systematic pattern of controlling, coercing and violent behavior intended to punish, abuse and ultimately control the thoughts, beliefs and action of another". Domestic violence comprises emotional abuse (e.g. isolation, mind games, manipulation, destruction of property); verbal abuse (e.g. insults, blaming, name-calling, yelling, denying); physical abuse (e.g. pushing, restraining, rape, hair pulling, hitting), and economic abuse (e.g. preventing employment, denying access to family).

Internationally, domestic violence is a continuing epidemic issue, especially against women and children (Golu, 2014). Meadows-Oliver (2009) notes that domestic violence is one of the major causes of homelessness. One out of four women experience domestic violence. Fortunately; in South African, there is a Domestic Violence Act 116 of 1998, implemented with "international commitment and obligation of the State towards ending violence against women and children". However, the victims of domestic violence are not only women and children. Campbell (2010) argues that approximately two in every five men experience domestic violence. But unfortunately it is more difficult for men to report or seek support in the lines of domestic violence because, in South Africa, abused men are confronted by shortage of resources (e.g., peer and community supports), skepticism from law enforcement agents (e.g., police, civil society officials) and other dimensions such as legal matters (Robinson and Segal, 2016).

In addition, some of the male victims of domestic violence might opt to avoid further abusive actions by leaving their homes for an alternative shelter elsewhere - as a way of escaping, or avoiding, abuse (Meadow-Oliver, 2009). Alternative shelter may be a family, friend or public home for the homeless people. One of the worst-case scenarios come with the absence/inadequate social and/or financial means for securing an alternative home. In such circumstance, the male victim ends up being homeless or sleeping rough. Jewkes et al. (2009) state that some of the male victims remain silent about their experiences (which may negatively affect the security of an alternative home with a friend or family), because, in general, male victims face societal concerns about and criticisms of their manhood or masculinity.

Furthermore, domestic violence can lead to other issues such as ill health and substance abuse. Again, both the ill health and substance abuse can root from other matter(s) in one's live and independently link to homelessness (Mojtabi, 2005; and Springer, 2000). In terms of ill health, for example, Dobbins et al. (2016) highlights that there is close a relationship between HIV and homelessness and this association is complex in nature. As there is often one or more additional issue involved (e.g., disability, drug abuse). South Africa is one of the countries with high number of people living with the deadly and incurable illness, HIV/AIDS (Jewjes et al., 2009; Springer, 2000; and State of Cape Town, 2015).

Jewjes et al. (2009) conducted a study to understand the interface of HIV/AIDS and rape (i.e. another issue that has the highest rates in the country). One of the findings is that more incidences of the sexual abuse occurred on strangers or acquaintances more than on the perpetrator's partner. Homelessness may possibly results where abuse victim gets sexual molested by their acquaintance, e.g., landlord, housemate, relatives such as step-parent and uncle/aunty (Mojtabi, 2005). The victim, for instance, may be kicked-out of the house for the some reason(s) such as refusing (orally or physically) to let the reoccurrence of the domestic violence incident(s) and reporting or threatening to report the domestic violence incident(s). Moreover, according to Mojtabi, 2005, the domestic violence victim may voluntarily leave the house, without an alternative dwelling or shelter accommodation, due to the physical, emotional and/or mental impacts on them (e.g. pains, loneliness, and bizarre behavior).

In the interim of planning and implementing the socio-psychological and economic development interventions for The Homeless), it worth re-emphasizing that it is equally important to consider and integrate their existing spatial arrangements where they sleep, especial for those in public places. As these spatial arrangements may be encouraging and offering convenient rooms for (additional) perpetrators of the poor and vulnerable homeless individuals and groups - but this aspect is beyond the scope of this research, although the study touches accessibility of the public to sleeping locations of The Homeless. In an extreme case where a homeless individual's origin of homelessness is sexual abuse, if the victim continues happening even outside the wall of a conventional dwelling or shelter, the likelihood of the person to recover become slim or non-existence even when the social and housing interventions offer by (non-) government reach out to them (CoT Research Report, 2015). Alternatively, in a less fortunate case, the victim may require intense and possible prolonged intervention to re-live like ordinary citizens (CoT Research Report, 2015; and Springer, 2000). The latter may hinder severe consequences

on the adequacy and/or financial aspect of the intervention to make a successful story of combatting homelessness and this may be one of the possible reasons from the ongoing homelessness.

2.1.2.2 Economic Aspect

Elliot and Krivo (1991), Hoch (2000) and Lee et al. (2001), amongst others, share that the economic aspects connect to homelessness in the form of financial crisis. In an instance where 'one or more persons with a house start to experience financial difficulties. Depending on the severity of these financial difficulties, these persons may ended-up in the street. Especial if the person(s), for example, cannot honor the payments of their home as required, as result of other possibilities and/or one or more of the following three possible reasons for financial crises (Ramin Mojtabi, 2005). (a) The dependable person or bread-winner losing their opportunities to generate income. (b) The rental or mortgage instalment being increased beyond the affordability level; inflation in the currency leading to money for habitation inadequate. (c) Simply missing to make the house payment on the cut-off date or a month.

As per Stats SA (2014), in the year 2014, the working population in South Africa was approximately 15 million. Out of the 15 million; approximately 7 million (46%) were semi-skilled, 4.3 million (29%) low-skilled and 3.8 million (25%). Where semi-skilled workers hold the following occupations: clerks; sales and services; skilled agriculture; craft; and machine operators. Low-skilled workers include elementary and domestic workers. Skilled workers comprise managers; professionals; and technicians. According to the latest (2016) salary review of South Africa compiled by Career Junction, the lowest semi-skilled workers (i.e. tellers and cashiers) have an income of R5 259 per month (Business Tech, 2016). Cape Town CBD Census (2013) extracted from SA census 2011 that here are 12.2% households with monthly income below R6 400 in Cape Town – whereby, 11% are without income, 3.7% receive income in the range R1 – R1 6000, 3.2% (R1 601 – R3 200) and 8.5% (R3 201 – R6 400). However, majority of the citizens, during the 2014 and 2015 period were still not working.

There are three groups used to classify citizens that are not working and these are as follow, including their statistics. (a) Unemployed (taking up 14.5% of the population in Apr-Jun 2015); (b) discouraged work-seekers (6.8% of the population in Apr-Jun 2015 after increase with 0.1% from Jan-Mar 2015 period); and (c) others or not economically active (35.1% of the population during Apr-Jun 2015 after 0.4% increase from Jan-Mar 2015).

Table 3: A 2015 summary report of Quarterly Labor Force Survey in South Africa. Source: Stats SA (2015)

Labor Force Status/Category	Proportion of the Population between 15-64 years		
	Apr-Jun 2014	Jan-Mar 2015	Apr-Jun 2015
Employed	42.7%	43.2%	43.5%
Unemployed	14.6%	15.5%	14.5%
Discouraged work-seekers	6.8%	6.7%	6.8%
Other (not economically active)	35.8%	34.7%	35.1%

In Table 3 (above) is a 2015 summary report of quarterly labour force survey in South Africa for the Population aged 15 to 64 years. An outstanding point is that the employed population is below 50% mark. Moreover, the very same less than 50% proportion of the working population is occupying employment opportunities that do not necessarily secure decent living standards according to the country's Nation Development Plan Vision of 2030 - in which, one of the determining factors of such living standards is decent work with rising employment, productivity and income as well as sustainable livelihoods.

In addition, another outstanding point based on the Stats SA (2015) report (refers to table 3) is the non-employed categories (namely, unemployed (14.5%), discouraged work-seekers (6.8%) and other or not economically active (35.1%) during Apr-Jun 2015 period). Although it is not stated in the report, but the linkage is visible between The Homeless and individuals in three employment categories. As prolonged unemployment, for instance, is considered as a key element to homelessness at least by the City of Cape Town Street Policy (Finch, 2013).

State of Cape Town Report (2012) show that the poverty line in the City of Cape Town is R 3,500 per household and 35.7% of the household in the City live on poverty. In addition, 13% of the household acquire their incomes from social grants and the percentage increased from 9% in the year 2009 to 2011. Although there seem to be some sort of income for most the South African households, nonetheless, the key question is whether the income is adequate to service and support the livelihoods (including housing security) or not. Hartshorne (1992, in CoT Research Report, 2015) understands that majority of The Homeless in City of Tshwane are receiving incomes, yet they still cannot afford housing closer to their workplaces (i.e., in the City) or at least travel to their homes outside of the City on a daily basis, as a result, they opt to sleep in public places.

South African census 2011 declares that 0.0% informal dwelling/shack in backyard, 0.2% informal dwelling/shack NOT in backyard, and 99.1% formal dwelling types in the case study region or Cape Town CBD (Cape Town CBD Census, 2013). In terms of tenure status, Cape Town CBD Census (2013) displays that only 11.1% of homes are owed and paid off and the remaining large amount is for rented (76.3%), owed but not yet paid off (10.7%), occupied rent-free (1.3%) and other (0.6%). Clearly, in a general event of severe financial crisis (e.g., recession), over 88.3% households may be at the risk of home loss - especially, because (residential) properties in Cape Town CBD are very expensive for majority of the South Africans or locals.

CCID Annual Report (2015) denotes that average residential property rentals are R10 375 (studio/Bachelor), R15 860 (one bedroom), R20 120 (two bedroom), and R36 000 (three bedroom). As for student accommodation, the rental average ranges from R2 850 (double room, sharing) to R6 000 (studio). The average sale/market price for residential property was R1.428 million (in the year 2013), R1.552 million (in 2014) and R2.031 million (in 2015).

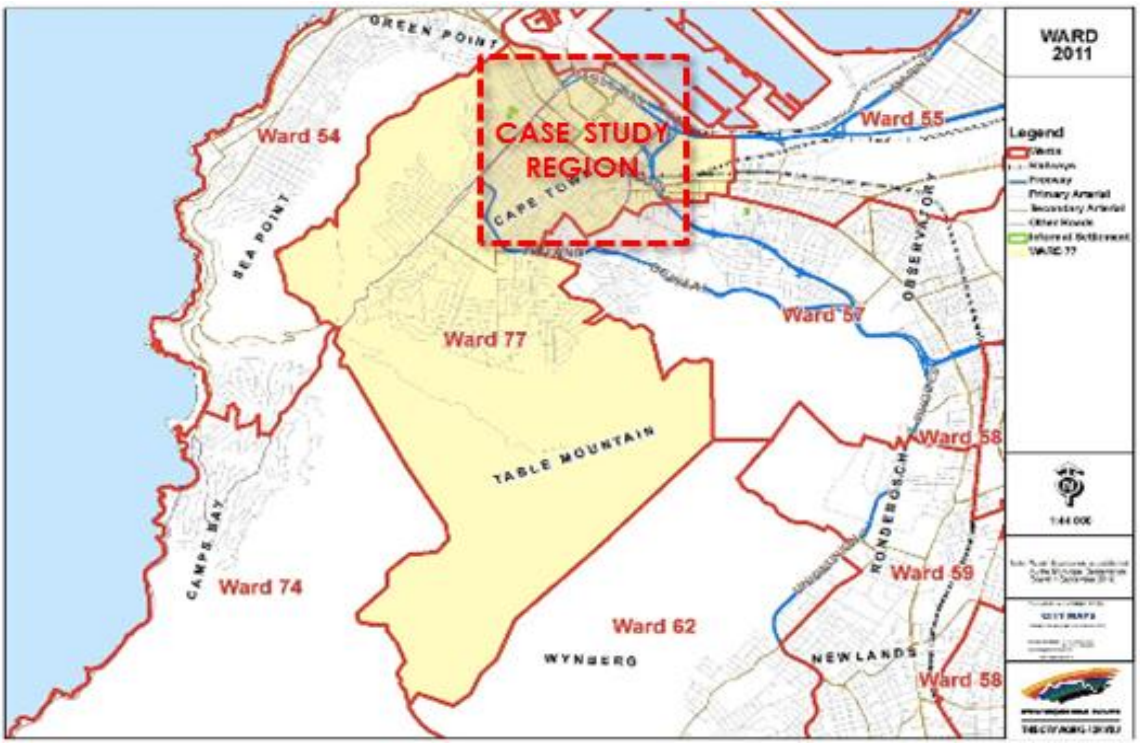


Figure 4: Map of Wards sections, i.e., 54 and 77, which are covered by the case study region. Source: CoCT Census (2011, Ward 077)

The above indicates that working population struggles to secure housing. In addition, it explains the increased and expected to growth of homelessness. Therefore, the growth suggests that if the current socioeconomic, environmental and political dynamics continue in the future (ABS, 2012; CoT Research Report, 2015; Gloger et. al., 2004; HSRC, 2015; Ismail and Turiman, 2016; and United Nation CHR, 2005). Consequently, it raises the impracticality of achieving the 2030 Nation Development Plan goal (or 2030 International target) of ensuring that everyone secures a decent standard livelihoods, based only housing (SA NDP, 2011; and United Nation CHR, 2016). Let other factors that give rise to 'decent standard livelihood' such as education and skills, employment, nutrition, safety and security.

On the aspect of education, for instance, Ismail and Turiman (2016) oppose that some of the homeless are rural-urban migrants without good human and financial capitals (e.g., education, skills, money), they leave their homes because they cannot compete for socioeconomic activities but hope for better stances in the city. South African Census 2011 respectively indicates that ward 54 and 77 (refers to figure 4 above) adult education (i.e., aged 20 and more) higher than grade 12 is 53.6% and 60.4%, grade 12 is 30.9% and 24.2% and no schooling is 0.4% and 0.7% (CoCT Census, 2011, Ward 054 and CoCT Census, 2011, Ward 077). Based on Ismail and Turiman's (2016) above argument and the above statistics; it can be drawn that socioeconomic activities competition for migrates coming into the Cape Town Center is higher. That is, one may need to, at least, have education higher than grade 12 to stand a better chance of improving her/his livelihood and this is probably shocking and sad news for some migrants, especially those without minimum required level of education. More discussion on this topic is below in (this chapter, 2) subsection 1.5.4.

2.1.2.3 Political Aspect

Springer (2000) briefs that homelessness is very much of a political topic, a sensitive one too. Since, politics is closely related to the nature of the governance and well-being of citizens, including those sleeping in public spaces. For a democratic governed country such as South Africa; Wakhidah (2013), amongst other, argues that the public spaces should be in a nature that provide everyone (including The Homeless and other marginalized groups such as women, children, elderly and undesired people) access to pursue their various socioeconomic and cultural activities as well as other sorts of livelihood interests.

Internationally, United Nations' (1948) Article 25, section 1, of Universal Declaration of Human clearly highlights that. "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control". Locally, SA Constitution (1996), section 26 and 27 respectively, state that: "[everyone] has the right to access to adequate housing… [and the government] must take reasonable legislative and other measures, within its available resources, to achieve the progressive realization of this right"; and each person should get access to "…social security, including, if they are unable to support themselves and their dependents, appropriate social assistance".

Unfortunately; some of the homeless individuals and groups, who are (also) supported by the human rights mentioned above (amongst others), are still not exercising their human rights as they are unable to acquire adequate livelihood services and supports, especial the one offered by the state. Springer (2000) and Gloger et al. (2004) debate that the latter is linked or rooted in the definition of homelessness, furthermore, other studies (such as CoT Research Report, 2015; Du Toit, 2010; HSRC, 2015; and United Nation CHR, 2005) also indicate that the preferred homelessness definition generates limitation and exclude other homeless individuals. Consequently, certain individuals and groups are excluded from the social services, support and other financial plans and assistances.

In contrast, United Nation CHR (2016) clearly states that homelessness is the result of the failing state or government to provide adequate housing and other services and support structures that significantly and appropriately mitigate/eliminate socioeconomic and cultural circumstances and causes. Thus, homelessness is not much more of personal failure resultant. The latter is primarily based on various patterns of inequalities within society, which the United Nations' Special Rapporteur mentions that these inequalities disable The Homeless from exercising their human rights.

In South Africa, for instance, the exclusion of homeless people is a sensitive topic because it is linked to the country's historic (or political) background (i.e., apartheid governance), in which majority of the population was literally discriminated from housing schemes and other standardized socioeconomic activities and interests based primarily on race (Du Toit, 2010; HSRC, 2015; and SA Constitution, 1996). It is argued that the traces of apartheid legacy still existing even after two decades of post-apartheid.

One of the good examples is the emerging and anticipated high statistics of The Homeless as a result of rural-urban migration, unemployment, poverty, lack of education and other factors such as domestic violence, marginalization and inequality (CoT Research Report, 2015; du Toit, 2010; HSRC, 2015; and United Nation CHR, 2005). Hence why there the SA Constitution (1996) indicated in section 27 (subsection 7) that: "[a] person or community dispossessed of property after 19 June 1913 as a result of past racially discriminatory laws or practices is entitled, to the extent provided by the Act of Parliament, either to restitution of that property or to equitable redress".

Based on the above and the aim to achieve the goal of ensuring adequate housing in 2030 (which is outlined as target 11.1 in the Agenda for Sustainable Development, 2030); United Nation CHR (2016) urges governments, worldwide, to urgently start to consider relationship between homelessness and human rights. As doing so keeps governments in synchrony with their human rights obligations. The 'three-dimensional approach' that links The Homeless to their human rights as proposed and highlighted in United Nation CHR (2016:1) include the following. (a) "[Addressing] the absence of home in terms of both its physical structure and its social aspects". (b) Considering homeliness as a form of systemic discrimination and social exclusion, whereby "the homeless" become a social group subject to stigmatization. (c) "[Recognizing] homeless people as resilient in the struggle for survival and dignity and potential agents of change as rights holders".

2.1.2.4 Environmental Aspect

Homelessness is directly linked to environment activities such flooding, mass-slides, hurricanes and so forth. Studies (e.g., Mukheibir and Ziervogel, 2007; and State of Cape Town, 2012) confirm that there are no precedents of future environmental activities, for the most part due to global warming. In which certain areas of the Earth may face severe environmental shocks/impacts. As a result, these environmental impacts may possibly overwhelm other people depending on the experienced degree of the negativity on their homes. Depending on resilience of a home and financial standing, which play significant roles in overcoming these negative environmental impacts.

Resilient homes can absorb the negative environmental shocks without any major reconstructions or any reconstruction of the homes at all. In contrary, non-resilient homes may experience reconstruction or demolish. As such, the financially standing of the people may be the primary determinant of homelessness or not. For instance, the citizens with non-resilient homes may be homeless, if they do not have their homes insured for environment impacts nor have adequate money/means to reconstruct their homes aftermath the environmental shock(s).

For instance; article of Gqirana (2016) on News24 (i.e., South African popular and public news broadcaster) reads that approximately 6,500 residents from poor communities were negatively impacted by the floods around 19 June 2016. Whereby; approximately 1,600 households (particularly shacks) are affected. On the 17 November 2013, TimeLive (also a popular South African news broadcaster) published an article title "Western Cape starts mopping up after floods". The article notes that in an area near Cape Town, known as Somerset West, severe floods were experienced. Consequently; some of

the shops (including banks) had to be closed and people were stranded as several roads were also closed. Amongst affected people, 129 patients were evacuated from one hospital to another due to floods.

According to City Views (2013), Cape Town is surrounded by 300 km coastline and some theses coastlines (e.g., Hout Bay and case study region – refers to figure 1 above) are artificial, consequently, they are susceptible to climate change, particular change in mean sea level that is coupled with various storms. Based on the above; in an event of intense coastal storm(s), thousands to millions households in low, middle and high income communities may be displaced, thereof, living large number of people homeless, e.g., refers to figure 5 and 6 below.

Figure 5 (below) illustrates two distinct but yet similar storm impact events in different areas at different time-period. Figure 5 (a) shows low income area or rather informal settlement in City of Cape Town. The potholes in the streets are filled up with water and the available hard surface is muddy and slippery making navigations around the neighborhood difficult and almost impossible. Furthermore, the conditions seem to result from an ordinary rainfall that is adequate to trigger surface runoff. On the hand, i.e., figure 5 (b) displays extra-ordinary results of rainfall or storm. In which, the water level is up to waist-level of (South African) adult. Such case is very extreme as many, if not all, aspects of human livelihood are negatively impacted (e.g., mobility, property/assets, food, daily routines). Although storm water impacts for figure 5 (a) and (b) are different, however, they are both critical as they alter human livelihoods.

(a) (b)

Figure 5: Recent storm impacts (a) on one of the low income areas in Cape Town and (b) middle-to-high income area Port Alfred, Eastern Cape, South Africa. 2008. Source: https:/www.news24.com

The images under figure 6, below, were taken locally, in Camps Bay – which is located roughly 8 km south-east of the case study region. The area is along the coastline. The difference in the storms between figure 5 (b) and 6 is brought in by the water levels, to mention the least. In figure 6; the water level is just below the knee of an average adult whilst in figure 5 (b) is higher (i.e., covering almost the entire adult torso). Nonetheless; such storm impacts are extra-ordinary, they aggressively penetrate and sweep off the human livelihoods occurring in places such as roadways, sidewalks, beach, shops and so forth.

Figure 6: Recent storm impacts on one of the high income areas in Cape Town, Camps Bay, on the 08 Sep. 2008. Source: Camps Bay Info (http://www.campsbayinfo.com/blog/camps-bay-news/the-cape-of-storms)

That said, in each of the cases (i.e., either ordinary or extra-ordinary storm event); mitigations strategies for negative impacts are very crucial (Mukheibir and Ziervogel, 2007; and State of Cape Town, 2012). Studies confirm the climate changes in the past, at present and in the future, but there are uncertainties associated with the magnitudes of these changes and their impacts. Since, there available climate models are still unable to accurately provide forecasts, i.e., there is "uncertainty in the science" (Mukheibir and Ziervogel, 2007, 3). It became clear to scholars that some of the climate change impacts may leave some of the citizens being homeless, depending on following. (a) The magnitudes of negative impacts, the resilience of their homes, and (b) the people's "adaptations to climate change", as noted by Mukheibir and Ziervogel (2007, 1), which refers to the "process whereby individuals and communities seek to respond to actual or expected climatic stimuli or their effects".

As a result; Mukheibir and Ziervogel (2007) highlight that United Nations Framework on Conventions on Climate Change (UNFCCC) for Least Developed Countries (LDCs) have developed a National Adaptation Plans of Actions (NAPA), which South Africa also agreed to, as a way of mitigating the vulnerabilities related to climate change amongst various communities and at various levels. As one of the City's accolades in the year 2015, CCID Annual Report (2015, 3) mentions that the City of Cape Town is "recognized as a leading city in international efforts to combat climate change, joining 10 cities worldwide" few other countries include Oslo, New York and Washington DC.

2.1.3 The Homeless Types and Statistics

Amongst other reasons; categorization and statistics of The Homeless help to inform the development of socio-psychological and economic interventions as well as policies (ABS, 2016; and Kekana, 2013). For instance; Ismail and Turiman (2016), regarding homelessness in Johor Bahru City Center, Malaysia, share that a larger number of people are working far from their homes due to working times (i.e., shifts), financial constraints and unfeasible daily commuting between home and work, consequently, they become homeless. The above finding is similar to that of a case study in City of Tshwane, South Africa, as per CoT Research Report (2015).

Following approach similar to other scholars, Ismail and Turiman (2016) categorize the homeless based on the possible causes or the reasons of homelessness. United Nation CHR (2005) argues that there are difficulties associated with identifying the cause of homelessness. Moreover, it is not easy to denote a clear linkage between the causations and categories of homelessness (Hartshorne, 1992, in CoT

Research Report, 2015). Nonetheless, the scholar (Hartshorne, 1992) classifies The Homeless into four categories, which include:

> *Economic Homelessness – "…people who arrived in the city in search of sustainable livelihoods, then find themselves unemployed and eventually on the streets";*
>
> *Situational Homelessness – "…people whose homelessness results from acts of domestic violence or abuse, or from conflict within families and across generations over property, inheritances and even accusations of witchcraft";*
>
> *Chronic Homelessness – "…people who are on the streets as a result of chronic mental health or substance abuse problems"; and*
>
> *Near Homelessness – "…people who are in particularly precarious circumstances and at risk of becoming homeless any day".*

That said, the detailed statistics of The Homeless is one that, at least, include information of each of the above categories of homelessness. Instead of only providing outlines based on gender, age and/or living/sleeping space. This can be a lesson for South Africa and other countries (especial developing countries), which have inadequate homelessness information (Tipple and Speak, 2005; and United Nation CHR, 2005), to incorporate detail homelessness aspect to their future, still-to-be-implemented regional statistics.

Busch-Geertsema, Culhane and Fitzpatrick (2016) share that at present the census authorities do not conduct the detailed surveys. Instead, their operations are limited to an extent of providing a comprehensive national number of The Homeless. In spite of the difficulties raised by homeliness complexity and limited understanding thereof, scholars (such as Gloger et al., 2004; Springer, 2000; and United Nation CHR, 2005) have indicated that reduced details of the homelessness statistics (also) root from the preferred definition of the homeless for conducting the statistics. Since, each country, for instance, has its own jurisdiction and therefore option to utilise its own definition from the multiple ones in existence or draw a new one, refers to table 2 in subsection 2.1.1 above (United Nation CHR, 2005).

Internationally; United Nation made an attempt to count the number of The Homeless in the year 2005 (United Nation CHR, 2005). The outcomes indicate that there are approximately 100 million homeless people (incl. children) and 1 billion when the standard of the housing (i.e., inadequacy housing such as shacks, informal settlement) forms part of the homelessness definition. The rural-urban migration is emerging and anticipated (CoT Research Report, 2005; Ismail and Turiman, 2016; and United Nation CHR, 2005). The influx in the top two national economic hubs of South Africa, namely; Gauteng and Western Cape Province were estimated to be 1,169,837 and 350,569 respectively for the period 2011-2016 (Stats SA, 2015b). The cities are becoming crowded and the plots of people struggling to secure houses (incl. land) are indicating positive trends.

In Cape Town, for instance, State of Cape Town (2012) declares that the 20% of the estimated 3,740,026 population to be living in informal settlement, in the year 2011 – with the 30.6% and 39% growth of informal settlement in the period 2001-2011 and 1996-2011, respectively. As as informal

dwelling in backyards growth of 128% and 244% in the period 2001-2011 and 1996-2011, respectively. It suffices to state that statistics of The Homeless have significantly increased since the last survey in 2005 by United Nations.

Other statistics of the homeless people around the world include the following. In India, there is an estimate of 1.77 million homeless people living in open spaces (e.g., on the streets, public parks) and approximately 449,761 households or families are experiencing homelessness, during the 2011 census (Jha, 2013; Kumuda, 2014; and Tewari. 2014). HA (2016) reports that each night there are about 105,000 people faced with homelessness, in Australia. In Barcelona, (Spain); Font (1998) shares that there are approximately 273,000 homeless people out of the general population of 39.6 million. Busch-Geertsema, Culhane and Fitzpatrick (2016) denotes that the number The Homeless from 2011 census in some of the European Union countries: Czech Republic (11,496); Italy (34,653); Slovakia (23,483); Poland (8,699); Austria (5,811); and Hungary (5,571). In the U.S. Cities; NLCHP (2014) indicates that: 610,042 homeless individuals each night in 2013; 74% of The Homeless are unware of any safe and legal place for sleeping; 1.6 million kids are homeless (i.e., 1 in 45 children).

Locally, there is no adequate or satisfactory statistics of homelessness (CoT Research Report, 2015). Homelessness is not specifically denoted in the national census, which is conducted by Statistics of South Africa. However, there are attempts on understanding the numbers of The Homeless, amongst others. For instance, in the period 2006 and 2010, Human Sciences Research Council (HSRC) estimated between 100,000 and 200,000 homeless people living in the streets in the country, South Africa (CoT Research Report, 2015). In City of Tshwane, it is estimated that 6,244 people are homeless and living on the streets. In City of Tshwane; Finch (2013) notes that there are approximately 7000 people sleeping on the streets (i.e., open spaces and river banks) and these homeless individuals and groups are predominantly in the City Center and public passengers transportation areas, which serve the socio-economic opportunities for them. Western Cape Government (2015) and Finch (2013) share that City of Cape Town had 7,000 individuals living on the streets. Hendricks et al, (2016) denote 643 homeless individuals living on the streets of Cape Town City Center.

2.1.4 Homelessness Challenges

2.1.4.1 Exclusive Interventions

Some of the homeless people are facing severe challenges of exclusion based on the criteria of interventions in place. In this research study, there is an understanding that an intervention can exclude the homeless individuals and groups, either directly, indirectly or both (i.e., direct and indirect). However, the line between direct and indirect exclusion is very thin. A direct exclusive intervention refers to one developed primarily based on the observed patterns of the homeless individuals and groups with the aim is to alter these patterns occasionally, temporarily or permanently. On the other hand; an indirect exclusive intervention refers to an intervention developed primarily based on other factors and processes unrelated to homelessness but its implementation imposes severe alteration of The Homeless'

livelihood pattern(s). There is variety of exclusive interventions; the range is from political to social and physical.

A. Political Exclusive Interventions

Key policies and legislations relating to The Homeless in this research's case study are listed in chapter 1, subsection 1.8.7 above. In general; the policy, legislation and regulating activities can give rise to exclusion of The Homeless as follow. Various advocates and policy makers, who are focusing on homelessness, prefer various definitions of homelessness (Toro, 2007). HSRC (2015) shares some insights that how homelessness is defined, it determines the design of an intervention or how the homelessness is to be addressed. For instance, there is an understanding of homelessness as 'chronic and absolute'. As a result, the associated interventions respond through housing development for those who sleep on the streets and this is customary in South Africa (Du Toit, 2010). Consequently, other homeless individuals experience exclusion. For example: homeless individuals staying in inadequate housing or informal settlements; those who sometimes sleep on the City's streets and on other days travel back to their homes, which are located around the City or elsewhere; and others who are at the risk of losing their homes.

Moreover, HSRC (2015) also gives an example of interventions that are developed based on definition of homelessness in terms of substance abuse. On which; the target of the homeless individuals is narrow and come in the form of treatment and housing facilities. In the process, not only homeless individuals who are not abusing substances or sleeping on the street permanently are excluded, but also those who are affected by other forms of socio-psychological factors.

NLCHP (2014), in the 'No Safe Place - The Criminalization of Homelessness in United State Cities' report, provides an exclusive summary on how the laws in some of the United State Cities are creating limitations and/or criminalizing people for sitting down, eating, camping/sleeping and/or begging in public spaces. Some of the prevalent laws for criminalizing homelessness include prohibition of the following:

- Camping in public (34% and 57% of the cities are intolerant in any public space city-wide and in certain public places, respectively);
- Sleeping (18% and 27% of the cities have zero tolerance in all and certain public spaces, respectively);
- Begging (24% and 65% of the cities have zero tolerance in all and certain public spaces, respectively);
- Sitting or lying down (53% of the cities have zero tolerance in certain public spaces);
- Sleeping in vehicles (53% of the cities are against sleeping in vehicles); and
- Food sharing (9% of the cities do not allow sharing food with The Homeless).

B. Social and Physical Exclusive Interventions

Social and physical exclusive interventions can be explained simultaneous as follow. Some of the 'home' societal groups are willing to help certain homeless individuals and groups provided these homeless people make a 'payback' somehow. For instance; Ramesh (2010) shares through an article in

The Guardian (i.e., one of the United Kingdom news broadcasters) that some for The Homeless engage in sexual activities solemnly for the sake of being accommodated for one or more nights, to be precise 14% of males and 27% of females.

NLCHP (2014) notes that in the United State Cities the law enforcers (i.e., the police officials) harass The Homeless for sleeping (81%), loitering or hanging out (78%) and sitting or lying down (66%). Some the arrest include the homeless individuals: sleeping (30%), loitering or hanging out (26%) and sitting or lying down (25%). In addition, there criminalization of homelessness has been increasing since the year 2011. According to Best MSW Programmes (2016), which provides guidance "…to finding Master's in Social Work degree programs" and its operations are independent and online, states that 21 - 40% of the American in prison were homeless at the time of arrest and few years before that.

Moreover, Best MSW Programmes (2016) also states that the rate of violent crimes around homeless population is 40 times higher than 'home' population whilst the rate of nonviolent crime is 27 times higher. However, NLCHP (2014, 16) argues that most of the laws that criminalize The Homeless in United States are "ineffective, expensive, and violated the civil rights" of these people. Let alone that such actions violate the obligation of human rights binding the United States and The Homeless commit minor or petty crimes (e.g. sitting down, sleeping, taking few coins from a stranger's bag). In addition, the arrests of The Homeless are questionable or suspicious, and those in authority claim these actions are for the public's interests.

In the context of indirect and direct terminology, the above-mentioned actions (i.e., criminalization of The Homeless) can be classified as both direct and indirect exclusion. Direct exclusion in a sense that the laws, which some of the United State Cities have in place, prohibit the basic actions of life and The Homeless are primarily victimized. Given that the homeless people do not have any other place to go to (e.g., for sleeping, lying down) or other means to survive (e.g., food, money, clothing, medicines). On the flip side, criminalization of homelessness causes indirect exclusion because in some instances, certain places are designed and intended to serve a particular socioeconomic standards and investment-returns (e.g., restaurants, hotels, tourist attractions). In such cases, often times, the entire public is excluded (not primarily The Homeless), as certain individuals of certain class cannot match up to or want to be associated with places of particular socioeconomic standards.

An example of physical exclusive intervention, yet direct and indirect in nature, includes installation of studs in private or public spaces. In London, for instance, RT (2014 – i.e., one of the online international television news network, broadcasting news in English, Arabic and Spanish) shows that the outrage that busted out after the studs installations on the doorsteps of one of the luxury flat in Southwark bridge Road – refers to figure 7 below. After the implementation of this physical exclusive of controversial intervention; there was a protest and this extended to online platform, where people also vented out their outrage on social media (such as twitter), including the online petition and the protest or campaign with 'anti-homeless spikes' hashtag to it.

Figure 7: Example of 'anti-homeless spikes' installation or exclusive intervention for The Homeless on the doorsteps of (luxury flat), Southwark Bridge Road in London City Central. Clear display of the doorstep (left) and doorstep with protesters' posters expressing outrage of the interventions, common mark was 'home not spikes' (right). Source: RT (2014)

Apparently, the studs (in figure 7 above) are installed to deter homeless woman and child who sleep there. The local government officials express their opposition to the intervention (including the Major of London who wrote on social media "Spikes outside Southwark housing development to deter rough sleeping are ugly, self defeating & stupid. Developer should remove them ASAP") and it turn out the studs are not included in the property-building plan during approval stage of the development by the local state department.

2.1.5 Homelessness Lifestyle

The studies show that The Homeless are part of the poorest of the poor and also marginalized from the socioeconomic spaces and activities (HA, 2016; Ismail and Turiman, 2016; Rahimian, Wolch and Koegel, 1991; Saxena and Mander, 2011; Springer, 2000; Toro, 2007; United Nation CHR, 2005; and United Nation CHR, 2016). The normal or typical daily routine of an urban citizen, for instance, is very different from those of The Homeless. Typical routine referring to: snoozing or switching-off the morning alarm; brushing teeth; bathing/showering; putting on clean clothes; eating breakfast; catching transport to and from work/school; bathing/showering; eating dinner; locking and going to bed at a preferred time and with high confidence level regarding security of the place. In contrast, homelessness lifestyle is different as follow.

2.1.5.1 Homelessness Waking-Up Patterns

There is no literature available that focused on the homelessness waking-up patterns, especial for street homelessness. Some of The Homeless may have alarms, friends and other factors waking them up in the morning,. While others receive 'law-enforcement alarm' from law enforcement officials and/or security guards, more especial, the homeless individuals and groups who chose to sleep in 'restricted areas' such as taxi ranks, bus terminus, active social passages, building doorsteps and so forth.

2.1.5.2 Food Insecurity

Internationally; food insecurity is one of the contemporary top-list challenges (SA NDP, 2011; and Smith and Richards, 2008) and one of the key issues closely associated with homelessness and poverty (Wax-

man and Reyes, 1987) as well as morbidity and mortality (Weiser et al. 2009). It (i.e. food insecurity) refers to "…limited or uncertain availability of nutritionally adequate and safe food or limited or uncertain ability to acquire foods in socially acceptable ways" (Anderson, 1990, in Smith and Richards (2008, 1). Unfortunately; there is little literature focusing on homelessness food insecurity (Herault et al., 2014; and Smith and Richards, 2008). The current knowledge on the subject of homelessness food insecurity is based on low-income household (Dachener and Tarasuk, 2002), examples include Waxman and Reyes (1987).

The Homeless do not have the luxury of having at least three meals each day or adequate meals in general, thus, they are constantly starving (Cheng and Yang, 2010). The availability of food is not the only challenging aspect of food insecurity. Weiser et al. (2009), after conducting a study to examine the prevalence of and factors of related to homelessness food insecurity (particular for individuals affected with HIV/AIDS), indicates that the following. Food insecurity is highly associated with The Homeless with low CD4 blood-type counts, substance abuse, lack of medical insurance and poor health (both physical and mental).

Other studies also indicate that food insecurity, especially in homeless children, has detrimental impacts on their well-being and growth (McCoy-Roth et al., 2012). As for older individuals (i.e., youth and adults); Smith and Richards (2008) debate that, for some counterintuitive reasons, high body mass index (BMI) or rather 'pediatric obesity' is common and this statement is based on the literature of in low-income households. Also guided by literature; Palar et al. (2014) argue that the negative impacts of food insecurity, especially on women in general, include poor mental health status and depression– and these impacts occur independently of social and economic status.

Furthermore, the food issues among homelessness do not only evolve around insecurity or rather unavailability. Even when food is available, there are other issues, which are unique or similar to when there is no food or enough food. Some of the challenges come with the food preparation and storage facilities (Herault et al., 2014). For instance; The Homeless (esp. those sleeping on the street) do not have cutleries, pots, cups and other items to prep their meals. The Homeless' storages include items such lunch containers, boxes and plastics, instead of items that preserve the food in good conditions such as tight and hygienic containers and refrigerators (to store food that needs lower temperature after opening or preparing).

Consequently; such procedures of preparing and storing food lead to health threats (Waxman and Reyes, 1987), particular food poisoning and/or malnutrition or rather deficiency in nutrients and nutrition, which trigger pains, weakness and other form of discomfort (Smith and Richards, 2008). Even more saddening, the food insecurity increases the rates of heart diseases, hypertension and diabetes (Weiser et al., 2009) and other types of health threats. On the other hand; Herault et al. (2014) argue that securing food, including storage and preparation facilities, are less of a concern for the homeless individuals and groups, as the main pressing factor is finding 'home' or decent dwelling to sleep in, which they can call home.

According to Pelham-Burn et al. (2014), at present, there is limited literature focusing primarily on the improvement of food nutrition for The Homeless, including charity food. However; studies show that the limited attention paid to appropriate food nutrition for the homeless people is associated with the aspects of budgetary, charity and acceptability (Dachener and Tarasuk, 2002). Smith and Richards (2008) noted that most of the homeless youth get food through charity programs, begging and stealing. The Homeless also extend their food gathering by asking strangers for money or simply by requesting the person to buy them food. However; Dachener and Tarasuk (2002), in their study that focused on homeless youth, reveal that achieving food security is very complex and the phenomenon is coupled with food acquisition, income generation, health-improvement, and seeking home, safety and privacy.

2.1.5.3 Bathing/Showering

The public's stereotypical view of The Homeless is rooted in their dirty appearances, as such, they are associated with public health alerts (Cheng and Yang, 2010) and because of this, their environment or rather the locations that homeless people use (e.g., for sleeping, chilling, making a living). The narrow public perception of The Homeless as 'health alerts' is on the account of their relatively unclean bodies, hair and covering materials, which are favorable conditions for parasitic insects, particularly the "body lice" that feed only on human blood, are dirty and unchanged clothes as well as unclean body skin (Denise et al., 2009). Regarding The Homeless' clothes (including sleeping material); unfortunately, there is no study available that estimates how many times The Homeless change their clothes in a week.

The Homeless' sporadic and less frequent routine of bathing (i.e. less than once a week, state Cheng and Yang (2010)) and changing clothes (Bonilla et al., 2009) have given rise to their susceptible to hepatitis C virus (HCV) i.e., a blood transmitted virus that can survive on dry blood outside the body for weeks or months (Neale and Stevenson, 2012). According to WHO (2016); HCV is associated with liver diseases, hepatitis C. It is estimated that 700,000 people die annually from hepatitis C related liver illness and 130 – 150 million people are chronically infected in the world. Currently there is no vaccine for hepatitis C, access to diagnosis procedures and the treatment is low.

Despite the lack of the testimony or study confirming the risk factor(s) of HCV infection among homeless people, Neale and Stevenson (2012) denote that HCV is transmitted mainly through injecting drug use. Since The Homeless do not practice a safe injection process, thus, equipment are not sterilised and there is transfusion of unscrewed blood and product, thereof (WHO, 2016).Based on literature, Neale and Stevenson (2012) argue that the most vulnerable homeless groups to HCV include those with: longer injection career, tendency to share needles, drug use habits, and prison records.

Among other limiting factors to bathing, such as private space, toiletries, and water containers; water scarcity is a major challenge in generally (State of Cape Town, 2012), even though it is one of the basic human needs that have to be accessible to everyone, at least, in accordance with the SA Constitution (1996). For example, a homeless individual's act of bathing/showering in public can be classified as 'public indecency' according South African Law Commission Act, 1973 (Act 19 of 1973). Committing

'public indecency' (as outlined under section 19(b) of the Act) is when an individual "…willfully and openly exhibits him or herself in an indecent dress or manner at any door or window or within the view of any public street or place to which the public have access, commits an offence" (SA Law Commission, 2002, 119). However, the latter is amorphous. In the act, for instance, the term 'indecency' is not clear defined, instead, it is applied "…in terms of the standard of the 'ordinary reasonable member of contemporary society'"; and the offence only applies if the "…accused intends to be seen" (SA Law Commission, 2002, 119-120).

Whether those in authority (strictly) impose the offence on the homeless or marginalized people in instances like the one mentioned above (i.e., bathing in public with clothes off) or not that is another debate that this study does not cover. Nevertheless, if they do, their actions can be counteracted. NLCHP (2014), for instance, argues on anti-homelessness laws in United State Cities that criminalization of The Homeless is based on 'dubious theory'. To rephrase it, enforcing the law is in the interest of the public and it is also a solution to reduce homelessness and improve the economic health in the city.

With a strong tone, Mitchell (1997, 5) argues that an "[a]nti-homelessness legislation is not about crime prevention, more likely it is about crime intervention". In the view that the authors of such legislations are clear, thus, their intentions is "…to control behavior and space such that homeless people simply cannot do what they must do in order to survive without breaking laws". Mitchell's (1997) words can be reiterate in the context of South Africa with reference to public indecency when The Homeless bath in public with their clothes off.

2.1.5.4 Employment

Unemployment is one of the key challenges affecting citizens in general all over the world, refers to both chapter 1 (subsection 1.8.3) and chapter 2 (subsection 2.1.2.2) above for entry and additional discussions, respectively. There is little attention for literature on homelessness employment according to Barman-Adhikari and Rice (2014), in spite, the long established close association between employment and homelessness (Dachner and Tarasuk, 2002; Finch, 2013; and NLCHP, 2014). From The Homeless' perspectives, Cheng and Yang (2010) illustrate that over 77.4% of homelessness (in Taiwan) is primarily rooted from prolonged unemployment, amongst other factors such as lack of housing affordability, personal maladjustment and family disruptions. Although high numbers of homeless people remain poor or rather unemployed (Barman-Adhikari and Rice, 2014; CoCT Statistics, 2012; SA NDP, 2011; State of Cape Town, 2012; United Nations CHR, 2005); but most of them have, at least, participated in an income generating activity in the past or at present and also earned a living (Cheng and Yang, 2010).

Predominant number of The Homeless struggle to find jobs due to: lack of employment experience; poor job search, acquisition and retention and/or communication skills; increased likelihood of mental disorder and/or substance abuse problems; incarceration; adjustment difficulties; early pregnancy; victimisation; involvement in criminal activities; and increased educational problem (Barman-Adhikari and Rice, 2014; Ferguson et al., 2011; and Lenz-Rashid, 2006). The above mentioned barriers reduce the employment competitiveness of The Homeless (Ferguson et al., 2011).

Social networks are known to be the primary key to employment for the homeless community (Barman-Adhikari and Rice, 2014; and Wolch et al., 1993). As such, these networks determine the legitimacy of employment. Wolch et al. (1993) declare that there two network or interaction channels for The Homeless, namely, amongst each other, and between them and the general public or 'homed' people. In addition, the paths an individual takes on a daily basis determine his/her abilities to cope with homelessness. Based on literature, Wolch et al. (1993, 117) share that coping with homelessness is measured by one's "…success in obtaining food and clothing, shelter, personal security, income and/or employment, social services, and social support". Thus, those who successful cope with being homeless, their self-esteems are boosted or enhanced and vice versa and the results can be positive/negative or illegal/legal.

The Homeless' illegal economic activities remain unclear, Ferguson et al. (2016) argue, in study that focused on homeless youth. The uncertainties associated with the latter activities are embedded in the complex nature of the dynamics and influential interactions (i.e., strains of homelessness and how the victims respond to it). That is; it is more of a survival mechanism to homelessness, which consequently induce the likelihood of homeless youth to engage in illegal activities than 'homed' youth (Barman-Adhikari and Rice, 2014; and Ferguson et al., 2016). Ferguson et al. (2011) debate (on a correlation between homelessness duration and illegal employment) that the longer one spends time being homeless, the more likely s/he will get involved in illegal activities. Some of the illegal economic activities for The Homeless include panhandling; stealing; drugs dealing or usage; and prostitutions (Barman-Adhikari and Rice, 2014; and Ferguson, Bender and Thompson, 2015). As a result, some of the latter introduce The Homeless to "dangerous" people, causing them to be further exploited, traumatized and victimized (Ferguson, Bender and Thompson, 2015).

It is difficult to some extent to outline legitimate income generating activities conducted by The Homeless, other than formal employment. For instance, begging (for money, food and other items such as clothes) is considered illegal in some of the United State Cities, including getting assistances from the public (NLCHP, 2014). In Cape Town, the City of Cape Town By-law Relating to Streets, Public Places and the Prevention of Noise Nuisances (2007, subsection 2.1 (c)) states the following. "No person, excluding a peace officer or any other official or person acting in terms of the law, shall… continue to beg from a person or closely follow a person after the person has given a negative response to such begging". Furthermore; survival mechanisms in the form of informal economic activities are often classified as illegal (Barman-Adhikari and Rice, 2014; Ferguson et al., 2016; and Wolch et al., 1993) or some of aspects of these informal activities are illegal.

The street business requirements in the City bring forth additional stumbling blocks for majority, if not all, of the homeless individuals. As such a business is required to align itself and comply with the City of Cape Town's informal trading by-laws and polices – which comprise the list of do's and don'ts (CoCT Law Enforcement, 2016). Amongst others, the do's list includes applying for a permit and updating it every three months for informal trading or economic activity at a particular spatial location. On the other hand, the don'ts include no obstruction of sidewalk and selling imitation or counterfeit goods.

2.1.6 Disability

Any type of disability/impairment (from mobility through emotional to intellectual) has the potential to place an individuals in a different societal position to match and/or fairly compete with those without disability – often times these positions are lower or dissatisfying. For instance; Kabel, Dimka and McBee-Black (2017) note that there is a lack of appropriate clothing and shoe choices for individuals with disability. The two authors also make a note that the clothing and shoe options are often overlooked as barriers or communication-complicating factors in the disabled individuals' livelihoods. Where the barriers or communication-complicating factors are environmental in nature, which include transportation, building accessibility and all other forms of community participation (i.e., from social through economic to every-day life events). According to Brown et al. (2012) and Kirchner et al. (2008), as cited in Kabel, Dimka and McBee-Black (2017); the poor community participation negatively impacts the health and well-being of the subject individuals.

Furthermore; instead of adopting a more specific or personally orientated approach, studies treat the disabled people as a homogenous group (Tomas et al., 2015). In other instances, the disabled people are considered heterogeneous groups to a limited and somewhat unfair extent. Moreover, the social models in place perceive the disability people through the lens of social justice instead of individual impairments, and the disabled group receives assistances/responses mainly in the form of charity issues rather than exercise of their human rights (McKenzie, 2016). McKenzie (2016) argues that the existing social/human rights model had adopted the approach of goods redistribution based on the social contract (i.e., everyone is free, equal and independent individual), although the disability people do not have the normal range of ability to participate and thus, their freedom, equality and independency are debatable.

Tomas et al. (2015) denote that the abundant literature available on disabilities focuses on the social or societal models. The physical societal models in places also add to the equation of burdening the disabled homeless people (and the public). In urban planning, for instance, Yoshie Inada et al. (2014) indicate that the traditional research and planning are not based on the disability groups (e.g., blind, wheelchair disabilities), as such the disability groups are hard-hit with a mobility barrier with the urban spaces.

Gaete-Reyes (2015) supports Yoshie Inada et al. (2014) that some of the urban designs, such as underground transportations (e.g., trains), are not friendly to individuals with disabilities (especial those on wheelchairs). Such barriers or marginalizing designs do not only physical limit the disable people, but also promote stigmatization and victimization of disabilities. Since the concept of "citizenship" is based on the 'remunerated work', which amongst others, further disable those with disabilities the opportunities of conducting 'remunerated work' due to the unfavorable set-ups in various places – as such, The Homeless with disabilities are not referred to as citizens or individuals who exercise their citizenships (Gaete-Reyes, 2015).

In consequence; Dobbins et al. (2016) state that The Homeless with disability are likely to suffer/experience more social, economic and other citizen's contemporary issues when compared with public or 'home' community with similar disability. Due to multiple and unbearable other challenges faced by the homeless individuals (as discussed above – subsection 2.1.4). Accordingly, the homeless individuals with disability carry extra 'loads' of challenges. Dobbins et al. (2016) also emphasize that often time, disability is associated with one or more issues, especially health illness (such as HIV/AIDS, chronic medical problem, drug addictions). When choosing a spatial location for sleeping, for instance, the homeless individuals using wheelchairs are victims of environmental or rather urban design/planning barriers such as pavements, roadways, barricades, buildings accesses and other types of infrastructure, plantations/vegetation and activities (e.g., traffic, strong winds/storms).

2.1.7 Homeless Initiatives

It is worth emphasizing that this research study does not intend to negatively criticize, but it aims to share, acknowledge, applaud and encourage improvement of all past, current (and planned to be actioned) efforts, initiatives/programmes and institutions that focus(ed) on eliminating/mitigating homeless issues and challenges. Of which most, if not all, see the homelessness as topic of social (and housing) development and apply elimination/mitigation measures along those lines (Du Toit, 2010).

Du Toit (2010) also argue that initiatives, programmes or action-plans often respond to homelessness in one or two ways, namely: empirical and non-empirical. Whereby; the empirical approach (i.e., research) focuses on causation and socio-economic conditions of The Homeless, which leans towards addressing the causes of the homelessness such as: social dependency; inadequate or lack of affordable homes; mental illnesses; and moral failures. On the other hand; the non-empirical approach (i.e., theoretical and normative) takes a critical social science perspective and focuses much on the welfare reforms (i.e., housing subsidies and social services), which then, leans towards: building more houses, implementation of housing subsidies and reducing the social services of The Homeless or in and around the communities where these houses are built.

2.1.7.1 Government

The South African government, in the post-apartheid era, has adopted non-empirical approach in addressing homelessness (Du Toit, 2005) to tackle the persisting housing backlogs dating back to the early 1970s (Napier, 1993). The government primarily focuses on providing housing for the historically disadvantaged and/or poor members of the society (Goebel, 2007). The policy framework, White Paper on Social Welfare (1997), for example, is rooted in the understanding that housing is a basic need, which is in accordance with the section 26 of the Republic of South Africa's Constitution, that is, "[e]veryone has the right to have access to adequate housing" (SA Constitution, 1996). According to Huchzermeyer (2001, 3); "adequate housing" in the Housing White Paper of 1994 refers to "[a] permanent residential structure and with secure tenure, ensuring privacy and providing adequate protection against the elements; and potable water, adequate sanitary facilities including waste disposal and domestic electricity supply".

The White Paper on Housing has committed to develop one million homes with a once-off capital subsidy from the year 1994, for citizens in need in five years, according to Department of Housing (1994, in Huchzermeyer, 2001). Whereby; there are two different subsidies in place, namely: individual subsidy to enable citizens to buy properties, and institutional subsidy providing rental and co-operative housing opportunities (Huchzermeyer, 2001). On the other hand, Napier (1993) says that there are two approaches proposed to address the issue through both 'current' and 'future' housing developments. The 'current' housing development approach is fundamentally focusing on the backlog of 1.22 million housing units and its annual need of 113,000 units. The 'future' housing development approach comprised the backlog and an estimate future population grow, which subsequently translated into an annual need of 174,000 units to address the backlog and arising need in the next twenty years.

According to Wilkinson (2014), based on the Department of Human Settlement feedbacks; it is also debated that there is a slow provision of housing since 1994 election, thus, approximately 61,000 and 75,000 housing units were provided in the year1994 and 1995, respectively. Between 1996 and 1997, about 130,000 units provided for the needy and the peak was between 1998 and 1999 where 235,000 housing units were delivered. Furthermore; after 1998/99 period, a fluctuation of 140,000 housing units serves as provision each year.

Since housing delivery is guided by legislations; Huchzermeyer (2001) scrutinizes the housing policy documents and their translations into reality and argues that the South African's housing policy is irrelevant to the poor communities. Due to the existing difference between the housing procedure and implementation on the ground. The scholar notes that the existing difference is rooted in financial shift, which traces back to the early 1990's. Whereby the three different sectors of the society were involving in directing and shaping the housing developments in the "new" democratic South Africa. These three sectors include the following. (a) Mass Democratic Movement (i.e. organized labor and community - including African National Congress, Congress of South African Trade Union and the civic movement - that have dominant political position in the last stage of the apartheid government with the democratization and redistribution thinking approach for mass housing). (b) Urban Foundation (i.e. private sector – business, mining and industry - that dominated the formulation of policy in National Housing Forum with the concern of economy rather than that of human rights with the thinking of Black owned-homes). (c) The Homeless People's Federation/People's Dialogue alliance (i.e. a social movement that emerged through international movement's inspiration and support for the people/poor groups to mobilize their resources and also find solutions for inadequate housing and other aspects of inequality, the likes of building social capital, mutual trust and credit means).

The Mass Democratic Movement played an instrumental role in formulating housing programme that also formed part of the African Nation Congress manifesto of 1994 election, which is known as RDP (i.e., Reconstruction and Development Programme). As stated on the White Paper on Reconstruction and Development of 1994, RDP "is a policy framework for integrated and coherent socio-economic progress… [that] seeks to mobilise all our people and our country's resources towards final eradication of the results of apartheid… [with the goal of building] a democratic, non-racial and non-sexist future",

and one of its five key programmes is "meeting basic needs" that, amongst other, comprises building houses for the poor and marginalized groups (RDP, 1994, 7).

On the ground; the strategies are integrated and implemented at various levels of government (i.e., national, provincial and local) as part of the content of Housing Act (1997) and these relate to, at least, two of the six basic principles of RDP, namely: Integration and Sustainability; Meeting Basic Needs and Building the Infrastructure. This Act outlines that each tier or level of government has responsibility of ensure the constitution right that "[e]veryone has the right to have access to adequate housing" (Wilkinson, 2014).

Housing in Cape Town, for instance, the Cape Town Community Housing Company (Pty) Ltd (CTCHC) holds the primarily responsibility, which aims to provide residential housing for the poor and disadvantage members of the community (CTCHC 2013). This institution was found in 1999 and is funded and fully owned by the National Housing Finance Corporation. Further mandate of CTCHC is to ensure affordable housing through covering integrated and sustainable spectrum of Human Settlement, i.e., "redressing spatial planning and development through the delivery of socially, economically and spatially integrated housing delivery which includes amenities, schools and places of work" (CTCHC, 2013).

Du Toit (2010) applauses that the theory of a 'non-empirical' approach to addressing homelessness, which South African local governments have adopted, are essential because they have a room to include the spatial aspect of homelessness. For instance, consideration of current spatial locations and surrounding arrangements of homeless individuals and groups. However; Huchzermeyer (2001) is of a different opinion that the poor society as the targets of housing policy are ignored in the second term of the post-apartheid government due to housing financial shifts and also the fact that integration of locations where subsidized housing developments take places are inadequately integrated in the plans/actions and these remains unchallenged. Thus; the beneficiaries of the large-scale developments (i.e., uniform, 30/40 square meters, free-standing households that are inadequately subsidized by the government) are expressing dissatisfaction and declare that these homes are poverty traps instead of eradicating poverty (Asian Coalition for Housing Rights, 1998; and Tomlinson, 1996, both in Huchzermeyer, 2001; and Napier, 1993). According to Tripartite Alliance (1994, 8, in Huchzermeyer, 2001); these housing developments are below the dignified standard of "reasonable living space and privacy".

Other additional debates around subsided housing include the following. (a) The houses are delivered in a number of forms, i.e. subsidy housing, incremental housing with or without tenure, and upgraded and redevelopment of housing for renting (Huchzermeyer, 2001; and Wilkinson, 2014). (b) The beneficiary of housing subsidies are citizens with some sort of employment that pays little money and those without any form of employment remains unattended (Huchzermeyer, 2001). (c) The poorer households often have greater transportation expenditure to and from places that sustain their livelihood such as work, school, amenities and so forth, as locations of these houses are far or rather in the cities' outskirts (Huchzermeyer, 2001; and Jocoy and Del Casino, 2010). (d) The population growth in low-income communities of the cities is a growing problem and the future rate is unprecedented due to natural

increase and in-migrants from rural and other areas with a drastic growing shortage of affordable housing based on the large number of settlers in backyards and shacks (Napier, 1993).

2.1.7.2 Private and Individuals

Many private and non-governmental initiatives and strategies that respond to homelessness all over the world. Each of these interventions target various aspects of homelessness, ranging from socioeconomic resources and housing subsidies to parcel-drives of items such as clothes, blankets and food to promote decent livelihood developments of homeless people. A few examples are as follow.

In Texas, McCarthy (2017) in the Longview News reported a woman (by the name Pamela Benson) that she makes mats from plastics for The Homeless. The motive for Pamela seeds from the story of a 72 years old man, who apparently died from the cold because he was homeless. In her words, crocheting mats with plastics for The Homeless "[has] given [her] a sense of purpose and a vision". Later; more than 30 people joined Benson at community center (Green Street Recreation Center) and assisted her with the entire crocheting mats with plastics (i.e. from collecting, cutting, folding, rolling and crocheting).

In England, there is a charity organization that holds a national membership, which is called "Homeless Link" (HL, 2017). According to HL (2017); this charity organization aims at improving services and influencing policy strategies to better the lives of homeless people, as it strives to make England "a country free of homelessness…[through outlining] what needs to happen for homelessness to end".

Web Urbanist "is a city-centric, visual-oriented online publication about art, design, and build environments", specializing with blogs from various people around the world to sharer their "most innovative, compelling and cutting-edge designs and ideas" about art, architecture, traveling and so forth (Webist Media, 2017). According to Webist Media (2017); in Saudi Arabia, a business man was given a "hero" title after storing leftover edible food into the refrigerator outside his restaurant for anyone to grab (including the homeless people) and his effort inspired a number of communities in Europe. Furthermore; in Germany, the latter is implemented and growing in which online food-sharing applications are used as well as thousands of volunteers.

Putman (2017) reports that above 50 homeless veterans are assisted to get jobs in America Mid-States. A group of volunteers helps to distribute $200,000 from the U.S. Department of Labor. These volunteers' programme aims to support the veterans to get to a stage where they can sustain their employment (and consequently their livelihoods), and hope to work hand-in-hand with the public (which they also refers to those who assist them or the veterans directly as Volunteers). Additional support from the public (or additional volunteering individuals) is along the line of enable veterans to travel (e.g., issue them with bus passes and gas cards) to interviews and workplaces. That is, assist them with clothing for interviews and few days after they get the job until these veterans get on to their feet, with items such as lunch boxes and food parcels. In summary, the programme prepares the veterans to create resumes, line up for interview and dress them accordingly for appointments.

Mould, Empower and Serve (MES) is a South African based organization found in 1989, its slogan is "changing the heart of the city" and the targets include Cape Town, Johannesburg, Kempton Park and Port Elisabeth (MES, 2015). On their website, MES (2015) primary focuses on the socio-economic well-being of the society, especial the vulnerable groups in city communities. MES employs a holistic and innovative approach to address issues around poverty, spiritual, education, skills development and health, so as to help those in need to be able to attain sustainable livelihood.

Furthermore; there is an event called "the CEO Sleepout™" in South African that raises funds to better the living standard of the homeless and vulnerable communities through winter's night outdoor sleeping activities (CEO Sleepout, 2016). Participants of the CEO Sleepout (TM) are executives or rather business leaders and influencers, in which minimum of R100, 000 is a joining fee/requirement for each participant during the June 2017 event – and that is for sleeping outside on one of the winter nights. The aim is not only to raise funds but also to gain empathy for these poor people (i.e., the homeless and vulnerable groups). The driver behind the event is The Philanthropic Collection, viz., a social enterprise and not an NGO. On record, 2015 and 2016 South African CEO Sleepout even has exceeded the global norms for an event of this nature by giving away its 75% earning to its beneficiaries.

2.2. GEOGRAPHIC INFORMATION SCIENCE (GISc)/GEOGRAPHIC INFORMATION SYSTEM (GIS)

2.2.1 Background

Geographic information science (GISc or GIScience) was first defined in 1992 and adopted in 1995 leading to change in the new journal from International Information Systems to International Journal of Geographic Information Science (Goodchild, 2009). Possibly the reason behind: the confusion around the abbreviation GIS (which stands for geographic information system); the interchangeable usage of the abbreviation GIS when denoting geographic information systems and geographic information science; and the unclear difference between GISc and GIS. There are various definitions of GISc, but all hold similar base that Godchild (2009, 5) describes as the "science behind the systems, in other words the scientific knowledge on which GIS is based"

According to Wan et al. (2017: 2), geographic information system (GIS) "is a specific and very important spatial information system, which is based on the collection, storage, management, analysis and description of the whole or part of the Earth's surface and the geographical distribution of station information system-related data". The above definition is based on other scholars' contribution such as Zhao et al. (2008) and Nyerges et al. (2014).

The focus in this research is more on GIS. In recently years, i.e., after some of the global governments have adopted the Agenda 21, the literature of cross-disciplinary research including GIS is gaining momentum. URISA (2000) outlines some (if not all) of various categories of GIS research areas, in page 4 under the heading "Editorial: Revised Mission and New Appointments", as follow: urban and regional information science; applications**;** social, organizational, Legal and Economic Sciences; geographic

information science; spatial data acquisition and Integration; geography, cartography and cognitive science; and education.

Table 4: Various geographic information sciences research fields and their descriptions. Source: URISA (2000)

GIS Research Category	Description
Urban and Regional Information Science (URIS)	"… sciences which advance research in the spatial and temporal relationships of phenomena in the natural and human-modified environment, including advances in planning, urban modeling and in environmental, transportation and engineering information systems"
Applications	"… [aims at advancement related] to information system developments in areas such as public health, emergency response, crime analysis, marketing, cadastral mapping, vehicle routing, infrastructure development, environmental assessment and similar applications"
Social, Organizational, Legal and Economic Sciences (SOLES)	"..[focus on] advances in understanding the social, organizational, institutional, legal, ethical and economic environments affecting the design and use of information technologies in urban and regional settings"
Geographic Information Science (GIS)	"… [primarily based on] tools, techniques and methods for analyzing, displaying, visualizing, and communicating spatial data, including the tools, techniques and methods of geographic information systems (GIS), spatial statistics, spatial analysis and computer science"
Information and Media Sciences (IMS)	"…emerging and related areas pertaining to multimedia, virtual environments, spatial simulation, digital libraries, human computer interaction, and web-based GIS".
Spatial Data Acquisition and Integration (SDAI)	"…[are fundamentally rooted in] tools, techniques and methods of geodesy, surveying, photogrammetry, global positioning systems, remote sensing [and] engineering [as well as] computer science to acquire, manage and integrate spatial data"
Geography, Cartography and Cognitive Science (GCCS)	"... [focus on] advances in understanding the manner in which people think about and represent their geographic surroundings, including advances in geography, cartography, cognitive science, computer science and related sciences"
Education	"… [are based on] advances relating to the teaching and learning of material in any of the above described areas"

Table 4 above, is a list and descriptions of the eight existing GIS research themes or categories, namely: Urban and Regional Information Science (URIS); Applications; Social, Organizational, Legal and Economic Sciences (SOLES); Geographic Information Science (GIS); Information and Media Sciences (IMS); Spatial Data Acquisition and Integration (SDAI); Geography, Cartography and Cognitive Science

(GCCS); and Education. This research study leans more towards the "application" category, which focuses on and encourages the use and development of spatial information systems. Particularly in the homelessness (or rather in the broader scheme called Human Settlement in the context of South African government) and other (in)directly related fields that can benefit from the use of geo-spatial data.

2.2.2 Spatial Studies

There is little literature on homelessness that comprise the spatial aspect of The Homeless; examples include Cloke, May and Johnsen (2008); and Wakhidah (2012). Out of the little available literature, majority examine the spatial aspect around homelessness through angle of mobility (e.g., Jocoy and Del Casino, 2010; Mitchell, 1997; NLCHP, 2014; and Rahimian, Wolch and Koegel, 1991). In the remaining fraction of literature, there are analyzes of spatial locations where the homeless individuals and groups sleep, however, the surrounding characteristics of these locations are not included or rather spatial locations where the homeless people sleep/live are house (e.g., Chan et al., 2014b; Chan et al., 2014b; and Hashimah et al, 2016). Furthermore; there is very little to almost no literature on GIS and homelessness and the focus is primarily on spatial distribution and integration (i.e., accessibility of and proximity to community resources) - Chan et al. (2014a and 2014b).

In order to enhance our knowledge and understating of homelessness, Cloke, May and Johnsen (2008) argues that it is essential to deviate or think beyond the traditional way. That is, the paradigm of only examining the sociocultural and economic aspects homelessness needs to shift. The three authors' argument is primarily based on the inclusion of the spatial aspect to homelessness research, which they state that it provides more knowledge about 'rationalities' and 'irrationalities', i.e., how The Homeless understand, what they make of and their negotiation or resistance tactics for the urban spaces.

To some degree, The Homeless shape the urban spaces in an unintended manner, through exercising their autonomy via complex social networks amongst each other and with the public (Cloke, May and Johnsen, 2008). The latter, over the years, has given rise to prohibition and privatization of urban spaces. Wakhidah (2012) argues that the public urban spaces are for and should accommodate everyone, especial the marginal people. In context, the marginal people include The Homeless, informal street vendors, different ability people and other marginalized groups such as women, children and the elderly. In essence, Wakhidah (2012) implies that a good urban space takes in to account the marginalized groups. Thus, there is a need for improving the urban spaces. One of the dimensions/ways of improvement include avoiding and eliminating marginalization of certain individuals and groups (e.g., the homeless and undesirable people), who are trying to survive in confined spaces of the urban that led to the uniqueness of their socioeconomic and cultural activities and interests (Cloke, May and Johnsen, 2008).
Argument by Mitchell (1997) is that public spaces are the least 'sovereign' areas, in general. Nevertheless, this creates a major challenge for The Homeless, unlike the public or 'home' people, who have a place (i.e., their homes) where they can sleep, bath and protect themselves. It is explained that 'sovereign' is reduced by the fact that accessing prohibited and private spaces or properties requires permis-

sion from the owner or stakeholder. In addition; the limitations of urban spaces make the homeless people 'powerless'. Jocoy and Del Casino, (2010), based on the literature, debate that correlated space and power, which state that if one could easily move around, then power in her/him is implied. The two scholars (Jocoy and Del Casino) elaborate their argument that The Homeless are powerless because these individuals are constantly experiencing spatial injustice. Since most, if not all, of The Homeless' movements are 'involuntary'. That is; The Homeless' movements are guided by 'direct actions' (such as arrest and violence), arrangements made with authorities to avoid direct actions; and/or consciousness and constant fear of spatial locations that can bring upon direct actions (Jocoy and Del Casino, 2010; Mitchell, 1997; and NLCHP, 2014).

At present time, the urban spaces further impose mobility challenges for the homeless community. In a study on the socio-spatial culture of homelessness, which focused on the mobility of the male homeless individuals by correlating their migration behavior with the coping status; Rahimian, Wolch and Koegel (1992) establish that highly mobile homeless individuals tend to be: young; never married; white; mentally disabled; and either new or cycled homelessness history. In addition; the reasons for moving was associated with finding better opportunities to improve their livelihoods and majority of these male homeless individuals preferred being in one spatial location than moving around.

Further, Jocoy and Del Casino (2010) in their contribution to the topic of the homelessness and traveling behavior, elaborate that the travelling behavior of the homeless people is highly constrained by the spatial characteristics and the homeless individual's sociocultural relations, economic status and personal responsibilities. Into the bargain, the author that the research of transportation planning, for instance, exclude the spatial characteristics of the homeless community in the same manner as other types of exclusion from the city. The types of exclusions incorporate - geographical; exclusion from facilities; physical; time-based; economic; and fear-based space - refers to table 5 below for details or key factors of each type. Geographical exclusion of The Homeless is mainly around steep/incline, vegetated, uneven and rough regions where homeless individuals with physical disabilities and challenges, non-sober habits, health problems and elders find challenge to move around (Jocoy and Del Casino, 2010).

Hashimah et al. (2016) also argue (on a geographical note) that most of The Homeless strive and choose to sleep in quite places. Whereby others occupy partially enclosed areas (e.g., building sides, hallways, below staircases, and abandon buildings. Whilst others turn to rest in non-enclosed or open spaces (e.g., parks, pavements and on public chairs). The scholars to boot note that the latter spaces are equally preferred and intruded by the public. In addition, the choices for the homeless people are influenced by the weather, precisely rainfall frequency. In terms of sleeping time; Hashimah et al (2016) establish that majority slept in early hours of the morning, thus, they walk around the city until midnight when most shops and restaurants close and the city is quiet and inductive for resting.

Table 5: Different types of the homeless people's exclusion from mobility. Source: Church et al., (2000, in Jocoy and Del Casion, Jr, 2010)

Exclusion	Key Factors
Geographical	Natural geographic features and a lack of transportation infrastructure to overcome them.
Exclusion from facilities	Lack of proximate goods and services, retail, and public facilities.
Physical	Characteristics of individuals who are physically or mentally unable to use the transportation system (e.g., people with physical and mental impairments, small children, people who do not speak or read the language on signs and schedules).
Time-based	Inability to organize commitments to allow time for travel (e.g., caregivers, single parents).
Economic	Lack of income to pay for transportation and lack of connectedness of networks that provides information about employment.
Fear-based	Fear of traveling through particular places.
Space	Exclusion of stigmatized groups from public spaces by surveillance and regulation. However, space exclusion may enable travel for those fearful of places occupied by stigmatized groups.

Chan et al (2014a and 2014b) used geographic information science (GISc) approach to understand the community integration of the people that were once homeless. The scholars understand that the former homeless people have a larger physical presence in the area. However; their frequent visits to homeless services, which are scattered and required greater travelling distances from their home, might counter-productive the efforts of integrating them in the community. As most homeless individual further turn to engage or rely on the homeless services for social interactions and activities. As a result, this suggests that they can possibly decide to go back to being homeless as some point. The latter applies to The Homeless of all demographic characteristics (i.e., age, race, diagnose, income, education, housing type and so forth). In addition, Chan et al (2014a and 2014b) note that GIS is essential in revealing the above-mentioned findings that may be difficult or unclear to achieve from a spreadsheet or significant approach.

2.2.3 Location Protection

Lu and Lui (2012, 2) share that as much as socio-spatial studies (such as this one) presents "new opportunities to better describe and understand people's spatial and social behavior", so are the "challenges for appreciating and responding to the social implications of these data and technologies". It is essential to consider and ensure location protection and data privacy. The ethical discussions around the location protection, data privacy and anonymity gain more momentum in the early 21st century (Armstrong, 2002 and Curtis et al., 2006 both in Lu and Lui, 2012). Curitis et al., (2010) argue that the concerns

associated with the spatial confidentiality impose severe limitation in sharing of data amongst researchers and other users, consequently, reduce the understanding of spatial patterns/characteristics.

Table 6: Framework expansion of adaptive geographic masking approaches of Armstrong et al. (1999). Source: Haley et al. (2016)

Approach	Description	Strengths	Challenges
Record Transformation	Records are aggregated across covariate patterns, certain records are suppressed, sampled or multiplied by random noise	Limits individual re-identification	Obscures spatial details needed for spatial analyzes (e.g., cluster detection) Results in missing data
Spatial Aggregation	Data is summarized by spatial units (e.g., assigned to an area unit polygon such as a census tract)	Limits individual reidentifcation, even at very small units (A. Curtis et al., 2011) Depending on unit, may facilitate easier data sharing/access	Obscures spatial details needed for spatial analyzes (e.g., cluster detection) (Hampton et al., 2010) Units may not correspond to meaningful social or spatial divisions (e.g., modifiable unit problem) (Oakes and Kaufman, 2006) Spatial units may not perform the same for all outcomes (Krieger et al., 2002)
Point Aggregation	Points which are in geographic proximity are replaced by a composite point (e.g., points are clustered and assigned to an areal unit centroid)	May allow for analyzes that require point data	Clustering techniques in and of themselves are not benign and may introduce error in spatial analyzes (e.g., inaccurate cluster detection) (Hampton et al., 2010)
Affine Transformation	Points are displaced by fixed increments (translation), scaling constants (scale), rotating each point by a fixed angle around the pivot point (rotation), or a combination of the above (concatenated)	Translation preserves overall density, relative density, and directional information Techniques can be combined to introduce more uncertainty	Displacement constants cannot be shared May not provide sufficient anonymity (Wieland et al., 2008) Spatial attributes of data skewed/lost
Random Perturbation	Displaces points by a random increment and direction. Common techniques include randomized skew and Gaussian skew.	Displacement can be bounded by geographic boundaries (e.g., within census tracts) Introduction of random effects may reduce re-identification risks Gaussian skew displacement varies by population density (e.g., points in rural areas are displaced by greater distance than urban areas) (Cassa et al., 2008) Cluster detection superior to aggregation (Hampton et al., 2010)	Does not preserve relative locations and orientation of points Randomized skew does not account for underlying population density Points may be displaced a very small distance from original point Release of multiple, datasets masked using Gaussian skew may provide sufficient data for reconstruction of original data points (Cassa et al., 2008) Gaussian skew displacement parameters are user defined and requires an understanding of acceptable re-identification risk

In response to opposite debates against the socio-spatial studies, various available attempts provide guidelines. Both for the replicable and non-replicable science, to the academic body (and data providers) on potential strategies to help reengineer the risks related. Few examples include handbook on spatial data by NAACCR (North American Association of Cenrtal Caner Registries), summary by National Academies Press panel of Confidentiality Issues Arising from the Integration of Remotely Sensed and Self-Identifying Data, and GIS conference and journal articles (Guttman and Stern, 2007, and Kamel Boulos et al., 2009, both in Curitis et al., 2010). For instance, legislation of location protection is strong in Europe, data is secured under the Data Protection Act of 2000, in Austria, "which restricts further use of data collected by means of such as surveys and sensor networks" (Seidl et al., 2015, 3).

In addition; recent academic contributions also indicate that geographic masking or obfuscation methodologies are potentially effective in protecting locations and preserving privacy and anonymity - the likes of Ahas et al., 2008, Ahas et al., 2010, Gonzalez et al., 2008, Markkula, 2001, Piorkowski, 2009, and Silm and Ahas all in Lu and Lui, 2012). The flexibility in grid sizes of obfuscations provide effectiveness such that there is relative no room to reveal sensitive information, argue Curitis et al., (2010). Furthermore, the risks of spatial confidentiality vary according to following, amongst others. (a) Sensitivity of the data (i.e., uniqueness of the subject), (b) research type (i.e. complexity of spatial analysis required), availability of attributes (i.e., indicators related to individuals that could help narrow down the search in a society), and (c) availability of previously generated maps, end users of the data as well as (d) the nature of the underlying geography.

Armstrong et al, (1999 in Kounadi and Letner, 2015) are the first to provide detailed summary of general groups and their categories that give rise to functions of geographic masking or obfuscation. Later; other scholars' contributions, which lead to comprehensive summaries of obfuscation methodologies including the descriptions, examples are Bridwell (2007), Cottrill (2011), and Gambs et al. (2010), all in Kounadi and Letner, 2015. Recent expansion of Armstrong and colleagues (Armstrong et al, 1999) framework for adaptive obfuscation approaches is from scholars such as Allshouse et al., 2010, the summary of Hampton et al., 2010, and Wieland et al., 2008 in Haley et al. (2016) is on table 6 above.

2.2.4 GIS Benefits and Examples

GIS is capable of capturing, storing, manipulating, analyzing and presenting various form of information from the same and/or different datasets (Batsche and Reader, 2012). The benefits of GIS are high and rising due to the increasing attempts to discover, describe and explain new, sustainable, effective and efficient strategies to sustainably use resources, growth the economy and/or develop our society and/or ecology (Reddy, 2008; and Wan et al., 2017), which are often embedded in large spatial data (Lu and Lui, 2012). Although the first the established benefit of GIS (decades ago) is associated with land-use mapping (developed in Canada), today there are wide range of benefits embedded in wide applications of GIS (Batsche and Reader, 2012) as well as the increasing expansions and adoption of geo-spatial technologies (Goodchild, 2009).

Jayarathna et al. (2017) illustrate the importance of GIS in supporting the decision-making processes of managing water resource demands and supplies, in the face of environmental changes. In their study case, the authors make estimations of water demands in Queensland area (in Australia) and identify the associated key variables of water usage (i.e., household size, availability of swimming pools, income and residents over 65 years of age). Whereby, GIS is integrated to form a spatial decision support system (SDSS), which provides details and maps related to water usage and factors that trigger water demands in the area. Moreover; Jayarathna and peers also argue that the SDSS can played a key role in policy making processes to strategically manipulate and evaluate effective way to supply and use the scarce resource, water - based on its capabilities to be flexible in adjusting strategies relating to both spatial and temporal natures. Thus, GIS has the potential to and can play significant role in sus-

tainable water management (and other resources). In addition; it (i.e., GIS) can be used to evaluating the effect on the decion-makers' performance through the lenses of the monetary and non-monetary approaches relating to water management (Jayarathna et al., 2017).

As for Jeong et al. (2016), the scholars successfully proposed a multifaceted model for planning housing in rural areas for tourism purposes. Their model produces realistic or rather reliable results, which are aided by the application of GIS. This model is able to highlight areas that are suitable for housing development and those that are not, through production of (thematic) maps. In the model, there are sixteen criteria in total, which are grouped into four categories, namely: socio-economic, natural, environmental and physical. Categorical criteria are assembled to adequately define or shape suitability of housing sites. As a result, a conclusion is reached in an instance where predefined criteria are similar to the outcome (including the nature of the geography), i.e., the model highlights the suitable site(s). On that note, GIS is beneficial in most, if not all, spheres of government/organizations for planning and decision-making processes associated with sustainable development and ensuring and instilling resilience due to the flexibility nature of the model (at hand).

Other scholars include Mentis et al. (2015); who apply GIS to explore various options of planning and strategizing electricity access and service to the society of Nigeria. The options that the authors use range from "grid extensions" to "mini-grid and off-grid solutions". The primary reason for including GIS in the study is based on their intuition that the tool/application is compatible with other key components relating to socio-economic planning and development/growth. That is, GIS can effectively account for one of the crucial component/criteria of the study geography, let alone represent the geography with and/or in terms components such as infrastructure and socioeconomic characteristics of the region of study. Moreover, Mentis and fellow scholars, with aid of GIS, deduce which of the electric options are viable for which region(s) of the country, including percentiles for each of the suggested options based of the geography and the density of the population amongst other key criteria.

Brewington et al. (2016) also incorporate GIS for planning and generating strategies for climate change adaptation concerning the ground water pumping in Hawaii. The authors intend to enhance the knowledge of how the past, present and future land covers and groundwater interactions in the face of the changing climate. Since participatory scenario, approach is employed, and thereof, various maps are successfully created matching each of the defined realistic scenarios associated with three different periods (i.e., past, present and future). The outputs of the study, particularly the maps (which are easy to produce with GIS) are helpful for the stakeholders to strategize appropriately and relevantly around the needs and adaptive management of ground water pumping.

To add to the above; Wan et al. (2017) is another instance where their study investigates the coordination of society-nature development, in consideration that the society plays a significant role or rather that it is directly link to economic development, especially those that depend on natural resources. Thus; Wan and colleagues intend to contribute to or enhance the knowledge of ensuring social, ecological and economic sustainability through developing and utilizing a model called "system dynamics" (SD). Where SD is "a crossed and integrated discipline studying complex nonlinear feedback sys-

tems" (Wan et al., 2017: 2). Over and above, GIS holds key role of verifying and supporting/supplementing the datasets (hence the SD). In addition; GIS supplies the theoretical base for analyzing and interpreting the development coordination of the ecological environment. These (GIS) results indicate that the societal growth do contributes to the ecological deterioration. However, the growing population has little to insignificant contribution. Instead, depletion of natural resources and unnecessary development has higher contribution in ecological deterioration.

A good health-related example includes that of Dogru et al. (2017); in an attempt to gain insight on the geographic characteristics associated with Hepatitis A incidences in Turkey where the children between the age of 0 and 14 years are considered. Using GIS, the scholars are successful in manipulating, analyzing and presenting the temporal distributions of monthly Hepatitis A incidences from 2001 to 2011. The results include the spatial patterns, hot spots and clusters of the subject (i.e., children's Hepatitis A incidences). Most importantly, GIS enables the scholars to identify regions/provinces that are highly vulnerable to mortality of the deadly health issue, Hepatitis A, as well as the less vulnerable regions.

Robbin, Carnes and Oreskovic (2016) also emphasize the benefits of GIS application in enhancing our knowledge about real life aspects and the associated circumstances amongst adolescent youth. The three authors aim to understand the correlation between crime and moderate-to-vigorous physical activity (MVPA). The inspiration come from the inconsistencies brought up by previous studies that do not provide clarity as to how the two aspects (i.e. crime and MVPA) relates or are linked. GIS is applied, which utilizes crime data from the police department in the city whilst the eighty adolescents provide the physical activities and the locations where they occur. The findings (through the capability of GIS to overlap information) reveal that there is a strong positive correlation between crime and physical activities amongst/around adolescent youth. Furthermore, the study provides the locations that are desirable or popular for and/or promote physical activities, so are crime incidents.

In a similar light wavelength; this study attempts to highlight the importance of GIS in homelessness literature, viz., through the inclusion of the spatial locations component. The spatial locations refers to the locations where the homeless individuals and groups sleep/rest (at night or) early hours of the morning. In order to gain insight of the homeless community (living in the city) - i.e. the nature of spatial locations and their surrounding characteristics that the homeless individuals and groups seem to choose/use for sleeping/resting.

CHAPTER 3: ANALYTICAL METHODS

3.1 DATA COLLECTION

3.1.1 Datasets

Datasets are categorized into two groups, i.e., secondary and primary, in this research. Secondary datasets are all data types gathered from third parties. These include supporting vector and raster data from City of Cape Town's GIS Department; and weather elements (i.e., temperature, rainfall, cloud cover and wind speed) records from both South African Weather Service (SAWS) and World Weather Online. These secondary datasets are accepted as they are with the assumption that they are error "free".

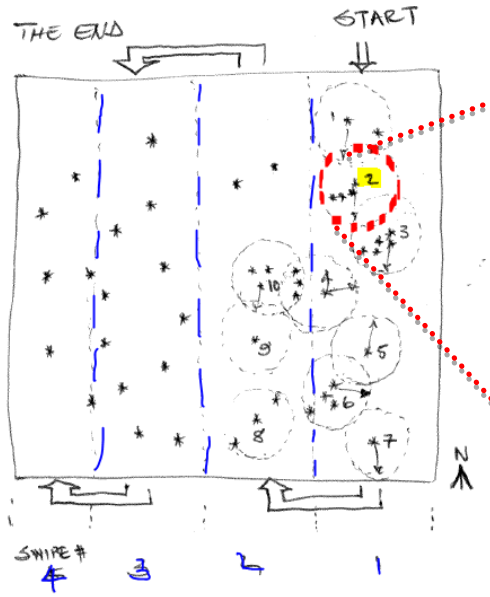
Primary datasets are all observed sleeping locations of The Homeless (excluding people counts) and their surrounding indicators (or attributes of the locations, which are defined in subsection 3.1.2 below). Whereby; a sleeping location is not equivalent to one homeless individual but a sleeping-setup that accommodate one or more individuals with undivided covering material (e.g., one blanket/plastic cover, one structured built by boxes/metal/plastic materials to cover one or more homeless individuals/groups). Therefore, each sharing set-up is recorded as one sleeping location. Moreover, there is neither conducting of interviews with The Homeless nor information gathering about them near their sleeping locations from anyone and any other type of data source (e.g. surveillance camera).

The collection of primary datasets is over 14 consecutive days, two weeks period (from 13 – 26 October 2018). Whereby each day receives two visits and this serves to confirm the weekly pattern of the number of sleeping locations of The Homeless. The process, of collecting primary datasets, is merely observing these locations and the associated surroundings indicators, and thereafter, marking them off on the prepared map and note-scripts – i.e., locations are precise with accuracy of about a meter. Refers to table 7a, below, which illustrates a typical overall sampling route plan.

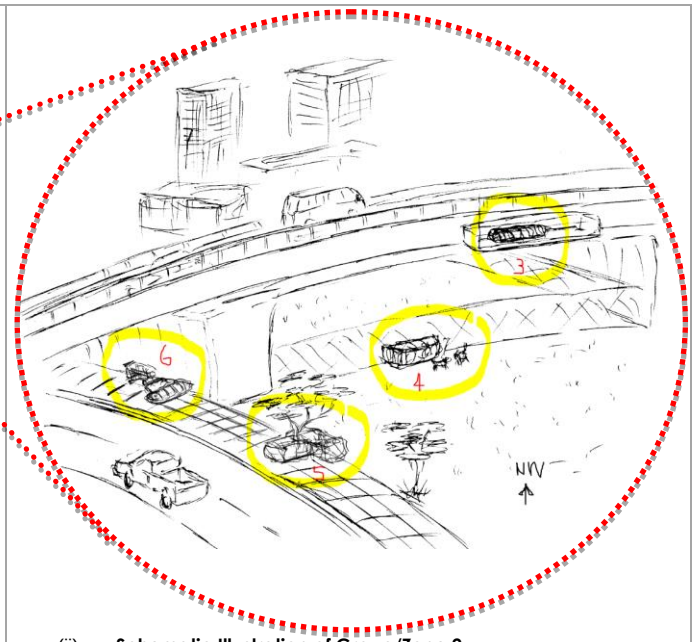
In the sampling route plan (i), the study area comprises four swipes, sampling route that starts on swipe 1 and sequentially ends on swipe 4. The observations are zonal, that is, when one or more sleeping locations is/are encountered, a zone of about 3 meters radius is set and all other sleeping locations falling within this 360˚ zone are recorded and assigned to that zone. Each location is observed and recorded once (the relationship: each zone can have one or more unique locations in the entire study area). For instance, group/zone 4 and 10 in the sample route plan (i) share locations, however, the locations shared are recorded under zone 4 as a precedent observation zone. The zones are numbered, marked down and retain the same numbering throughout the data collection period (i.e., some zone can have zero sleeping locations on one or more days). Moreover; these zones are utilized to create groups (refers to i, iii and iv) at a later stage for the purpose of the point pattern data analysis (Hampton et al., 2010 in Hampton et al., 2016, see table 6 above) as required my GIS tools - see more details below in subsection 3.1.3.

The approach of marking off sleeping locations introduces accuracy limitation. Since some of the locations cannot be reached and they are observed at a distance of, a meter or so away. However, this approach remained to be the best. Because the use of geographic positon system device (GPS), for instance, cannot mitigate but produce almost the same accuracy limitation. On the other hand, the conspicuous data-gathering materials (e.g. cellphone, GPS device) cannot be used or carried for safety concerns. Other associated limitations and impacts are introduced by date period, are discussed more in subsection 1.7.2 (above), in which neither of the weaknesses (i.e., inability to include/acquire data that allow bi-weekly/monthly/seasonal variation analyses) are mitigated.

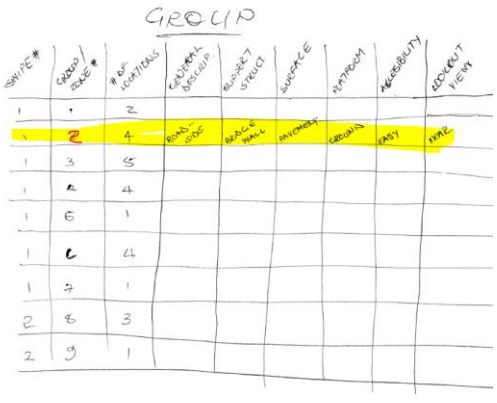
Table 7a: A typical illustration of overall sampling route plan, incl. schematic representation of the sleeping locations, and a single focus of notebook-recording on Group/Zone 2 for both group of and individual sleeping locations of The Homeless



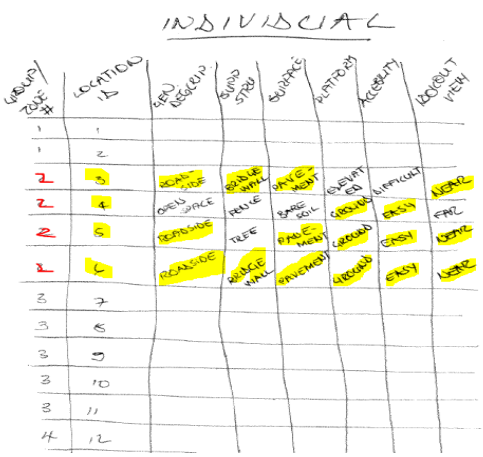
(i) **Overall sampling route plan**



(ii) **Schematic Illustration of Group/Zone 2**



(iii) **Group record with emphasis on Group/Zone 2**



(iv) **Individual sleeping locations record, focus on Group 2**

The times slot for primary data collection, on the other hand, follow that of Hashimah et al. (2016), i.e., 6am - 8:30am. The authors (Hashimah and peers) came to realize that majority of The Homeless walk around the city until midnight when most shops and restaurants are close and the city is quiet and in-

ductive for resting. This time slot limits acquisition/observation of all the sleeping location (which fit the description, on each particular day/night). Nonetheless, the optimum/majority numbers of the sleeping locations of The Homeless are captured, since the time slot falls within "peak hours" zone - Hashimah et al. (2016). At the same time, the earlier time slot than the one for this research is not an option because conducting fieldwork at dark hours imposes a threat to personal security, according to the City officials. As they work during "peak hours" with armed Law Enforcement officials when conducting homelessness field work (Finch, 2013). In to the bargain of no usage of surveillance footage and interviewing of anybody near the sleeping locations of The Homeless, the weakness triggered by the time slot remains unmitigated (additional discussion in subsection 1.7.2 above).

3.1.2 Surrounding Indicators

According to Yin (2009, 2); when collecting data in the field for a methodological approach such as this, case study, "there [are] many more variables of interest than data points. In response, an essential tactic is to use multiple sources of evidences". Snow and Mulchahy (2001, 6) elaborate that in order to precisely capture the surrounding indicators of The Homeless "it is imperative to understand the array of constraints that impinge on the daily routines and subsistence activities of the homeless". Furthermore; the two authors also state that there are multiple constraints (such as organizational, political, moral, spatial and so forth) defining the homeless community. Nevertheless, the most essential constraint is the spatial constrain because it largely defines the "routines and adaptive practices" of The Homeless. Since, the local control agents (e.g. police, private securities) are constantly enforcing the "strategy that seeks to reduce the public visibility of the homeless and their likely interactions with other citizens by curtailing their mobility and ecological range" (Snow and Mulchahy, 2001, 12).

Guided by Mazumdar and Paul (2018), the surrounding indicators in this study are established in attempt to capture how the locations, where The Homeless sleep, support their routine and adaptive practices in an urban space/ecology. NLCHP (2014) notes that in the United State Cities the law enforcers (i.e., the police officials) harass and arrest The Homeless. Where the harassment records for sleeping are 81%, loitering or hanging out (78%) and sitting or lying down (66%). Whilst arrests for sleeping are 30%, loitering or hanging out (26%) and sitting or lying down (25%). As a result; the marginalized, socially isolated and/or other types of vulnerability-triggering urban spaces are the sole options for The Homeless to use for sleeping, resting and personal privacy (between sexual partners for example) without or in order to avoid interactions with or incriminations by the law officials.

In that regard, explorative, descriptive and explanative surrounding indicators entail the following. (a) The closest type of urban infrastructures to somewhat denote the level of marginalization. (b) The nature of features that support and strengthen the sleeping setups from being easily blown away/destroyed by people and/or harsh surrounding (weather) conditions. (c) The nature of platforms where the sleeping locations are setup to depict the type of accessibility, visibility, social isolation, predictability and preferred surface warmth; and (d) the unobstructed distance range between sleeping locations and anyone approaching these locations.

Table 7b: List of Surrounding Indicators of the location where The Homeless sleep and their Descriptors

Surrounding indicator	Description	Possible Depiction	Descriptor/Entry Type and Its Accessibility
General Description	The closest (2 meters or less away) type of built up urban infrastructure	Degree of marginalization and social isolation – since local law enforcers are constantly controlling type and form of urban spaces occupancies (NLCHP, 2014; and Snow and Mulchahy, 2001)	• *Building* – any form of building, e.g., warehouse, restaurant, community hall • *Roadside* – the side of road that is covered with tar. When such road and a building sandwich sleeping location, roadside entry is used when the building is far with about 2 feet steps from the location, otherwise, building entry is used instead. This is utilized because most, if not all, roads are government own unlike variability in ownership of buildings as well as level of security in place to control occupancies/utilizations. • *Rooftop* – publicly accessible surface almost similar to public walking surfaces (in terms of texture and elevation level) but represents a roof on an observable building structure. In a conflict with building and roadside entries (i.e., when all entries are approximately within 2 feet steps distance range with sleeping location), roottop takes first preference/is used. Given the high level of security and surveillance around/near these surfaces. • *Open space* – entry used when none of the above three entries or any form of urban infrastructures are approximately within 2 feed steps range with sleeping location
Supporting Structure	A physical structure attached to and gives some form of support (e.g., from windblow) to the sleeping setup for The Homeless	Degree of personal privacy/protection – as The Homeless' sleeping structures are predominantly attached and/or against form of rigid structure	• *Building side-wall* – a wall of any form of building (e.g., church, club, offices) • *Bridge wall* – a wall or pillar of a bridge • *Fence* - wire or metal structure used for demarcating a property/land parcel • *Tree/None* – any form and size of natural plant or structure other than any of the three above (building side-wall, bridge wall and fence)
Surface	Nature or type of land cover underneath the sleeping location	Degree of marginalization and stigmatization – given that predominant land cover is modified/constructed with some form of cement (incl. public spaces)	• *Pavement* – surface constructed and covered with some form of cement or artificial and non-vegetation cover • *Bare soil* – unconstructed surface covered with natural cover (e.g. grass, sand)
Platform	Relativity of the surface of the sleeping location to the predominant public surface	Degree of personal security – given that, for instance, social movements turn to be on predominant surround surface	• *Elevated* – raised relative to predominant surrounding surfaces • *Ground* – unraised or at the same level with predominant surrounding surfaces
Accessibility	Ability to approach and see or obtain something for the sleeping locations	Degree of personal security/privacy – given that the sleeping locations are in public spaces and the personal spaces (in)directly intruded	• *Easy* – provide minimal or no form of barrier for intruders (incl. the elderly and disability individuals) to approach, see and/or obtain something • *Difficult* – somewhat provide barrier (e.g., narrow, rocky, slippery, steep) for intruders, unfriendly to the elderly and disability groups and even so to the assisted wheelchair users
Lookout view	Maximum unobscured distance view between The Homeless (in/near their sleeping setups) and anyone approaching	Degree of social isolation – given that the distance provides relativity of The Homeless to the general social activities	• Near – less than building block distance away • Far – a building block or more away

Table 7b above, provides a detailed list of six selected surrounding indications, including their respective various entries/descriptors. The selected surrounding indicators are attributes to each individual sleeping locations to denote the associated degree of marginalization, victimization, stigmatization, and personal privacy/safety (amongst others) of The Homeless in (using) urban spaces. Given that the local law enforcers are constantly controlling type and form of urban spaces occupancies (NLCHP, 2014; and Snow and Mul-chahy, 2001), and urban designs/models comprise the physical and social barriers, which largely disadvantage the homeless community (Dobbins et al., 2016; Tomas et al., 2015; and Yoshie Inada et al., 2014).

Six surrounding indicators with their descriptors/entries are as follow: (a) general description indicator (open space; roadside; rooftop; and building-side); (b) supporting structure (building sidewall; bridge walls; fence; and tree/none); (c) surface (pavement; and ground); (d) platform (ground; and elevated); (e) accessibility (easy; and difficult); and (f) lookout view (far; and near).

3.1.3 Data Pre-Processing

Data pre-processing is essentially assembling and preparing of all acquired datasets for the next stage/phase, viz., data analysis. Pre-processing is done using QGIS (version 3.4.2 Madeira) software package, and this can also be done using any other (GIS) software package. Firstly; all secondary datasets are assembled to serve as a basement/base-data for this research and this include ensuring that these datasets are set to the same current South African Coordinate Reference System (SACRS), i.e., geographical coordinates (ellipsoid - World Geodetic Reference System 1984 (WGS 84); datum: Hartebeesthoek94).

Secondly, the individual sleeping locations of the homeless individuals and groups are geocoded (i.e., transformed from the marked off locations on the field map and assigned respective XY coordinate or actual location on Earth's surface) as point geographic features and the surrounding indicators/properties are attached accordingly as attributes. In additions, the features are combine according to their observation date and the results are daily geographic layers.

Third and lastly; the sleeping locations (point features) within each daily geographic layer are aggregated so that the point pattern analyses can be done, and this is also another form of obfuscation or geographic masking approach (Hampton et al., 2016, refers to list of masking approaches, their strength and challenges in table 6 above). Aggregation uses the sleeping locations within each zone of observation (see subsection 3.1.1 regarding zones) and create a centroid (i.e., point of intersection of medians of subject sleeping location(s)). The centroid is then marked off as a point of representation (or group) of all the individual sleeping locations within the subject zone – refers to subsection 3.2.1.1 regarding computations of centroids/mean centers. In addition, the creation of respective mean centers for the groups of sleeping locations is another form of privacy protection (i.e., geo-masking) of the sleeping locations (Zandbergen, 2014). As the actual spatial locations are not only hidden and reduced to single representations but these representations of the locations within various groups are de-

noted with their center points, which are less likely to coincide with the actual locations, especial when the locations are less clustered. The result is a daily geographic layer with relatively reduces points/features (i.e., table 7a (iii)), to original/ungrouped points ((i.e., table 7a (iv)), representing sleeping locations of the homeless individuals and groups (The Homeless).

Furthermore; each daily geographic layer has the same number of groups/aggregated points with the same XY coordinate. At this point; all daily individual sleeping locations are selected, their surrounding indicators are reviewed, and the representative group/aggregated point adopts predominant surrounding indicators – refers to table 7a (iii and iv). The results are two sets of geographic layers for each day, namely; aggregated/grouped and ungrouped sleeping locations, which are both be used for the preceding data analyses.

3.2 DATA ANALYSIS

All data analyses are done using both QGIS and ArcGIS Desktop (version 10.5.1 by ESRI Company) interchangeably depending on the convenience and preference of the author and other GIS software packages can be used. Additional and optional software is Microsoft Excel (2016) to interpret or summarize (incl. plotting of graphs) the attributes/surrounding indicators of the sleeping locations.

The analyses/analytical methods are selected following Seidl et al. (2015), where the following bring in the slight differences. (a) Additional methods (i.e., proximity and weather analysis) to try to supply additional evidence supporting the answer to the research question (or fulfill the premises set); and (b) more efficient and yet providing-comprehensive-outputs method (i.e., average nearest neighbor, which replaces the k-nearest neighbor, clustering and semivariogram analyses).

Figure 8b, below, is an overview of the entire data analysis process. The process consists of two distinct and unlinked stages (i.e., first/left – focusing only on analyzing the original sleeping locations; and second/right – focusing on both original and masked sleeping locations) and sequential application of eight analytical methods; spatial distribution, attribute analysis, proximity analysis, weather analysis, and obfuscation/geographic masking – in that order. Some of the nature of the results/outputs are the same (e.g., mean center, standard deviational ellipse) and others vary (e.g., maps, surrounding indicators).

3.2.1 Spatial Distribution

This analysis, geographic/spatial distribution, is linked to the first premise (refers to subsection 1.5 above), which states that there are insignificant or little variations in the distributions of sleeping locations throughout the study period of full two weeks. That is, although there are movements of The Homeless in the study area, however, these shifts in social behavior are insignificant to modify the overall spatial distribution patterns. The centers, compactness and orientations of all observed locations are investi-

gated. Four distinct tools are used to conduct geographic distribution: mean center; standard deviation; and standard deviation ellipse (SDE). Each tool is utilized all daily geographic layers of sleeping locations, that is, ungrouped/non-aggregated daily sleeping locations.

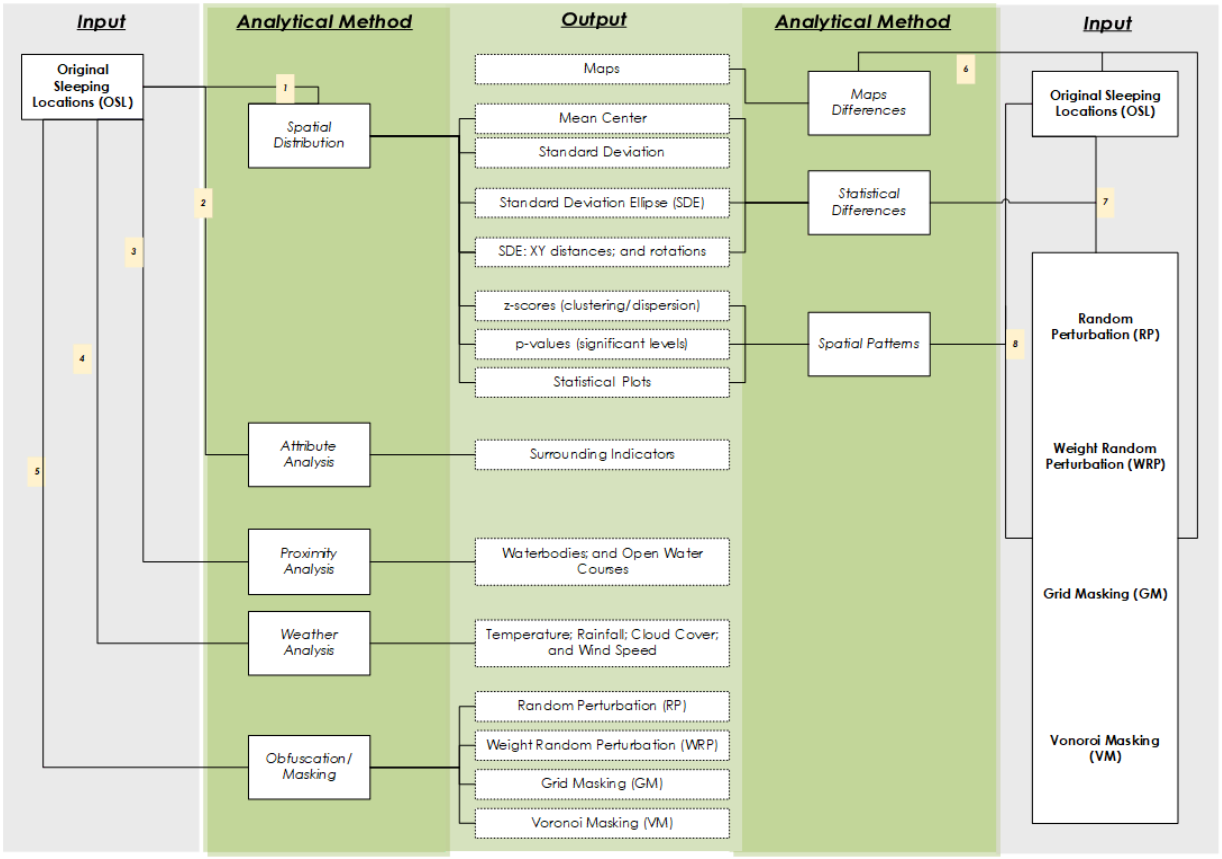


Figure 8b: Data analysis flow chart

3.2.1.1 Mean Center

Mean center tool takes the subject sleeping locations (inputs) and compute the geographic/mean center, which represent then represent center of concentration (output), refers to figure 9, below. The geographic or mean center is average x and y coordinates these locations (ESRI, 2016; and Seidl et al., 2015). Two different types of mean centers are generated. First type is called overall mean center, which is computed for each of the daily sleeping locations layers. The regional/zonal mean center is the second type, which are multiple mean centers for all the observation zones within each of the daily sleeping locations, to represent the grouped/aggregated sleeping locations (refers to subsection 3.1.1 and 3.1.3 regarding observation zones and grouping). The mean center coordinates are calculated as follow:

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n} \quad , \quad \bar{Y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

Equation 1

Where x_i and y_i are the coordinates for the sleeping location *i,* and *n* is equals to the number of sleeping locations within the subject geographic layer. Another way of measure the central tendency of features is through the median center tool, which uses an iterative algorithm to minimize the distance to the subjects features. Drawbacks of median center, unlike mean center tool, is that the output can include more than one location.

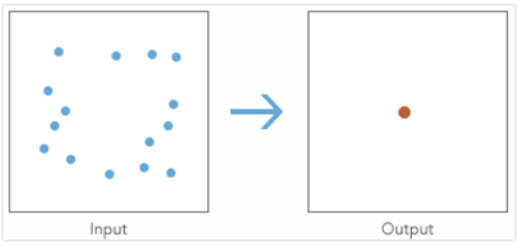


Figure 9: Overview of mean center computation, concept. Source: ESRI (2016)

3.2.1.2 Standard Deviation

The standard deviation tool computes the degree to which the sleeping locations concentrate or disperse around the mean center. The tool functions like standard deviation around statistical mean by providing measure of distribution of data values (ESRI, 2016). The result is a standard distance, which geographically or on a map can be represented by a circle (polygon), refers to figure 10 (below) and thus, standard deviation is the radius of the circle, which is given by:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n} + \frac{\sum_{i=1}^{n}(y_i - \bar{Y})^2}{n} + \frac{\sum_{i=1}^{n}(z_i - \bar{Z})^2}{n}}$$

Equation 2

where x_i, y_i and z_i are the coordinates for the sleeping location *i,*, $(\bar{x}, \bar{y}, \bar{z})$ represents the coordinates of mean center (refers to equation 1) and *n* is equals to the number of sleeping locations within the subject geographic layer. Standard deviational tool returns the standard deviation together with the average or mean x, y coordinates.

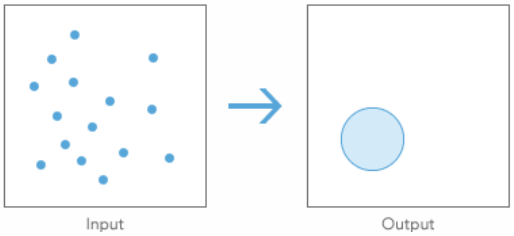


Figure 10: Overview of standard deviation tool concept. Source: ESRI (2015)=

3.2.1.3 Standard Deviation Ellipse (SDE)

SDE is very a common analytical method in the socio-spatial studies, dating back to the early 20th century, first noted by Lefever in 1926 (Gong, 2002; and Yuill, 1971), which evolved from only computing the mean center to also measuring the dispersion or concentration and orientation tendency of the geographical features (Wang, Wenzhong and Zelang, 2015; and Yuill, 1971). SDE is given by the following equation:

$$C = \begin{pmatrix} var(x) & cov(x,y) \\ cov(y,x) & var(y) \end{pmatrix} = \frac{1}{n} \begin{pmatrix} \sum_{i=1}^{n} \tilde{x}_i^2 & \sum_{i=1}^{n} \tilde{x}_i \tilde{y}_i \\ \sum_{i=1}^{n} \tilde{x}_i \tilde{y}_i & \sum_{i=1}^{n} \tilde{y}_i^2 \end{pmatrix}$$

Equation 3

$$var(x) = \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2 = \frac{1}{n} \sum_{i=1}^{n} \tilde{x}_i^2$$

$$cov(x,y) = \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y}) = \frac{1}{n} \sum_{i=1}^{n} \tilde{x}_i \tilde{y}_i$$

$$var(y) = \frac{1}{n} \sum_{i=1}^{n} (y_i - \bar{y})^2 = \frac{1}{n} \sum_{i=1}^{n} \tilde{y}_i^2$$

where *Equation 4,5 and 6*

and where *x* and *y* are the coordinates for the sleeping location *i*,, ($\bar{x}$, $\bar{y}$) represents the coordinates of mean center, and *n* is equals to the number of sleeping locations.

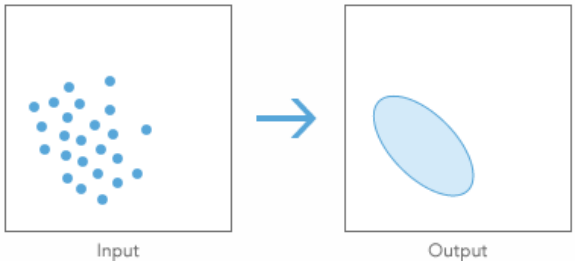


Figure 11: Overview of standard deviation ellipse (SDE) concept. Source: ESRI (2016)

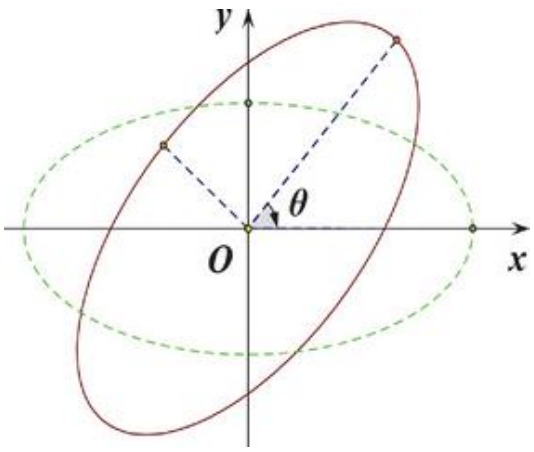


Figure 12: Overview of standard deviation ellipse (SDE) XY axes plane and angle of rotation. Source: Wang, Wenzhong and Zelang (2015)

Figure 11, above, shows the output of the SDE, on a map – i.e., an elliptical polygon rotated clockwise from north. In figure 12 (above) is a display of the SDE on a Cartesian plane (y-axis along north (positive) and south (negative) direction; and the x-axis along east (positive) and west (negative) direction), and the angle of rotation give by 90˚ - Θ, where 0˚ is north/along positive y-axis and increasing clockwise. The size of the ellipse denotes the distribution density. When the size of the SDE is very small relative

to the study area, this imply that the geographic features are densely distributed (i.e., concentrated or clustered) and vice versa, refers to figure 11 (Gong, 2002; and Yuill, 1971). Using the area of the study area, the geographical features within and outside of the ellipse can be counted (Yuill, 1971).

3.2.1.4 Cluster and Outlier Analysis (COA, Anselin Local Morain's I)

Although the size of the SDE also to denote the clustering or dispersion of the sleeping locations, instead, the Cluster and Outlier Analysis (COA) is employed for it is strictly focus on the clustering/dispersion of features in detail. Figure 13, below shows a template output of the COA. The results of the COA include z-scores and p-values, which denote whether to reject or accept the null-hypothesis (ESRI, 2016). That is; whether the sleeping locations where the spatial pattern display similarity (clustering/concentration) or dissimilarity (dispersion/outlier). Clustering is depicted by high positive or low negative z-scores and/or p-value lower than 0.10 (i.e., rejection null hypothesis) and the opposite is true.

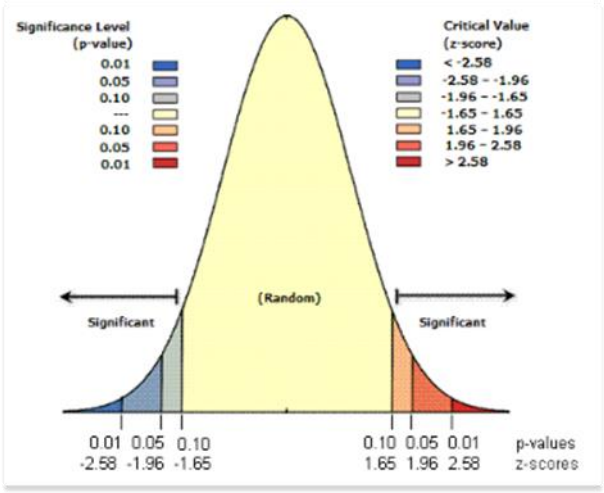


Figure 13: A COA template indicating various significant levels of p-value and critical values of z-score, which are both associated with a normal distribution. Source: ESRI (2016)

In addition; in an uncorrected scenario (i.e. when the confidence level is not specified or checked), the p –value, 0.10, 0.05 and 0.01 correspond to the confidence level is 90%, 95% and 99% respectively. Where the 90% confidence level denotes that there is less than 10% probability that the dataset pattern results from random chances, whilst the 95% and 99% confidence levels mean less than 5% and 1% chance(s) that pattern in the data is generated by random processes. The output of the COA tool, despite the z-scores and p-value, include the plot (see figure 13 above) and the position of spatial pattern on the plot.

3.2.2 Attribute Analysis

During the attribute analysis, the (tabulated/populated) surrounding indicators are examined by selecting similar and/or pivoting them and explaining the results, with the aid of graphs/plots. The analysis is firstly run on the overall daily sleeping locations and lastly, on the clusters (i.e., the outputs of the COA in

subsection 3.2.1.4 above). The objective is to evaluate the degree of vulnerability (i.e., marginalization, stigmatization victimization, social exclusion and lack of personal privacy/security and human dignity) of The Homeless, embedded in the sleeping locations (and the associated surroundings) in the urban public spaces.

The strength of this analytical method is rooted in its ability to focus on the non-spatial properties (i.e., attributes/surrounding indicators) and link them with the relevant spatial properties (i.e., distribution patterns of the sleeping locations) to provide a bigger picture of the events/features in the study area. That is, overview, dominance, similarities and differences of/in/between sleeping locations and therefore, the routine and adaptive practices of The Homeless in the urban spaces) - although this can be done using any other application/approach but GIS is very efficient and orientated in this kind of analysis.

3.2.3 Proximity Analysis

Proximity analysis is conducted to highlight various number of sleeping locations near the specific subject feature(s) at various offset distances. The strength of this approach resides in the numbers of locations highlighted/selected at particular distance range(s) in relation to a particular subject urban feature (considering its purpose on human livelihood activities), which help to examine the degree of vulnerability of The Homeless in urban space (i.e., scarcity of or isolation from human basic needs).

In that regard, the water resources are utilize as subject urban features for the following reasons, amongst others. (a) The country's Bill of Rights subsection 27.1b states, "Everyone has the right to have ace to sufficient food and water". (b) Cape Town is experiencing arguably the world's first recorded draught crisis and the drop in water in Western Cape Water Supply System dates back to 2015 (CSAG, 2018; and GroundUp, 2018). (c) Various public and private water ponds within the study area are empty. (d) Various people have been observed (who some may be The Homeless) acquiring water in buckets and bottles form various water sources such as public toilets, stormwater manholes, open water courses, waterbodies etc.. (d) Base on the latter (i.e., point c), there are various water sources that are well distributed all over the study area (as compared to other features such; clinics, hospital, police station, restaurants, tourist attractions, public toilet/transport terminus/ranks and so forth). Therefore, the outputs of the analysis restrict tracking down/identification of the actual sleeping locations of The Homeless (i.e., ethics considerations associated with detailed spatial examination of homelessness).

The limitation of proximity analysis comes with the spatial accuracy of the sleeping locations. The challenge in this study is that the locations are precisely geocoded, with the accuracy of about 3 meters (refers to subsection 3.1.1 above), As the analysis entails generating buffer zones or offset distances (intuitively defined) around urban subject feature(s) and highlighting/selecting the sleeping locations falling within and touching the boundary of the derived buffer. Figure 14, below, illustrate four distinct stages on how buffer zone is created around a specific urban feature (namely, line, point, multipoint and polygon). As such, the buffer zones are different; however, the stages of buffer creation are the

same for any geographic feature. In the first stage, the feature is selected (in this study, water resource), followed by intuitive distance range (offset and in the last stage a buffer zone is derived.

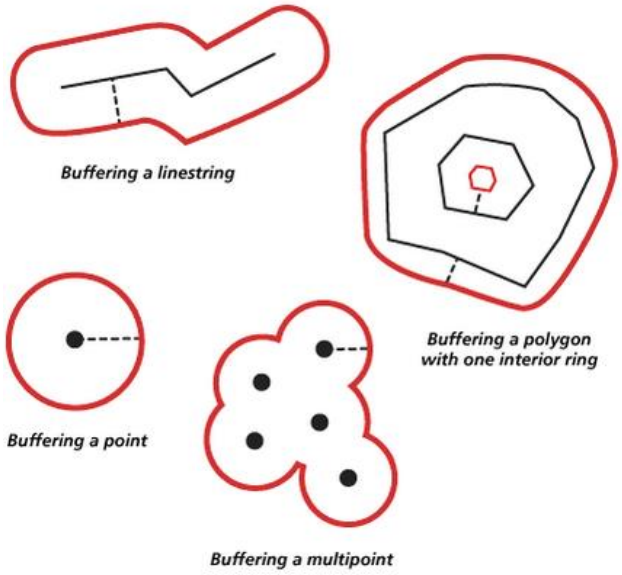


Figure 14: Overview buffer creation around different types of features. Source: ESRI (2016)

3.2.4 Weather Analysis

In weather analysis; the changes in weather conditions are examined with respect to the total numbers of sleeping locations (including plotting of respective graphs), which ultimately can be interpreted with respect to the results from other analyses that focus on variations spatial distributions of the sleeping locations and provide holistic findings. Weather analysis is considered since one of the findings of Ismail and Turiman (2016) is that The Homeless turn to choose their locations for sleeping based on the physical characteristics that match or serve protection against weather conditions. Four weather elements are considered which include temperature, rainfall, cloud cover and wind speed - which are acquired from SAWS (South African Weather Service) and World Weather Online.

The analysis is done across all the weather conditions and total number of sleeping locations for each of the 14 days. As mentioned under the limitations section (subsection 1.7.2 above); the 14 days period imposes bi-weekly, monthly and most importantly seasonal analysis limitations, which unfortunately could not be mitigated. For the reason that there are, at least, no corresponding data, viz., the sleeping locations of The Homeless.

3.2.5 Obfuscation/Geographic Masking

Although the social spatial studies (e.g., this study) generally help to enhance the knowledge and understanding of the community/society of interest (The Homeless in this research). Nevertheless, they can

also impose the risks of compromising or disclosing personal privacy and/or social behavior (Curitis et al., 2010, and Lu and Lui, 2012) and thereof, trigger the societal vulnerability. This disclosure/compromise is generally a severe ethical concern (Armstrong, 2002 and Curtis et al., 2006 both are in Lu and Lui, 2012; and the UCT (EBE Faculty) Ethics Committee also emphasize this concern). In this research, the latter is more severe seeing that the community/society of interest is the homeless individuals and groups, whom are already vulnerable members of the public.

As a result, this study adopts the mitigation measure or conventional solution to overcome, reduce or rather eliminate the risk of disclosing confidential locations where The Homeless sleep, in Cape Town City Central region. That is, the usage of four suitable and customary aggregations, geographic masking or obfuscation methodologies, namely; grid masking (GM), random perturbation (RP), weighted rand perturbation (WRP) and voronoi masking (VM) – following Seidl et al. (2015). The implication is that the actual sleeping locations of The Homeless are altered, whilst preserving spatial distribution, primarily and solely for protection of the sleeping locations and privacy/confidentiality (Curitis et al., 2010, and Seidl et al., 2015) of The Homeless.

The four obfuscation or geographic masking methods are employed to test which one best performs (i.e. preserve the spatial distribution whilst protecting the spatial confidentiality of The Homeless), and this approach have been adopted, although altered, from Seidl et al (2015). The test includes examining and highlighting: (a) differences; (b) statistical differences; and (c) spatial pattern plots.

3.2.5.1 Maps Differences

This test is primarily for visualization of all unmasked or original and masked sleeping locations using maps followed by comparisons of general spatial distributions. A random sample of unmasked or original sleeping locations (OSL) is used as guide (i.e., number of points parameter) and to aid running the four masking methods (i.e., GM, RP, WRP and VM). The details of each of the four masking methods are as follow.

A. Random Perturbation (RP)

In RP, masking encompasses generating random locations within the constraining feature using the random number generator and seed (Zandbergen, 2014). Where the constraining feature is the sample OSL. Figure 15, below, displays an overview of some of the scenarios of the random locations placement in relation to the respective OSL. Random locations are generated anywhere within the circle/buffer zone, where the OSL is the centroid. The circle has a radius of 10 meters, given that the size of the observation zone when doing fieldwork is approximately 7 meters (refers to refers to subsection 3.1.1). Each of the OSL is used to a centroid, which is ultimately for the drawing of the corresponding circle/buffer zone, i.e. 10m buffer (or circle with 10m radius). The buffer zone serves as a constraining extent for random location. Where the generator and seed set a uniform distribution environment for

the new locations - i.e., it ensures that any region within the circle have the same chance to be chosen as a new location, including the original location and this is a disadvantage for the method, as it can compromise the spatial confidentiality (ESRI, 2016).

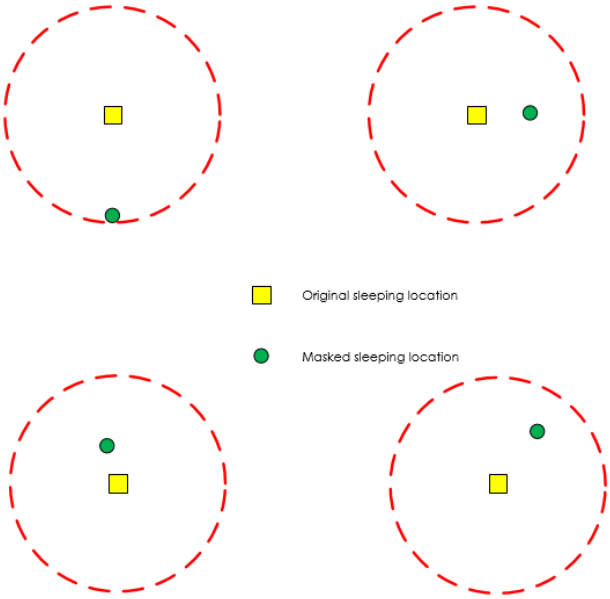


Figure 15: Overview of random perturbation (RP) scenarios depicting some of the possible locations of new sleeping locations (green circle), where original sleeping location (OSL) is the yellow square) and the big red dotted is the set buffer zone/circle around OSL for locating new data.

Thereafter; the generator and seed provide random value on the x-axis and then on the y-axis, as a result, the values serve as XY coordinates for the newly generated altered/random sleeping location. Once the new location has been set for first original sleeping location, the next original sleeping location is considered for creation of its associate new location, and the process is repeated until the entire sample OSL is covered. The result is RP sleeping locations. Another disadvantage of the method is that where the original locations are dense (i.e., clustered), the masking process can generate less dense (i.e., dispersed) new locations, and therefore, this compromises the general spatial distribution/integrity.

B, Weight Random Perturbation (WRP)

WRP sleeping locations are generated similarly to RP. That is, constraining feature is the sample original sleeping locations (OSL); the radius around each OSL is also 10 meters; and new locations are generated only with the circle/buffer zone. However, the WRP generator and seed do not use uniform distribution approach (ESRI, 2016; and Seidl et al., 2015). That is, region towards the boundary of the circle and the centroid have less likelihood to be chosen for assigning new location, and this applies to the entire sample OSL. The latter is an advantage because the risk of disclosing spatial privacy is reduced.

C. Grid Masking (GM)

Unlikely RP and WRP; GM utilizes fishnets or grid cells instead of the study area boundary (as constraining feature). The creation of fishnets comprises the following (ESRI, 2016). (a) Defining the spatial extent

(which is the study area boundary). (b) The number of rows and column (which the use of study area boundary layer allowed setting). (c) The height and width of individual cells, which is 10 by 10 meters cell size. Since a single observation zone's diameter is about 7 meters, refers to subsection 3.1.1 above for observation zones during fieldwork, and it is also reasonable based on the theory that the bigger the cell size the greater the disposition from the original location and vice versa). (d) The angle of rotation (the use of study area boundary layer allow default setting, i.e., zero rotation).

Once the grid cells have been created, the centroids represent destinations for the new sleeping locations, i.e., the locations are moved to the centroid positions (Seidl et al., 2015). This imply that the bigger the cell and the more distant is the original location to the centroid, the greater the displacement, and therefore, the spatial integrity is compromised. The resulting, moved points to the centroids, is what is known as GM sleeping locations.

D. Voronoi Masking (VM)

Unlike GM, which uses fishnet to create masking, VM uses voronoi polygon (also known as thiessen polygons). Figure 16, below, show and overview of how voronoi cells/polygons are created from the point datasets. In summary; each point data is enclosed by an irregular cell and between every two points there is at least one cell boundary or rather each voronoi cell has only one point input feature (ESRI, 2016). Voronoi cells are generated based on the study area boundary with the aid of the sample OSL.

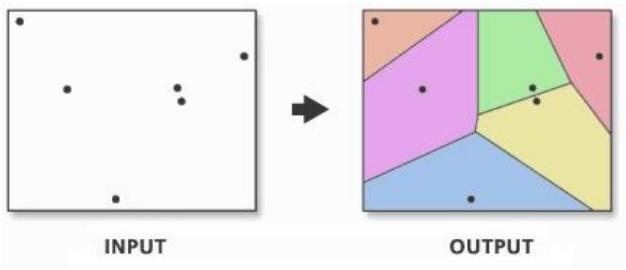


Figure 16: Overview of voronoi/thiessen polygon creation from point data. Source: ESRI (2016)

The background theory is that if the original sleeping location, *k*, lies within the study area boundary, there is one location that is closest to *k* (except where *k* is equidistant to two or more locations, then the first calculated point priority is applied). Once all the distances closest to *k* are calculated, the respective boundaries (to enclose *k*) are created. The result is a single proximal cell/polygon for *k* sleeping locations, and this process is conducted for all the original sleeping locations. The final output, comprising single proximal cells for all OSL, is a voronoi cells layer.

At this stage, unlike in GM, sleeping locations are move to the edges of the voronoi polygons that make them equidistant to the respective sample original sleeping locations and the resulting edged points represent the VM sleeping locations (Seidl et al., 2015). Where the density of sleeping locations is higher, points move a short distance and this is an advantage for VM. Another advantage is that some of the points have the potential to be moved onto the same edge and this increase the anonymity of the locations.

3.2.5.2 Statistical Difference

Both mean center and standard deviational ellipse (refers to subsection 3.2.1.1 and 3.2.1.3 above, respectively, on how the each of methods works) are computed. Thereof, the results of OSL and each of the masked methods are compared. The results include mean center (XY coordinates), standard deviations and ellipsoid rotations.

3.2.5.3 Spatial Patterns Plots

The average nearest neighbor tool is used to derive spatial patterns plots, because it provide comprehensive information adequate to compare the spatial patterns/trends of unmasked and masked sleeping locations. The outputs are normal distribution plots (refers to figure 11 above), which denote the z-score, p-value and ultimately whether the location display clustering or randomness and corresponding level of significance in the case of clustering, i.e. either 90%, 95% or 99% (ESRI, 2016). The latter are given by the computations of both average nearest neighbor ratio (equation 7) and z-core (equation 10). When average nearest neighbor ratio (index) is less than 1, the pattern exhibits clustering and vice versa, this ratio is given by:

$$ANN = \frac{\bar{D}_O}{\bar{D}_E}$$

Equation 7

where D_0^-, is the observed mean distance between each sleeping location and its nearest neighbor, and its given by:

$$\bar{D}_O = \frac{\sum_{i=1}^{n} d_i}{n}$$

Equation 8

whilst D_E^-, is the expected mean distance for the sleeping locations given in a random pattern and its given by:

$$\bar{D}_E = \frac{0.5}{\sqrt{n/A}}$$

Equation 9

In equation 8 nearest neighbor, d_i is equals to the distance between sleeping location *i* and its nearest neighbor, and *n* (which also appear in equation 9) is the total number of input sleeping locations, and A is the size of the study area.

Furthermore, the statistical average nearest neighbor z-score, z, is computed as:

$$z = \frac{\bar{D}_O - \bar{D}_E}{SE}$$

Equation 10

where:

$$SE = \frac{0.26136}{\sqrt{n^2/A}}$$

Equation 11

CHAPTER 4: RESULTS

There are two sets (i.e., first and second part) of the results of the analyses. Where the first part of the analyses (i.e. spatial distribution, attribute analysis, proximity analysis and weather analysis) only focuses on the original sleeping locations of The Homeless, and therefore, addresses the following five premises:

- The geographic distributions of the sleeping locations are similar or display insignificant/little variations throughout the study period – Spatial Distribution
- Majority of the sleeping locations of The Homeless are in marginalized urban spaces that deny The Homeless personal privacy/security, human dignity and perpetuate stigmatization and social isolation, therefore, they are highly vulnerable (members of the society) – Attribute Analysis
- The sleeping locations of The Homeless are situated further away from sources of basic needs to enhance The Homeless' livelihoods (water resources are used as examples) – Proximity Analysis
- Weather conditions have a direct/indirect relationship(s) with total numbers of individual sleeping locations, taking into account that The Homeless choose the sleeping locations that serve protections from harsh weather conditions (Ismail and Turiman, 2016) and vice versa – Weather Analysis

The second part of the analyses (i.e. obfuscation/geographic masking) focuses on both masked and a sample of original sleeping locations in order to address the last premise, which states that the locations where The Homeless sleep can be presented without compromising the spatial confidence while preserving the spatial distributions and patterns of the general locations. Four different masking methods are tested using Map Difference, Statistical Difference and Spatial Pattern analytical methods. The masking methods include; Radom Perturbation, Weight Radom Perturbation, Grid Masking and Voronoi Masking (guided by the approach of Seidl et al. 2015).

4.1 SPATIAL DISTRIBUTION

The spatial distribution comprises of four distinct analytical methods (i.e., mean center, standard deviations, standard deviation ellipse, and cluster and outlier analysis – Anselin Local Morain's I), which aim to explore the spatial nature of original individual sleeping locations of The Homeless. This is in line with the proposition/premise that there are insignificant or negligible variations in the distributions of the sleeping locations throughout the study period of the full two weeks.

4.1.1 Mean Center

The two types of mean centers are generated (namely; regional/zonal and overall.), in order, to illustrate that there are no significant variations in the geographical concentrations (and therefore spatial distribution) of the daily observed individual sleeping locations of The Homeless throughout the study

period. Where the daily observed individual sleeping locations are shown in figure 17, below. That is, the sum of all the observed individual locations is 9515, where the lowest daily total of individual locations is 624 (on first Wednesday), highest is 729 (last Friday), and the daily average is 680. The daily total numbers of these locations fluctuate throughout the study period and the trend is positive (i.e., increasing over the period). The increase is possibly due to the either influx of The Homeless, the existing homeless community spreading (as a results of favorable conditions, e.g., weather, acquisition of additional sleeping setup materials) or both – unfortunately, there is no sufficient evidence (e.g., statistics of The Homeless) to define the cause-effect relationship.

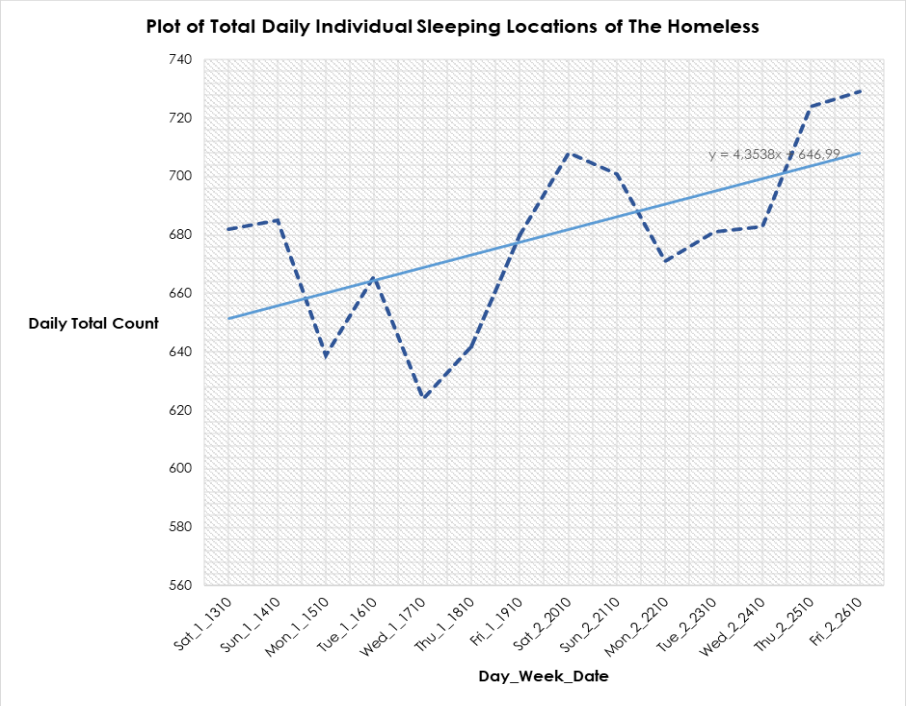


Figure 17: Total number of individual sleeping locations for each of the 14days of study period

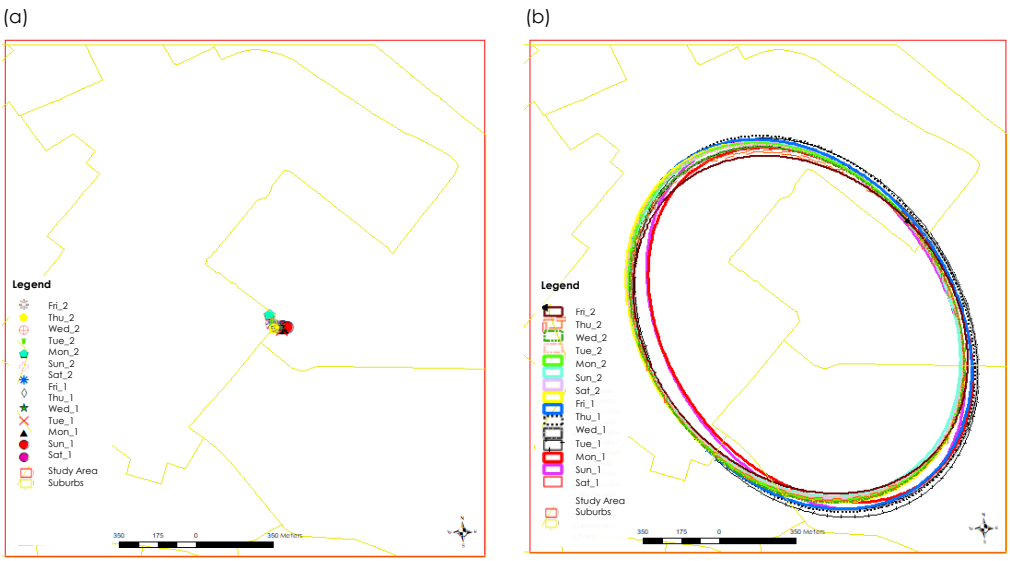


Figure 18: All daily (a) overall mean centers, and (b) standard deviational ellipses of individual sleeping locations

Figure 18 (a), above, shows all the 14 overall mean centers for daily individual sleeping locations layers. The distance range between all in week 1 and the last 4 days of week 2 is 10 - 20 meters while the distance range between all the overall mean centers is 50 meters. The latter suggest some form of movements in the sleeping locations, and therefore, The Homeless. Nevertheless, at the scale of the study area or rather overall, these changes in sleeping locations (due to the shifts in social behaviours) are negligible or insignificant - all the overall mean centers are almost on top of each other, when overlaid In other words, the variations in the sleeping locations over the study period is insignificant or negligible.

Figure 19, below, displays the resulting regional/zonal mean centers, i.e., the multiple centroids for all the observation zones within each of the daily sleeping locations, which represent groups/aggregations of sleeping locations (i.e., another form of obfuscation) falling within the same observation zone (refers to subsection 3.1.1. regarding observation zones). Each day has 61 zonal mean centers and each of these zonal mean centers, in a daily layer of sleeping locations, entail the corresponding zonal mean centers in all other layers. All the corresponding zonal mean centers are almost the same, in terms of x and y coordinates. Furthermore, the predominant attributes/surrounding indicators of respective sleeping locations are attributes of the zonal mean centers, which are the same for corresponding zonal mean centers throughout, refers to appendix 1.

In closing, there is generally no significant variations between all the types of mean centers or geographic concentration of the individual sleeping locations over the 14 days (two weeks) period. Therefore, the observed spatial distributions of the sleeping locations are the same throughout the study duration with insignificant variations.

4.1.2 Standard Deviation

The standard deviation tool, applied to all daily individual sleeping locations, indicates the degree to which the sleeping locations are concentrated/dispersed around the respective overall mean center. Table 8, below, shows standard deviations of all daily individual sleeping locations. The high standard deviations are generally on weekends (i.e., Friday to Sunday) and low values during the week. The values are fluctuating throughout the two weeks period. The largest standard deviation value is 12.3 meters (corresponding to the first Sunday) and the smallest is 9.5 meters (second Tuesday). The variation range between the values is less than 2,8 meters and this, supported by the preceding subsection (4.1.3), implies that there is insignificant to almost no variation on the degree to which the individual sleeping locations are distributed around the mean center throughout the study period.

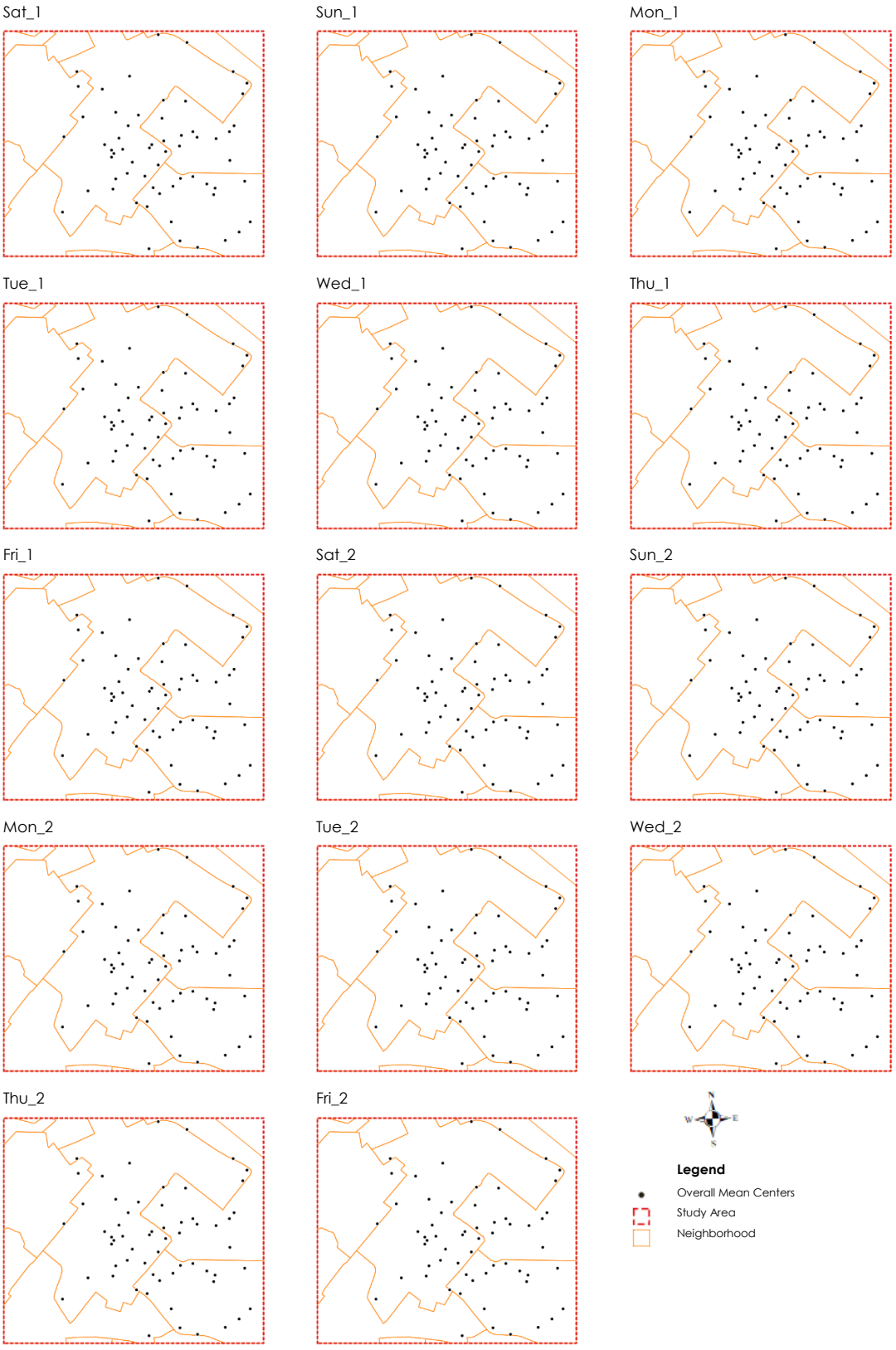


Figure 19: Daily maps of 61 regional/zonal mean centers or groups/aggregations of individual sleeping locations of The Homeless

Table 8: Daily overall standard deviations, and XY standard distances and rotations of standard deviational ellipses of sleeping locations of The Homeless

Day_Week	Standard Deviation (m)	XStdDist (m)	YStdDist (m)	Rotation (^{0})
Sat_1	11.6	643,3	909,7	148,0
Sun_1	12.3	651,5	885,6	143,5
Mon_1	11.0	710,6	929,7	145,7
Tue_1	10.4	704,6	902,5	141,3
Wed_1	10.1	705,1	928,3	144,5
Thu_1	9.8	699,7	916,6	143,0
Fri_1	9.8	690,3	893,0	141,9
Sat_2	10.5	682,7	879,5	142,9
Sun_2	10.0	681,1	869,3	143,0
Mon_2	9.5	689,7	882,2	142,3
Tue_2	9.5	684,8	877,6	140,7
Wed_2	9.7	692,2	874,3	142,7
Thu_2	10.0	684,2	866,3	140,0
Fri_2	10.0	681,8	846,3	136,2

4.1.3 Standard Deviation Ellipse

The standard deviation ellipses (SDE) or polygons for all the daily individual sleeping locations are illustrated by figure 18 (b) above. The SDE indicates both the density and direction of distribution of the sleeping locations of The Homeless, where the smaller the size of the polygon relative to the study area the denser the distribution (i.e., clustering) and vice versa. All the SDE are first order, that is, each covers approximately 68% of the centroids of the sleeping locations for spatial normal distribution (Wang, Shi and Miao, 2015). Moreover, these SDE are situated in the inner and southeast regions of the study area (i.e., CBD and Foreshore neighbourhood areas).

Although the SDE size for the first 2 days (of week 1) are relatively narrow (ellipse size, isolating them on the west side); overall, the sizes of all SDE for the daily individual sleeping locations show little or insignificant variations between each other and are big relative to the study areas – implying dispersion instead of clustering spatial distribution. The insignicant variations between the SDE are also confirmed, refers to table 8, above, which indicates the rotations as well as both the x and y standard distances of all the SDE. The SDE variations are within 100m, at most, in all directions (and axes). Whilst the rotations variations are within 10 degrees, which also imply insignificant changes overall.

In summary; there is no variations in the size and rotation for all the SDE for daily individual sleeping locations of The Homeless. All SDE cover the inner and south-east regions of and are relative big to the study area, which also means that all the distribution of the sleeping locations are dispersed, not clustered, around the mean centers through the two weeks study period.

4.1.4 Cluster and Outlier Analysis (COA, Anselin Local Morain's I)

The COA is for denoting the clustered and dispersed groups of the sleeping locations of The Homeless. Where the clustering is depicted by the high positive or low negative z-scores and/or p-value lower than 0.10 (i.e., rejection null hypothesis) and the opposite is true. The p –value, 0.10, 0.05 and 0.01 correspond to the confidence level 90%, 95% and 99%, respectively. Where the 90% confidence level denotes that there is less than 10% probability that the dataset pattern results from random chances, whilst 95% and 99% confidence levels mean less than 5% and 1% chance(s) that pattern in the data is generated by random processes.

Figure 20, below, shows the cluster and outlier analysis maps of aggregations of locations - this is also another form of masking/obfuscation, refers to table 6 in chapter 2, showing a list of masking methods by Haley et al. (2016). In which high-high (represented by rose pentagon) and low-low (represented by sky circle) are clusters defined by the high positive z-scores. Whilst the low-high (represented by the blue square) and high-low (represented by the red triangle) are outliers denoted by low negative z-scores. The rest (represented by the grey pentagon) do not show any clustering nor dispersion. Statistically, they are the results of random processes, and thereof, they are not of interest. Both clusters and outliers are within the 95% statistical confidence level.

There is no significant daily variation pattern(s) for all daily sleeping locations. Although there is a decrease in outliers/clusters and an increase in randomness over time. The low-low clusters (compared to high-high clusters) are dominant and lies at the center, slightly to the south-west of the study area, i.e., the CBD. There is a steady drop in the total number of clusters over time on a daily basis, that is, there are more clusters on the first week than on second week (negative trend). Whilst the number of individual sleeping locations increase with time (i.e., positive trend), as mentioned earlier, subsection 4.1.1 (reference: figure 17). This may be the result of clusters not changing but the number of The Homeless, i.e., increase of the homeless community – however, more evidence (i.e., statistics of The Homeless) is required to deduce this relationship. Likewise, the number of outliers also decrease with time relatively on each day. Both the clusters and outliers are relatively fewer than the random groups throughout and thereof, the general trend of randomness is positive with time.

In summary, throughout the two weeks period, there are more outliers or dispersed groups of the sleeping locations than those displaying clustering on each day. Few existing clustered locations are predominant and lie in the inner region of the study area, i.e., the CBD. Although overall spatial distributions vary on a daily basis, however, as proposed, there is generally no significant/negligible variations in clusters and outliers of sleeping locations throughout the study period.

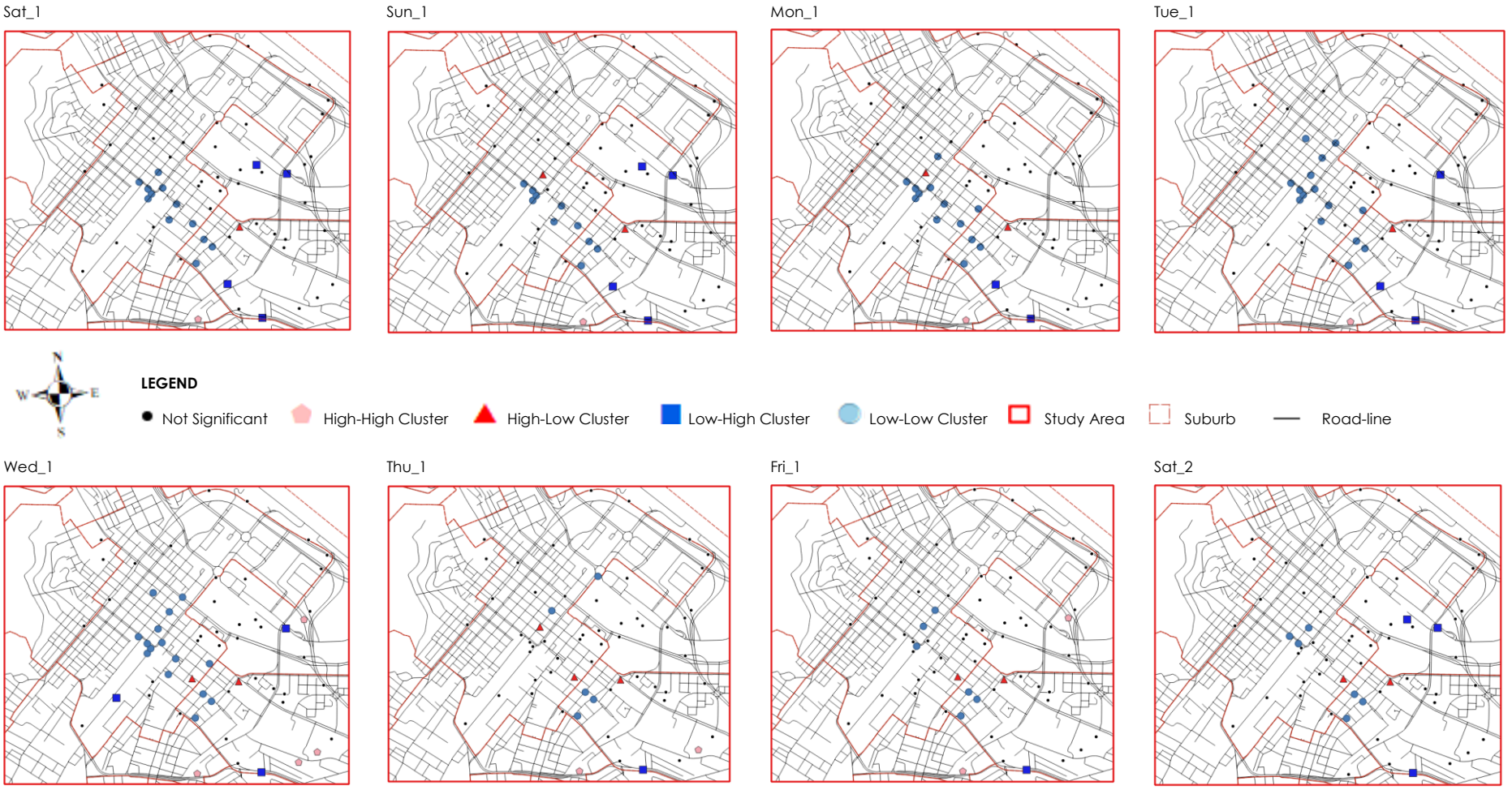


Figure 20: Cluster and outlier analysis outputs of aggregated sleeping locations for each of the 14days of study period (part 1 0f 2)

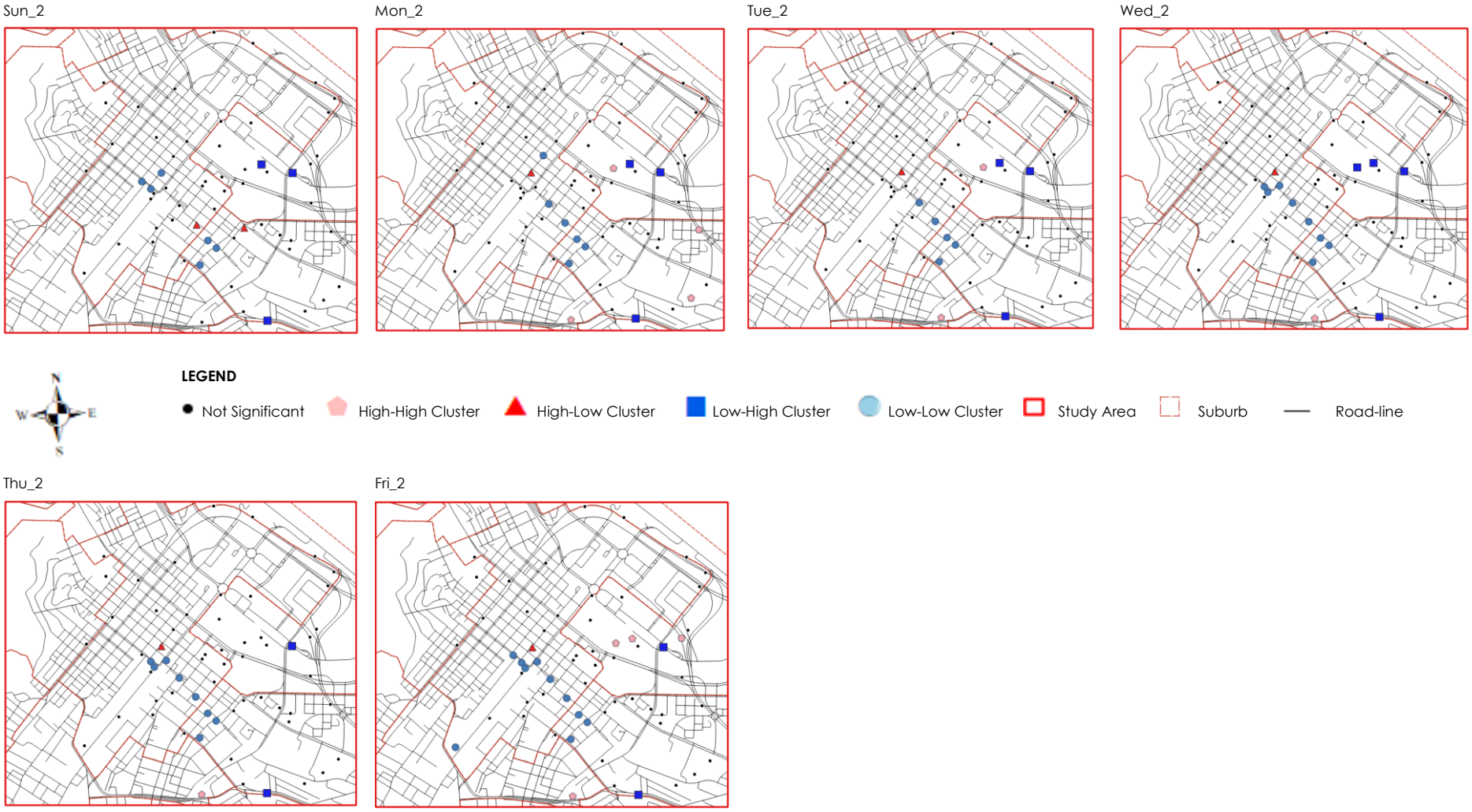


Figure 20: Cluster and outlier analysis outputs of aggregated sleeping locations for each of the 14days of study period (part 2 of 2)

4.2 ATTRIBUTE ANALYSIS

The attribute analysis supports and/or provides evidences linked to (social science) literature, which states that the urban models (i.e. bylaws, rules, regulations, social activities and infrastructures) remain to marginalize, victimize, stigmatize and give no room for personal privacy for The Homeless, and therefore, these people are highly vulnerable (members of the society). Although the latter is probably well known based on knowledge from Social Science, for instance, but not so much, if any, from the GISc (geo-information science)/socio-spatial perspective.

Appendix 1 illustrates the properties of the aggregations/groups (i.e., the regional/zonal mean centers) of all the daily sleeping locations of The Homeless over the 14 days period, including appropriate surrounding attributes of and around these sleeping locations. Refers to table 7b (above in Chapter 3) for the full list of all attributes and their entries that are selected following Mazumdar and Paul (2018) in attempt to capture how the locations, where The Homeless sleep, support their routine and adaptive practices in the urban space/ecology.

The attribute analyses are done using the each of the selected six surrounding indicators (i.e., general description, supporting structure, surface, platform, accessibility, and lookout view), which are considered as the primary keys, more descriptive or "landmark" attributes to denote the surroundings of and around the sleeping locations in the urban space. The results are structured in a way that each indicator is assigned a subsection, which is designed in such a way that the indicator is firstly discussed separately and then, the pertaining cross-parameter or indicators are included to provide more insight of the subject nature of vulnerability. Where the criteria, to depict the associated vulnerability nature of a surrounding indicator, are discussed in detail in the respective subsection.

4.2.1 General Description

The general description helps to indicate the degree of marginalization of The Homeless in the urban area. Since various forms of local law enforcers are constantly controlling the type and form of urban spaces occupancies (NLCHP, 2014; and Snow and Mulchahy, 2001). The four various entries/descriptors of the general description include: building, roadside, rooftop, and open space.

Figure 21 (a), below, shows the proportions of the groups/aggregations (i.e., zonal mean centers) of the daily sleeping locations of the homeless people in Cape Town City Bowl with respect to various entries of general description indicator. The findings are as follow the 17 groups (28%) are approximately within two feet steps distance range to some form of building. In addition, the 21 groups (34%) are near the

roadside; the one group (2%) is situated on the rooftop; and the 22 groups (34%) are not near to or rather are far away from any form of urban infrastructure (i.e., they are in open spaces).

(a) (b)

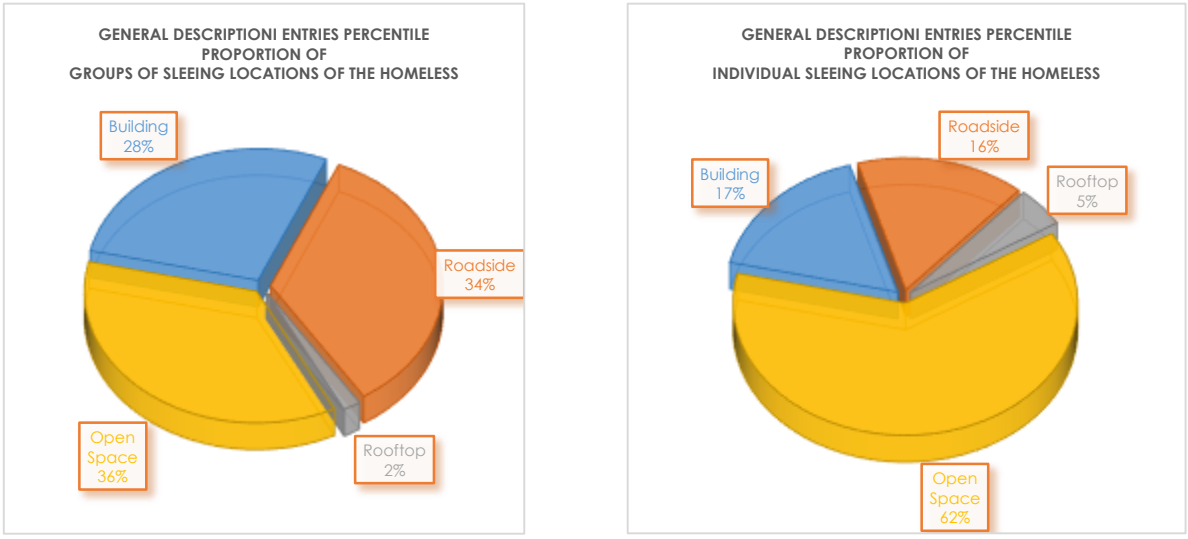


Figure 21: Percentages of general description entries for (a) group and (b) sum of individual sleeping locations of The Homeless

In terms of the individual sleeping locations; figure 21 (b) above, shows a pie/percentage proportions chart of the sum of all the observed individual sleeping locations in accordance with their entry types/descriptors of the general description indicator. This shows that majority of the sleeping locations are in open spaces (62%) and the least locations are on the rooftops (5%), whilst both roadside and building locations comprise 16% and 17% proportion of the entire locations count, respectively.

Table 9: Daily percentage proportions of observed individual sleeping locations for general description indicator

Entry Type	Sat_1	Sun_1	Mon_1	Tue_1	Wed_1	Thu_1	Fri_1	Sat_2	Sun_2	Mon_2	Tue_2	Wed_2	Thu_2	Fri_2
Building	18,5	18,1	13,0	13,1	12,5	13,9	17,8	19,1	20,1	18,3	18,9	16,1	15,9	19,9
Road-side	15,2	12,3	14,1	15,5	17,5	17,4	16,3	16,5	16,7	15,8	16,3	17,1	16,0	15,8
Rooftop	5,6	5,5	4,2	4,5	4,5	4,2	4,6	5,4	5,1	5,1	5,0	5,0	4,3	4,4
Open Space	60,7	64,1	68,7	67,0	65,5	64,5	61,3	59,0	58,1	60,8	59,8	61,8	63,8	59,9

By comparing the groups of and individual sleeping locations (figure 21a and b), there are few groups of sleeping locations situated in the open space than the sum of individual sleeping locations (this is also true for other groups with a general description of rooftop and the opposite case is true for both the building and roadside entries). In principle or other words, the observed few groups of sleeping locations in the open spaces (36%) comprise relatively large number of summed up individual sleeping locations (62%) – that is more than individual locations of the other three entries combined.

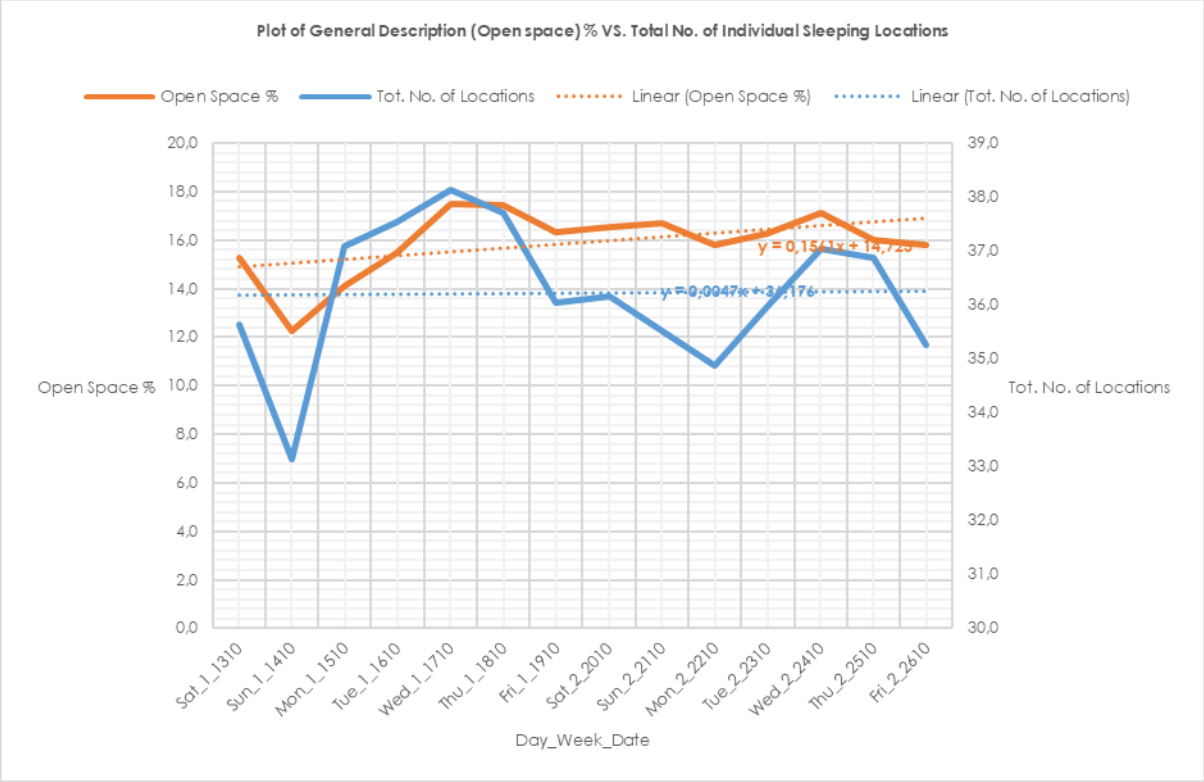


Figure 22: Daily percentages of total individual sleeping locations in open spaces against total number of individual locations

On each day, there is a minimum of 50,9% individual sleeping locations in the open spaces and there rest are on the rooftops and near the buildings and roadsides – refer above to table 9 and figure 22. On average, there are 54,7% of the individual sleeping locations situated in the open spaces in Cape Town City Bowl. Throughout the study period, the percentiles of the individual locations in the open spaces fluctuates between 50,9% and 58,3%.

Figure 22 above, indicates the daily total number of individual sleeping locations against percentile proportions of the individual sleeping locations situated in the open spaces. There is declining trend for percentages of locations in the open spaces whilst there is an inclining trend for the daily total number of individual locations. This implies that the increase in the total number of sleeping locations is due to or match with locations entailing other types of the general description instead of the open space.

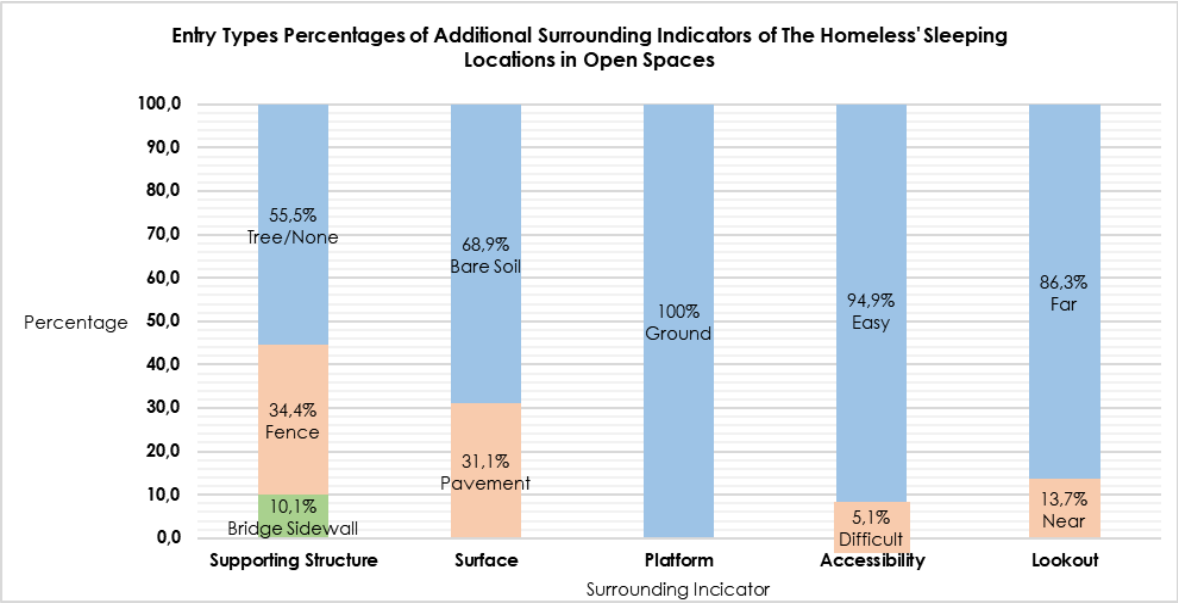


Figure 23: Entry percentages of additional surrounding indicators of individual sleeping locations of The Homeless in open spaces

In figure 23, above, is the cross-parameters or surrounding indicators relationships of the individual locations in the open spaces. That is, the percentage proportions of the entry types of additional surrounding indicators relating to the individual locations situated in the open spaces. Each day through the study period, on average, 55,5% of the sleeping setups in the open spaces are either not supported by any form of physical structure (not constructed by The Homeless) or they are supported by a tree, which translates to less personal security/protection of setups and therefore, The Homeless. Out of these individual locations in the open spaces: 68,9% are over the unpaved surface or bare soil (which implies high level of marginalization/stigmatization), and 100% are on the ground platforms (which means high exposure to ecological health-implicating concerns, e.g., dump ground, surface water runoff). Moreover, 94,9% of the locations in the open spaces are easily accessible by any person (i.e., low level of personal security), and 86,3% entail far lookout views (i.e., they have relatively higher level of social exclusion/isolation). The above supports that the locations in the open spaces are highly marginalized.

In summary, majority of the locations where the homeless community sleep in City Bowl, on each day of the study period, are in highly marginalized urban space – i.e., far away from any form of urban built-up infrastructure, incl. roads. Since, on each day of the study, there is more than 50,9% (58,3% at most and 54,7% on average) of sleeping locations of The Homeless in open spaces. Where 55,5% provide low or no personal protection (supported by trees/none), 68,9% are on bare soil (i.e., high level of stigmatization), 100% are on ground platform thus, high exposure to health concerns, 94,9% are easy accessible or provide low level of person protection, and 86,3% have a far lookout view or relatively

high level of social isolations. Therefore, The Homeless are highly vulnerable members of the society as they are in urban spaces that deny them personal privacy/security, human dignity and perpetuate stigmatization and social isolation.

4.2.2 Supporting Structure

The supporting structure refers to some form of firm and fixed structure (not constructed by The Homeless) that the sleeping setup(s) of The Homeless is against or attached to, in order, to gain some sort of support. As such, the supporting structure is used to measure the degree of personal privacy and protection of The Homeless. This is depicted by the size and rigidity (i.e., unbending/fixed nature) of the structures. Where the big size structure refers to one that is large enough to hide, at least from one side, the entire sleeping setup and a standing adult with an average height, +/-170cm. High rigidity structure is one that is seemingly unbending, unmoving, fixed and erected. Therefore, a big size and high rigidity structure denotes high degree of personal privacy and protection and the opposite is small size and less rigid structure (i.e., low degree of personal privacy and protection). The descriptors of supporting structure include the building sidewall (big size and high rigid), bridge wall (big/moderate size and high rigid), fence (moderate/small size and high/less rigid), and trees (small size and less rigid – this descriptor also includes cases where there is no any form of supporting structure).

In figure 24 (a) below, is the percentage proportions of the groups/aggregations of the daily sleeping locations of the homeless people in the Cape Town City Bowl with respect to the four entry types of the supporting structure indicators. Entry type with more groups of the sleeping locations (24) are trees/none and the one with the least are the bridge walls (5), which capture 39% and 8% proportions of the total 61 groups, respectively. The remaining proportions are for the building sidewalls (33%) and fence (20%) taking the 20 and 12 groups out of the total 61 groups, respective.

On the other hand, figure 24 (b) shows percentages proportions of the sum of all the observed individual sleeping locations according to their entry types/descriptors of the supporting structure indicator. As expected, more individual location, 3443 (36%), are without the support structures or rather attached to trees and the least of the individual locations, 808 (8%), are supported by bridge walls. The remaining 2535 and 2731 individual locations are supported by the building sidewalls (27%) and fences (29%), respectively.

(a) (b)

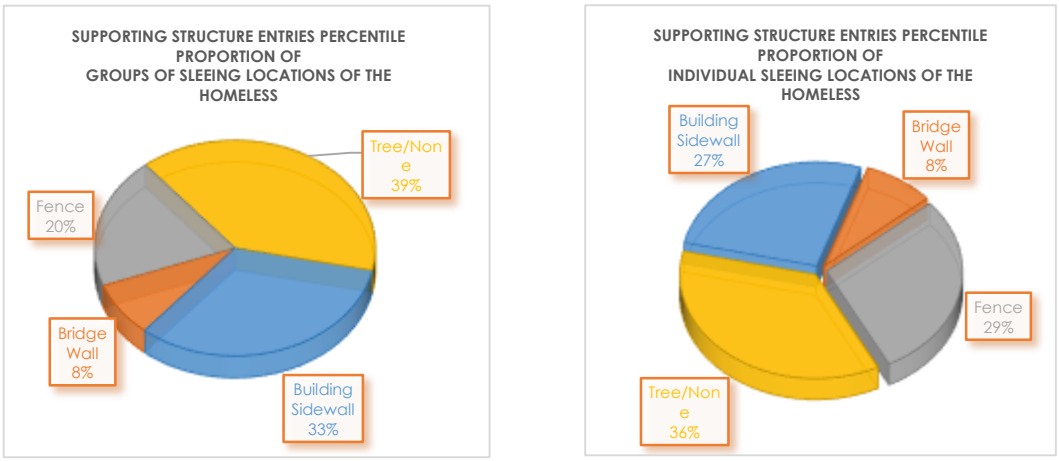


Figure 24: Percentages of supporting structure entries for (a) group and (b) sum of individual sleeping locations of The Homeless

When comparing the groups of and individual sleeping locations of The Homeless, whist focusing mainly on the tree/non entry type; the percentile of the groups of locations (39%) is greater than the one of the individual sleeping locations (36%). This is the same for the fence entry types but the opposite for the building sidewall entry types while the bridge wall entry types comprise the same proportions both the groups of and individual locations (i.e., 8%). In essence, there are more groups with relatively few individual sleeping locations of The Homeless supported by the trees or no form of structure.

Table 10: Daily percentage proportions of observed individual sleeping locations for supporting structure indicator

Entry Type	Sat_1	Sun_1	Mon_1	Tue_1	Wed_1	Thu_1	Fri_1	Sat_2	Sun_2	Mon_2	Tue_2	Wed_2	Thu_2	Fri_2
Building	30,6	30,4	22,5	21,8	21,8	22,9	26,9	29,2	30,2	27,7	27,9	25,3	25,0	29,4
Bridge	8,5	9,3	11,1	10,2	8,5	8,3	7,8	7,5	7,6	7,9	7,8	7,8	9,5	7,1
Fence	25,2	27,2	29,3	30,5	31,6	31,2	29,3	27,1	26,7	29,5	28,3	29,9	28,6	28,3
Tree/None	35,6	33,1	37,1	37,5	38,1	37,7	36,0	36,2	35,5	34,9	36,0	37,0	36,9	35,3

Table 10, above, indicates the daily percentage proportions of the individuals sleeping locations for the supporting structure type of the surrounding indicators. Similar to the above mentioned, majority of the sleeping locations (maximum of 38% and minimum of 33%) are supported by the trees or not supported by any form of structure and the least number of the locations (maximum of 11% and minimum of 7%) are supported by the bridge walls. The latter is true throughout the two weeks study period and the existing percentile fluctuations in all categories are insignificant or negligible.

In addition; figure 25, below, indicates the daily total number of the individual sleeping locations against the percentile proportions of the individual sleeping locations situated in open spaces. In the

two weeks of the study, although the percentiles of the locations with the trees/none entries for the support structure fluctuates, there is almost constant trend. Interesting findings are on week one, Monday to Friday; on these days, the total numbers of individual locations are touching the lowest counts whilst locations with tree/none entries are touching the highest counts/percentiles. Taking into consideration the almost constant trend of the locations with the tree/none entry types and the positive trend of the daily total number of individual locations. It suffices to note that the increase in the daily total number of locations over the study period is due to the locations with different entry types (i.e., building sidewall, bridge wall and/or fence) instead of the locations with the tree/none entry types.

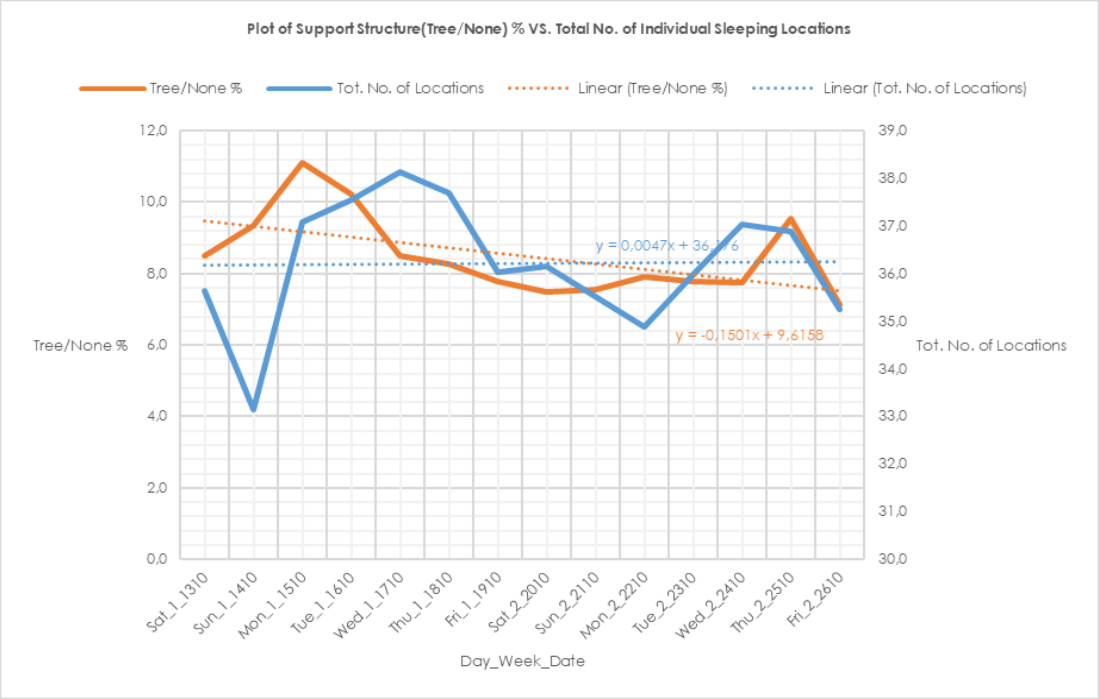


Figure 25: Daily percentages of total individual sleeping locations with tree/none entry for support structure against total number of individual locations

Figure 26, below, illustrates the cross-parameters or indicators relationships of individual locations with the supporting structure entry type of trees/none. The percentage proportions of the entry types of additional surrounding indicators relating to the individual locations supported by the trees or without any form of supporting structure (which is not constructed by The Homeless). Each day of the study period, on average, 87,2% of the sleeping setups with the trees/none support structures are in the open spaces (which depicts zones of high marginalization). Where 81,5% of the locations are over the unpaved surface or bare soil (which implies high level of marginalization/stigmatization), 100% are on the ground platforms (which means high exposure to ecological health-implicating concerns, e.g., dump ground, surface water runoff). Furthermore, 100% of the locations with the trees/none support

structures are easily accessible by any person (i.e., low level of personal security) and 89,0% entail far lookout views (i.e., relatively higher level of social isolation/exclusion). In that light, the individual sleeping locations with the trees/none supporting structures comprise high degree of vulnerability.

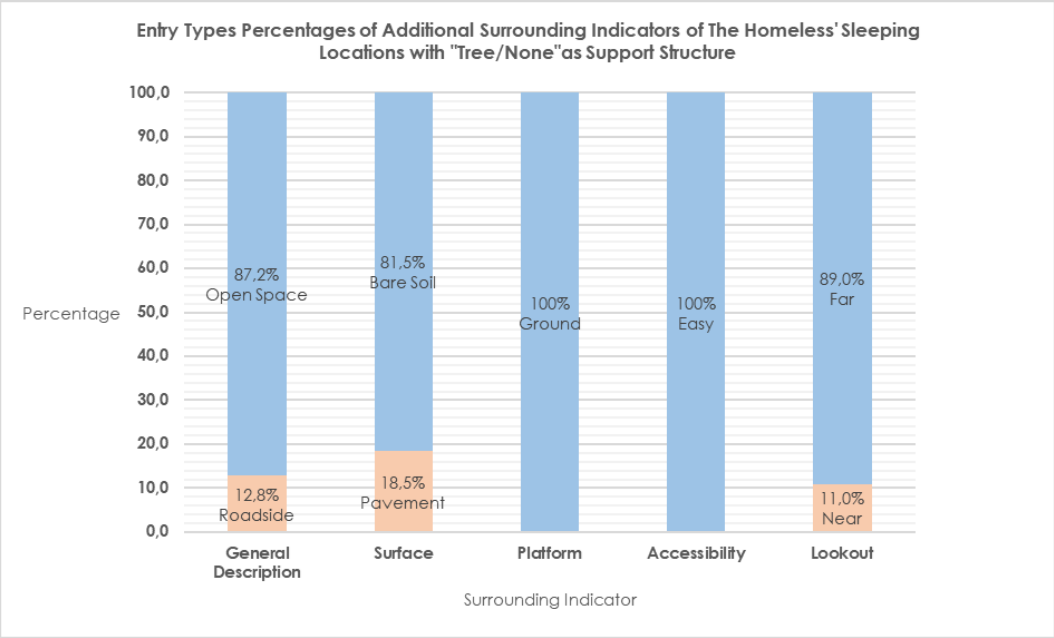


Figure 26: Entry percentages of additional surrounding indicators of individual sleeping locations of The Homeless with tree/none as support structure

In summary, when excluding the support structures created by The Homeless, out of the four options, majority (i.e., 35% minimum on each day) of the sleeping locations encompass the tree/none descriptors for the support structure type of the surrounding indicators. That is, majority of the sleeping locations of The Homeless are supported by the trees or are not supported by any form of structures. In principle, the existing support structures entail small sizes and they are less rigid. Therefore, the predominant individual sleeping locations are highly lacking personal privacy and protections, consequently, the homeless people. Out of these locations: 87,2% are situated in the open spaces (i.e., highly marginalized zones); 100% are on the ground platforms (i.e., high exposure to ecological health-implicating concerns, e.g., dump ground, surface water runoff); and 100% are easily accessible by the public/anyone (i.e., low level of personal security). In addition, out of these locations with the tree/none entries: 81,5% are over the unpaved surfaces or bare soils (which implies high level of marginalization/stigmatization); and 89,0% are with tree/none supporting structure comprise far lookout views (i.e., relatively higher level of social isolation/exclusion).

4.2.3 Surface

The surface describes the nature or type of the land cover underneath the observed sleeping locations of The Homeless. Two descriptors of the surface indicator are employed, namely; pavement (i.e., artificial surface constructed with some form of cement) and bare soil (i.e., non-paved or nature surface, including grassland). Figure 27, below, is a map illustrating various surface types in the study area, which can be accessed by the public, include The Homeless (i.e., pavement and bare soil), and those that are private, reserved and not suitable to setup a sleeping location, e.g., the ocean (these are denoted by reserved/other label in the map). Since this study only considers the sleeping locations situated in public spaces, relevant surface types are the pavement and bare soil. The area of the pavement is 2,54746 km^2 (i.e., 87,6% of the total public area) whilst the bare soil is 0,360985 km^2 (i.e., 12,4% of the total public area).

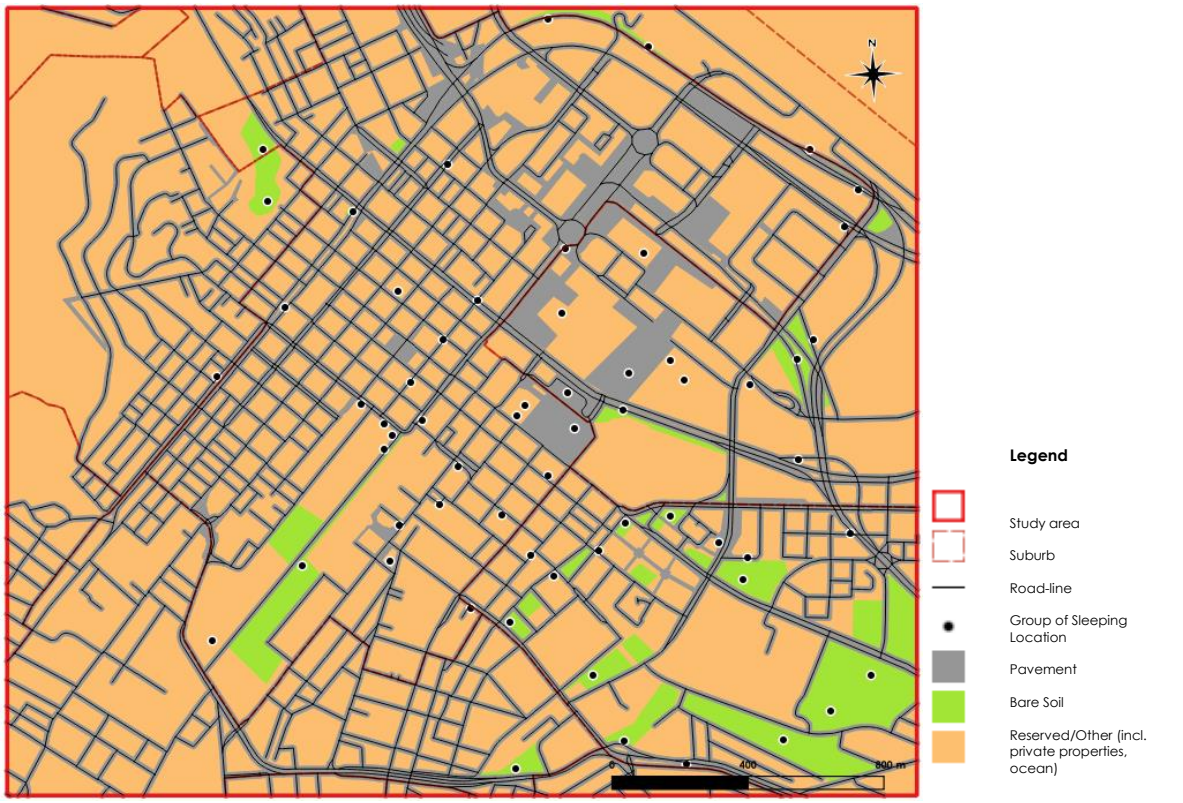


Figure 27: Map showing various types of surfaces that are accessible to the public (pavement and bare soil) and those that are not (reserved/other) in the study area

In that light, the predominant surfaces in the urban public areas are modified, to be specific, covered with some form cement instead of natural soil/vegetation. Therefore, the surface indicator helps to depict the degree of marginalization and stigmatization of The Homeless. Where the high degree of marginalization/stigmatization is depicted by the zones that are not modified, covered or constructed

with some form of cement but natural soil and/or vegetation (i.e., bare soil), and the opposite is depicted by the pavement entry type.

(a) (b)

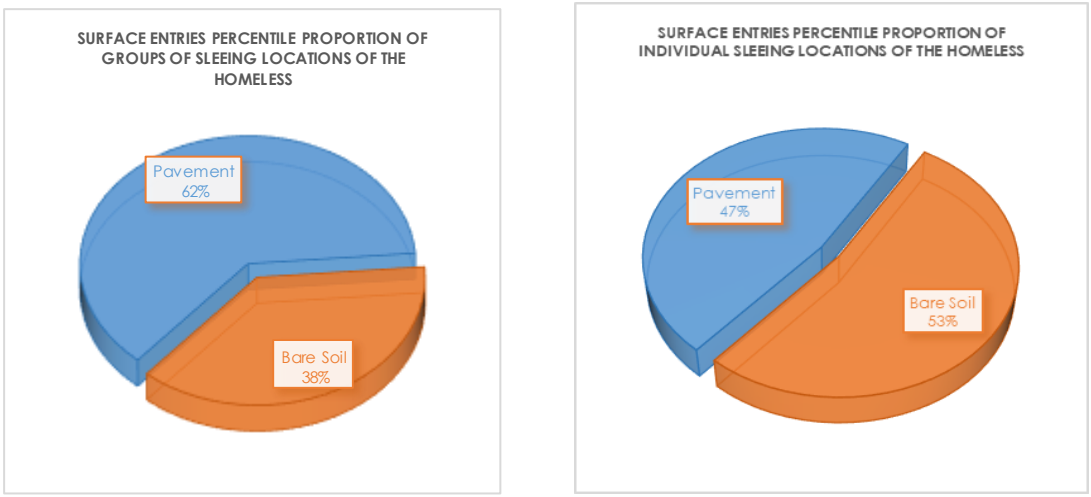


Figure 28: Overall percentage proportions of surface entries for (a) group and (b) sum of individual sleeping locations of The Homeless

Figure 28 (a), above, illustrates the overall percentage proportion of the two entry types of the surface indicator for the groups (i.e., aggregates/zonal mean centers) of sleeping locations of The Homeless. There are more sleeping locations on the paved or cement-constructed surfaces (i.e., 62%) than those on bare soil, nature or unmodified grounds.

On the other hand, figure 28 (b) displays the overall percentage proportion of the two entry types of the surface indicator. The chart shows that there are 53% of the individual sleeping locations (i.e., are 5,024 in counting) on bare soil, and 47% (i.e., 4,491 in counting) are on the paved or cement-constructed surfaces. Moreover, table 11 (below) shows that the latter is true, i.e., there are more locations on bare soil than on pavement, throughout the study period. The percentile proportions fluctuate throughout the study period with maximum of 56% (i.e., on first Monday) and minimum of 48% (on second Sunday).

Table 11: Daily percentage proportions of observed individual sleeping locations for surface indicator

Entry Type	Sat_1	Sun_1	Mon_1	Tue_1	Wed_1	Thu_1	Fri_1	Sat_2	Sun_2	Mon_2	Tue_2	Wed_2	Thu_2	Fri_2
Pave-ment	46,6	45,7	43,7	45,9	43,6	45,3	47,8	50,4	51,8	48,3	48,6	45,7	47,8	48,6
Bare soil	53,4	54,3	56,3	54,1	56,4	54,7	52,2	49,6	48,2	51,7	51,4	54,3	52,2	51,4

Furthermore, figure 29, below, displays the daily total number of the individual sleeping locations against the percentile proportions of the individual sleeping locations situated on bare soil surfaces. There is a negative trend, where the highest values are during week one and the lowest on week two, for the individuals locations situated on bare soil surfaces, and this is opposite for daily total number of

individual locations. Similar to the predominant entry type for the general description above (subsection 4.2.1), this serves as evidence that the increase in the total number of sleeping locations is due to or match with the locations with other entry type of surface indicator (i.e. pavement) instead of those on bare soils.

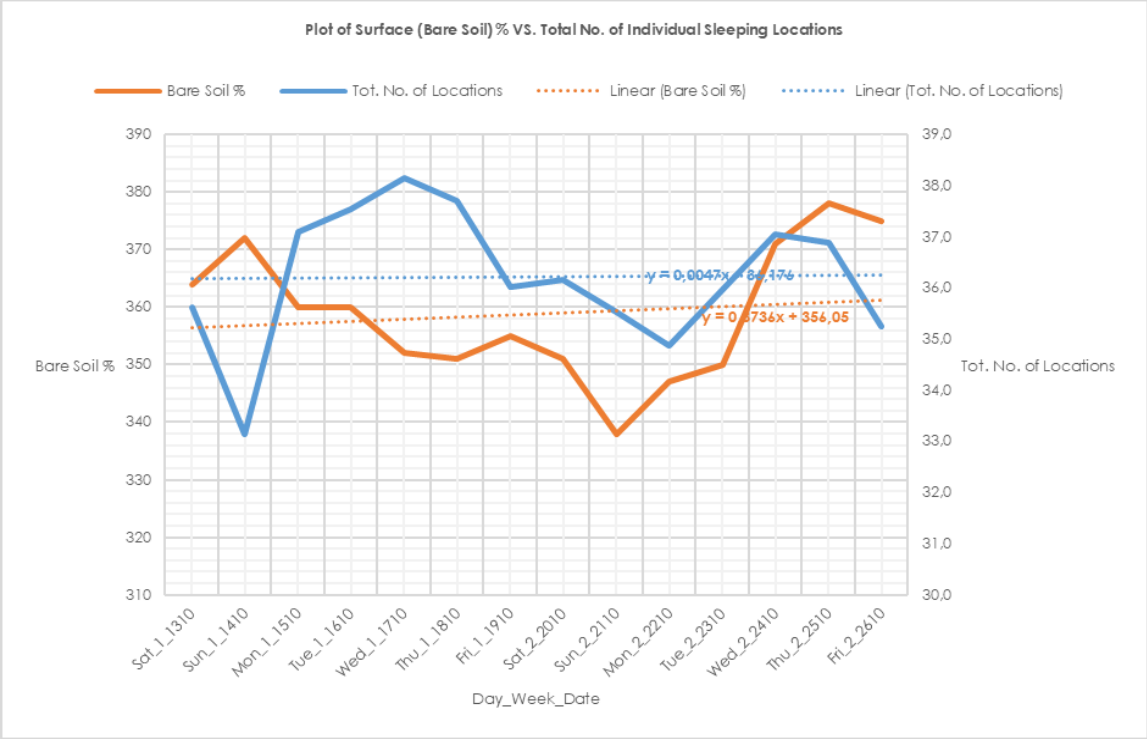


Figure 29: Daily percentages of total individual sleeping locations on bare soil surfaces against total number of individual locations

Figure 30, below, displays the cross-parameters or indicators relationships of the individual locations over the bare soil surfaces. That is, the percentage proportions of the entry types of additional surrounding indicators relating to the individual sleeping locations over the non-modernized or bare soil surfaces. Throughout the study period, there is a daily average of 74,1% of sleeping setups are situated in the open spaces (which further depicts that these locations are highly marginalized). Out of these locations over bare soil surfaces: 55,8% are supported by the trees or without the support structures (which implies low personal security and privacy); and 100% are on ground platform (which means high exposure to ecological health-implicating concerns, e.g., dump ground, surface water runoff). Furthermore, 94,6% are easily accessible by any person (i.e., low level of personal security); and 94,6% have a far lookout view (i.e., they relatively have higher level of social exclusion/isolation). The above examinations support that the individual sleeping locations comprise high degree of vulnerability.

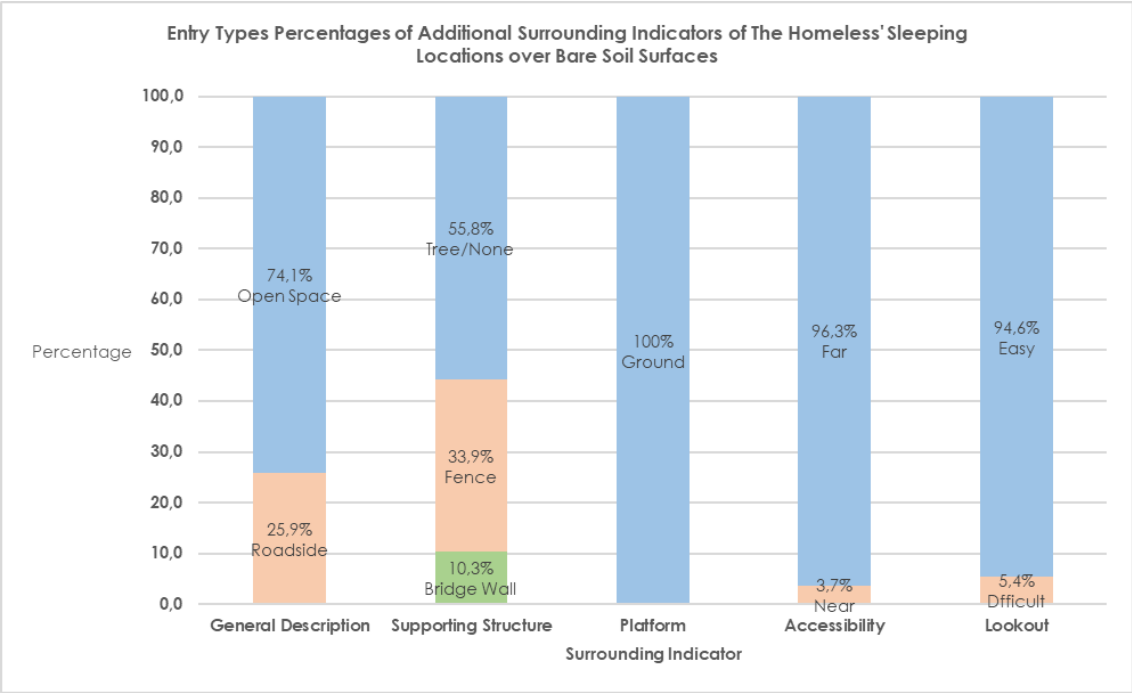


Figure 30: Entry percentages of additional surrounding indicators of individual sleeping locations of The Homeless over bare soil surfaces

In summary, majority (i.e., 53% overall) of the sleeping locations are situated where the surfaces underneath are bare soil – i.e., not constructed or modified to match majority of the surrounding surfaces or rather to suit dignified lifestyle (in urban area). Given that the bare soil is about 12% of the public space possible to set up the sleeping locations of The Homeless (considered in this study) and the remaining percentile (i.e., 88%) is for the pavements surfaces.

In addition, out of these locations on bare soil: 74,1% are situated in open spaces (i.e., highly marginalized zones); and 55,8% are supported by the trees or without support structures (i.e., low personal security and privacy). In the bargain, 100% are on the ground platforms (i.e., high exposure to ecological health-implicating concerns); 94,6% are easily accessible by any person (i.e., low level of personal security); and 94,6% entail far lookout views (i.e., they relatively have higher level of social exclusion/isolation). It, then, suffices to state that the locations where The Homeless sleep/rest encompass high degree of marginalization and stigmatization; as a result, the homeless people are in highly marginalized and stigmatized urban space.

4.2.4 Platform

The platform refers to the relativity of the surface of the sleeping location(s) to the predominant public surface. Two entry types/descriptors of the platform indicator are elevated and ground. Where

elevated descriptor denotes a raised surface relative to the predominant surrounding surface used by the public and the opposite is the unraised surface, which is depicted by the ground descriptor. Since majority, if not all, the ecological activities (e.g., surface water runoff, health hazards) take place on predominant surface, such these activities have impacts on the personal security/wellbeing of The Homeless.

For instance, surface water runoff penetrates and/or wash off some of the material for the sleeping setups, and social movements, at times, entail health implications to The Homeless (e.g., littering, shifting/disturbing sleeping setups, ground saliva/mucus spitting). Hashimah et al. (2016) came to realize that majority of The Homeless walk around the city until most shops and restaurants close, and the city is quiet and inductive for resting. That said; ground entry type depicts low level of personal security for The Homeless, and the opposite is denoted by elevated entry type.

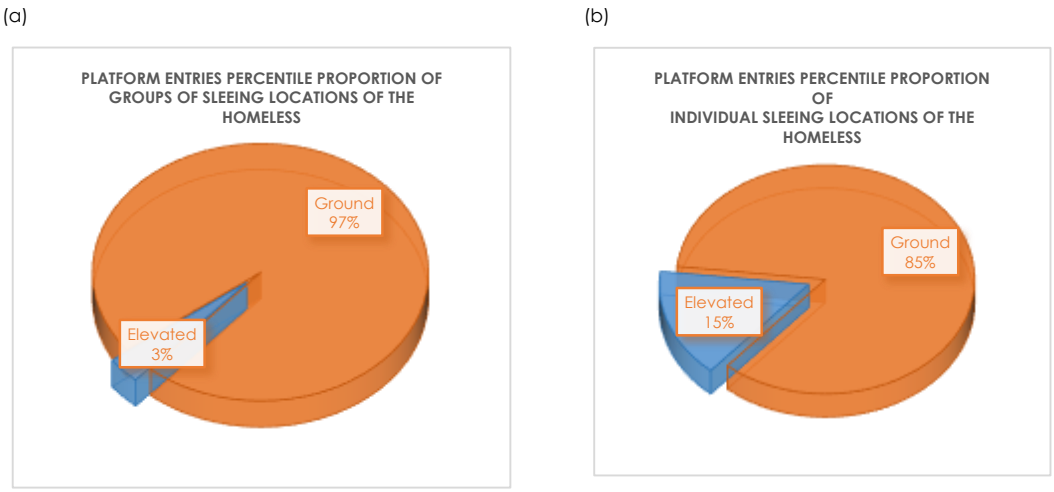


Figure 31: Overall percentage proportions of platform entries for (a) group and (b) sum of individual sleeping locations of The Homeless

In figure 31 (a), above, is a chart showing the overall percentile proportions of the entry types of the platform indicators of the groups (i.e., zonal mean centers) of sleeping locations. Overall, there are 97% of the groups of sleeping locations of The Homeless situated on unraised surface relative to the predominant surrounding surface (i.e. the ground entry type) and the remaining 3% is for the groups of locations on the raised surfaces (i.e., the elevated entry type).

Figure 31 (b) displays the overall percentile proportions of the entry types of the platform indicators of the individual locations of The Homeless. The chart indicates that there are 85% (i.e., 8048 in total/counting) of the individual sleeping locations of The Homeless situated on the unraised surface relative to the predominant surrounding surface (i.e. ground entry type). Whilst the remaining 15% (i.e.,

1467 in total) of the locations are on the raised surfaces (i.e., the elevated entry type). Moreover, table 12 (below) displays that high percentile proportion lies with the ground entry and low percentile proportion with elevated entry type, throughout the 14 days study period. There is a minimum of 82,9% (i.e., on the first Monday) and maximum of 85,9% (i.e., on the second Thursday) for the locations with ground entries.

By constrasting the groups of and individual sleeping locations with the ground entries, there are more groups as oppose to the individual sleeping locaitons. In other words, there are more groups (i.e. zonal mean centers) with relatively low numbers of the individual locations with the ground entries.

Table 12: Daily percentage proportions of observed individual sleeping locations for platform indicator

Entry Type	Sat_1	Sun_1	Mon_1	Tue_1	Wed_1	Thu_1	Fri_1	Sat_2	Sun_2	Mon_2	Tue_2	Wed_2	Thu_2	Fri_2
Elevated	15,5	17,1	15,8	15,3	16,0	15,0	15,1	15,4	14,8	15,2	15,0	14,9	14,1	16,6
Ground	84,5	82,9	84,2	84,7	84,0	85,0	84,9	84,6	85,2	84,8	85,0	85,1	85,9	83,4

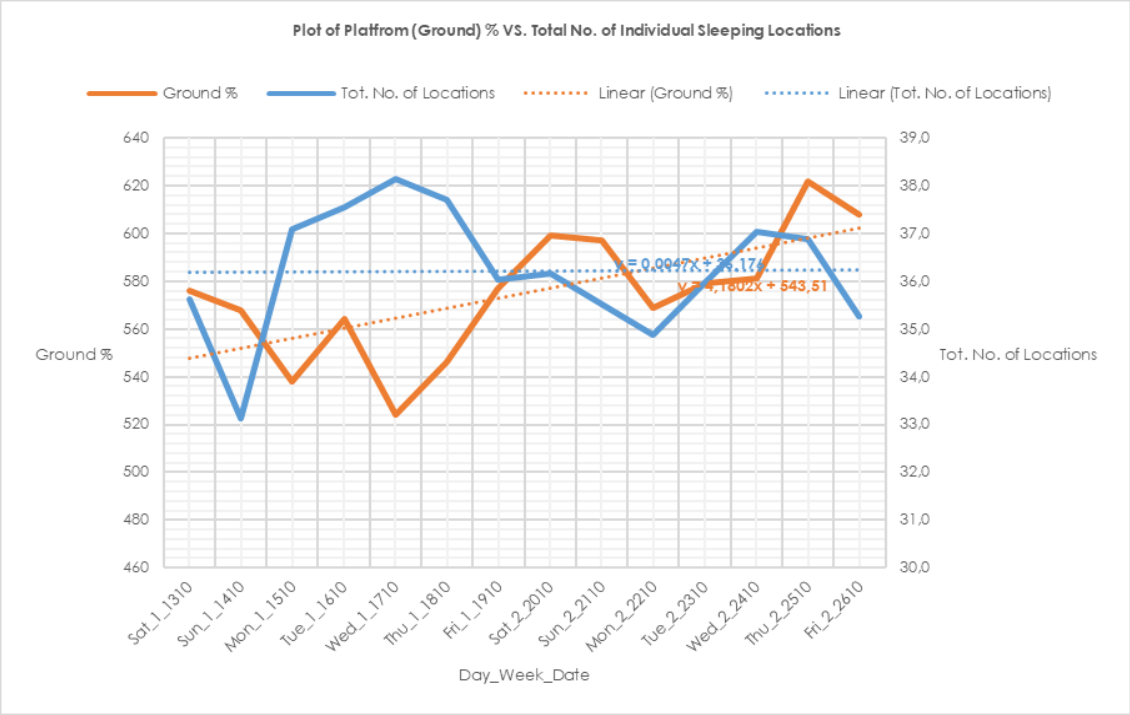


Figure 32: Daily percentages of total individual sleeping locations with ground entry type for platform indicator against total number of individual locations

Figure 32, above, depicts the individual locations on the ground platform against the daily total numbers of individual sleeping locations of The Homeless. Both the trends of daily total numbers of the locations and those locations on the ground platform are positive and their fluctuations almost mimic each other, especial during the weekdays of the first week. This suggests that the locations with ground

entry types are increasing over time and their increase is directly proportional to or rather directly contributes towards the increase in the total number of the individual sleeping locations.

The cross-examinations results of the other indicators with the individual locations with the ground entry types are on figure 33, below. Out of the 85% locations with the ground entries for platform indicator: 60,3% are situated in the open spaces (i.e., highly marginalized zones); and 33,8% are supported by the trees or without support structures (i.e., low personal security and privacy). Furthermore, 55,9% are on bare soils (i.e., high level of marginalization and stigmatization); 95,6% are easily accessible (i.e., low level of personal security); and 72,9% comprise the far lookout views (i.e., they relatively have higher level of social exclusion/isolation). In that regards, majority of the locations are highly vulnerable, that is, high exposure to ecological health-implicating concerns, e.g., dump ground, surface water runoff.

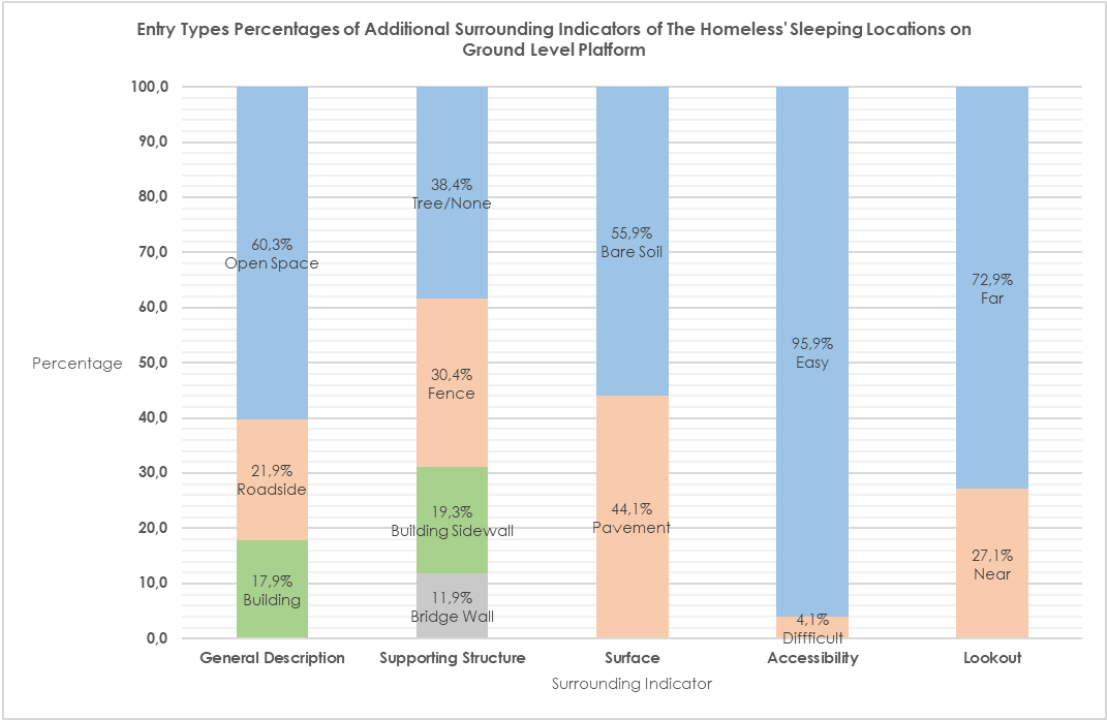


Figure 33: Entry percentages of additional surrounding indicators of individual sleeping locations of The Homeless with ground entry types for platform indicator

In conclusion, almost all of the individual sleeping locations provide low degree of personal security/wellbeing of The Homeless. Due to 94 - 95% of the sleeping locations on unraised surface relative to the predominant public surface (i.e., the ground entry type of the platform indicator). Where majority, if not all, of the ecological activities that threaten the personal security/wellbeing of The Homeless takes place (e.g., surface water runoff, health hazards). The trend of locations with ground entries is positive and it is similar to that of daily total number of individual locations, which means direct

proportional relationship. Where out of these locations with the ground entries: 60,3% are situated in the open spaces (i.e., highly marginalized zones) and 33,8% are supported by the trees or without support structure (i.e., low personal security and privacy). Moreover, 55,9% are on bare soils (i.e., high level of marginalization and stigmatization), 95,6% are easy accessible (i.e., low level of personal security), and 72,9% entail the far lookout views (i.e., they relatively have higher level of social exclusion/isolation).

4.2.5 Accessibility

The accessibility denotes the ability to approach and see or obtain something, at close range, from the sleeping locations. Bi-entry types or descriptors include easy and difficult. Where easy entry types denotes the provision of minimal or no form of barrier for the non-homeless people or intruders (incl. the elderly and disability individuals) to approach, see and/or obtain something from the sleeping locations of The Homeless. Whilst the difficult entry denotes the opposite, that is, some form of barrier (e.g., narrow, rocky, slippery, steep) for the intruders, unfriendly to the elderly and disability groups and even so to the assisted wheelchair users. As such, easy entry type depicts low degree of personal security (i.e., privacy and protection) for The Homeless and vice versa for the difficult entry type.

(a) (b)

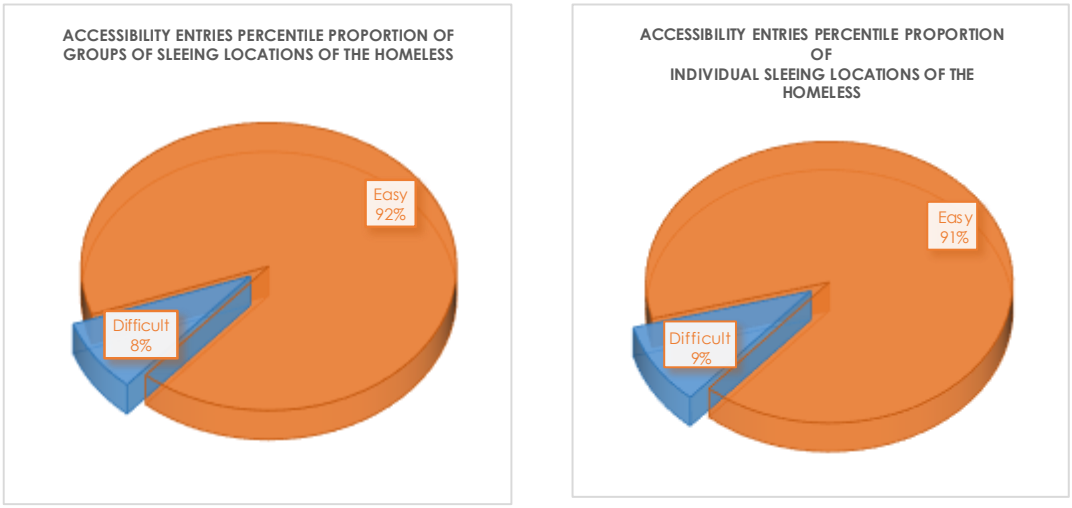


Figure 34: Overall percentage proportions of accessibility entries for (a) group and (b) sum of individual sleeping locations of The Homeless

Figure 34 (a), above, illustrates the overall percentile proportions of the entry types of the accessibility indicators for the groups of sleeping locations. In general; majority, 96% (9,149 in total), of groups of sleeping locations of The Homeless are situated in the urban spaces that provide easy accessibilities, that is, there are minimal or no form of barriers for the intruders to approach, see and/or obtain something from the sleeping locations of The Homeless. Only 4% (533 in total) locations provide minimal

or no form of barrier for the intruders (incl. the elderly and disability individuals) to approach, see and/or obtain something from the sleeping locations of The Homeless. As for the individual sleeping locations, figure 34 (b), shows that majority of the percentile proportion (i.e., 91%) is for locations with easy accessibilities, that is, one with the minimal or no form of barriers for the intruders. The remaining 9% is for the locations with the difficult entries for accessibility.

When comparing the groups of and individuals sleeping locations, majority vs. minority percentile proportions are similar. In that, majority proportion goes with easy entry type and minority proportion with difficult entry type. However, with respect to easy entry, groups of locations entail a larger percentile proportion (i.e., 92%) as oppose to the individual sleeping locations (i.e., 91%). Practically, this implies that there are more groups with slightly fewer individual sleeping locations, since the groups are mere aggregations or zonal mean centers of individual locations.

In detail, table 13 and figure 34 show that the majority of the percentile proportions are for locations with easy entry types throughout the study period. Where the percentiles fluctuates between 87,4% (i.e., minimum value falling on the first Saturday) and 91,7% (i.e., maximum value falling on the last Thursday).

Table 13: Daily percentage proportions of observed individual sleeping locations for accessibility indicator

Entry Type	Sat_1	Sun_1	Mon_1	Tue_1	Wed_1	Thu_1	Fri_1	Sat_2	Sun_2	Mon_2	Tue_2	Wed_2	Thu_2	Fri_2
Difficult	11,1	12,6	9,2	8,6	9,1	8,7	9,1	9,2	8,8	9,5	9,4	9,1	8,3	9,5
Easy	88,9	87,4	90,8	91,4	90,9	91,3	90,9	90,8	91,2	90,5	90,6	90,9	91,7	90,5

In addition, figure 35, illustrates that both trends are positive for the individual locations with easy entries for accessibility and total number of individual sleeping location. Where lowest peak values are during the week one whilst the highest values are on the second week for the two patterns. These similar trends depict direct proportional relationship, i.e., the rise in the total number of the sleeping locations is accompanied by the increase in percentile proportion of the locations with the easy entry type for accessibility indicator.

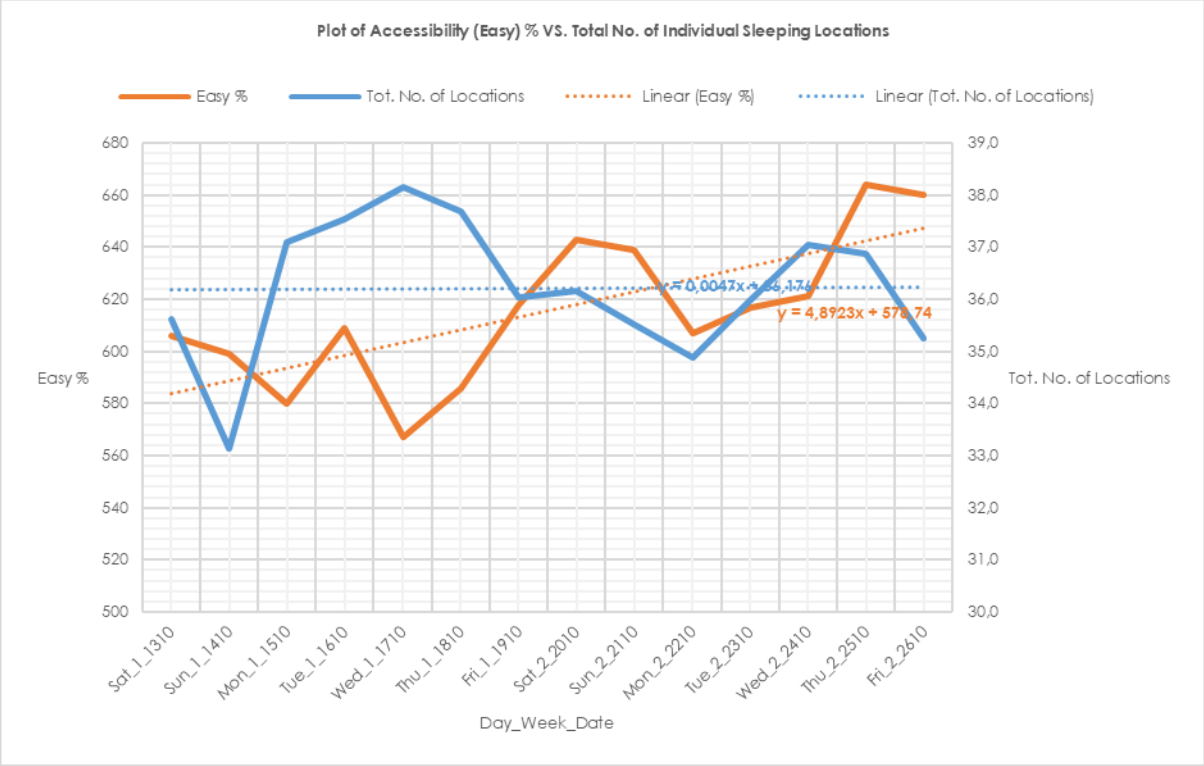


Figure 35: Daily percentages of total individual sleeping locations with easy entry type for accessibility indicator against total number of individual locations

The cross-indicators results are shown in figure 36, below, which relates to the majority of the individual locations (i.e., those with the easy entry types). Out of 91% overall of the individual locations with the easy entry types: 59,7% are situated in the open spaces (i.e., highly marginalized zones) and 40,0% are supported by the trees or without support structure (i.e., low personal security and privacy). In addition, 55,1% are on bare soil (i.e., high level of marginalization and stigmatization); 100% are on the ground platforms (i.e., high exposure to ecological health-implicating concerns); and 72,8% comprise the far lookout views (i.e., relatively high level of social exclusion/isolation). The above supports that majority of the sleeping locations of The Homeless are in the highly vulnerable urban spaces.

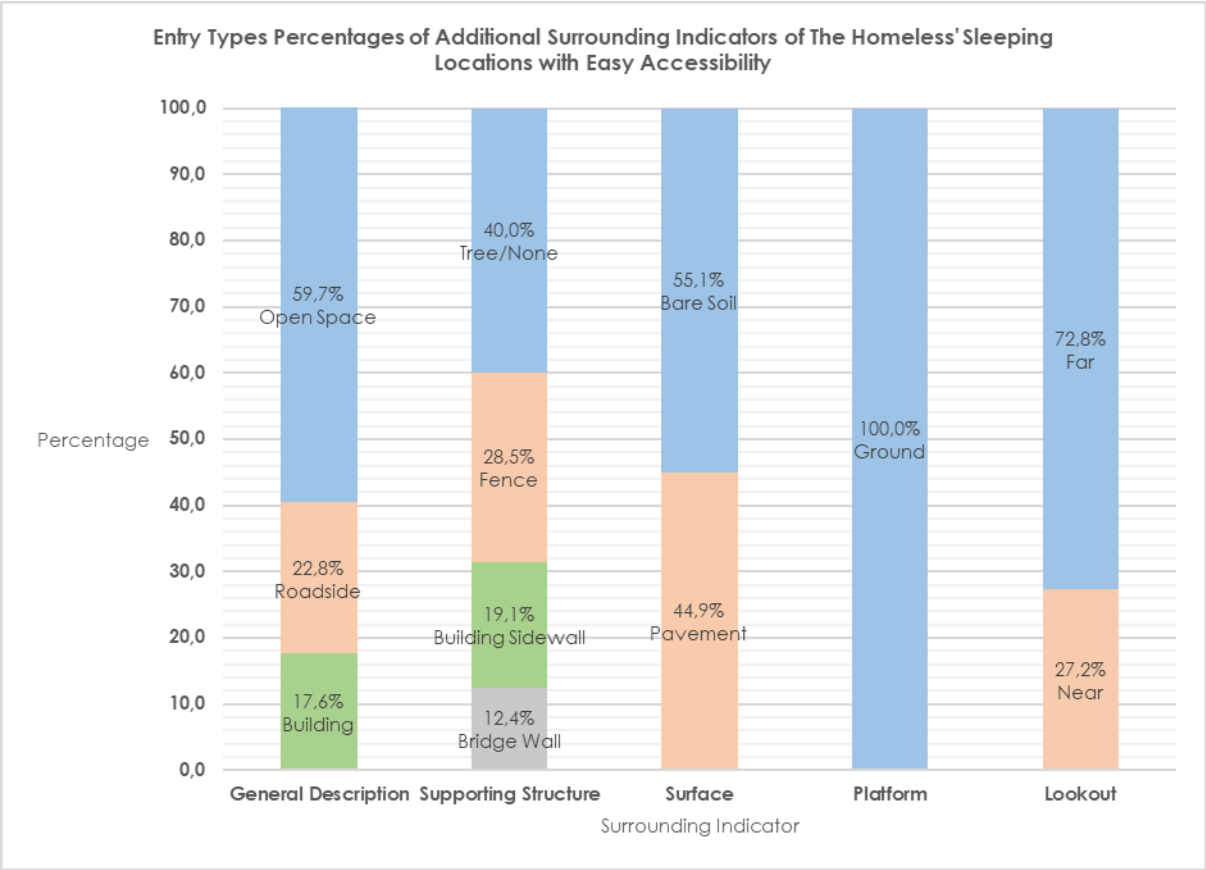


Figure 36: Entry percentages of additional surrounding indicators of individual sleeping locations of The Homeless with easy entry types for accessibility indicator

In summary, majority of the individual sleeping locations are situated in urban spaces that cater low degree of personal security/privacy for The Homeless and this is true throughout and increases over the study period. As there is at least 91% of locations with the easy entry types under the accessibility indicator on a daily basis. Where out of the latter: 59,7% are situated in the open spaces (i.e., highly marginalized zones); 40,0% are supported by the trees or without support structures (i.e., low personal security and privacy) and 55,1% are on bare soils (i.e., high level of marginalization and stigmatization). Furthermore, 100% are on the ground platforms (i.e., high exposure to ecological health-implicating concerns); and 72,8% entail the far lookout views (i.e., relatively high level of social exclusion/isolation). Furthermore, these locations with the easy entry increase over time and are directly proportional to the daily total number of individual locations.

4.2.6 Lookout View

The lookout view, using two entry types (i.e., near and far), indicates the social exclusiveness of the sleeping locations using the maximum/minimum unobscured distance of approximately a building

block, from all sides, between the sleeping locations and public or anyone approaching these locations. The building block distance is chosen because of the spatial planning approach associated with the development in the study area (i.e., the city's), particularly the cadaster. The land is divided into polygons of various sizes that are distinguished by the nature of their (un-)productivity. Where a 'productive' polygon is relatively bigger - one on which; at least, one building block (e.g., house, office, shop) can be built. In contrast, an 'unproductive' polygon is relatively smaller, unsuitable for developing buildings and it is only used for public passages, pedestrian walk etc.

In that light, a building block distance helps to denote the degree of social isolations. Where a far entry type refers to the unobscured distance of a building block or more, and therefore, implies relatively high level of social isolation of the subject location. The near entry type, on the other hand, depicts the unobscured distance less than a building block (i.e., unproductive polygon size), and therefore, it implies relatively less degree of social isolation.

(a) (b)

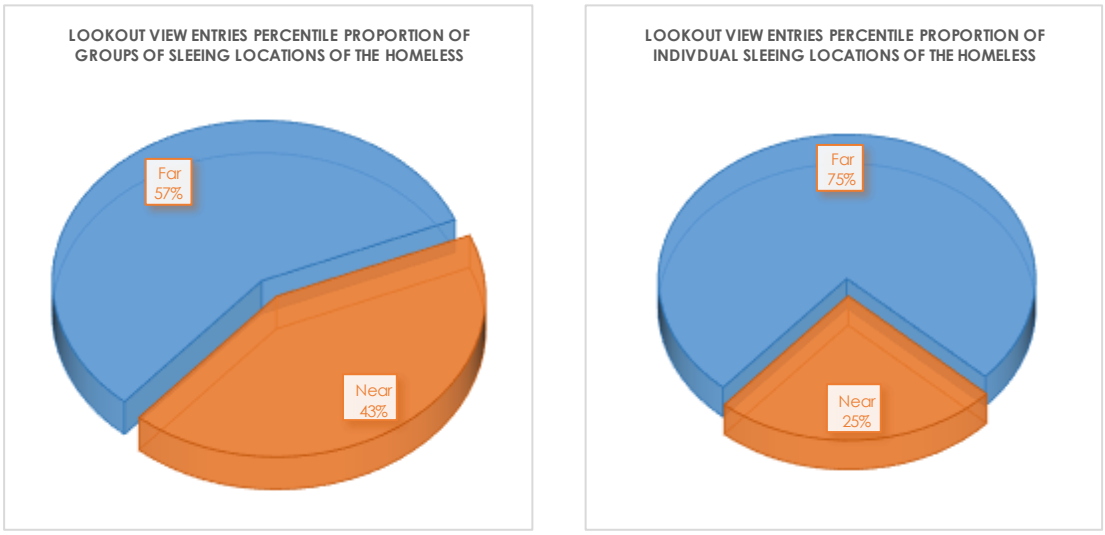


Figure 37: Overall percentage proportions of lookout view entries for (a) group and (b) sum of individual sleeping locations of The Homeless

In figure 37 (a), above, is overall percentile proportions of the entry types of the lookout view indicators for the groups of sleeping locations. Overall majority, 57% of the locations are situated in urban spaces with far entries for lookout view, that is, relatively higher level of social exclusion/isolation. Whilst the rest of the proportion (43%) depicts the opposite and is denoted by the near entry type.

Figure 37 (b) shows the overall percentile proportions of the entry types of lookout view indicators for the individual sleeping locations. Similar to the groups of sleeping locations (the above), overall

majority, 75% of the locations are situated in the urban spaces with the far entries for lookout view, that is, relatively higher level of social exclusion/isolation. Consequently, the remaining 25% is for the near entry type locations.

When comparing the groups of and individual sleeping locations, both types encompass the far entry type with the predominant percentile proportions. However, there is relatively smaller percentile sleeping locations. Fundamentally, this means that there are few groups (i.e., zonal proportion of far entry type for groups of location in contrast with that of individual mean centers) with relatively many individual sleeping locations with the far entry type for the lookout view indicator.

Whilst at it, the far entry types are dominating throughout the study period on a daily basis (daily maximum: 79,2%, and minimum: 70,3%), this is illustrated in the below table 14 and figure 37. Although the existing daily fluctuations are no more than 10% across the study period, figure 38 indicates that the individual locations with the far entries decreases over time (i.e., they produce a negative trend) and the opposite is true for the total number of individual locations – this implies an indirect proportional relationship. Therefore, over time, there increasing total number of the sleeping locations are contributed by the entry type, near, instead of the far entry type.

Table 14: Daily percentage proportions of observed individual sleeping locations for lookout view indicator

Entry Type	Sat_1	Sun_1	Mon_1	Tue_1	Wed_1	Thu_1	Fri_1	Sat_2	Sun_2	Mon_2	Tue_2	Wed_2	Thu_2	Fri_2
Far	24,5	23,5	20,8	22,5	21,6	23,2	25,9	27,4	29,7	25,3	24,2	23,9	24,0	25,7
Near	75,5	76,5	79,2	77,5	78,4	76,8	74,1	72,6	70,3	74,7	75,8	76,1	76,0	74,3

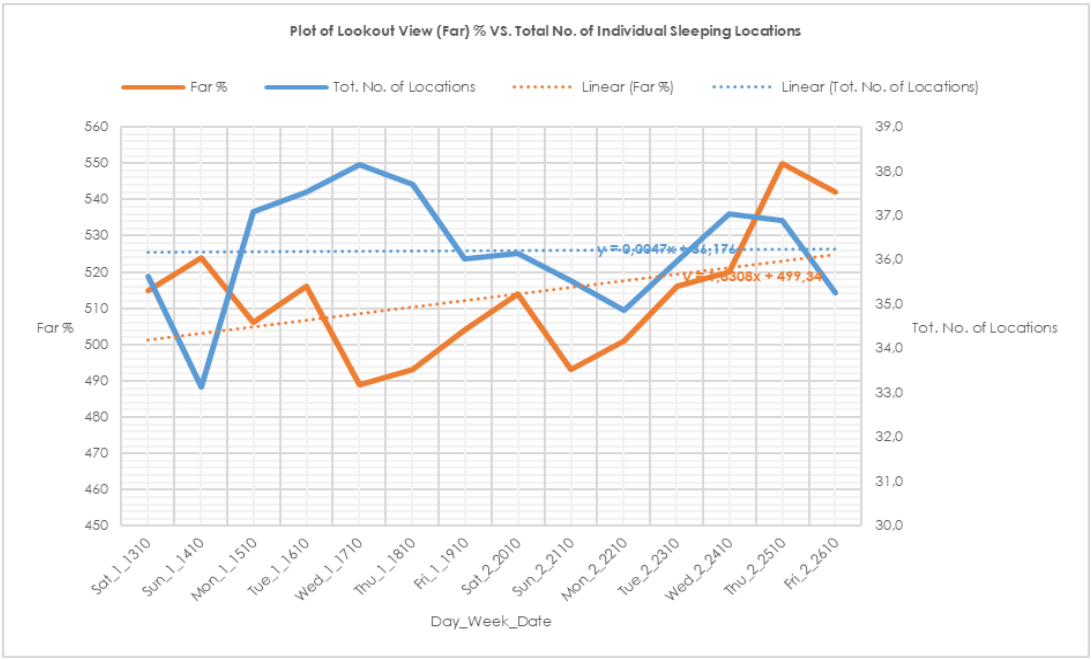


Figure 38: Daily percentages of total individual sleeping locations with far entry type for lookout view indicator against total number of individual locations

In addition, figure 39 (below) display the results of the cross-examination or surround indicators relating to the individual sleeping locations with the far entry times. Where out of 75% of the individual locations with the far entry types: 66,8% are situated in the open spaces (i.e., highly marginalized zones) and 43,8% are supported by the trees or without support structures (i.e., low personal security and privacy). Moreover, 69,1% are on bare soils (i.e., high level of marginalization and stigmatization), 93,5% are on the ground platforms (i.e., high exposure to ecological health-implicating concerns), and 89,5% are easily accessible (i.e., low level of personal security).

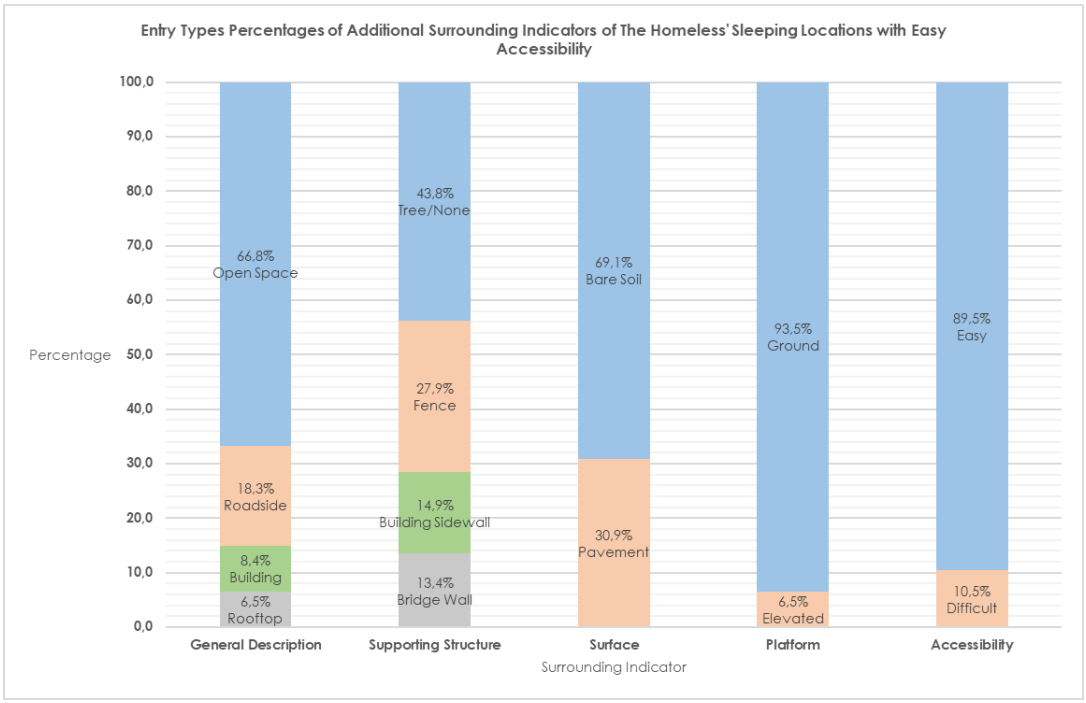


Figure 39: Entry percentages of additional surrounding indicators of individual sleeping locations of The Homeless with far entry types for lookout view indicator

In summary, the predominant sleeping locations of The Homeless in the urban spaces entail relatively high degree of social isolation. As a result of many (daily maximum: 79,2%, and minimum: 70,3%) of the individual sleeping locations with the far entry types for the lookout view indicator, that is, an unobscured distance between the sleeping location and public/anyone approaching is building block or more. Where 66,8% of these locations are situated in the open spaces (i.e., highly marginalized zones) and 43,8% are supported by the trees or without support structures (i.e., low personal security and privacy). In addition, 69,1% are on bare soils (i.e., high level of marginalization and stigmatization), 93,5% are on the ground platforms (i.e., high exposure to ecological health-implicating concerns), and 89,5% are easily accessible (i.e., low level of personal security).

4.3 PROXIMITY ANALYSIS

The proximity analysis is conducted to test whether the sleeping locations of The Homeless are situated away from the source(s) of the basic needs (i.e., the key aspects to enhancers of their livelihoods) or not. The selected example of basic needs is water, where the two sources of water include the waterbodies (which predominantly privatized) and open watercourses. Water as a basic need and its two sources as part of the analyses inputs are chosen the following reasons, amongst others:

- South Africa's Bill of Rights subsection 27.1b states that "everyone has the right to have ace to sufficient food and water"
- Cape Town is experiencing arguably the world's first recorded draught crisis and the drop in water in Western Cape Water Supply System dates back to 2015 (CSAG, 2018; and GroundUp, 2018)
- Various public and private water ponds within the study area are drained or not refilled for quite some time since the announcement of Cape Town's draught phase
- Different people have been observed (who some are possibly The Homeless) acquiring water in buckets and bottles form various water sources such as public toilets, stormwater manholes, open water courses, waterbodies etc.
- The selected water sources are many and well distributed/dispersed all over the study area as compared to the other features (such; clinics, hospital, police station, restaurants, tourist attractions, public toilet/transport terminus/ranks and so forth), which are either clustered or only one exists in the study area. Usage of the well-distributed features, which exist in large numbers, for proximity analysis reduces tracking down/identification of the sleeping locations or hinder a room for the detailed spatial examination of homelessness (i.e., ethical consideration).

Unfortunately, water from the selected water sources (i.e., waterbodies and open water courses) is only suitable for and the observed usages include washing and cleaning. The sources of public drinkable water sources are very limited/scarce in the study area, neither single tap water is observed (except in the public restrooms) nor is acquisition/availability of the public drinkable water sources layer (e.g., from the City's GIS department) within the study area.

Figure 40 below, illustrates waterbodies and open water courses situated in the study area, as captured by the City of Cape Town's GIS department. Waterbodies include ponds, reservoirs, sea and so forth whilst the open waterbodies are ponds-like in the open runoff drainage systems. Waterbodies are few relative to the open waterbodies and they are situated in the outskirts of CBD along the north, southeast and south-west boundary of the study area. Open water courses are predominant in the inner region of the study area and few near the northeast, east and southwest of the study area

boundary. There is total of 9 waterbodies and 24 open water courses within the study area. The smallest and largest waterbody has an areas of 362,2 and 7620,4 square meters, respectively. The smallest open watercourse is approximately 1,7 meters whilst the largest is 429,8 meters.

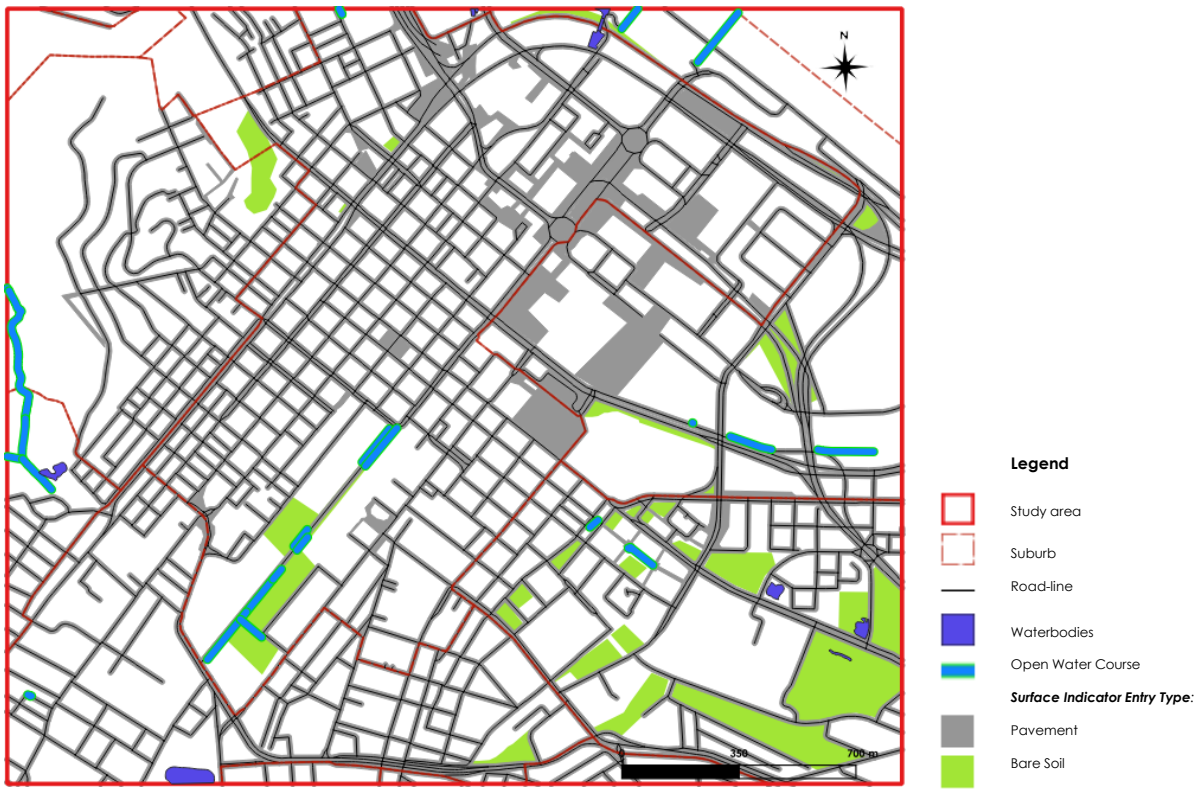


Figure 40: Map of waterbodies and open watercourses recorded within the study area. Source: City of Cape Town GIS Department

In addition; majority of the open waterbodies are closer/nearer to the bare soil surfaces, which is one of the two surface types for the public urban space that can be utilized by The Homeless to sleep/rest – refers to subsection 4.2.3 above for more discussion on surface types and sleeping locations. Bare soil entail small proportion relative to the counterpart, pavement, and it denotes regions of high level of vulnerability (i.e., marginalization and stigmatization) in urban space, which coincides with high daily percentages of the individual sleeping locations, and this forms part of the explanation of the findings below.

Table 15: Summary of proximity analysis results for both open watercourses and waterbodies

Water Resource	Buffer/Radius Distance	No. of Groups	Group No.	Tot. No. of Individual Sleeping Locations
Waterbodies	100m	1	9	380
	50m	0	0	0
Open Water Course	100m	10	7,19,20,42,53,55,56,57,58,59	7,830
	50m	7	20, 55,56,57,58,59	4,903

Table 15 (above) shows a list of outputs of the proximity analyzes of both the water resources (i.e., waterbodies and open watercourses). Where the proximity analysis of each of the water resources is limited to two radius distances of 100m and 50m, as 100m is intuitively maximum-reasonable walking distance and 50m is a rational measure to explore the changes. Especial because majority of the observed homeless individuals and groups seem to clean and wash themselves (including their materials) directly from these water sources, instead of carrying the water and use it elsewhere – which may be due to the preferences, scarcity of water carriers or both. The returned sleeping locations, per analysis, are only those situated completely within the boundary of the buffer zone or radius distance. Despite the buffers/radius distances, the list includes the returned number of the groups, group number and the total number of the individual sleeping location of The Homeless, in each buffer case. The findings show the following.

For waterbodies, throughout the study period, not a single sleeping location is returned for 50m buffer/radius distance. When 100m buffer is generated, one group (namely, 9) is returned on each day of the study, leading to 380 individual sleeping location, in total. Where a daily minimum and maximum of the locations is 25 and 28, respectively.

As for open water courses, 50m buffer entails 7 groups (namely, 20, 55, 56, 57, 58 and 59) and the associated 4903 total number of individual sleeping locations. Where a daily minimum and maximum of the locations is 14 and 35, respectively. On the other hand, 100m buffer comprises 10 groups (namely, 7, 19, 20, 42, 53, 55, 56, 57, 58 and 59). Where a daily minimum and maximum of the locations is 65 and 91, respectively.

In addition, figure 41 (below) shows a plot of the daily total locations percentages for various proximity distances of both the waterbodies and open watercourses as well as the total number of individual locations of The Homeless over the study period. Where all the total locations percentages show fluctuation patterns throughout the period of the study, and their trends are positive but vary in magnitudes. The trend for 100m waterbodies is almost zero (i.e., 0,002), which implies insignicant variations or rather no overall change. Since there is a positive trend for the daily total number of the sleeping locations. Therefore, there is a direct relationship between the general daily total number of the sleeping locations and daily total locations within 100m buffer zone of the waterbodies. That is, the overall number of sleeping locations increase, almost constant, over time with the increase in the total number of the locations closer to the waterbodies.

On the other hand, plots of both applied radius distances of open water courses have similar fluctuations patterns throughout the study period and the trends ratio 0,1615. As a result, a direct relationship between daily total number of the sleeping locations and the daily total number of the

sleeping locations within the buffer zones of the open water courses. This implies that there are more locations that are distributed closer or nearer to open water courses over time and this is not surprising as many, if not all, of the open water bodies are accessible to the public, i.e., they are not within privately owned boundaries.

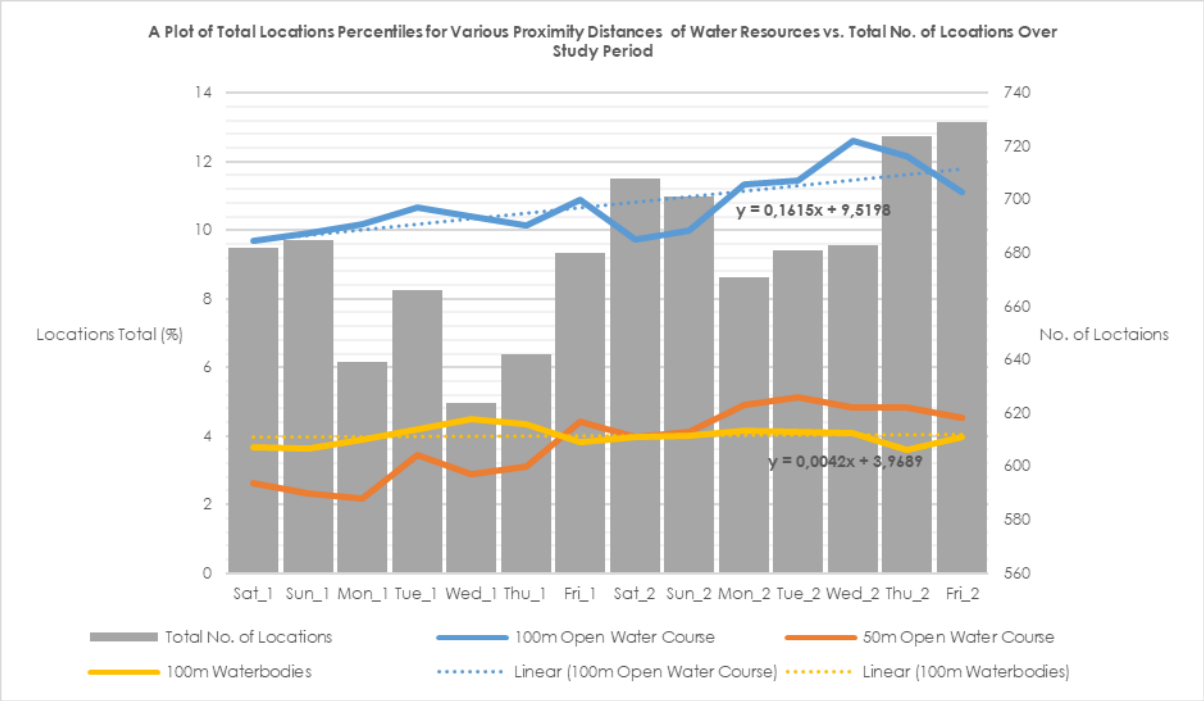


Figure 41: Daily total locations percentages for various proximity distances of both water resources and open water courses against total number of individual sleeping locations

In summary, majority of the sleeping locations of the homeless individuals and groups are further way from the sources of human basic needs, particularly water (for washing and cleaning). On each day throughout the study period, there is 0% and less than 14% of locations within 100m radius of the waterbodies and open watercourses, respectively. Moreover, there is less 6% of the locations within 50m distance for both types of water sources. This also implies that when the sources of human basic need (in this case, open water courses) are accessible to the public or rather not within privately own boundaries, relatively more sleeping locations of The Homeless are found nearer. Another reason for ore sleeping locations near the open watercourses relative to waterbodies, is that the open water courses are closer to the surfaces types of high level of marginalization and stigmatization (i.e., bare soil). Of which bare soil surfaces are relatively small proportions of 'available' urban spaces, where (majority of) The Homeless capitalize on, unlike on the counterpart, pavement surfaces – which is one of the distinguisher of the urban spaces with others and it matches/favors urban lifestyle (e.g., trolley pushing, skating, minimal contact with dust).

4.4 WEATHER ANALYSIS

The weather analysis entails examining any existing patterns/relationships between the daily total numbers of the sleeping locations and weather conditions (i.e., temperature, rainfall, cloud cover and wind speed). This is based on the findings of Ismail and Turiman (2016) that The Homeless turn to choose their locations for sleeping based on the physical characteristics that match or serve protection against weather conditions. The link to the proposition is that there is some sort of relationship between the weather conditions and total number of sleeping locations in the public spaces, given that some of the spaces offer no protection against the weather conditions.

4.4.1 Temperature

The temperature can influence the nature of The Homeless' sleeping setups. For instance, low temperature can trigger The Homeless to gather more materials and situate their sleeping setups in and around surrounding environments that boost or generate warmth, and this is one of the reason this weather element is considered in this study. Figure 42 (below) illustrates a plot of both maximum and average temperature verse the daily total numbers of the sleeping locations of The Homeless for the 14 days study period. Both temperatures and daily total number of sleeping locations fluctuates throughout. Moreover, all the plots have positive trends (i.e., increasing values over time with ratio of 0.84 and 0.749 for maximum and average temperature respectively). In the first week, all values (i.e. average and maximum temperature and numbers of sleeping locations) are lower compared to the values on the second and last week of the study. The average and maximum temperature plots exhibit similar patterns right through.

The most interesting finding is brought forth by the daily fluctuations/relations of the maximum/average temperatures and/with total numbers of the locations. Thus, the increased daily total number of the sleeping locations occurs the day after the high maximum/average temperature value, and the reduced total number of the sleeping locations follows the day after the low/decreased maximum/average temperature value. This pattern/relationship is true for any random consecutive two days of the study period. The implication is that high temperature today triggers increase in the total number of sleeping locations of The Homeless tomorrow or vice versa.

This relationship between the temperature and total number of the sleeping locations of The Homeless can be linked to the scientific fact that hot days lead to warm nights (Hinds, 2018; and Wu et al., 2014). As such, seeking of shelter or rather sharing of the sleeping location(s)/material(s) for warmth purposes becomes less of a priority for The Homeless. Especially because the pavement surfaces are cooler as compared to unpaved or bare soil surfaces (Wu et al., 2014). In that light, majority of the groups of the

sleeping locations, which illustrate this relationship, entail the pavement entry types (i.e., situated on warmer surfaces), instead the bare soils (i.e., cooler surfaces) for the surrounding indicator called the surface (refers to the subsection 4.2.3 above regarding discussion around this indicators and its entry types).

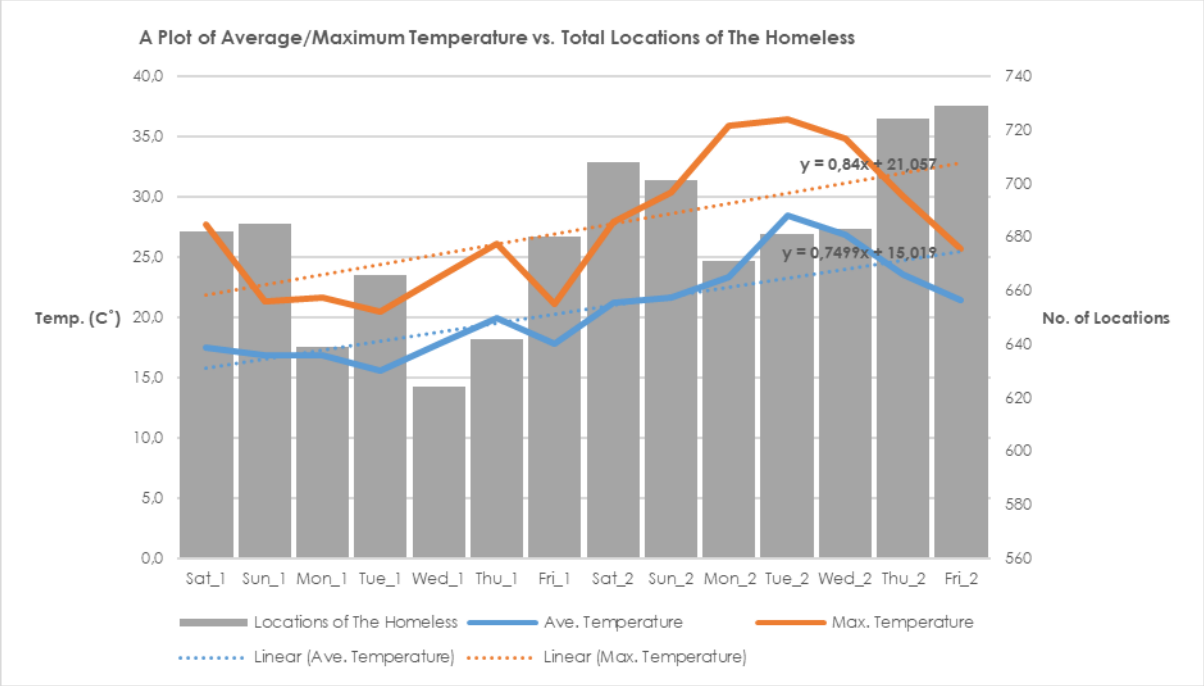


Figure 42: A plot of average/maximum temperature against total numbers of sleeping locations on each of the 14days

For example (refers to figure 42 and appendix 1), on the first Monday and Tuesday. Out of the 21 groups (i.e., 4, 9, 11, 16, 17, 18, 23, 26, 30, 31, 32, 34, 36, 37, 40, 41, 46, 56, 57, 58 and 61), which are linked to the higher total number of the locations on Tuesday, 62% of these groups are situated on the pavement surfaces. Another example is the first Thursday and Friday, where out of 10 groups (i.e., 4, 29, 32, 37, 40, 49, 51, 56, 57, and 58) linked to the higher total number of the sleeping locations on Friday, 62% of these groups are on the pavement surfaces. In essence, on the hot days/warmer nights, The Homeless seek cooler sleeping setups; hence, the shared sleeping locations are reduced/subdivided. Consequently, the number of sleeping locations are higher on that night, however, these locations are observed the following morning. In addition, the temperature is directly related to the total number of sleeping locations and this is also indicated by positive trends of both temperature and total number of the individual sleeping locations of The Homeless, refers to figure 42 above.

In conclusion, the evidences show that when the daily temperature is high today, there is an increase in the daily total number of the sleeping locations of The Homeless the preceding morning during observations, and the opposite is true. That is, there is a direct proportionality relationship between the

temperature and total number of the sleeping locations for The Homeless. When the temperature is relatively higher, majority of The Homeless seek for the sleeping setups that are relatively cooler, i.e., non-sharing or sleeping in isolation/individually, especially those who are situated on pavement (i.e., warmer) surfaces.

4.4.2 Rainfall

The rainfall is capable to make The Homeless and/or their sleeping setups wet, and possibly destroy or alter the usability of some of the sleeping materials of The Homeless (e.g., boxes, cloths, blankets), and this is one of the reason this weather element is important. In figure 43, below, is a plot of both the maximum and average rainfall against the total numbers of the sleeping locations of The Homeless on each of the 14 days of the study period. Unlike the trend of daily total number of sleeping locations, both the maximum and average rainfall trends are negative, i.e., -0.0077 and -0.0037, respectively. Overall, the latter implies indirect proportionality between the rainfall and total number of the individual sleeping locations; however, this relationship still requires further exploration. As there are only two clear peaks (i.e., on the first Monday and second Tuesday), where both average and maximum rainfall are above 0.10mm. In addition, the peaks lie between the high regions ("ridges") of total numbers of sleeping locations.

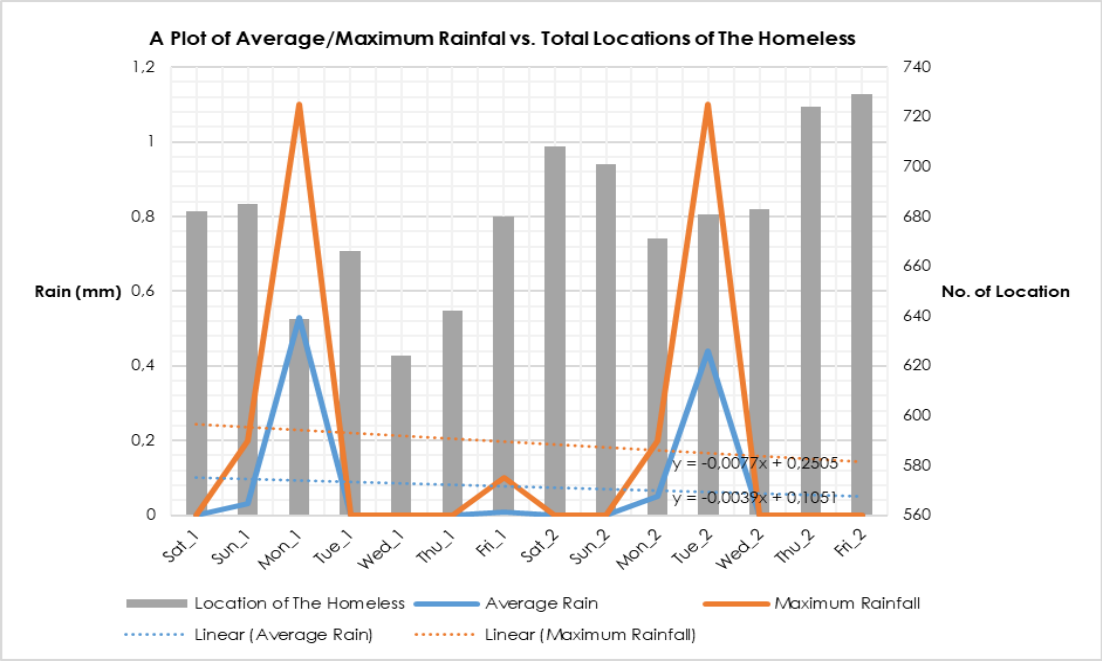


Figure 43: Average/maximum rainfall against total numbers of sleeping locations on each of the 14 days of study period

Nonetheless, these two days of rainfall illustrate interesting findings. Firstly, after a rainy day, there is an increase in the daily total number of the individual sleeping locations of The Homeless. This may be due

to wet on or destroyed sleeping materials that cater for sharing setups, thus, reduced sharing and induced individual sleeping locations. Secondly, an increase in total numbers of locations is observed on an unexpected day of rainfall (i.e., 4,05% increase) as opposed to an expected day of rainfall (i.e. 0.14% increase). Where an unexpected day of rainfall (i.e., first Monday) depicts a day when it rains after sunset, that is, suddenly after or when some of The Homeless are resting/sleeping. Whilst an expected day of rainfall (i.e., second Tuesday) is the opposite, it depicts the day when rain starts before sunset and before (majority of) The Homeless (prepare to) sleep, refers to figure 43 and appendix 3.

Thirdly, the day following an expected day of the rainfall witnesses a decrease in the percentages of the locations on the elevated platforms and pavement surfaces, refers to figure 44 and 45 below. These decreases or rather shifts can be explained as The Homeless seeking the sleeping locations in the surroundings that are relatively warmer, especially because some, if not all, of the sleeping materials to keep them warm may be wet on or destroyed by the rain on the previous night. Forth and lastly, the day following an unexpected day of rainfall, similar to the day after expected rainfall, there is a decrease in locations situated on elevated platforms. In addition, there is an increase of the locations on or shift towards pavement surfaces, unlike the day after expected rainfall; this can be explained as The Homeless prioritizing on the less humid and/or muddy surfaces due to the sudden rainfall on the previous night, which possibly left them in despair.

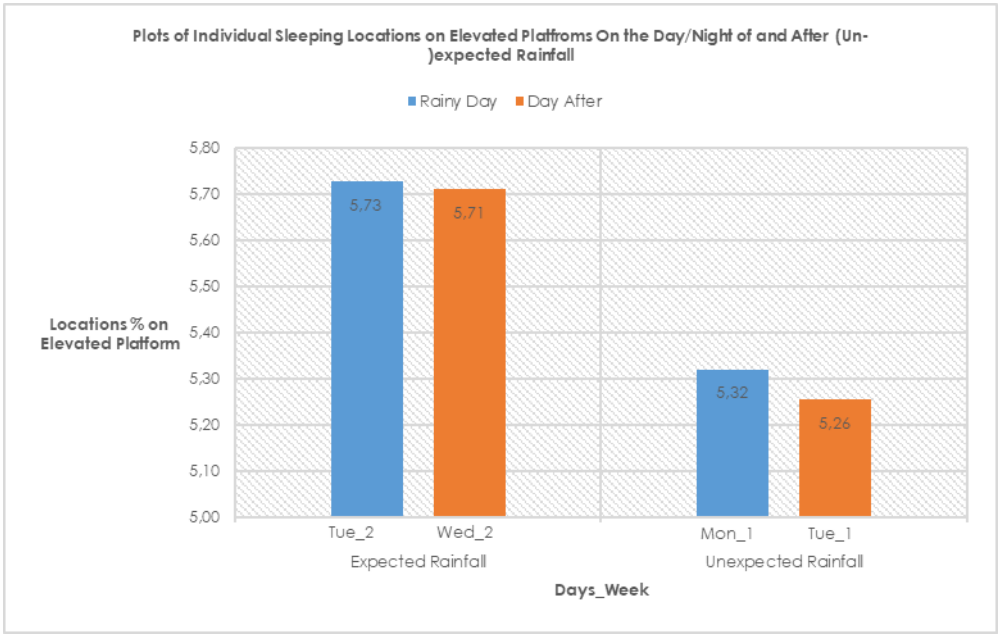


Figure 44: Percentages of total numbers of sleeping locations on elevated platforms for the two days of and after rainfall

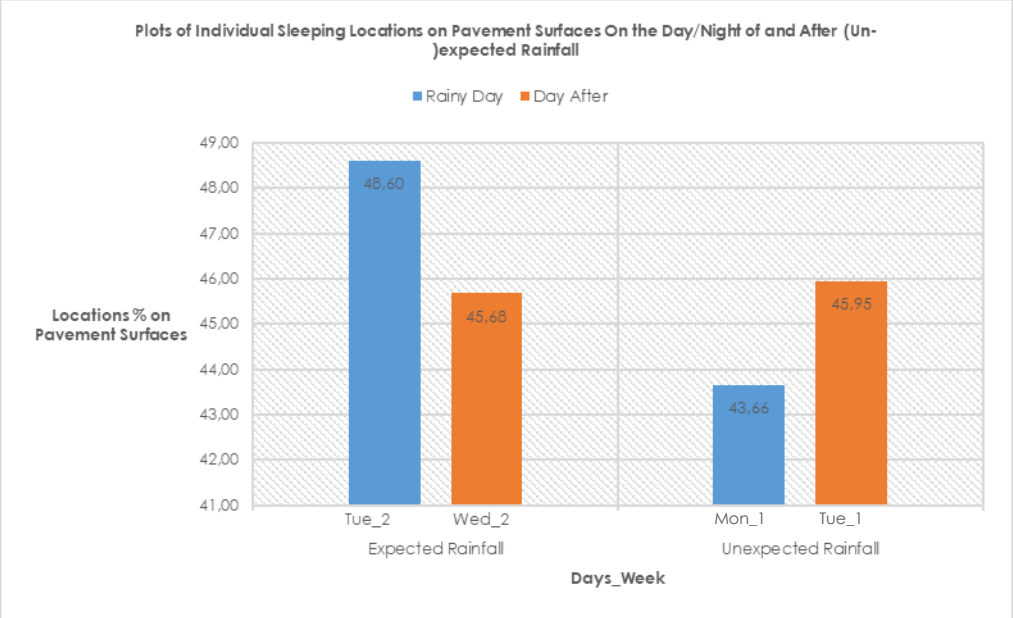


Figure 45: Percentages of total numbers of sleeping locations on pavement surfaces for the two days of and after rainfall

In closing, there is generally no (significant) rainfall records for the study period. However, the observed/recorded little rainfall indicates that there is an indirect proportionality relationship between the rainfall and daily total numbers of the individual sleeping locations. Where the two days that show significant amount of rainfall show interesting findings, which include. The daily total number of the individual sleeping locations increases the day after the rainfall. If the rain starts before sunset and throughout the night, the following night, The Homeless shift away from the elevated platforms and pavement. On the other hand, if it starts raining after sunset or at night, on the following night, The Homeless still avoid the elevated platforms. However, they shift towards pavement surfaces and thus, there is a decrease of the sleeping locations on the unpaved or bare soil surfaces.

4.4.3 Cloud Cover

Figure 46 (below) shows a plot of both the maximum and average cloud cover verse the total numbers of sleeping locations of The Homeless on each of the 14 days of the study period. Cloud cover helps to somewhat prepare or alert The Homeless of the possibility of rainfall and/or drop in temperature, especially when the cloud covers are heavy or dense (i.e., over 40%). On record, there are 3 days (i.e., first Monday and Friday, and second Tuesday) with average cloud cover of over 40%. Where the values decrease with time. Hence the steep negative trends of both average and maximum cloud cover (where the trend is -0.0216 for maximum and -0.0163 for average records). Since the daily total numbers of the sleeping locations have a positive trend, therefore, overall, the cloud cover is indirectly proportional the total numbers of the individual sleeping locations. This is expected, given that the

trend of rainfall is found to be negative (refers to previous subsection 4.4.3) and meteorologically, the cloud cover is strongly linked to rainfall, amongst other weather elements.

The latter is also supported by figure 46 below, that is, there are similar relationships between the sleeping locations and two rainy days (i.e., first Monday and second Tuesday). Where the sleeping locations increase after a rainy day. In this instance, the daily total numbers of the individual sleeping locations increase after the dense cloud cover, particularly, when the cloud cover is over 40%, this includes the corresponding two days, i.e., first Monday and Tuesday. The most interesting findings pertaining to cloud cover, is that there is another day (i.e., first Friday, refers to figure 46), where cloud cover exceeds 40% but there is no record of (significant) rainfall (refers to figure 43).

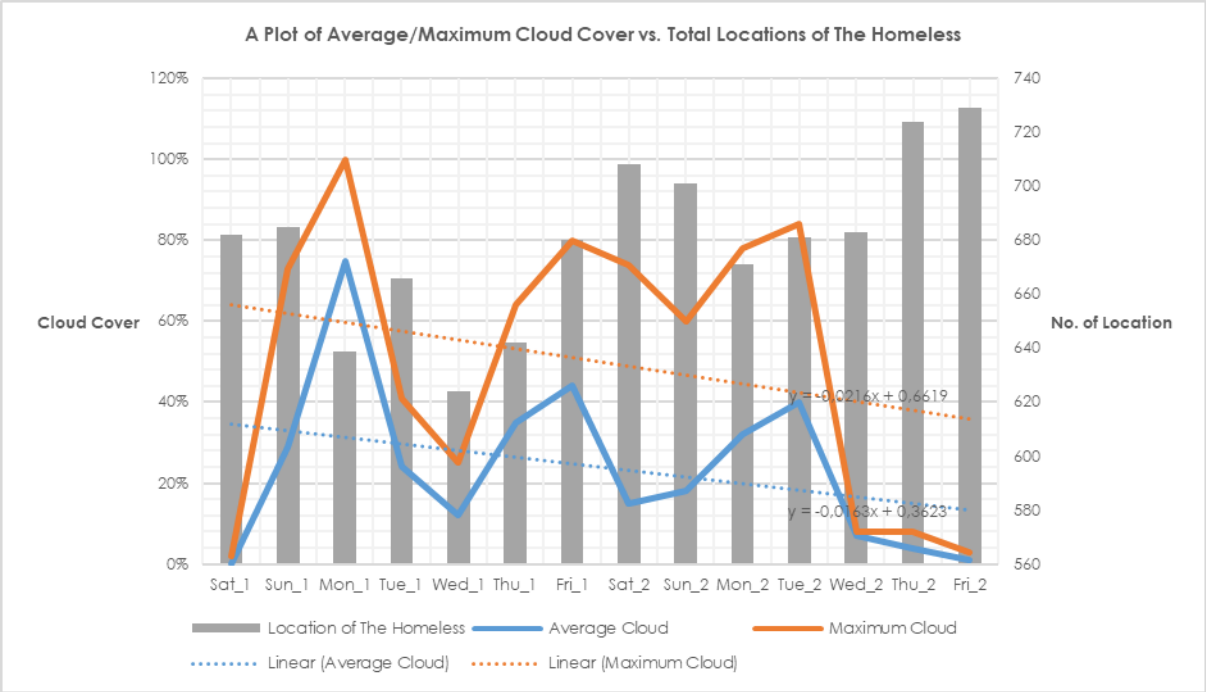


Figure 46: Average/maximum cloud cover against total numbers of sleeping locations for each of the 14 days of study period

Nonetheless, a similar relationship, of increased total number of individual sleeping locations the following day, is present. This may possibly due to the rise in the temperature on the following day, i.e., second Saturday, where average and maximum temperatures shift from below 17^{0}C to above 22^{0}C and from slightly above 20^{0}C to almost 30^{0}C, respectively (refers to figure 42 above). Similar temperature shifts (i.e., rise) are also present on other corresponding days with dense cloud cover and significant rainfall.

In that light, the increased total numbers of individual sleeping the locations can be the results of The Homeless opting for less sharing sleeping setups. Simply because they can gathered, share and use

relatively warmer materials for the sleeping setups the day/night before, in preparations for dense cloud cover (i.e., above 40%) and/or relatively lower temperature conditions, of which, the opposite is true on the present day. That is, the materials or rather the sharing sleeping setups do not match up with the priority conditions for the present day. Therefore, the new sleeping setups of less sharing to adjust to the temperature, amongst other things, inevitably, the increased total numbers of the individual sleeping locations. The above is another reason for other days with dense cloud cover or rather when significant rainfall is present, that is, it also supports findings and propositions in the previous subsection 4.4.2.

In summary, the cloud cover strongly relates to rainfall and thus, similarly to how rainfall relates to The Homeless. That is, The Homeless prepare their sleeping setups the same way on a cloudy or rainy day and this is clear on the following day after dense (i.e., over 40%) cloud cover or (significant) rainfall. Where The Homeless opt for less sharing sleeping setups, which leads to induced total numbers of the sleeping locations and this is true throughout the study duration, including on the day when there is no rainfall but dense cloud cover. In essence, dense (i.e., 40% and above) cloud cover today leads to increased daily total numbers of the sleeping locations on the following day. Moreover, there is an indirect proportional relationship between cloud cover and the daily total numbers of the individual sleeping locations.

4.4.4 Wind Speed

The wind speed or magnitude can influence nature of the sleeping setups and perhaps material thereof. High wind speed, for example, can trigger The Homeless to setup their sleeping location nearer to high, big and/or rigid structure (e.g., building sidewall, bridge wall) to avoid the setup from being blown away. Furthermore, The Homeless can be triggered to situate themselves in warm surrounding urban spaces, as strong wind can be felt and linked to low temperature. As such, the above are one of the reasons for considering wind speed. Unfortunately, this study does not consider another important aspect of the wind, i.e., wind direction, which can also influence or rather helps to enhance the knowledge and understanding of how The Homeless adjust and adapt to various conditions in urban spaces. For instance, The Homeless might opt to setup their sleeping locations in a particular nature to avoid/minimize the direct wind blow or high wind exposure. Wind direction is not consider primarily because the weather station used is far from the study area. Therefore, the wind direction can be misleading, especially because of the neighboring high mountain ranges and urban infrastructures, which can redirect the wind within the pocket of the study area.

In figure 47 (below) is a display of both the maximum and average wind speed against the total numbers of the sleeping locations of The Homeless on each of day of the two weeks study period. Both

the maximum and average wind speed fluctuate throughout the study period, however, their trends are almost constant. It is interesting that low regions of maximum/average wind speed coincide with relatively low total numbers of the sleeping locations and the opposite is true throughout the study duration. Moreover, on the day that follows the day with higher record of wind speed, there is a drop in total number of individual sleeping locations. In essence, on the day of high wind speed, there is decrease in the total number of the sleeping locations. Since the average wind-speed record is for the whole day (i.e. from 12:00am to 11:59pm), and therefore the wind speed of the today matches with the sleeping locations of the following day, as the observations are done in the morning between 06:00 and 08:30.

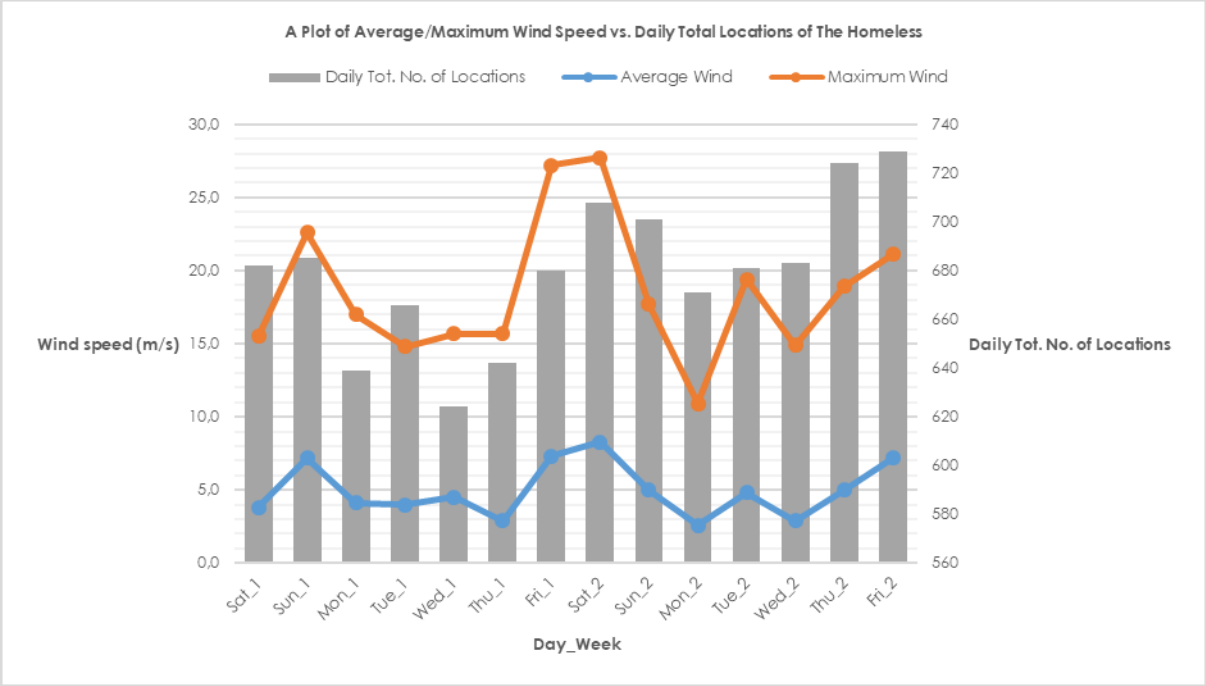


Figure 47: Average/maximum wind speed verse total numbers of sleeping locations on each of the 14 days study period

That said; more interest is on the two days with higher wind-speed records (i.e., the first Sunday and second Saturday), which are followed by drop in the total numbers of the individual sleeping locations. On each of these days, the average wind speed is approximately 7meters per second (i.e., the high or strong wind). The drop in the total numbers of the individual sleeping locations may be due to a shift towards sharing sleeping setups, where The Homeless combine their sleeping materials and setup semi-permanent structures, instead temporary, one-blanket/cardboard/plastic sleeping setups.

Furthermore, figure 48 (below) shows the sleeping locations percentages for various entry types of the general descriptions (i.e., the attribute that defines the general surroundings of the sleeping locations, refers to the subsection 4.2.1 for more discussion), which correspond to the days/nights of and after the

high/strong wind speeds. The figure indicates that there is a significant decrease in percentiles of the locations in open spaces (which also translates to urban spaces of high wind exposure) and an increase near the buildings (which can translate to the urban spaces of less direct/high wind exposure). The above is in line with the subsection 4.2.1 above, which discusses that although there are high percentages of the locations in the open spaces, however, there is a decrease over time (i.e., negative trend of the locations in the open spaces) whilst the daily total numbers of the individual sleeping locations increase (i.e., positive trend). Given that the trend of wind speed is constant throughout the study period, this suggests that wind speed is possibly the one of the reasons for the shift in the sleeping locations away from the open spaces, as these are relatively spaces of direct/high wind speed exposure.

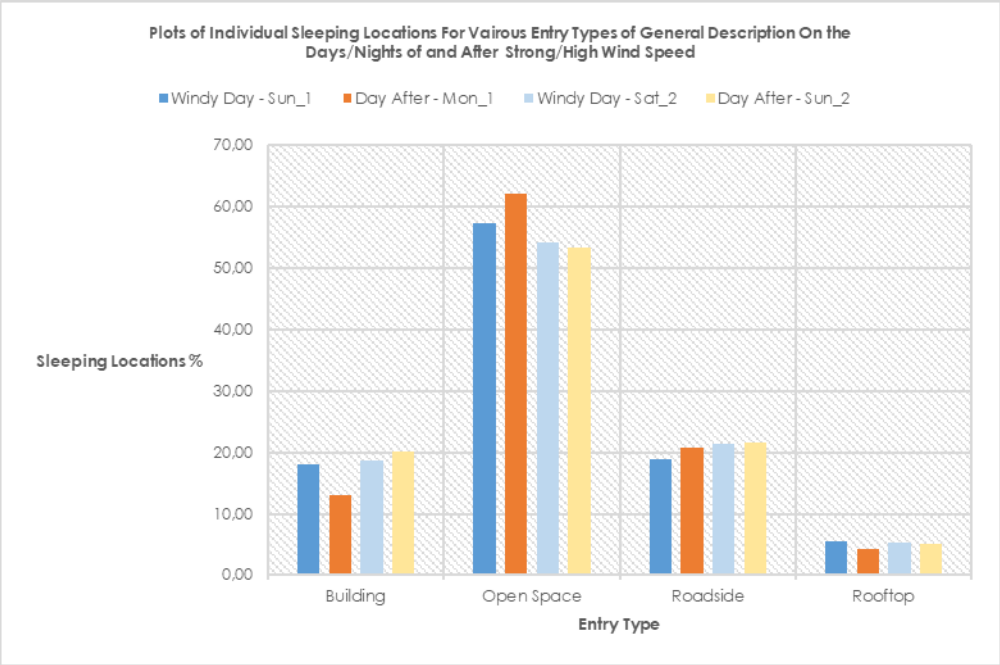


Figure 48: Individual sleeping locations percentages for all entry types of general description on nights/days of and after strong/high wind speed

The below can also be linked to figure 49, which displays the sleeping locations percentages for various entry types of the supporting structure (refers to the subsection 4.2.2 for more discussion on this attribute or surrounding indicator). Where over time, there is a decrease in the locations percentiles with the tree/none entry types, which corresponds to the open spaces, and a relative increase in the locations supported by the building sidewall. That is, as explained in details in the subsection 4.2.2 above, the sleeping locations shift towards bigger and more rigid supporting structure, particularly the building sidewalls, over time. On the first day of high/strong wind speed (i.e., first Sunday), although there is an increase and a high percentile proportion of locations with the tree/none entry types, there are also increases in percentages of the locations supported by the bridge walls and fences. The combined percentile increment of the locations with attribute entries, bridge wall and fence (which represent the

large in size and more rigid support structures), is larger than that of the tree/none (which represents none or small size and less rigid support structures). In essence, as expected, the predominant individual locations shifts towards the support structures that are bigger in size and more rigid (i.e., bridge walls and fence) when there is strong wind.

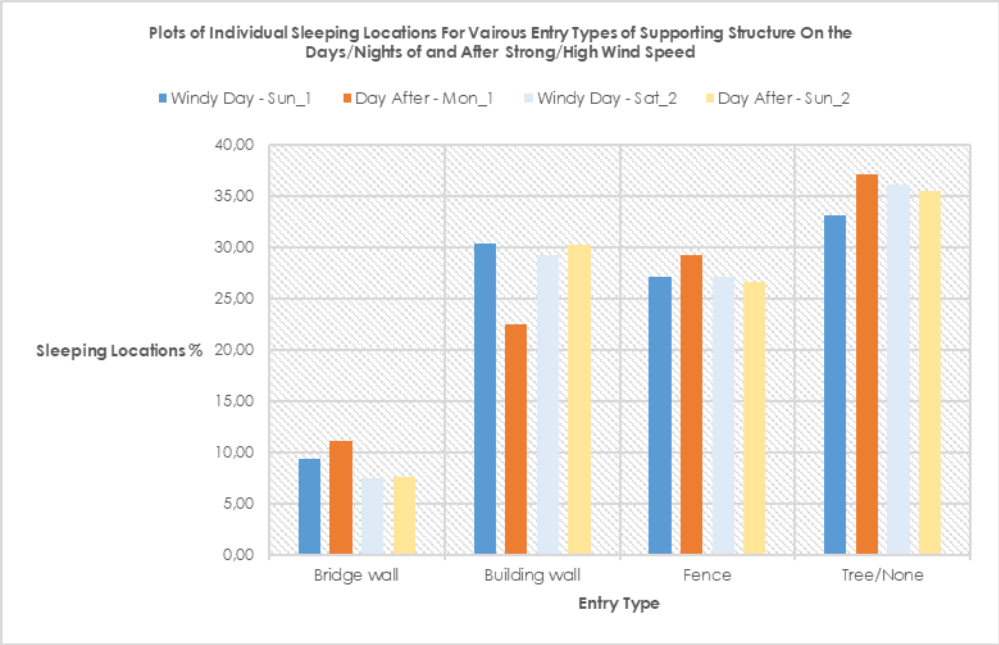


Figure 49: Individual sleeping locations percentages for all entry types of support structure on nights/days of and after strong/high wind speed

As for the second day with high/strong wind speed (i.e., second Saturday), there opposite to the first windy day is true. In a sense that the locations percentiles decrease are evidence for the tree/none, fence and bridge wall entry types of support structure, and increase is only for the locations supported by the building sidewalls. However, the key message remains, that is, the individual sleeping locations of The Homeless increase towards the support structures that are big in size and more rigid (in this case, these are building sidewalls), when the wind speed is high/strong.

In conclusion, high/strong wind speed leads to increased percentiles of the individual sleeping locations supported by big in size and more rigid structures (which include; fence, bridge wall, and building sidewall). Instead of the locations percentiles with or without the support structures that are relatively small in size and less rigid (e.g., trees). Especially when there is a reduced number of the locations situated in the open spaces. Moreover, in general, high/strong wind speed leads to a decrease in the total individual sleeping locations, as a result of The Homeless opting for sharing sleeping setups or rather combining/merging their sleeping materials to setup strong sleeping structures to sustain the wind, which turns to be against big in size and more rigid supporting structures.

4.5 OBFUSCATION/GEOGRAPHIC MASKING

Over the years, the scholars established and utilized various obfuscation/geographic masking methods – refers to chapter 2, subsection 2.2.3 for some of the examples listed by Haley et al. (2016). These methods utilize various algorithms and produce various results, but the goals are the same. That is, to alter the actual spatial data, in order to protect the locations) whilst preserving the spatial integrity or distribution pattern.

Guided by the approach of Seidl et al. (2015), the four different masking methods are tested to see which one(s) best protect the spatial confidentiality (i.e. the location identification) of where The Homeless sleep while preserves the spatial integrity. These include - Radom Perturbation (RP), Weight Radom Perturbation (WRP), Grid Masking (GM) and Voronoi Masking (VM). Where the testing analytical methods are the Map Difference, Statistical Difference and Spatial Pattern. Three analytical methods are utilized to make the test, namely; map difference, statistical difference and spatial pattern.

4.5.1 Map Differences

The map differences entail examining the map (i.e. overall spatial distributions) of all the masked sleeping locations against the used sample of the original sleeping locations. Where the masking method that produced overall spatial distribution pattern of sleeping locations similar the sample original sleeping locations, is considered best/good in preserving the pattern of spatial distribution, whilst protecting identification of sleeping locations of The Homeless.

Figure 50, below, illustrates the samples of the original sleeping locations and the results of the four applied obfuscation methodologies. Focusing on the regions towards all the boundaries of the study area, OSL comprises few locations on the north, east, south and west region. Likewise, the VM and WRP comprise fewer locations towards the same four sides of the boundary of the study area. However, both the RP and GM on the other side have completely different spatial distributions along the four boundary sides of the study area. RP have almost nothing towards the south side and relatively many locations towards the northwest and northeast boundary sides. The GM entail relative more locations towards the northeast, northwest and southwest region of the study area. In addition, there are relatively fewer locations in the inner part of study region compared to the OSL.

In summary, GM and RP generally show great redistributions of the spatial patterns of sleeping locations of The Homeless, especial along the boundary of the study area as well as the inner region (for GM). Meanwhile VM (voronoi masking) and WRP (weight random perturbation) show best performance in maintaining the extent and shape of the original sleeping locations.

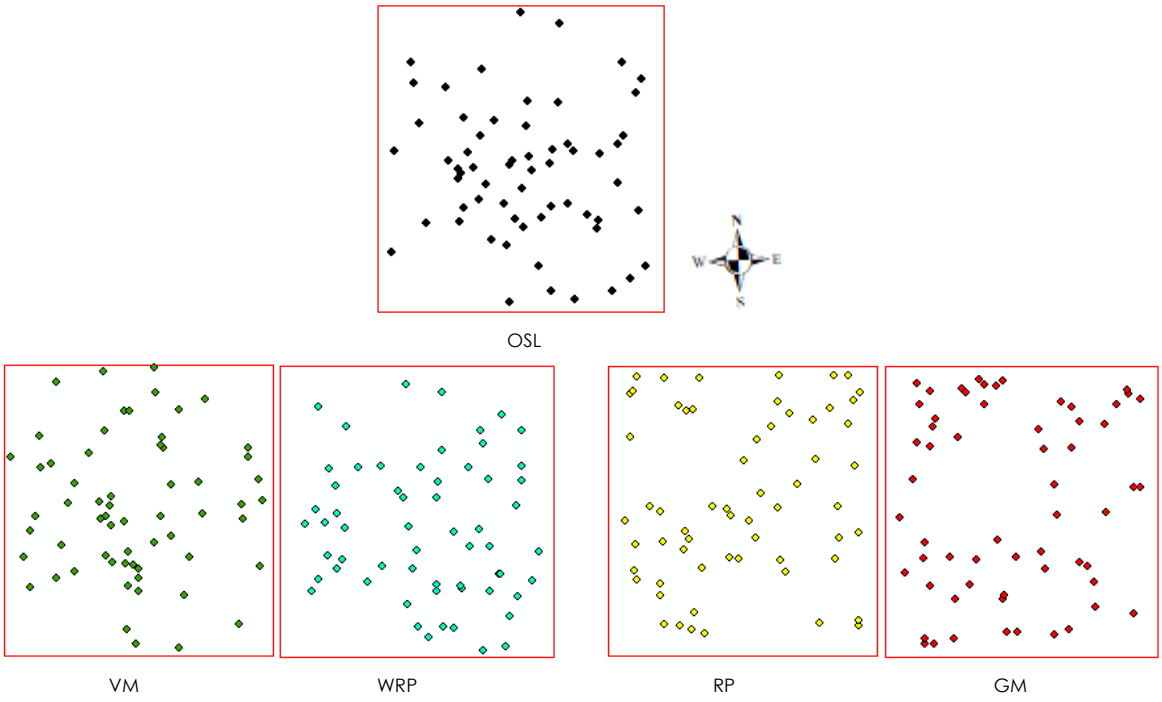


Figure 50: Sample of OSL (at the top) and obfuscated locations (VM, WRP, RP and GM at the bottom)

4.5.2 Statistical Difference

The statistical difference, as the second analytical method for testing the best obfuscation/masking method(s), it comprises the mean center and standard deviation ellipse. The outputs of the mean center and standard deviation ellipse, which helps to show which masking method(s) is best, are as follow.

4.5.2.1 Mean Center

The mean center helps to locate a point that represent the center of concentration for the subject sleeping locations (i.e., OSL, RP, WRP, GM and VM). That is, the average x and y coordinates of these sleeping locations (ESRI, 2016; and Seidl et al., 2015). Each of the masked locations' mean center is compared to the OSL's mean center. Where the closer the mean center, the more similar the concentration of overall sleeping locations.

In figure 29 (a) below, there are all mean centers labelled accordingly. WRP and VM are the most closest to OSL; they are within 20 and 30m distance range, respectively. Whilst the RP and GM are relatively the furthest from OSL (within 130m distance range). This implies both the WRP and VM display the dispersion/clustering pattern around the mean center similar to the OSL.

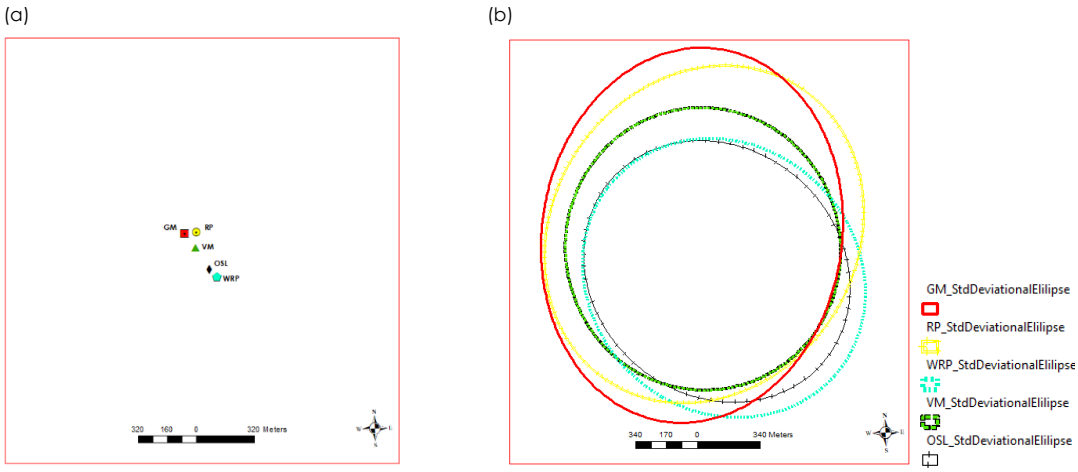


Figure 51: (a) Mean centers and (b) standard deviational ellipses/directional distributions of both OSL and masked locations (VM, WRP, RP and GM).

4.5.2.2 Standard Deviation Ellipse (SDE)

The SDE assists in measuring the dispersion or concentration and orientation tendency of the geographical features (Wang, Wenzhong and Zelang, 2015; and Yuill, 1971), which are represented by the polygon on the map (refers to figure 51 b, above) and attributes, namely rotation, and x and y standard distance (refers to table 15 below). In that light, when the results of masked locations are more similar with or have less variation (i.e., the polygon shape, size and rotation) against the unmasked locations or OSL, the corresponding masking method is considered the best/good in protecting the sleeping locations whilst preserving the spatial distribution of the original datasets.

In figure 51 b, above, is an illustration of the labelled ellipse polygons for all the masked locations and OSL. Although the positions vary; however, the size (i.e., small relative to the size of the study area, which favors clustering more than dispersion) and orientation direction (i.e., the southeast) of WRP and VM ellipses are similar to OSL ellipse. The ellipse of RP and GM, on the other hand, are relatively bigger in size (which suggest/favor dispersion more than clustering) and orientation direction is different (i.e., northeast instead of southeast).

The ellipses attributes or rather the SDE statistics are shown in table 16 (below). The results indicate that both the VM and WRP are within 50 meters x and y standard distances to the OSL. Whilst the GM and RP within larger x and y standard distance ranges, i.e., 100 meters. In addition, the difference in rotations between the VM/WRP and OSL are less than 30 degrees and they are within the same second quadrant. The large rotation variations are shown by both RP and GM against the OSL, where the difference are over 100 degrees and they lie in the quadrants, which are different from the OSL (i.e. first instead of second quadrant).

Table 16: Statistics of standard deviational ellipses with distances in meters

Obfuscation Method	X standard distance	Y standard distance	Rotation
Unmasked (OSL)	768,2	678,1	133,5
Voronoi masking (VM)	750,7	781,0	171,0
Weight random perturbation (WRP)	809,1	731,1	134,4
Random perturbation (RP)	833,6	965,8	31,4
Grid masking (GM)	819,3	1040,0	8,2

In summary, the WRP and VM exhibit less divergence from the OSL in all cases (i.e., mean center, ellipse and SDE statistics), whilst the high divergences are displayed by the RP and GM. Therefore, the WRP and VM are by far the best methods to protect identifications of the sleeping location of The Homeless, whilst preserving the spatial integrity of the original datasets.

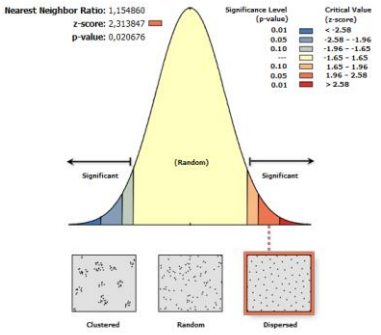
4.5.3 Spatial Patterns Plots

The spatial patterns are explored using the average nearest neighbor tool, which produce the spatial patterns plots of normal distribution described by the z-score and p-value to denote the clustering or randomness as well as the corresponding level of significance in the case of clustering, i.e. either 90%, 95% or 99% (ESRI, 2016). As such, the masked results are compared with the OSL result, whereby the less divergences or similar spatial patterns/normal distribution properties depict the best suitability to protect spatial confidentiality of the sleeping locations of The Homeless.

Figure 52 (below) displays the detail reports for all the masking methods and sample OSL, which are derived from using the average nearest neighbor tool (in ArcGIS). These reports detail the nature of spatial pattern associated with each unmasked or masked dataset but do not allow exploration of privacy of the locations of The Homeless. The results display that the VM and WRP exhibit similar dispersion spatial pattern as OSL both at 95% significant level of confidence. Whereas, both RP and GM demonstrate random spatial patterns, which consequently denote high divergence from the OSL.

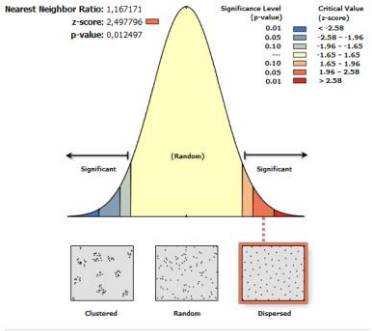
In conclusion, the WRP and VM display the spatial distribution patterns that are similar or entail relatively insignificant variations to the OSL for almost all analyses. As a result, both the WRP and VM are by far the best masking methods for sleeping locations The Homeless. That is, they can alter and protect identifications of the sleeping locations of The Homeless and yet present the locations in the same nature in the spatial space as the original data.

OSL



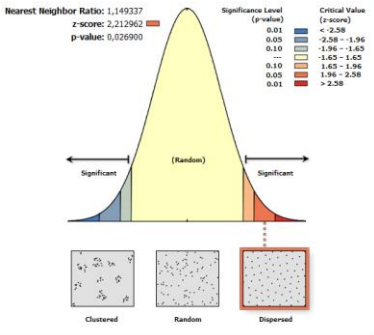
Given the z-score of 2.31384711009, there is a less than 5% likelihood that this dispersed pattern could be the result of random chance.

VM



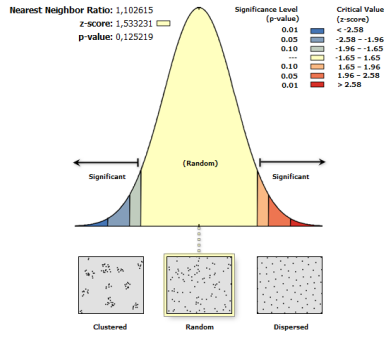
Given the z-score of 2.4977615205, there is a less than 5% likelihood that this dispersed pattern could be the result of random chance.

WRP



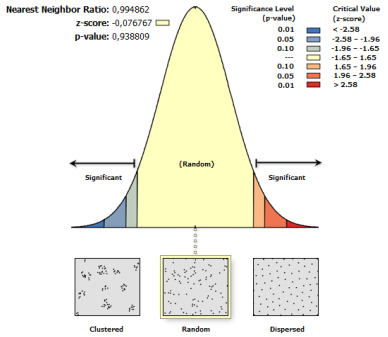
Given the z-score of 2.21296233829, there is a less than 5% likelihood that this dispersed pattern could be the result of random chance.

RP



Given the z-score of 1.53323100704, the pattern does not appear to be significantly different than random.

GM



Given the z-score of -0.0767669433331, the pattern does not appear to be significantly different than random.

Figure 52: K (average) nearest neighbor result for OSL and masking methods

CHAPTER 5: DISCUSSION

There are five premises or hypotheses in this study. All premises are tested. Through the implementation of various analyses, the findings prove or indicate that all premises are valid. Each premise matches up with a specific type of analysis. The types of analyses include spatial distribution, attribute analysis, proximity analysis, weather analysis and obfuscation/geographic masking – and these are outlined below.

5.1 SPATIAL DISTRIBUTION

The premise under the spatial distribution states that geographic distributions of the sleeping locations are similar or rather display insignificant/negligible variations throughout the study period. Where the sum of all observed individual locations is 9,515, the lowest daily total of the individual locations is 624 (on the first Wednesday), highest is 729 (on the last Friday), and the daily average is 680. The premise for the spatial distribution is tested using four distinct analytical methods namely; mean center, standard deviations, standard deviation ellipse, and cluster and outlier analysis – Anselin Local Morain's I. Where different aspects of the sleeping locations are identified and analyzed.

- Mean center – computes the 14 daily overall mean centers or geographic concentrations of sleeping locations of The Homeless. The findings indicate that the distance range is less than 50 meters between all the daily mean centers, where majority (i.e., all week 1 and last 4 days of week 2) are within 20-10 meters distance range. These distance ranges between all the mean centers are little or insignicant for the given number of the sleeping locations within 7.1 km^2 study area. That is, the existing socio-spatial movements associated with The Homeless, viz., the sleeping locations do not significantly contribute to the overall variations in spatial distributions. As a result, this is in support of the premise that there is no significant daily/weekly variations between sleeping locations through the study period.

- Standard deviation – examines the degree to which all the sleeping locations are concentrated/dispersed around the overall mean center, and it is calculated for each of the daily datasets. The difference between the highest and smallest standard deviation is 2.8, which implies negligible or insignificant variations between the daily datasets regarding how their respective locations distribute around the overall mean center. Similar to mean center, the observed socio-spatial movements associated with The Homeless, viz., the sleeping locations do not significantly contribute to the overall variations in spatial distributions. Therefore, this also support the premise that there are no significant variations between all the daily overall sleeping locations of The Homeless in the two weeks study period.

- Standard deviation ellipse – measures the dispersion or concentration and orientation tendency of the daily total sleeping locations for the study period, and it reveals the following. All 14 the daily ellipses are situated in the inner and southeast regions of the study area (i.e., CBD and Foreshore neighborhood areas) – i.e., the second quadrant mathematically, where variations

in rotations are within 10 degrees range. The sizes of all ellipses are big in relation to the study area, which suggest dispersion of sleeping locations rather than clustering. In addition, variations in x and y standard distance ranges are negligible (i.e., 100m) given the size of the study area. Based on these findings, it is clear that variations in daily sleeping locations are negligible/insignicant across the study duration.

- Cluster and outlier analysis (Anselin Local Morain's I) – depicts the groups of the sleeping locations of The Homeless that are clustered and dispersed with each of the daily datasets. The findings indicate insignificant/negligible fluctuations in the daily number of clustered and dispersed sleeping locations. Where the both clustering and dispersion are presented with 95% statistical level of confidence. Furthermore, on each of the 14 days, there are more outliers and dispersions than clusters. Based on these grounds, the premise is validated, i.e., there are no significant variations in daily sleeping locations of The Homeless in the 14 days period.

In conclusion, all the above finding supports the premise that the geographic distributions of the sleeping locations are similar or rather display insignificant/negligible variations throughout the study period.

5.2 ATTRIBUTE ANALYSIS

For attribute analysis, the premise is that The Homeless sleep in marginalized urban spaces that deny them personal privacy/security and perpetuate stigmatization and social isolation (i.e., they are highly vulnerable). Since in United State Cities, for example, the law enforcers (e.g., security guards, police officials) harass and arrest The Homeless sleeping, loitering or hanging out and sitting or lying down in urban space (NHLP, 2014).

Guided by Mazumdar and Paul (2018), the surrounding indicators are established in attempt to capture how the locations, where The Homeless sleep, support their routine and adaptive practices in an urban space/ecology. The established six explorative, descriptive and explanative surrounding indicators with their descriptors/entries are as follow: (a) general description indicator (open space; roadside; rooftop; and building-side); (b) supporting infrastructure (building sidewall; bridge walls; fence; and tree/none); (c) surface (pavement; and ground); (d) platform (ground; and elevated); (e) accessibility (easy; and difficult); and (f) lookout view (far; and near). Each of the surrounding indicator is analyzed and the findings are as follow.

- General description – measures the degree of marginalization and social isolation of the sleeping locations of The Homeless. The findings reveal that on each day, there is more than 50,9% of sleeping locations of The Homeless in marginalized areas (i.e., open spaces, where no form of the urban infrastructure, e.g., road, building, bridge, is at least 2m closer) and 54,7% on average throughout the study period. This serves as the basis that the homeless community sleeping in the urban spaces are highly marginalized (over 50,9% individual total locations each day) in the City Bowl and this is true throughout the study period. Where 55,5% are supported by the

trees/none (i.e., low or no level of personal protection) and 68,9% are on bare soils (i.e., high level of stigmatization). Moreover, 100% are on the ground platforms thus, high exposure to the health concerns, 94,9% are easily accessible or provide low level of person protection, and 86,3% is for those with far lookout views or relatively high level of social isolations.

- Supporting infrastructure – evaluates the degree of personal privacy and protection of the sleeping locations, and thus, The Homeless. Out of the four options, majority (i.e., 35% minimum each day) of the sleeping locations entail the tree/none descriptor for the support structure type of surrounding indicator. That is, many locations are supported by the trees, if not by any form of artificial/natural structure. These support structures are small sizes and are less rigid. Where 87,2% are situated in the open spaces (i.e., highly marginalized zones), 81,5% are on bare soil (i.e., high level of stigmatization), 100% are on the ground platforms thus, high exposure to health concerns, 100% are easy accessible or provide low level of person protection, and 89,0% comprise the far lookout views or relatively high level of social isolations. As a result, predominant individual sleeping locations are highly lacking personal privacy and protections, consequently, the homeless people.

- Surface – helps to depict the degree of marginalization and stigmatization of The Homeless, where marginalized/stigma zones are not modified, covered or constructed with some form of cement but natural soil and/or vegetation. The findings show that majority (i.e., 53% overall) of the sleeping locations are situated in the marginalize/stigma-bearing areas, i.e., the surfaces underneath are not constructed or modified to match majority of the surrounding surfaces or rather to suit the lifestyle in urban area. Where 74,1% are situated in the open spaces (i.e., highly marginalized zones), and 55,8% are supported by the trees or without the support structure (i.e., low personal security and privacy). In addition, 100% of the locations are on ground platform (i.e., high exposure to ecological health-implicating concerns), 94,6% are easily accessible by any person (i.e., low level of personal security), and 94,6% comprise far lookout views (i.e., relatively higher level of social exclusion/isolation). Therefore; the locations where The Homeless sleep/rest encompass high degree of marginalization and stigmatization; as a result, the homeless people are in highly marginalized and stigmatized urban spaces.

- Platform – evaluates the degree of personal security of the sleeping locations against the social and ecological activities (e.g., people movements, surface water runoff) take place on predominant surface. Thus, platform measures the relativity of the surface of the sleeping location(s) to the predominant public surface. It is established that the individual sleeping locations situated on unraised surface relative to the predominant public surface (i.e., the ground entry type) ranges between 94% and 95% on a daily basis throughout the study period. Where 60,3% are situated in the open spaces (i.e., highly marginalized zones), and 33,8% are supported by the trees or without support structure (i.e., low personal security and privacy). Moreover, 55,9% of the locations are on bare soil (i.e., high level of marginalization and stigmatization), 95,6% are easily accessible (i.e., low level of personal security), and 72,9% comprise far lookout views (i.e., relatively higher level of social exclusion/isolation). As a result, almost all the observed indi-

vidual sleeping locations of The Homeless provide low degree of personal security (i.e., quietness, peace, protection etc.) for the homeless individuals and groups.

- Accessibility – focuses on the ability to approach, see and/or obtain something, at close range, from the sleeping locations, which translates to the degree of personal security (i.e., privacy and protection) for The Homeless. The findings show that in general, majority, 96% (i.e., 9,149 in total, minimum a day) of the individual sleeping locations of The Homeless are situated in the urban spaces that provide easy accessibilities. That is, there are minimal or no form of barriers for intruders (incl. the elderly and disability individuals) to approach, see and/or obtain something from the sleeping locations of The Homeless. Where 59,7% are situated in the open spaces (i.e., highly marginalized zones), and 40,0% are supported by the trees or without support structure (i.e., low personal security and privacy). Moreover, 55,1% of the sleeping locations are on bare soila (i.e., high level of marginalization and stigmatization); 100% are on the ground platforms (i.e., high exposure to ecological health-implicating concerns); and 72,8% comprise far lookout views (i.e., relatively higher level of social exclusion/isolation. Therefore, predominant sleeping locations cater low degree of personal security/privacy for The Homeless.

- Lookout view – examines whether the maximum unobscured distance is less than 3 meters (i.e., one block) or more between the sleeping locations of The Homeless and anyone approaching, where 3m and below unobscured distances (i.e., near) denotes low degree of social and/or personal security/privacy and vice versa. The study reveals that majority (at least 62% daily proportion) of the sleeping locations of The Homeless in the urban spaces encompass low degree of social and/or personal security/privacy for them. That is, predominant sleeping locations are situated in a position that gives The Homeless no room to physically/mentally/emotionally prepare themselves for the upcoming parties. Where out these locations; 66,8% are situated in the open spaces (i.e., highly marginalized zones) and 43,8% are supported by trees or without support structure (i.e., low personal security and privacy). In addition, 69,1% are on bare soils (i.e., high level of marginalization and stigmatization), 93,5% are on the ground platforms (i.e., high exposure to ecological health-implicating concerns), and 89,5% entail easy accessibility (i.e., low level of personal security).

It is for the above evidences that the premise is true or validated, viz., majority of the sleeping locations of The Homeless are in marginalized urban spaces that deny them personal privacy/security, human dignity and perpetuate stigmatization and social isolation. Therefore, the homeless individuals and groups are highly vulnerable (members of the society)

5.3 PROXIMITY ANALYSIS

The proximity analysis tests the premise, which states that the sleeping locations of The Homeless are not nearer to the sources of basic needs - to enhance their livelihoods. The analysis helps to evaluate whether the sleeping locations of The Homeless are situated nearer the source(s) of basic needs (i.e.,

key to enhancers of their livelihoods) or not. Where the selected example of the basic needs is water and the two sources of water include waterbodies (which are predominantly privatized) and open watercourses.

Waterbodies are few relative to the open waterbodies and they are situated in the outskirts of CBD along the north, southeast and south-west boundary of the study area. Whilst the open water courses are predominantly distributed almost in the inner region of the study are and few near the northeast, east and southwest of the study area boundary.

The findings indicate the following. On each day throughout the study period, there is 0% and less than 14% of locations within 100m radius of the waterbodies and open watercourses, respectively. Moreover, there is less than 6% of the locations within 50m distance for both types of water sources. This also implies that when the sources of human basic need (in this case, open water courses) are accessible to the public or rather not within privately own boundaries, relatively more sleeping locations of The Homeless are found nearer. Another reason for more sleeping locations near open watercourses relative to waterbodies, is that open water courses are closer to surfaces types of high level of marginalization and stigmatization (i.e., bare soil). Of which bare soil surfaces are relatively small proportions of 'available' urban spaces, which (majority of) The Homeless capitalize on, unlike on the counterpart, pavement surfaces – which is one of the distinguisher of urban spaces with others and it matches/favors urban lifestyle (e.g., trolley pushing, skating, minimal contact with dust).

In conclusion, the locations, in public urban spaces, are situated far from water resources (i.e., the waterbodies and open water courses, which their water is, at least, used for cleaning and washing). Therefore, The Homeless are situated further away from the sources of basic needs to enhance their livelihoods.

5.4 WEATHER ANALYSIS

The weather analysis evaluates the premise that outlined that the weather conditions are directly/indirectly related to the changes in the total numbers of sleeping locations. Based on the findings of Ismail and Turiman (2016) that The Homeless turn to choose their locations for sleeping based on the physical characteristics that match or serve protection against weather conditions. The four weather conditions are examined over the two weeks period, namely; temperature, rainfall, cloud cover and wind speed.

- Temperature – when daily temperature is high today, there is an increase in the daily total number of the sleeping locations of The Homeless the preceding morning during observations, and the opposite is true. That is, there is a direct proportionality relationship between temperature and total number of the sleeping locations for The Homeless. When temperature is relatively higher, majority of The Homeless seek for the sleeping setups that are relatively cooler, i.e., non-sharing or sleeping in isolation/individually, especially those who are situated on the pavements (i.e., warmer) surfaces.

- Rainfall –the little rain observed/recorded, during study period, indicates that there is an indirect proportionality relationship between rainfall and daily total numbers of the individual sleeping locations. Where the two days that show significant amount of rainfall show interesting findings, which include. The daily total number of the individual sleeping locations increases the day after the rainfall. If the rainfall starts before sunset and throughout the night, the following night, The Homeless shift away from elevated platforms and pavement. On the other hand, if it starts raining after sunset or at night, on the following night, The Homeless still avoid elevated platforms. However, they shift towards pavement surfaces and thus, there is a decrease in the sleeping locations on the unpaved or bare soil surfaces

- Cloud cover – the cloud cover strongly relates to the rainfall and thus, similarly to how rainfall relates to The Homeless. The Homeless prepare their sleeping setups the same way on a cloudy or rainy day and this is clear on the following day after dense (i.e., over 40%) cloud cover or (significant) rainfall. Where The Homeless opt for less sharing sleeping setups, which leads to induced total numbers of the sleeping locations and this is true throughout the study duration, including on the day when there is no rainfall but dense cloud cover. In essence, dense (i.e., 40% and above) cloud cover today leads to increased daily total numbers of the sleeping locations the following day. Moreover, there is an indirect proportional relationship between the cloud cover and the daily total numbers of the individual sleeping locations.

- Wind speed - high/strong wind speed leads to increased percentiles of the individual sleeping locations supported by the big in size and more rigid structures (which include; fence, bridge wall, and building sidewall). Instead of the locations percentiles without the support structures or with support structures that are small in size and less rigid (e.g., trees). Especially when there is a reduced number of the locations situated in the open spaces. Moreover, in general, high/strong wind speed leads to a decrease in the total individual sleeping locations, as a result of The Homeless opting for sharing sleeping setups or rather combining/merging their sleeping materials. As a way, to setup strong sleeping structures to sustain the wind, which turns to be against the supporting structures that are big in size and more rigid. Unfortunately, the wind direction is not consider primarily because the weather station used is far from the study area. Therefore, the wind direction can be misleading, especially because of the neighbouring high mountain ranges and urban infrastructures, which can redirect the wind within the study area.

In conclusion, weather conditions are directly/indirectly related to the total numbers of the individual sleeping locations. In addition, this finding, is at least, in line with Ismail and Turiman (2016), who came to realize that The Homeless choose their sleeping locations based on the physical characteristics of the weather.

5.5 OBFUSCATION/GEOGRAPHIC MASKING

The obfuscation/geographic masking's premise is that the sleeping locations of the homeless can be presented without compromising the spatial confidence of The Homeless, and the spatial distribution and patterns of the sleeping locations. Guided by Seidl et al. (2015), thefour masking methods are used for the test and these include grid masking (GM), random perturbation (RP), weight random perturbation (WRP) and voronoi masking (VM). The three analytic methods (i.e., map difference, statistical difference and spatial pattern) are used to evaluate the performance of the masking methods in comparison with the sample of the original sleeping locations (OSL).

- Map difference - examines the map (i.e. overall spatial distributions) of all themasked sleeping locations derived from the sample of OSL. GM and RP show major redistributions of the general spatial patterns of the sleeping locations of The Homeless, especial along the boundary of the study area as well as the inner region (for GM). In contrast, both the VM (voronoi masking) and WRP (weight random perturbation) best perform in maintaining the extent and shape of the original sleeping locations.

- Statistical difference - tests the best obfuscation/masking method(s) using the mean center and standard deviation ellipse (SDE). For the mean center, both the RP and GM are relatively the furthest from the OSL (within 130m distance range); whereas both WRP and VM closer (i.e., within 20-30 meters range), and therefore, they display similar dispersion/clustering pattern around the mean center like OSL. As for the SDE, both the GM and RP within a longer x and y standard distance ranges, i.e., 100 meters, and their rotations deviate about 100 degrees from OSL. Whilst the VM and WRP are within 50 meters x and y standard distances to OSL, and VM/WRP and OSL are less than 30 degrees and they are within the same second quadrant. Therefore, WRP and VM exhibit less divergence from OSL in all cases (i.e., mean center, ellipse and SDE statistics), that is, WRP and VM are by far the best methods to protect identifications of the sleeping location of The Homeless, whilst preserving the spatial integrity of the original datasets.

- Spatial pattern – analyses the best masking method(s) using the average nearest neighbor tool, which produce spatial patterns plots of normal distribution described by the z-score and p-value to denote clustering or randomness as well as the corresponding level of significance in the case of clustering, i.e. either 90%, 95% or 99% (ESRI, 2016). The results display that the VM and WRP exhibit similar dispersion spatial pattern as OSL both at 95% significant level of confidence. Whereas, both the RP and GM demonstrate random spatial patterns, which consequently denote high divergence from the OSL. Therefore, both the WRP and VM display spatial distribution patterns that are similar or have relatively insignificant variations to the OSL. In other words, they can protect the identifications of the sleeping locations of The Homeless and yet present the locations in the same nature in spatial space as the original data.

In summary, all the masking methods are able to protect the spatial confidentiality of the sleeping locations of The Homeless. However, not all preserve the spatial distribution pattern of the OSL. Only the VM and WRP best perform in preserving spatial distributions of the OSL and protect the spatial confidentiality of the sleeping locations of The Homeless, and this is true throughout the analyses, i.e., the two obfuscations show less divergences from the original datasets. Unlike in Seidl et al. (2015), the VM is not the only geo-masking method that shows best performance out of the four tested methods.

CHAPTER 6: CONCLUSION

In concluding the research, there six objectives are successfully achieved. These include.

- Observing and recording sleeping locations of The Homeless and their surrounding characteristics situated in the public spaces within the Cape Town City Bowl at early hours of the morning. Where the public places are areas defined by and in compliance with the City of Cape Town's by-law relating to streets, public places and the prevention of noise nuisances (2007); and the observed sleeping location is not equivalent to one homeless individual but a (shared) set-up for sleeping. Since in some instance two or more homeless individuals used to cover themselves with the same blankets or other materials such as boxes and plastics.
- Assessing daily and weekly variations of sleeping locations of The Homeless.
- Evaluating the surrounding nature of and around the sleeping locations of The Homeless
- Investigating the proximity distances between the sleeping locations and water resources (i.e., privately and publicly accessible human basic need examples).
- Exploring the relationship between various weather elements (i.e., temperature, rainfall, cloud cover and wind speed) and the daily numbers of the sleeping locations.
- Highlighting the geographical masking or obfuscation methods that are most appropriate for visualization of (low scale) the locations where The Homeless sleep/rest.

Where the research study is empirical inquiry, i.e., case study, which is customary when answering the "how"or "why" questions. Although one study is considered, a theoretical generalization can still be made but not generalization about population or universe (Yin, 2012). Moreover, the case study approach avails room for addressing the real-life contemporary events. That is, there is a room to make real-life observations and interviews. However, in this study, no interviews are made (i.e., qualitative) but only observations of the spatial characteristics of and around where the homeless individuals and groups sleep/rest (i.e., quantitative).

Five various analyses, with various analytical methods, are employed to validate the five set expectations or premises are validated, where each methods matches up with the specific premise, and all the premises are as expected, valid or evidently true. These are as follow.

- Geographic distributions of the sleeping locations are similar or display insignificant/little variations throughout the study period – Spatial distribution analyses (analytical methods: mean center, standard deviation, standard deviation ellipse, and cluster and outlier analysis – Anselin Local Morain's I). The daily outputs of each of the analytical methods are almost identical and the existing variations are negligible.
- Majority of the sleeping locations of The Homeless are in marginalized urban spaces that deny them personal privacy/security, human dignity and perpetuate stigmatization and social isolation, therefore, The Homeless are highly vulnerable (members of the society) – Attribute analysis (analytical method: surrounding indicators). On each day, there are, at least, 50,9% of the locations that highly marginalized (i.e., situated in the open spaces), and 35% with low or no personal protection (i.e., supported by the trees/no structures). Moreover, 94% of the sleeping lo-

cations comprise high exposure to the health concerns (i.e., they are situated on the ground platform), 96% entail low level of person protection (i.e., easy accessibility), and 62% comprise high level of social isolations (i.e., far lookout view).

- The sleeping locations of The Homeless are situated far from sources of basic needs to enhance the livelihoods of The Homeless (water resources are used as examples) – Proximity analysis (analytical method: buffering). Majority of the locations are far from water resources, especially the resources that are in private properties and/or are not situated near marginalized/stigmatized zones (i.e., zones with unpaved surfaces).
- Weather conditions are directly/indirectly related to the changes in numbers of sleeping locations – Weather analysis (analytical: weather conditions/elements). The sleeping locations are directly proportional to the temperature; and have indirect relationship with rainfall, cloud cover, and wind speed.
- The locations where The Homeless sleep can be presented without compromising the spatial confidence of The Homeless, and the spatial distribution and patterns of the sleeping locations – Obfuscation/geomasking analyses and test (analytical methods: map difference, statistical difference, and spatial pattern). For all analyses, voronoi masking and weight rand perturbation show small divergence from original sample locations (OSL), and therefore, they best perform in preserving spatial distributions of OSL and protect the spatial confidentiality of the sleeping locations of The Homeless.

Scientifically, these findings are valuable on the following bases, to mention a few.

- The higher concentrations of homelessness are in the poorer and developing countries in Asia, Africa and Latin America, whilst recent increases are in wealthier and developed countries in North America and Europe (United Nations Center for Human Settlement,1996 in Dachner and Tarasuk, 2002).
- Urban models (i.e. bylaws, rules, regulations, social activities and infrastructures) remain to marginalize, victimize, stigmatize and give no room for the personal privacy and human dignity for The Homeless in urban public spaces.
- The sleeping locations of The Homeless are further away from most and various source(s) of basic needs (i.e., key aspects to enhancers of The Homeless' livelihoods) or not. The selected example of the basic needs is water and its two sources include waterbodies (which the predominantly privatized) and open watercourses. Water as basic need and its two sources as part of the analyses inputs are chosen the following reasons, amongst others: South Africa's Bill of Rights subsection 27.1b states that "everyone has the right to have ace to sufficient food and water"
- One of the findings of Ismail and Turiman (2016) states that The Homeless turn to choose their locations for sleeping based on the physical characteristics that match or serve protection against weather conditions.
- All of the above, although the some are probably well known based on knowledge from Social Science but there is currently none and little if there is any from the GISc (geo-information science)/socio-spatial perspective.

- Social spatial studies (e.g., this study) generally helps to enhance the knowledge and understanding of community/society of interest (The Homeless in this research), however, they can also impose the risks of compromising or disclosing the personal privacy and/or social behavior (Curitis et al., 2010, and Lu and Lui, 2012) and thereof, trigger societal vulnerability. This disclosure/compromise is generally a severe ethical concern (Armstrong, 2002 and Curtis et al., 2006 both are in Lu and Lui, 2012; and UCT (EBE Faculty) Ethics Committee also emphasizes this concern).

Finally, it is evident that the knowledge and understanding of homelessness can be enhanced through integration of geographic information system (GIS) and one way of doing so is following this research study. Echoing other scholars (Dogru et al., 2017; Robbin, Carnes and Oreskovic, 2016; and Tipple and Speak, 2005), GIS tool is powerful and capable of incorporating the spatial characteristics when addressing the social challenges (e.g., homelessness). In addition, the incorporation of GIS or the usage of its analytic results can help in further developing the urban spaces, sustainably, especial for the marginalized groups and these include The Homeless living in these spaces (e.g., plan/provide service deliveries; implement/improve socio-economic initiatives). That is, restructure the overall urban model to be more inclusive for all citizens.

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APPENDIX:

1. AGGREGATED/GROUPED ORIGINAL SLEEPING LOCATIONS

Group	*Gen_Desc*	*Supp_Infra*	*Surface*	*Platform*	*Access*	*Lookout*	*Sat_1_1 310*	*Sun_1_1 410*	*Mon_1_1 510*	*Tue_1_1 610*	*Wed_1_1 710*	*Thu_1_1 810*	*Fri_1_1 910*	*Sat_2_2 010*	*Sun_2_2 110*	*Mon_2_2 210*	*Tue_2_2 310*	*Wed_2_2 410*	*Thu_2_2 510*	*Fri_2_2 610*
1	Road-side	Bridge wal	Bare soil	Ground	Easy	Near	4	8	9	6	6	6	6	6	6	6	6	6	9	9
2	Building	Building	Pave-ment	Ground	Easy	Near	5	5	1	1	1	1	1	1	1	1	1	1	1	3
3	Open space	Fence	Pave-ment	Ground	Easy	Far	13	13	18	16	16	16	16	16	16	16	16	16	16	10
4	Building	Building	Pave-ment	Ground	Easy	Far	14	10	17	27	27	24	27	26	24	24	24	24	24	37
5	Open space	Fence	Bare soil	Ground	Diffi-cult	Far	26	37	22	17	17	17	17	17	16	16	16	16	16	24
6	Road-side	Bridge wal	Pave-ment	Ele-vated	Diffi-cult	Near	6	6	7	5	5	5	5	5	5	5	5	5	5	6
7	Road-side	Fence	Bare soil	Ground	Easy	Far	20	28	24	23	22	22	21	21	21	21	21	29	29	29
8	Open space	Bridge wal	Pave-ment	Ground	Easy	Far	17	24	26	26	11	11	11	11	11	11	11	11	24	11
9	Open space	Trees	Bare soil	Ground	Easy	Far	25	25	25	28	28	28	26	28	28	28	28	28	26	29
10	Open space	Trees	Bare soil	Ground	Easy	Far	26	26	26	26	26	26	26	26	26	26	26	26	26	26
11	Open space	Trees	Bare Soil	Ground	Easy	Far	17	11	14	17	17	17	17	17	17	17	17	17	17	17
12	Road-side	Bridge wal	Bare Soil	Ground	Easy	Near	4	4	2	2	2	2	2	2	2	2	2	2	2	2
13	Open space	Trees	Bare soil	Ground	Easy	Far	57	59	58	35	35	35	35	35	33	33	33	33	33	33
14	Open space	Trees	Bare Soil	Ground	Easy	Far	6	5	5	5	5	5	5	5	5	5	5	5	2	5
16	Open space	Trees	Bare soil	Ground	Easy	Far	23	23	23	21	21	21	21	21	19	19	19	19	27	19
17	Open space	Trees	Pave-ment	Ground	Easy	Far	5	5	5	7	6	6	6	6	6	6	6	6	8	6
18	Building	Building	Pave-ment	Ground	Easy	Near	6	6	6	8	6	6	6	6	6	6	6	6	6	6
19	Open space	Trees	Bare soil	Ground	Easy	Far	7	7	7	15	9	9	9	9	9	9	9	9	9	9
20	Open space	Trees	Bare soil	Ground	Easy	Far	12	12	12	12	12	12	12	12	12	12	12	12	12	12
21	Road-side	Building	Pave-ment	Ground	Easy	Near	0	0	0	0	0	0	0	0	0	0	0	1	1	1
22	Road-side	Building	Pave-ment	Ground	Easy	Near	2	2	2	2	2	2	2	2	2	2	2	3	4	4
23	Open space	Trees	Bare soil	Ground	Easy	Far	1	1	9	9	7	7	7	7	7	7	5	8	10	8
24	Open space	Fence	Bare soil	Ground	Easy	Far	18	16	14	19	19	19	19	19	17	17	17	19	19	19
25	Road-side	Building	Pave-ment	Ground	Easy	Near	0	0	3	2	2	2	2	2	2	0	1	1	1	1

26	Road-side	Building	Pave-ment	Groun d	Easy	Near	0	0	0	0	0	0	0	0	0	0	0	4	4	4

Gro up	***Gen_D esc***	***Supp_In fra***	***Surface***	***Plat-form***	***Ac-cess***	***Look out***	***Sat_1_1 310***	***Sun_1_1 410***	***Mon_1_1 510***	***Tue_1_1 610***	***Wed_1_1 710***	***Thu_1_1 810***	***Fri_1_1 910***	***Sat_2_2 010***	***Sun_2_2 110***	***Mon_2_2 210***	***Tue_2_2 310***	***Wed_2_2 410***	***Thu_2_2 510***	***Fri_2_2 610***
27	Road-side	Building	Pave-ment	Groun d	Easy	Near	10	4	6	14	14	14	14	16	16	9	8	10	11	11
28	Building	Building	Pave-ment	Groun d	Easy	Far	0	0	1	1	1	1	1	1	1	1	1	1	3	3
29	Road-side	Building	Pave-ment	Groun d	Easy	Far	1	0	0	0	0	2	2	0	0	1	4	1	1	2
30	Building	Building	Pave-ment	Groun d	Easy	Near	4	4	1	0	0	0	3	2	2	3	3	3	3	3
31	Open space	Trees	Pave-ment	Groun d	Easy	Far	6	6	7	11	6	11	10	6	6	13	24	17	22	16
32	Road-side	Building	Pave-ment	Groun d	Easy	Near	4	4	3	6	8	8	8	8	7	5	6	6	5	6
33	Building	Building	Pave-ment	Groun d	Easy	Near	37	39	6	16	11	11	21	35	35	15	21	17	10	17
34	Open space	Building	Pave-ment	Groun d	Easy	Far	32	33	22	20	22	22	22	25	26	20	18	20	26	26
35	Road-side	Fence	Bare soil	Groun d	Easy	Far	12	12	6	13	13	16	16	10	10	19	22	26	24	26
36	Building	Building	Pave-ment	Groun d	Easy	Far	18	18	18	11	14	14	14	22	16	14	14	10	8	14
37	Building	Building	Pave-ment	Groun d	Easy	Near	5	4	1	4	3	3	3	5	5	2	2	3	3	15
38	Roof-top	Building	Pave-ment	Ele-vated	Diffi-cult	Far	38	38	27	30	28	27	31	38	36	34	34	34	31	32
39	Building	Building	Pave-ment	Groun d	Easy	Near	4	4	2	2	2	2	2	5	7	2	2	2	2	3
40	Road-side	Trees	Pave-ment	Groun d	Easy	Near	7	5	3	3	3	4	3	11	11	4	2	2	2	2
41	Building	Building	Pave-ment	Groun d	Easy	Near	7	7	7	11	5	1	11	5	11	15	10	6	12	6
42	Road-side	Bridge wal	Bare soil	Groun d	Easy	Far	27	22	27	29	29	29	29	29	29	29	29	29	29	24
43	Road-side	Fence	Bare soil	Groun d	Easy	Far	16	12	15	13	13	13	13	13	13	13	13	13	13	9
44	Road-side	Trees	Bare soil	Groun d	Easy	Far	1	2	1	0	2	2	2	2	2	2	2	2	2	2
45	Road-side	Trees	Bare soil	Groun d	Easy	Far	4	3	1	0	5	1	1	1	1	1	1	1	1	3
46	Open space	Fence	Bare soil	Groun d	Easy	Far	28	28	29	29	29	29	29	29	25	25	25	25	25	25
47	Open space	Trees	Bare soil	Groun d	Easy	Far	25	25	25	30	30	30	30	30	28	28	28	28	28	28
48	Road-side	Building	Pave-ment	Groun d	Easy	Near	13	13	12	8	8	9	9	9	9	9	9	9	9	11
49	Road-side	Fence	Pave-ment	Groun d	Easy	Near	0	0	6	6	4	4	3	3	3	3	3	3	3	3
50	Building	Building	Pave-ment	Groun d	Easy	Near	2	2	2	0	0	2	3	3	3	3	3	3	3	3
51	Building	Building	Pave-ment	Groun d	Easy	Near	0	0	0	0	0	0	0	0	0	1	3	4	9	4

52	Building	Building	Pave-ment	Groun d	Easy	Near	7	7	5	0	0	4	7	7	9	9	7	6	5	6
53	Building	Building	Pave-ment	Groun d	Easy	Near	11	13	13	1	1	11	11	6	10	13	18	14	15	14

Gro up	***Gen_D esc***	***Supp_In fra***	***Surface***	***Plat-form***	***Ac-cess***	***Look out***	***Sat_1_1 310***	***Sun_1_1 410***	***Mon_1_1 510***	***Tue_1_1 610***	***Wed_1_1 710***	***Thu_1_1 810***	***Fri_1_1 910***	***Sat_2_2 010***	***Sun_2_2 110***	***Mon_2_2 210***	***Tue_2_2 310***	***Wed_2_2 410***	***Thu_2_2 510***	***Fri_2_2 610***
53	Building	Building	Pave-ment	Grou nd	Diffi-cult	Near	0	0	0	0	0	0	0	1	1	2	2	2	2	2
54	Road-side	Building	Pave-ment	Grou nd	Easy	Near	0	0	0	0	0	0	0	5	5	0	0	0	0	0
55	Building	Building	Pave-ment	Grou nd	Easy	Far	0	0	0	0	0	2	2	6	6	5	5	3	3	4
56	Building	Building	Pave-ment	Grou nd	Diffi-cult	Near	6	5	3	5	7	7	9	4	4	7	7	5	6	5
57	Road-side	Fence	Pave-ment	Grou nd	Easy	Far	7	5	5	7	6	6	7	6	7	9	9	6	6	6
58	Open space	Trees	Bare soil	Grou nd	Easy	Far	4	2	2	7	0	0	7	7	7	7	7	14	15	13
59	Open space	Fence	Bare soil	Grou nd	Easy	Near	1	4	4	4	5	5	5	5	5	5	7	4	4	4
60	Open space	Fence	Pave-ment	Grou nd	Easy	Near	23	23	29	28	25	25	25	25	25	25	25	28	32	32
61	Open space	Fence	Pave-ment	Grou nd	Easy	Near	8	8	15	28	28	28	28	28	29	29	19	19	20	19

2. TEMPERATURE (C˚): 13-26 OCTOBER 2018

DD	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	Avg.	mx	tm
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14,5			
13	14,4	13,4	12,7	10,2	8,9	8,3	12,9	15,3	18,6	21,0	23,5	25,2	26,0	25,4	26,6	26,2	24,4	22,7	19,4	18,2	18,1	17,4	17,1	17,2	**17,5**	27,7	1509
14	13,3	14,8	13,9	14,4	14,1	14,2	14,6	15,8	16,4	17,9	19,7	20,0	20,4	20,3	19,6	19,1	18,4	17,3	16,5	16,3	15,9	15,8	15,3	15,6	**16,9**	21,3	1304
15	15,6	15,5	15,1	14,8	14,8	14,4	14,5	17,0	17,9	18,7	19,8	18,6	20,0	21,3	19,5	17,7	16,4	15,3	13,9	13,0	12,3	12,8	13,3	13,8	**16,9**	21,7	1415
16	11,4	12,3	11,5	12,1	12,4	13,0	13,9	16,5	17,8	17,3	18,0	18,6	19,5	19,6	19,3	18,6	18,2	17,4	-	-	15,8	16,2	16,1	15,3	**15,6**	20,5	1404
17	14,7	13,0	14,0	14,2	14,1	13,8	15,0	17,6	18,9	20,0	21,7	22,3	23,0	22,3	21,7	21,7	20,0	18,5	17,0	16,4	16,1	16,1	16,5	16,2	**17,8**	23,4	1311
18	15,1	15,0	15,1	14,7	14,5	14,5	14,7	18,3	19,9	22,1	23,7	25,1	24,6	24,4	24,0	24,0	21,6	19,3	17,7	17,6	17,6	17,8	17,3	16,3	**19,9**	26,1	1226
19	15,9	16,3	16,3	16,2	15,3	14,5	15,3	16,6	18,3	18,8	19,2	19,6	20,6	19,7	19,1	19,3	18,7	17,7	16,4	16,3	16,3	15,8	15,5	15,5	**17,8**	21,1	1349
20	15,5	15,4	15,5	15,7	15,4	15,2	16,1	18,0	20,4	22,8	24,8	25,9	26,5	27,1	26,9	26,5	25,8	22,8	19,8	17,9	16,4	16,2	15,7	15,7	**21,2**	27,9	1326
21	15,9	15,0	14,5	14,3	14,5	14,6	15,1	17,6	20,1	23,9	23,7	26,7	28,1	29,0	29,3	29,9	28,5	26,0	22,6	22,2	20,7	18,9	18,7	17,8	**21,6**	30,4	1531
22	16,8	16,1	13,9	13,6	12,7	11,4	16,4	20,7	24,9	27,7	31,0	33,4	35,1	34,8	34,5	35,7	33,9	27,4	22,8	21,5	21,7	26,2	25,4	25,4	**23,4**	35,9	1418
23	24,0	24,4	23,2	24,8	26,1	25,4	27,0	30,1	32,4	34,0	35,5	34,7	33,2	34,3	31,1	30,9	31,9	31,1	27,7	25,4	24,8	24,0	23,9	24,6	**28,5**	36,4	1143
24	22,8	20,7	20,6	20,9	20,9	20,9	24,8	27,6	29,2	32,5	32,8	33,4	33,3	33,1	32,7	31,9	28,1	27,1	23,4	22,6	21,8	22,9	23,1	21,1	**26,9**	34,8	1210
25	19,3	19,5	18,1	18,8	18,0	19,7	21,2	22,2	24,3	26,7	27,4	28,8	28,4	26,6	23,4	22,2	20,7	19,3	18,4	18,1	17,9	17,4	17,5	17,3	**23,6**	30,1	1236
26	17,3	17,4	17,5	17,3	17,2	17,1	18,2	20,7	22,1	22,9	22,9	24,6	25,6	25,7	25,3	24,1	22,2	21,1	19,4	18,5	18,1	18,4	18,6	-	**21,4**	25,7	1301

Source: South African Weather Service (SAWS)

3. RAINFALL: 13-26 OCTOBER 2018

Day	00:00	03:00	06:00	09:00	12:00	15:00	18:00	21:00	Average	Maximum
Sat_1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sun_1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,03	0,20
Mon_1	0,70	1,00	1,10	1,00	0,10	0,20	0,10	0,00	0,53	1,10
Tue_1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Wed_1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Thu_1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Fri_1	0,00	0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,10
Sat_2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sun_2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Mon_2	0,00	0,00	0,00	0,00	0,10	0,10	0,00	0,20	0,05	0,20
Tue_2	0,70	1,10	1,00	0,70	0,00	0,00	0,00	0,00	0,44	1,10
Wed_2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Thu_2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Fri_2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Source: World Weather Online

4. CLOUD COVER: 13-26 OCTOBER 2018

Day	00:00	03:00	06:00	09:00	12:00	15:00	18:00	21:00	Average	Maximum
Sat_1	0%	0%	0%	0%	0%	0%	0%	2%	0%	2%
Sun_1	23%	41%	10%	22%	23%	13%	26%	73%	29%	73%
Mon_1	100%	91%	78%	88%	81%	72%	59%	32%	75%	100%
Tue_1	24%	21%	16%	18%	15%	24%	41%	29%	24%	41%
Wed_1	18%	10%	8%	6%	5%	14%	25%	13%	12%	25%
Thu_1	38%	64%	44%	36%	21%	18%	23%	33%	35%	64%
Fri_1	48%	54%	35%	80%	77%	53%	3%	0%	44%	80%
Sat_2	0%	0%	2%	8%	9%	2%	26%	74%	15%	74%
Sun_2	60%	22%	5%	11%	18%	13%	11%	5%	18%	60%
Mon_2	0%	0%	1%	27%	73%	48%	29%	78%	32%	78%
Tue_2	79%	84%	80%	49%	8%	9%	7%	6%	40%	84%
Wed_2	6%	6%	5%	7%	8%	8%	7%	8%	7%	8%
Thu_2	8%	6%	5%	4%	3%	2%	2%	2%	4%	8%
Fri_2	2%	1%	1%	3%	3%	1%	0%	0%	1%	3%

Source: World Weather Online

5. AVERAGE WIND SPEED (M/S): 13-26 OCTOBER 2018

DD	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	avg	mx	tm
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,9	7,9		
13	7,2	5,6	1,5	2,1	1,2	1,6	2,7	1,5	3,2	2,5	2,5	2,2	2,9	4,5	3,7	5,0	6,4	5,6	5,6	5,5	5,0	4,9	4,3	2,9	3,8	11,7	1738
14	1,6	1,3	2,6	3,7	5,2	7,2	8,0	8,1	9,5	9,3	9,4	10,3	9,0	10,0	9,9	10,3	10,2	9,8	8,2	6,8	5,8	5,9	6,0	5,8	7,2	15,4	1348
15	5,0	4,8	5,1	4,9	4,1	3,1	2,3	2,0	3,1	2,5	3,6	5,5	6,4	5,8	7,4	6,6	6,2	3,5	3,5	2,5	2,9	1,7	1,6	3,4	4,1	12,9	1457
16	2,5	2,0	2,4	2,6	3,0	2,3	3,1	3,3	4,4	4,6	4,6	4,6	4,1	5,0	6,1	6,5	6,7	6,6	-	-	4,2	3,4	3,7	3,3	4,0	10,8	1648
17	2,6	1,7	1,8	2,9	3,2	2,8	2,7	1,5	4,1	5,4	5,0	4,9	5,9	7,5	6,6	6,7	6,7	6,9	5,6	5,9	6,0	5,1	4,5	2,1	4,5	11,2	1317
18	2,1	1,2	0,0	1,6	2,9	2,5	1,9	2,1	1,7	2,0	2,1	2,7	4,8	6,1	6,9	5,9	4,6	2,9	2,0	0,0	2,9	3,4	3,1	3,9	2,9	12,8	1515
19	2,9	4,6	4,5	5,6	5,0	3,1	3,4	4,6	5,9	7,3	7,8	7,7	8,2	8,9	9,1	8,9	8,3	8,5	7,3	7,0	10,7	12,1	11,3	13,1	7,3	19,9	2308
20	13,0	10,9	10,8	11,1	10,0	9,0	9,3	5,8	7,3	8,3	9,9	7,3	9,8	9,4	10,7	10,3	9,8	9,0	7,8	7,4	6,2	2,5	2,4	2,1	8,3	19,4	0041
21	2,8	3,6	4,2	4,2	2,9	3,7	3,1	3,1	2,6	5,7	7,9	7,5	6,8	6,2	7,0	7,5	8,8	8,1	6,4	2,7	2,6	3,8	4,7	5,3	5,0	12,7	1703
22	4,7	3,0	2,2	0,0	1,7	1,3	2,4	1,5	2,3	2,6	2,6	2,7	3,0	3,2	3,5	3,1	3,5	4,3	2,9	2,9	2,4	3,1	2,7	1,6	2,6	8,3	1703
23	1,5	1,9	2,3	2,5	3,9	4,3	3,8	4,4	5,8	7,0	6,9	7,4	8,7	9,6	8,5	8,0	6,9	4,1	2,1	5,1	4,1	2,4	2,6	2,0	4,8	14,6	1339
24	1,2	1,2	1,9	0,0	0,0	2,8	2,0	1,3	0,0	2,1	4,5	4,8	5,8	6,9	6,5	3,7	4,6	2,6	3,7	3,0	3,2	3,7	2,1	1,6	2,9	12,0	1257
25	0,0	2,2	2,3	3,6	3,4	4,2	4,0	5,1	3,0	2,6	3,6	3,3	3,0	4,3	6,3	6,3	6,2	6,3	6,8	7,3	8,4	9,0	10,0	8,9	5,0	13,9	2253
26	8,3	7,1	6,5	6,5	6,2	6,6	6,7	6,2	6,0	6,1	7,5	7,9	7,9	8,0	7,8	8,0	8,3	8,3	7,8	8,1	7,1	6,2	5,4	-	7,2	13,9	1312

Source: South African Weather Service (SAWS)