



**INVESTIGATING SUCCESSES AND FAILURES OF IMPLEMENTING GREEN  
INFRASTRUCTURE AS A WAY TO ENHANCE SUSTAINABILITY  
-THE CASE OF TBILISI, GEORGIA**

**Supervisor: Dr. Tsepang Leuta**

**ANN TAVDGIRIDZE**

**Student Number: 2371485**

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of Masters of Urban Studies in the Field of  
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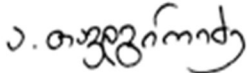


*Source: <https://www.telegraph.co.uk/travel/destinations/europe/georgia/articles/tbilisi-city-break-travel-guide/>*

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## DECLARATION

I, **Ann Tavgiridze** declare that this research report, except where otherwise indicated is my original, unaided work and has not been submitted before for any other degree or examination to any other university. It is being submitted to the Degree of **Master of Urban Studies in the field of Urban Management** to the University of the Witwatersrand, Johannesburg.



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Ann Tavgiridze  
March 2021

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## ABSTRACT

This study conducted an analysis of the Green Infrastructure Policy in Tbilisi, Georgia with the aim of determining its failures and successes. Green infrastructure is the interconnection of elements such as green areas, and natural features of the surroundings. Through the scrutiny of various documents such as the Green City Action Plan and other secondary sources, the study was able to determine the successes and failure of implementing green infrastructure in Tbilisi, Georgia. The sources showed that the city has not improved its infrastructure, which has further delayed its sustainability goals. Besides, the realization of the Green Infrastructure Policy in Tbilisi faces other problems such as lack of community participation. The researcher used case study analysis to develop the findings. Further, the study sought to determine whether implementation of green infrastructure has any effect on air pollution. The study found out that there exist both successes and weaknesses of the Green Infrastructure Project in Tbilisi.

**Key Words:** Green Infrastructure, Tbilisi, sustainability, urban, Green City Action Plan, air pollution

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## ACRONYMS

| Abbreviations | Definitions                                                             |
|---------------|-------------------------------------------------------------------------|
| <b>CABE</b>   | Commission for Architecture and the Built Environment                   |
| <b>EBRD</b>   | European Bank of Reconstruction and Development                         |
| <b>EU</b>     | European Union                                                          |
| <b>GCAP</b>   | Green City Action Plan                                                  |
| <b>GDP</b>    | Gross Domestic Product                                                  |
| <b>GIP</b>    | Green Infrastructure Project                                            |
| <b>GREET</b>  | Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation |
| <b>GTU</b>    | Georgian Technical University                                           |
| <b>LUMP</b>   | Land Use Master Plan                                                    |
| <b>NEEAP</b>  | National Environmental Education Advancement Project                    |
| <b>NUAF</b>   | National Urban Assessments Framework                                    |
| <b>RSS</b>    | Really Simple Syndication                                               |
| <b>SA</b>     | South Africa                                                            |
| <b>SEAP</b>   | Sustainable Energy Action Plan                                          |
| <b>SMSG</b>   | Sustainable Mobility Strategy in Georgia                                |
| <b>UHI</b>    | Urban Heat Island                                                       |
| <b>UN</b>     | United Nations                                                          |
| <b>US</b>     | United States                                                           |
| <b>WB</b>     | World Bank                                                              |
| <b>WHO</b>    | World Health Organization                                               |

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## CHAPTER 1. INTRODUCTION

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This research project sought to investigate the successes and failures of green infrastructure development for city sustainability in Tbilisi. Particularly, it sought to address the extent to which air pollution caused by vehicles has been reduced as a result of the implementation of the Green City Action Plan (GCAP). A green environment is not among the top priorities for most emerging nations. However, it plays a considerable part in the formation of harmony between city needs and livelihoods. Green infrastructure planning is a natural environmental management approach that entails the protection and restoration of the natural environment (Szalavetz, 2018). It is a suitable technique that fosters safety in the community by enhancing the quality of life.

Green infrastructure remains a pertinent issue **currently**. Since the last two decades, governments across the world have been creating awareness on green infrastructure and inputting various measures to ensure that cities and towns become more habitable. Climate change has been accelerated by the rising emissions from vehicles as well as industrial fumes (Tyabashe, 2018). As a result, policy makers have been keen on incorporating sustainability considerations into urban as well as industrial development. Social responsibility as well as sustainable development in the recent past have become increasingly essential strategies for businesses in almost every industry. **The main** roadmap towards sustainability in towns and cities is green infrastructure. In the recent past, green infrastructure has been used as a guiding principle towards sustainable land use.

While the approach to green infrastructure is gaining emphasis each and every day, it still remains an elusive term. One of the major reasons for the elusiveness is that it employs a broadness of scale. While the term can be used to address regional and national ecological networks, it can also be used in local storm water management projects (Tyabashe, 2018). Thus, one will need to

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clarify the scale he or she is using the term green infrastructure. This makes it easier to understand as well as apply.

Green infrastructure can be understood from different approaches. These approaches include integration, multi-functionality, and connectivity. By integration, it means that green infrastructure planning is supposed to consider making the urban centres greener and also integrate urban green with other urban infrastructures (Salata & Yiannakou, 2016). This includes the transport infrastructures, built-up water management structures. For example, in an effort to ensure that the urban centre becomes habitable and improve its sustainability, air pollution will be one of the factors to consider. In addressing air pollution, it is not possible to ignore the transport infrastructure, which is a major contributor to air pollution in urban centres.

Some of the techniques employed for strengthening green infrastructure include planting trees and restoring wetlands. Planting trees is an effective means of restoring the natural water cycle instead of temporary techniques such as building costly water treatment plants. Planting trees also makes the city look attractive and appealing.

This study focused on the public spaces in Tbilisi, the capital of Georgia. The city's municipality is actively working on improving its infrastructure and environment. Notably, the Green Infrastructure Project (GIP) of Tbilisi is an integration of existing and operational land use. Tbilisi, just like most cities in the world, is highly congested. The city does not intend to develop the green infrastructure on new land.

## **1.1 Background**

The interest in the topic arises out of the importance of improving society living through green sustainability. Green infrastructure is the interconnection of elements such as human-made systems, green areas, and natural features of the surroundings. According to Tzoulas *et al.* (2007),

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loss and degradation of urban and peri-urban green space could affect ecosystems and the overall health and well-being of humans. A significant association exists between green space, ecosystem and human health. Similarly, Mell (2009) argued that green infrastructure aids in the regulation of urban climate, water management, and provision of green networks in an urbanized area. Green infrastructure is an integral part of a city's welfare so it has a role in the city's sustainable development.

Cities are the primary engines of social, economic, and technological development. According to the 2018 World Census, 50% of the world's population lives in cities (Szalavetz, 2018). The underlying estimates are that the number of people in towns could increase to 60% by 2030 (European Bank for Reconstruction Development (EBRD), 2017). Notably, cities are a source of different environmental impacts. Most of the green concerns for cities are air quality, traffic congestion, and limited green spaces. Other issues are related to the limited land and water resources. Szalavetz (2018) stipulates that activities within towns and various arrangements of landscape features affect the quality of life. Thus, cities need to consider implementing green infrastructure to improve their sustainability. For this to be possible, it is essential to find the relationship existing between environmental aspects and economic and social issues (Mecca, 2019). The shift towards the development of green infrastructure is aligned to the sustainability mission of the United Nations (UN) (EBRD, 2017). Governments and civil society have various actions that aim at addressing the deteriorating conditions of urban cities, and the City of Tbilisi is no different.

## **1.2 Problem Statement and Rationale**

Urbanisation interferes with the balance of nature and hence the adverse impacts on the environment. Tbilisi city management has implemented a plan that is meant to yield a positive

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influence on the environment and result in social and economic benefits. The GCAP utilises the existing land instead of development of the green infrastructure on new land spaces. Importantly, the city has a higher population residing and working in the area. Also, there are many structures within the city. All these factors could inhibit the development of green infrastructure due to limited space. Notably, the city has not improved its infrastructure, which has further delayed the implementation of its sustainability goals. Tbilisi has half a million vehicles that are specified as old (more than ten years old) (World Health Organisation, 2017). They tend to cause more pollution because most of them are use diesel. All the above challenges contribute to increased pollution in Tbilisi which the GIP sought to address.

The city faces various environmental challenges that hinder its realisation of sustainability. In the year 2017, activists in Georgia protested against the city government of Tbilisi with claims that it was inefficient in reducing air pollution (World Health Organisation, 2017). The main problem addressed in this research is the increased pollution in Tbilisi. Although there are different kinds of pollution in the city, air pollution has been selected as the focus for this research. The aim is to understand whether the GCAP is effective in reducing air pollution and thereby enhancing sustainability by analysing the strengths and weaknesses of the project and the integration of green infrastructure in open spaces in the city.

The research is worthwhile since it aims at identifying flaws in the green infrastructure development plan of Tbilisi City. Such faults could hinder the successful implementation of the project.

### **1.3 Objectives**

The primary objective is to determine the successes and failures of the city's plans to implement and integrate green infrastructure elements with the end goal of improving

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sustainability in the city. The goal of the study is to determine the extent to which the implementation of green infrastructure has reduced pollution.

#### **1.4 Main Research Questions**

*The main research question is:*

What are the successes and failures of the Tbilisi GCAP in implementing green infrastructure as a way to enhance sustainability?

*The sub-questions are:*

- i. How does the City of Tbilisi understand the role of green infrastructure in reducing air pollution with an end goal of enhancing the city's sustainability?
- ii. What are the strengths and weaknesses of the GCAP in Tbilisi?
- iii. What barriers constrain the implementation of the GCAP in the City of Tbilisi?

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## CHAPTER 2: LITERATURE REVIEW

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### 2.1 Introduction

The aim of this literature review chapter is to explore what other researchers have contributed regarding the role of green infrastructure in making cities more sustainable. The chapter seeks to highlight common themes that have been explored by different authors and literature and review their findings, and identify gaps. To ensure that as much information on green infrastructure has been covered, the chapter relies on an array of sources which present different but significant perspectives of green infrastructure development in different countries across the globe.

Green infrastructure is a form of innovation aimed at enhancing the functioning of the built environment and protecting biodiversity. It contributes to sustainability and smart growth. According to Quintero (2012), the development of green spaces is one of the frameworks for biodiversity enhancement in urban areas. It leads to the restoration of degraded natural infrastructure in urban centres hence enhancing ecosystem services and adaptation to climate change. Quintero (2012) argued that developed towns could face immense challenges in their move towards green urbanisation due to the presence of inhabitants and the lack of development space.

### 2.2 Understanding Green Infrastructure

A majority of nations across the world, such as the United States (US), are shifting towards green infrastructure in their cities. The need to conserve the environment as well as rely on safer means of maintaining cities has led to the embracing of green infrastructure (Chapin & Coutts, 2016). While there might be no straightforward answer to this, many authors have tried to give an explanation as to what green infrastructure refers to. In a study conducted by Sturiale and Scuderi

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(2019), green infrastructure is defined as a network of natural areas that are planned at strategic levels with other environmental elements. They are aimed at and managed to offer a wide and broad spectrum of ecosystem services. In this study green infrastructure will be viewed from the angle of planting trees and restoring wetlands, restoring floodplains, controlling water flow and conserving ecosystem values.

Sturiale and Scuderi (2019) stated that the use of the term green infrastructure was first used when people realized the need to use alternative means to manage the ecosystem. Green infrastructure is related to landscape resources and places a great emphasis on ecological connectivity. Sturiale and Scuderi (2019) stated that green infrastructure is aimed at serving several functions, among them conserving and restoring biodiversity by way of increasing landscape permeability as well as providing means that mitigate fragmentation.

There exist fundamental links between urban green and impacts on climatic conditions coupled with the reduction of the heat island effects. Trees and parks provide cool and shaded areas and also protect from solar radiation. Green infrastructure is seen through actions such as provision of clean water and the conservation of the ecosystem values (Chapin & Coutts, 2016). This is a major reason why cities across the world are in a hurry to embrace the green infrastructure strategy. Since green infrastructures entail the inclusion of vegetation in the conservation process, the vegetation that is used on the outside of buildings helps a lot to balance the temperatures inside.

While there exist several definitions and understanding of green infrastructure, this current study relies on the definition by Sturiale and Scuderi (2019) which states that green infrastructure is aimed at serving several functions, among them conserving and restoring biodiversity by way of increasing landscape permeability as well as providing means that mitigate fragmentation and

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**reducing pollution.** This research runs with this definition because it fits to the Tbilisi GIP which is aimed at rehabilitating the city of Tbilisi and making it more habitable.

### **2.3 Global Development Frameworks and Georgia's Legislation and Policy**

The world is united towards fighting global warming and climate change. Pollution is one of the factors that lead to climate change. Green infrastructure frameworks such as the National Urban Assessments Framework (NUAF) have been applied in countries such as the US, Germany, Mexico, and South Africa (SA), among others in their attempt to address air pollution challenges in the cities (Hansen & Pauleit, 2014). This has seen some countries such as SA ban the importation of vehicles that are very old to reduce the extent of emissions in their streets (Hansen & Pauleit, 2014).

Particularly, Germany has developed a NUAF that is aimed at establishing an urban profile and identifying strategic priorities for targeted investments in the urban sector by putting into consideration the challenges and issues that affect urban development in the country (Hansen & Pauleit, 2014). Through this framework, Germany intends to understand the major urbanization trends in a bid to identify the challenges and opportunities that are present.

The global development frameworks like NUAF are aligned towards ensuring that the urban centres become the centre stages for controlling climate change. As a result, the Green Infrastructure Policy has been embraced across the globe as the major **support** towards having a safer environment (Ghosh, 2020). Germany's framework rested on three key analytical phases, namely urban profile and analysis, urban vision and strategic prioritization, and urban action (Hansen & Pauleit, 2014). The urban profile and analysis presupposed the identification of area within the city that the green infrastructure plan is conducted on. The urban vision entailed aligning

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the project to the visions of the city and urban action required the actual implementation of the green infrastructure on the identified areas.

### ***2.3.1 Efforts to Implement the Green Infrastructure Policy***

Fiksel (2006) looked at the various changes that are being observed in cities as governments try to deal with the various challenges that face their cities in this era. Fiksel (2006) stated that the global economy is faced with unprecedented challenges, especially in its effort to meet the needs for energy and mobility, which are increasing every day. There is always the nagging question about how the increasing energy and mobility services can be sustained without compromising future generations. Specifically, the energy and transportation industries are looking at a very broad portfolio where alternative energies can be used to mitigate some of the effects caused by the energies in use (Ghosh, 2020). However, there is always the challenge that the future social, economic, and environmental conditions still remain vague. It is not very clear how the future will appear.

Some of the efforts that have been applied to deal with the current situation as well as the future prospects include the well-to-wheels life cycle modelling, complexity science and sustainable mobility, and systems impacts of alternative fuels (Ghosh, 2020). Well-to-wheels life cycle modelling is concerned with the dependence on oil and greenhouse gases (Fiksel, 2006). These are considered as some of the leading causes of pollution in cities due to their high usage, especially the use of oil in industries and the transport system. To address this concern, green infrastructure supports the use of new fuels which are more environmentally friendly such as the use of hydrogen and biofuels, which are being championed for in advanced hybrid electric vehicles. The development of Greenhouse Gases, Regulated Emissions, and Energy Use in

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Transportation (GREET) model for well-to-wheels is a major step that is aimed at reducing emissions in vehicles. This model concentrates on two major stages. The first stage is well-to-pump, while the second one is pump-to-wheels. It addresses the life cycle resource use coupled with the emissions that are related to the production, delivery, use, as well as the disposition of both fuels and vehicles (Sturiale & Scuderi, 2019). A keener analysis of future technologies shows that hybrid-electric engines that use hydrogen fuel cells may be the best for the environment as they provide the best combination of greenhouse gases reduction and the emission of nitrogen in the urban areas.

The Sustainable Mobility Strategy in Georgia (SMSG) is aimed at seeking robust high-leverage solutions to the ever-increasing challenge of the unsustainable transportation and urban development patterns (Fiksel, 2006). There are efforts from across the globe to develop agent-based and system-dynamics models based on the evolution of the hydrogen infrastructure. This strategy focuses on the use of advanced biofuels, which are able to conserve the environment and have fewer emissions, which can lead to pollution of the environment. It also focuses on the use of hybrid vehicles in some of the world's megacities.

Systems' impacts of alternative fuels look at the best types of fuels that can be used that are more environmentally friendly. The use of fuel in the transportation sector is almost inevitable (Ghosh, 2020). Sadly, this fuel contributes to climate change and pollution. The use of bio-based fuels, which is being championed by different parties may imply the utilization of agricultural pesticides. This poses a great challenge as a result of the complexity of the supply chains and the uncertainties in data and models (Fiksel, 2006). Researchers are looking at the full life cycle impacts of the emerging technologies. Some of the fuels that are being studied to determine their impacts include ethanol, gasoline, hydrogen, and biodiesel.

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Although there is evidence that a lot of progress has been achieved, the complexity of sustainable energy remains daunting. In the current economy, it becomes very difficult to deconstruct the interrelationships among global energy flows (Ferreira et al., 2019). The concerns of global warming still remain an issue despite the fact that almost every nation in the world has contributed in one way or another to the fight against global warming. The impacts of electric power generation, coupled with internal combustion engines, are some of the major contributors to today's global greenhouse gas emissions (Sturiale & Scuderi, 2019). Some of the ways that have been employed to reduce the emissions include the dependence on carbon trading mechanisms as well as carbon emission inventory protocols. Despite this, the best protocols developed so far do not seek to address the issue of carbon management projects. However, the protocols include the procedures for life cycle analysis of secondary greenhouse gas effects.

With the current technologies, it may be possible to introduce market-based systems, which may lead to a reduced rate of emissions. Some of these market-based systems are cap-and-trade. Nations such as the US are also utilizing strategic adaptation as ways of dealing with greenhouse gas emissions (Ferreira et al., 2019). Even with this, it is important to note that adaptation to climate change is not an easy step but one that requires serious consideration. Nations, such as those in the tropics, are at the highest risk. The reason for this is that the variability of temperature is lower in the tropics than at the higher latitude areas. Thus, effects of global warming in the tropics are felt more than at the higher latitudes. To have strategic adaptation work effectively, global cooperation is essential among different nations (Fiksel, 2006). This task cannot be left to one nation. Besides, it will require large scale engineering and infrastructure investment as a way of reassuring the resilience of human society to ecosystem disruptions.

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## 2.4 Benefits of Green Infrastructure Development in Cities

### 2.4.1 *Environmental Benefits and Social/Health Benefits*

The green infrastructure in cities has both direct and indirect benefits to human beings. Green infrastructure makes it possible for cities to adapt to climate change and be able to institute measures that mitigate the effects of pollution (Ferreira et al., 2019). Some of the procedures include air purification, noise reduction, global climate regulation, and runoff control. Besides, it helps in temperature regulation. Runoff is considered one of the major causes of illnesses in cities. As water flows uncontrollably, it may mix with sewage waste and spread infections such as cholera, typhoid, and bilharzia, among others (Sturiale & Scuderi, 2019). To curb such effects, green infrastructures offer alternative means of managing wastewater, runoff, and sewage water. This way, residents are prevented from dangers such as diseases and illnesses. Studies such as one by Fiksel (2006) have shown that there exists a major and essential link between urban greening and impacts on climatic conditions. For example, parks and trees are essential since they provide shaded areas under which people can relax and also help to cool the air. Besides, parks and trees offer plant cover, which reduces erosion from runoff as well as makes the city less dusty. It is also essential to note that parks and trees protect from solar radiation. Sturiale and Scuderi (2019) also noted that the integration of vegetation on the roofs of buildings and facades boosts environmental aesthetics.

Successful implementation of the green infrastructure development strategy would help the city inhabitants to enjoy some benefits. According to Rostami *et al.* (2015), green spaces stimulate a sense and appreciation for nature. In particular, the implementation process should involve community members, identification of their needs, and satisfaction. The study by Rostami *et al.* (2015) has shown that green spaces in cities cause positive feelings that include happiness and a

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positive mood. Urban green areas are a place of memory, identity formation, and belonging that enrich human life. Thus, green spaces enhance the overall quality of life among citizens, which is a significant component of sustainability.

The study by Rostami *et al.* (2015) is essential in this project since it identifies the importance of green infrastructure development. Ecosystems can produce both services and disservices. Some of the services resulting from ecosystems are environmental protection, among others. Further, Harrison *et al.* (2014) assert that green infrastructure has some unique benefits. More so, it leads to the resolution of the main sustainability issues facing most urban centres. Most urban and regional strategies contain plans for how regions will develop and implement green spaces. Fiksel (2006) proposed the need for a better understanding on the impacts of ecological and human systems on climate change and associated policy and technological responses as a means of enhancing the development of green infrastructures. In addition to that, a multi-scale approach is critical in allowing for sustainability in cities. Understanding these functions would help in the development of ecological processes and spatial patterns in a way that leads to city sustainability.

Sturiale and Scuderi (2019) suggested that the benefits of green infrastructures also improve land management. Regarding the health and wellbeing of people, green infrastructure is beneficial in that it helps in increasing the life expectancy as well as reducing health inequality, improving mental wellbeing and social health (Fiksel, 2006). Green infrastructure also improves the usability of the land and makes the land look beautiful, clean, and more attractive (Fiksel, 2006). This is best seen, especially where different trees have been planted or when the trees have flowered. The city looks very appealing, and the scent from those flowers is also aromatic.

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Green Infrastructure Policy strategies are also beneficial to wildlife and habitats. It is to be noted that cities and towns are not only inhabited by human beings. There also exist animals, insects, and birds that require a conducive environment to thrive (Ferreira et al., 2019). Green infrastructure makes it possible to protect **some of the endangered** species that cannot thrive in an unprotected area. Besides, it makes it possible for species to move freely without any interference (Sturiale & Scuderi, 2019).

## **2.5 Green Infrastructures as Tools for Climate Adaptation**

Cities across the world are grappling with the negative effects occasioned by effects of climate change. Different studies, such as Haaland and van den Bosch (2015), have focused on how climate change has led to **poor** livelihoods in the cities. As such, there have been measures that have been put in place to help curb pollution and climate change. The European Union (EU), for instance, has developed a strong strategy to fight against climate change as well as enhance environmental protection. The EU has developed measures that are aimed at mitigation and adaptation. Sturiale and Scuderi (2019) observed that urban adaptation strategies usually revolve around the citizens as well as other relevant stakeholders who are actively engaged in the championing and installation of interventions that have the ability to solve the existing problems and bring immediate merits to increase adaptive capacity. This shows that citizens are at the **centre** stage of implementing green infrastructures. Without their input and commitment, then realizing tangible results from the strategy might prove impossible.

Sturiale and Scuderi (2019) noted that climate change could only be solved if innovative solutions are employed and new tools for urban planning installed. Besides, an increase of green areas, the use of advanced technologies to mitigate all types of emissions, and having new urban structures promote adaptation to climate change. Green infrastructure is associated with green

space, wetlands, waterways, forestry, parks, and urban gardens, among others (Jafari et al., 2019). As such, the green infrastructure is mainly aimed at making urban centres better places with lesser pollution. Waste products are also disposed of in a better manner so that they do not lead to pollution.

The figure below shows the link between green infrastructure and climate control. The disturbed village landscape shows an area on which green infrastructure has not been implemented. It is compared with the other areas where green infrastructure has been implemented. Climate control is best in areas such as the forested hill landscape which acts as the source of many rivers.

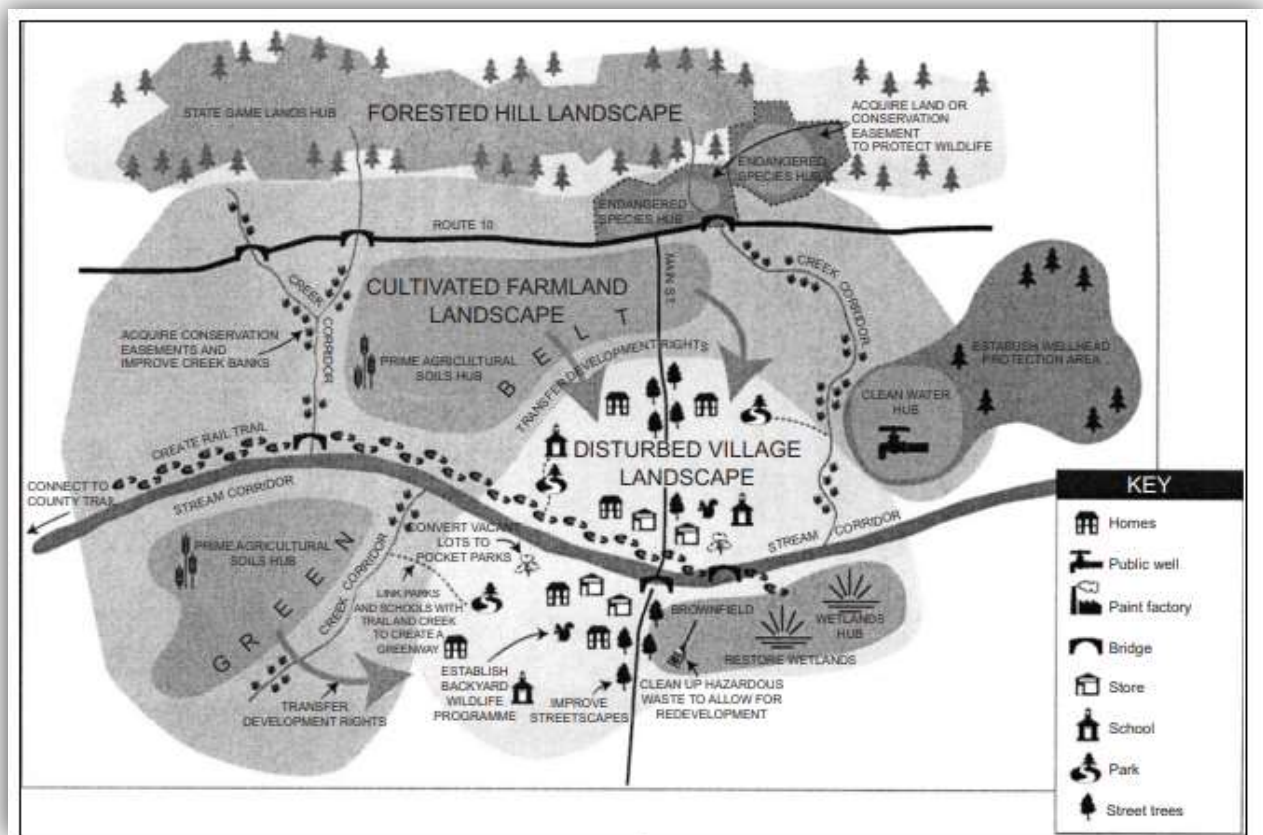


**Figure 2.1: Linking green infrastructure concepts with climate control. (Source: Mell, 2009).**

Figure 2.1 shows the difference between a properly maintained landscape and another one that is not taken care of. The area labelled “disturbed village landscape” shows an area that lacks

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trees and shrubs. This is contrasted to the “Green Belt” that has trees on it. The forested hill landscape and the street trees are essential in the climate control of an area. Conservation of land also helps in climate control. This is what green infrastructure is concerned with.

### ***2.5.1 Green Infrastructure and Climate Change***

For a long time, green infrastructure has been seen as a concept that has a potential role in combating the effects of climate change. As mentioned earlier, climate change is a global disaster that everyone is trying hard to defeat. However, the success story is yet to be written, if ever it will be. Mell (2009) argued that green infrastructure is one of the best ways that nations can embrace to fight climate change. The author notes that when cities and urban centres focus on green infrastructure, they help to develop and maintain their ecology. It is to be noted that ecological resources offer ecological sinks that help to mitigate environmental change. When this is done, Mell (2010) argued that this is achievable by ensuring that larger expanses of flora and fauna are developed.

In addition, the development of ecologically essential infrastructure is a long term environmental investment whose effects are felt by generations to come. For example, a tree planted in the city or a park that is well conserved will live to benefit generations to come. In this regard, trees, parks, and gardens are known to hold great ecological value. If addressed from a larger green matrix of urban and urban-ridge environments, the resources such as these just reveal how it is essential to create green spaces as they mitigate against the effects of climate change.

Climate change is caused by, among other things, environmental pollution (Chapin & Coutts, 2016). Aspects such as stormwater runoff, emissions from vehicles and industrial emissions are some of the cause of pollution. Green infrastructure reduces the pollution by ensuring that rainwater is properly harnessed and directed to areas where it cannot cause pollution

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or destruction (Chapin & Coutts, 2016). Besides, when stormwater is not properly harnessed, it can cause erosion, property destruction and flooding in urban streams. Green infrastructure entails the treatment of stormwater at its source therefore reducing possible cases of pollution. Planting of trees in the urban centres helps to reduce and slow stormwater by intercepting precipitation in their leaves and branches.

Firehock (2016) opined that some urban centres have established the use of green roofs. These are roofs that are covered with growing vegetation which enable evapotranspiration and rainfall infiltration of stored water. The use of green roofs has been beneficial where land values are high and stormwater management costs are high (Chapin & Coutts, 2016). Therefore, green roofs are effective means of managing stormwater as well as reducing energy costs for cooling.

### ***2.5.2 Green Infrastructure Promotes Urban Sustainability***

Mell (2009) conducted a study named “Can Green Infrastructure Promote Urban Sustainability?” In this study, Mell (2009) assessed the link between green infrastructure and urban sustainability. Mell (2009) termed green infrastructure as the green spaces that are located within the urban areas that offer social and economic benefits to the people. Additionally, these spaces also offer ecological benefits and promote sustainable living. In this regard, Mell (2009) suggested that green infrastructure is one of the best ways through which urban sustainability is achieved. Green infrastructure makes it possible to have areas within the cities that provide unlimited benefits to a bigger population. Despite the wide range of benefits arising from green infrastructure, there are various underpinning principles that come into play that must be addressed any time green infrastructure is involved.

Authors such as Fiksel (2006) have viewed green infrastructure as a tool that supports conservation goals. Besides, green infrastructure provides better avenues for getting better water

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for use within urban centres, which supports sustainability in those areas. It is to be noted that water is a basic need both for human consumption as well as for use in industries. Therefore, lack of clean water for use in urban centres may affect them adversely (Chapin & Coutts, 2016). Green infrastructure comes in to fill this gap by ensuring that there is a steady provision of clean water for use in urban centres.

Conservation of the environment and resource accumulation are some of the primary principles which are essential in cities, especially if there is to be the promotion of long-term sustainable land use. There exists a wide range of research conducted by different authors to determine what green infrastructure focuses on and whether it is economically viable or not. In another study that shifted the focus, Salata and Yiannakou (2016) conducted a study in the United Kingdom that found out that green infrastructure entails connecting the people with the environment. As such, it entails developing better access to green spaces across various urban centres. While these two studies cite different aspects of green infrastructure, it is evident that they both agree on the fact that green infrastructure aims at conserving the environment within the urban centres and making it habitable for human beings.

Mell (2009) found out that the success of green infrastructure lies in the guidelines developed, and it also borders on a checklist that needs to be fulfilled. The checklist comprises of social cohesion, regeneration, access to green spaces, linking people to local heritage, creating attractive places to live, and developing places for exercise and recreation. While there are other factors that are usually considered, this checklist provides some of the primary needs that should be addressed by green infrastructure.

Green infrastructure contributes to an urban renaissance (Salata and Yiannakou, 2016). A city cannot thrive without incorporating the aspects of green infrastructure. To add on to this, Mell

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(2010) stated that green infrastructure should also be placed in the same category as transport or services. These are essential aspects of any urban centre, and they have to be addressed exhaustively to ensure that the urban centre progresses (Chapin & Coutts, 2016). Thus, the role of green infrastructure in enhancing proper mobility, education, and health needs to be emphasized in the entire green infrastructure plan.

Mell (2009) stated that urban authorities need to be compelled to institute green infrastructure policies in their renewal plans. However, there is a major challenge among those that are focused on the implementation of green infrastructure policies since most of them seem to be doing it for economic gains. The danger of this, Salata and Yiannakou (2016) argued, is that the objectives of green infrastructure are not met since the intention is already skewed. Besides, cities are bound to put insufficient or weak green infrastructure structures as long as they fulfil their economic obligations.

In the United Kingdom, the Commission for Architecture and the Built Environment (CABE) played a great role as an advisor to the government. The primary work of the commission was to design, review and support as well as provide guidance to planning on public space. The membership of the commission comprised of academics and professionals who guided the renovation of cities. As Vandergert *et al.* (2012) observed, CABE was intended to provide direction on climate change mitigation and adaptation as well as make the emerging concept of green infrastructure known to people and lay down a foundation for its support. The CABE Sustainable Cities Framework is shown below.



**Figure 2.2: CAFE framework. (Source: Vandergert et al. (2012)).**

The CAFE Framework shared above shows the evolution of green infrastructure and identifies the range of spatial scales at which advice as well as guidance may be useful. The framework starts by identifying the most important spatial scales such as regional, sub-regional, city, site and building then looks at the themes that are most appropriate. Some of the themes include energy, water and transport among others. After the identification of the themes, the advice is sought through policy, practice and case studies (Chapin & Coutts, 2016). The use of the CAFE framework in this research is essential as it shows the various processes that are considered in changing the face of urban areas. CAFE framework shows how factors such as climate change affect the environment and also proposes the policies that can be used to address such challenges.

### **2.5.3 Green Infrastructure and Urban Renaissance**

Green infrastructure planning should be a major consideration for any urban centre. Mell (2009) noted that green infrastructure is essential. Still, if it is meant to enable increased human

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integration and economic regeneration, then various social and political factors need to be taken into account. In major cities across the world, there has been more emphasis on the development of urban areas with very little concentration on thoughtful design and planning (Chapin & Coutts, 2016). Additionally, very little consideration has been placed on traditional values such as those of cohesion and integration.

This needs to be reversed and more energy dedicated to proper planning of urban centres to ensure that integration and cohesion are given a high priority. Mell (2009) noted that this is what green infrastructure seeks to achieve. Green infrastructure supports urban renaissance by offering spaces that have the capacity to promote communal inclusion and use. Despite its importance, green infrastructure is not an easy project to integrate into existing land uses. It requires proper planning and enough time to realize (Sturiale & Scuderi, 2019). During the planning process, green infrastructure needs to be planned with the functions which they are to fulfil in mind. One of the major considerations is that green infrastructure must entail designing landscapes that provide a number of benefits to the involved community. Besides, the community needs to be involved in the planning process to ensure that they do not offer resistance or provide a hostile environment for development (Sturiale & Scuderi, 2019). Thus, for people to use a space, landscape functionality must be considered an essential component of development. Green infrastructure is seen as a better way of achieving this in an urban setting. Besides, it provides various simultaneous functions such as general wellbeing, recreation, and health. In this sense, green infrastructure development requires a systematic approach.

## **2.6 Challenges Facing Green Infrastructure Development in Cities**

The green infrastructure development in cities is hailed as a great **plan** but it faces several challenges. While some challenges may be specific to certain countries, there are others that cut

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across the board. Different nations are in a rush to find long-lasting solutions that may keep their cities safe and habitable. One of the major challenges is funding (Sturiale & Scuderi, 2019). There are a lot of funds and resources that are required to ensure that green infrastructure has been successfully implemented. The expenditure begins very early in the planning process until when the projects are implemented (Ferreira et al., 2019). Different cities have various terrains and to make them suitable for projects such as planting of trees requires a lot of capital. As such, some cities may require to spend more than others.

Another major challenge that is facing green infrastructure development is the political climate. Although there are efforts towards the implementation of green infrastructure, the purposes for urban change is understood differently by various parties. For instance, the political climate lays greater emphasis on the economic value of landscapes as opposed to what green infrastructure is supposed to address. Nations are **failing the** moment they attach economic value to green infrastructure development (Sturiale & Scuderi, 2019). Green infrastructure is supposed to enhance sustainability and urban renaissance but should not be considered as a profit-generating venture. If anything, it is the cities that are supposed to pump money into the project but not the other way round. This study agrees with these findings since the major role of green infrastructure should be to make the city more habitable but not a project for income generation.

Mell (2009) noted that cities across the world are not **keen** about health and psychological benefits that are associated with green infrastructure. He also noted that most planners are concerned about the economic benefits. Sadly enough, as Mell (2009) observed, the health and psychological benefits arising from green infrastructure development do not seem to have as much value as the financial **realizations** that arise from housing development. In most cases, the

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ecological and social functions of landscapes are held in low regard when compared to the economic incentives of development (Mell, 2009).

While regions such as Georgia are better ranked in terms of the innovation index, most of other countries are usually below the national average. The innovation index aims at looking at the extent to which a city or country utilizes technology in running its affairs (Tyabashe, 2018). The differences in these are rooted in various factors such as infrastructure, education as well as knowledge generation capacities in these regions. Considered cumulatively, the level of innovation in Georgia is low (Tyabashe, 2018). There lacks adequate human power to come with innovative measures to deal with some of the problems that hail the country.

Most cities in the world today have shown their dedication towards enhancing sustainability by green infrastructure development measures (Zuniga-Teran et al., 2019). The changes in the climatic conditions and the rising health issues due to the low air and water quality have contributed towards the greening approaches in Tbilisi. Such factors have created the need for cities to enhance resilience through green infrastructure development (Zuniga-Teran et al., 2019). In a bid to understand the challenges likely to influence green infrastructure development in Tbilisi, it is essential to understand the influence of different elements of green infrastructure, as proposed by various scholars. Notably, green infrastructure contains elements such as trees, forests, swales, rain gardens, green roofs, and wetlands, to mention a few. Developing green infrastructure is dependent on vegetation and soil suitable to support the green coverings (Staddon et al., 2018). However, the implementation of these factors would depend on the level of acceptance by the surrounding communities. Notably, green infrastructure has a significant impact on the people residing in a city. Enhancing community acquiescence would require a demonstration of how green infrastructure development enhances social inclusivity and overall

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well-being. Quintero (2012) stated that communities could appreciate the new green spaces if they help in improving their health and in instances where they reduce the living costs.

Another **important** issue likely to develop from the implementation of green infrastructure in cities is the development of a new green space. Most world cities are densely populated due to the rising number of people that have shifted from rural to urban areas in search of economic opportunities and services. Haaland and van den Bosch (2015) claimed that the unavailability of space is one of the issues prevalent in cities. Thus, it adversely influences the processes of green urbanisation. The reduced space is attributed to the high population, high density of the built structures, and increased traffic. In addition to that, the tall buildings in densely populated cities hinder effective sunlight penetration that could prevent effective growth of vegetation (Haaland & van den Bosch, 2015). In addition to that, the dense structures could pose the challenge of inadequate space for the development of green infrastructure.

## **2.7 Possible Solutions to the Identified Challenges**

Funding has been identified as a major challenge of green infrastructure development. Salata and Yiannakou (2016) noted that the budgetary allocation for green infrastructure development is usually very low to achieve anything significant. This calls for cities to acknowledge the importance of green infrastructure development and allocate enough funds to be able to push the development forward. Other than government funding, cities can rely on the private sector to offer essential money towards green infrastructure development. This is referred to as diversification of sources, and this may enable governments to close the funding gap. Various sources of funding, as mentioned above, may include the incorporation of the private sector, such as banks, which may offer grants to government to enable it to develop urban centres. Mell (2009) noted that the private sector might provide funds either in the form of loans, municipal bonds, or

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through the establishment of Private-Public Partnerships. Salata and Yiannakou (2016) stated that nations such as China, Brazil, and India are among the leading nations when it comes to the sourcing of funds through the implementation of Private-Public Partnerships. From 1990 to 2014, Brazil alone was able to attain more than US\$300 million through Private-Public Partnerships (Ferreira et al., 2019). Therefore, Tbilisi may use the private sector as a major partner in ensuring that the implementation of green infrastructure is achieved.

Salata and Yiannakou (2016) also noted that land-based financing might be a viable way of sourcing funds. Economically, the value of the land increases with urbanization coupled with public investment. Since this value is usually under what is referred to as “unearned increment,” it can be realized through betterment levies, value-based annual land taxes, land readjustment, and capital gains taxes.

The political climate is another identified major setback towards the implementation of green infrastructure. Green infrastructure development is a shared responsibility, and all stakeholders need to be brought to a common table so that they can agree on how to implement green infrastructure (Sturiale & Scuderi, 2019).

Additionally, the political class needs to understand the need for green infrastructure development in urban centres. This can be achieved when the advisors to the political class are experts in urban planning and development so that they can explain to them what issues such as green infrastructure entail. In a case where all information is not divulged to the stakeholders, there is the likelihood of dissenting voices increasing, especially from the political class. There have also been reported conflicts between the national government and the municipal authorities on the developments that need to be carried out especially in the US and Mexico (Mell, 2009). Such feuds may derail the establishment of a green infrastructure **plan** (Sturia & Scuderi, 2019). Therefore,

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both levels of governance need to be aligned to the common goal to ensure that their policies are not in conflict. In this way, it would create a better chance to enable the establishment and development of beneficial programs such as green infrastructure in urban centres.

## **2.8 Renewable Energy in Context**

One of the major goals of green infrastructure is to make the use of renewable energy a norm. Forms such as solar energy, coal and diesel can be used. Cities across the world are dependent on sources of energy which lead to pollution such as diesels and coal (Sturiale & Scuderi, 2019). For instance, the use of coal is not only hazardous to the environment through pollution but also destroys the terrain of places from which it is mined, leaving dangerous holes and gullies, which may cause accidents and also prevent further development through construction of infrastructure. So far, countries such as Germany and Mexico have developed rules and policies that are aimed at moving from destructive sources of energy to renewable energy, which is considered environmentally friendly. A study conducted by Salata and Yiannakou (2016) argued that renewable energy is a major consideration for the modern cities if green infrastructure is to be achieved.

Hansen and Pauleit (2014) asserted that the efforts of the Georgian government on the adoption of alternative energy could not go unnoticed. Some of the concerns related to the adoption of renewable energy include environmental, economic, and social concerns. Walker and Salt (2006) observed that the high percentage of greenhouse gas emissions witnessed today in various cities is a result of the high dependence on fossil fuels. Some other factors that have led to an increase in the percentage of greenhouse gas emissions include the increasing urbanization and high population in cities. Unlike in the past, when urban centres were considered areas for the elite few, current dispositions have seen people leaving the rural areas and moving to the urban centres

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(Tyabashe, 2018). This upsurge in population has led to an increase in activities that have led to a rise in greenhouse emissions. Again, the increased need for use of electricity has seen some cities resort to the use of electricity from fossil fuels such as coal, which has led to environmental pollution.

A study by Tyabashe (2018) showed that countries such as SA use a lot of fossil fuel leading to high amounts of carbon (II) oxide in the environment. Currently, SA is ranked twelfth in the world in terms of the greatest emitters of carbon (IV) oxide. The reason behind this is that more than 80 per cent of the energy used in SA comes from coal (Tyabashe, 2018). Green infrastructure is championing for the reduction of the use of such fossil fuels and resort to the use of renewable energy.

Georgia has been at the forefront of discouraging the use of fossil fuels in the major cities to reduce pollution. The decision to rely on renewable energy is driven by the benefits that come from its use. One of the major benefits is that this is a cheaper and safer option when compared to other sources of energy. Besides, the use of renewable energy mitigates the impact of climate change. Poteete *et al.* (2010) noted that the use of renewable energy does mitigate not only climate change but also promotes sustainability. Cognizant of this, it is essential for the Georgian government to promote the use of renewable energy as a major step towards the reduction of carbon emissions. However, as Sturiale and Scuderi (2019) warned, it is wise that such moves be made in such a manner that the access to renewable energy will be accessible to every citizen so that some are not disadvantaged. This is more so essential to the lower class citizens who are sometimes neglected in accessing basic and primary needs.

Besides, renewable energy generation technologies are also beneficial in that they help in the saving of water. Compared to other sources of energy, such as coal, which uses a lot of water,

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renewable energy does not require as much water to generate (Firehock, 2016). Therefore, dependence on renewable energy is a major boost toward achieving the objectives of green infrastructure. Wolf (2003) observed that the provision of affordable and reliable energy to citizens underpins every citizen's quality of life. A study conducted by Poteete *et al.* (2010) showed that the rise of the global economy is usually associated with the rise in carbon emissions.

This has been the trend for a very long time as an increase in factors that lead to economic development, such as the increased operation of industries and transportation of people and goods, always lead to an increase in carbon emissions. However, with the championing of the use of renewable energy, the world is prepared to observe and increase in economic development without an increase in carbon emissions. As a result, Wolf (2003) cited that there is growing evidence that if Georgia and other nations were to commit themselves to the promotion of the use of renewable energy, then it would mean a new era for the world where the rise of economic performance does not have to be related to an increase in the carbon emissions.

While renewables are preferred in urban areas, Wolf (2003) noted that they have some disadvantages which make them limited to several uses. Some of the limitations to the use of renewables include higher upfront costs, unreliability especially depending on the weather for the day and geographical limitations. Some regions have better geography than others. For example, an area that has an open space is better suited for a solar energy system while one that has larger buildings and shades may not be appropriate for solar energy system. Despite these limitations, the use of renewable energy sources has more benefits than limitations, therefore making it applicable for use in green infrastructure.

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## **2.9 Role of Green Infrastructure in Reducing Air Pollution**

Green infrastructure plays a great role in reducing air pollution. Green infrastructure promotes healthier living, lessens impacts of climate change by reducing the amount of carbon released to the environment, improving air quality and also enhancing ecological resilience (“Using Green,” 2019). Urban air requires to be purified by reducing the amount of emission of pollutants in the air. Tremper (2018) noted that pollutants such as particulate matter and nitrogen dioxide lower the air quality especially when they are in high concentrations. Green infrastructure supports the elimination or reduction of such materials from the environment thus lowering the rate of pollution.

Green infrastructure affects both dispersion and the deposition or removal of air pollutants. By planting trees in cities, some particulate and gaseous air pollutants collide and stick to leaves thus preventing them from affecting the quality of air. Better air saves the city health costs. Tremper (2018) noted that although the benefits of deposition may not be many as it only removes a few per cent of particulate matter, which little can be very effective in enhancing the health of the residents.

Policy is a major part of the CAFE framework mentioned previously. Air pollution can best be controlled if there exist proper policies within the city to ensure its control. The development of green infrastructure in Tbilisi was aimed at, among other things, reducing air pollution. Its development was based on policies that supported means to reduce air pollution and make the city a better place to live and do business.

Tremper (2018) addressed the contribution of green infrastructure towards reducing air pollution. There exists a close nexus between green infrastructure and air pollution. Where green infrastructure has been well developed, there is a better air quality as opposed to areas with poorly

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instituted green infrastructure (Firehock, 2016). As this study has shown, green infrastructure can lead to decreased air pollution as is the case in Tbilisi.

### ***2.9.1 Ecosystem Disservices***

While the ecosystems may have positive contribution to the life of people, there are times when they may have negative effects. Every organism has its role and purpose in an ecosystem (Chen et al., 2017). Effects such as deforestation destroy the ecosystem by enabling long term effects such as global warming. Thus, when the ecosystem is not taken care of, it ends up causing more harm than good to the people. In urban centres, humans destroy ecosystems by overusing natural resources and creating pollution (Abhijith et al., 2017). Human beings destroy trees and dispose of waste products anyhow and this causes harm to the ecosystem.

### 2.9.2 Conceptual Framework

The best framework for the successful implementation of the GCAP in Tbilisi is provided below and it involves three systems that include the ecosystem services, ecosystem health, and the wellbeing of humans. In the framework below, one can see the relationship existing between the ecological benefits of green infrastructure and the value for humans. Successful implementation of green infrastructure could lead to enhanced human health and wellbeing of the people. At the same time, it also ensures the maintenance of environment and natural resources. The framework below shows a model that could help in measuring the success and overall performance of a GIP. Land ownership issues/diminishing land resources, community resistance and poorly understanding the objectives of the plan are some of the elements.

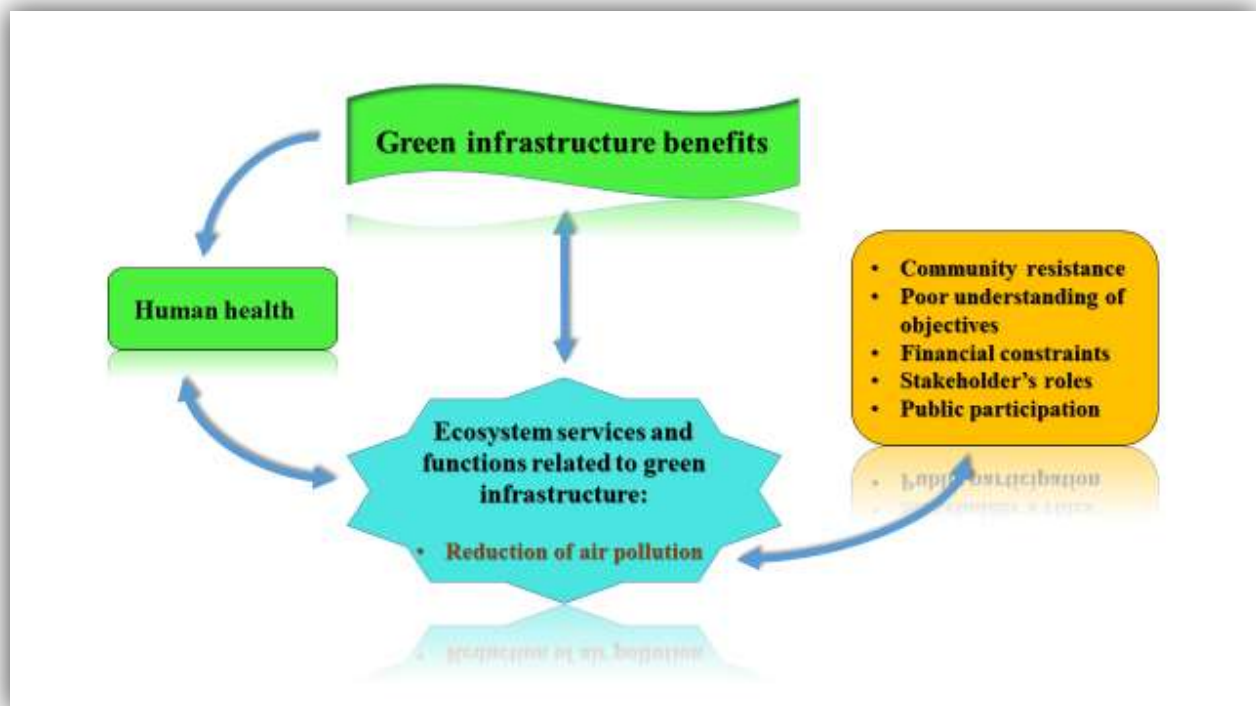


**Figure 2.3: Conceptual Framework**

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Due to the great variety of the benefits that can be linked to green infrastructure as it relates to human health, urban ecosystems, and human well-being, it is clear that various integrative frameworks have been designed to link human and ecosystem health (Mell, 2010). While there are several such frameworks, one of them is the human ecosystem framework. This framework was developed from the human ecosystem model. Its main aim was to study social-ecological systems in urban areas. It can be viewed as an integrated analytical framework that can be useful in the analysis of urban systems such as social, physical, and biological complexes (Tyabashe, 2018). This framework is made up of two interconnected patterns that help the researcher in conducting the analysis. These parts include the human social system and the resource system. The former includes social cycles, social order, and social institutions, while the latter includes cultural and socio-economic resources as well as the ecosystem structure and processes.

The human ecosystem framework was developed so as to address the interactions of ecological and social systems in cities. The framework addresses important variables, feedbacks, and interactions that are connected to land use change (Mell, 2010). The model makes it possible to have a proper understanding of the role of green infrastructure in urban areas. Besides, it helps in the understanding of the interactions between green infrastructure and urban social systems.

A model by Mell (2010) of environmental effects on physical and mental health can also be used in relation to green infrastructure. This model looks at the relationship between mental health and physical health and the environment. The model stipulates that there exists a connection between the environment and the health. In this regard, a properly conserved environment is associated with positive mental and physical health, while that which is not properly conserved and developed may lead to some sort of mental displeasure and deteriorating physical health

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(Firehock, 2016). This model suggests that there is a great possibility of environmental stress leading to chronic stress, anxiety, and other consequent health implications.

Models have also shown that there exists some connection between the ability of human beings to face major life issues and the environment that they are in. Mecca (2019) conducted research to determine the link between urban environments and the ability of human beings to address major life issues. Research has shown that nearby trees that can be seen from buildings in urban centres have some aesthetic and mental benefits (Mecca, 2019). Research by Fiksel (2006) showed that trees and grass that are visible from apartment buildings help people to face major life issues more courageously as well as lessen intra-family aggression by reducing the mental fatigue. It is also common in cities to see people at the balcony of the houses facing outside to calm their nerves. Psychologically, the people are able to handle their stress and mental disturbances better if they are looking at an appealing environment (Mecca, 2019). For example, observing trees and grass with different flowers may distract one's mind from negative thoughts and reduce their tension. This helps in the maintenance of their mental health.

A study by Mecca (2019) shows that a complete green infrastructure may be effective in the improvement of the health of urban residents. This observation is based on the assertion that changes in cognitive, emotional, and physiological processes that are induced by the environment have the ability to induce changes in health and well-being. This calls for better utilization and conservation of natural resources in the urban centres, something that green infrastructure seeks to address if it is properly implemented. Even with this, Mecca (2019) noted that it is not very easy to identify the causal relationship between components of the green infrastructure and health. Despite this, there is sufficient evidence to show that green infrastructure has an essential public health factor.

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Studies have established the relationship between health and socioeconomic status. The European Union Strategy on Environment and Health (EC 2003) and the European Ministerial Conferences on the Environment and Health Process cited that social factors and poverty are some of the major determinants of human health (Szalavetz, 2018). Despite this, it was also found that environmental threats are recognized. There exist a lot of studies that show evidence of a positive relationship between well-being, green space, and health (Szalavetz, 2018). While the evidence is not very strong, more research is being conducted to show the relationship between the two. As more research is being done on the existing relationship, it is evident that green space is an essential factor in the health and well-being of an individual. Green infrastructure is a project that is aimed at making urban centres greener and more habitable (Szalavetz, 2018). Its intention is to create a new environment that can exist in the urban centres. It is also bound to address the levels of cleanliness through proper treatment and discharge of wastewater. It is also to be noted that water that is not properly discharged leads to pollution of the environment and may be the cause of various illnesses.

### ***2.9.3 Theoretical Position Employed***

Any research must entail a relevant theoretical position that guides the researcher. The choice of the theoretical positions is determined by the type of research being conducted as well as the kind of data that the researcher uses. Thus, it is essential to collect the appropriate data which addresses the concept under study in the best manner possible. Besides, it must adhere to the principles of social constructivism which explains the human-nature interactivity (Fajgelj & Ambrus, 2000). As such, it is essential to understand that knowledge is neither static, nor supreme. The traditional positivist stance is that knowledge cannot be changed or challenged. As such, this theory tends to remain conservative in its approach to any topic. The researcher remains constricted

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and limited since they do not want to go to limits that they can appear like they are questioning the existing knowledge. However, with modern scholarship, there has emerged a post-positivist approach which states that knowledge is dynamic and is subject to change. Besides, existing knowledge can be challenged. This theoretical position gives power to the researcher to question existing knowledge and develop a new way of understating things. For instance, in the discussion of contemporary issues such as green infrastructure, the analysis is based on facts that are subject to change, and the researcher cannot be restricted to behave in a particular way. He or she must have the room to interrogate existing knowledge to determine whether it coincides or agrees with existing knowledge.

By trying to understand the underlying principles of green infrastructure as well as the associated assumptions, it has been possible to have a broader examination of social construction, and use of it be made. This has been possible due to the application of a discourse where explanations of various interactions of environment and human as well as political influences are central. The post-positivism approach perceives that since the world is changing rapidly, it is subject to different interpretations (Ghosh, 2020). Therefore, researchers must be allowed to question some things and agree with others at the same time. It is through questioning, that knowledge is acquired. As Szalavetz (2018) stated, good researchers must be able to interrogate certain knowledge. Through doubting, the questioning process begins, and to get a clarification of the knowledge in doubt, the researchers have to subject the knowledge to various tests. It is through this process that new knowledge is developed. Thus, sometimes researchers may opt to use comparisons in testing knowledge.

Research by Walker and Salt (2006) found out that learning and experience are related to the development of a person's theoretical knowledge. Besides, they are key to any form of

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understanding. This perception is applicable in the study of green infrastructure as the current research is determined to understand the subject in a better manner. In the same vein, Tyabashe (2018) opined that any time a concept is viewed through a triangulated system of the theoretical framework, it makes it suitable for providing an in-depth foundation that the researcher can use to analyse the world around.

In this regard, a post-positivist approach was used since it allows theoretical assumptions that are made in other research to be expanded upon and researched further. Besides, this makes it possible to depend on the previous research to develop new knowledge and understand various concepts better. Using a post-positivist framework helps in the development of research. Additionally, Salata and Yiannakou (2016) observed that it is necessary that the researcher is given the liberty to choose the methodological rigor over empirical control.

Even in doing this, it is essential to state that the freedom is not without limitations. No human is infallible, and anyone is subject to error, whether intentional or not. Due to this realization, post-positivism allows human beings to question what was developed by others as it could have been fallacious or have some weaknesses which need to be amended. While positivist perspective and empiricist perspectives do not support adaptive approaches of research, the post-positivist approach, like the one applied in this research, supports a multi-method framework in research development (Ghosh, 2020). This gives a wider purview to the researcher to be able to question issues and realize the most formidable truths as far as theoretical knowledge is concerned.

#### **2.9.4 Conclusion**

Green infrastructure aims to make the city a better place to live in. As opposed to the use of sources of energy that cause pollution, green infrastructure advocates for the use of renewable sources of energy as they are more environmentally friendly. The chapter also compares the green

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infrastructure to housing and cities need to institute GIP. However, the source of funds continue to be a challenge towards implementing green infrastructure in cities.

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## CHAPTER 3: RESEARCH METHODOLOGY

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### 3.1 Study Description and Source of Data

The study uses a desktop/policy analysis research method. The researcher reviewed secondary data to gain a broad understanding of the topic of study. In particular, data from the city government of Tbilisi was collected. The data showed the city's plan for implementing green infrastructure development. The documents, "The Tbilisi Green City Action Plan (2017-2030)" and "Sustainable Energy Action Plan: City of Tbilisi (2011-2020)" were analysed.

### 3.2 Data Analysis Method

The data obtained showed the city's plan for implementing green infrastructure development. The Sustainable Energy Action Plan (SEAP) contains trends in the city's strategic directions and the environment in a bid to promote green infrastructure. It contains information regarding the projects identified by the city in a move towards green infrastructure development. The GCAP refers to the strategy by the City of Tbilisi aimed at assisting people to achieve environmental objectives based on the understanding of the present environment, prioritisation of actions, and identification of potential opportunities that will improve the region's overall environmental condition.

### 3.3 Justification of the Selected Research Method

This research relied on two several documents namely "The Tbilisi Green City Action Plan (2017-2030)" and "Sustainable Energy Action Plan: City of Tbilisi (2011-2020)." The case study approach was used to address the implementation of green infrastructure in Tbilisi. The use of case study approach was preferred for a number of reasons.

One of the justifications for use of case study is that it helps in the generation of new ideas. Unlike some other approaches, a case study approach helps the researcher to develop new ideas

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from the existing case study. The other reason for the use of a case study is that it is in-depth and offers a multi-sided approach therefore shedding light on the aspects of human behaviour and human thinking. Additionally, case studies help to illustrate theories and can be useful in showing the way in which various aspects of the life of a person relate to each other. In this study, the case study approach was essential in showing how the implementation of the green infrastructure affects people.

### ***3.3.1 The Importance of using the desktop analysis***

By using the secondary sources for this study, the researcher was able to gather enough and relevant information. Besides, this enables proper scrutiny of qualitative data, which informed the findings of this research. Furthermore, qualitative study was essential as it helped the researcher to make formidable and relevant recommendations at the end of the study (Sturiale & Scuderi, 2019).

The use of a case study approach in this study made it possible to develop a level of overlap that made it possible to investigate each of the research questions and address it accordingly. Since the research questions require different information to investigate, a case approach made it possible to use sources that addressed different research questions. The qualitative approach used provided the liberty to answer all the questions with the available data. The use of a case study approach justifiable because it increases the validity of the results through increased methodological processes (Fajgelj & Ambrus, 2000).

Eraydın and Taşan-Kok (2013) have stated that in the development of a methodological structure, the researcher needs to have various outputs in mind. Szalavetz (2018) opined that the conceptual basis of research, as well as the methods used, need to be aligned to the data collected to inform the outcome of the research. If any of these outputs is faulted, it affects the others and

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ultimately affects the outcome of the research. Thus, as Szalavetz (2018) noted, it is necessary to develop an understanding of the intersection and the interrelationship between theory and practice, which is a central element of any research report, especially this one that seeks to expand the green infrastructure knowledge base. In addition, it provides supporting evidence for the various potential values of green infrastructure and also looks at a series of under-researched areas that make up its use in the academic literature. Thus, this method can be used to safeguard against results that are not expected since it is able to provide supplementary as well as complementary data, which helps to assess responses that are related to specific and replicable questions (Fajgelj & Ambrus, 2000).

The data obtained for this research report makes it possible to address various **issues** of green infrastructure. It has also been applied to the assessment of green infrastructure policy as well as its subsequent implementation. One of the major achievements of this method in this research is that without it, only sources discussing green infrastructure in Tbilisi would have been used and this would have denied the researcher to make comparisons which are necessary for any research process. Besides, sources on green infrastructure globally are so limited to make any conclusive findings. The researcher concluded that the weight of data obtained outweighs the need to use a simplistic methodology for a spatial region as using secondary sources provided detailed information that can be applied to a number of spatial contexts and locations.

### **3.4 The Rationale for Document Analysis**

As stated earlier, this research relied on two documents as earlier mentioned. The documents that the researcher relied on were obtained from Tbilisi and documented how the green infrastructure development is suggested to be carried out. The major documents used were “The Tbilisi Green City Action Plan (2017-2030)” and “Sustainable Energy Action Plan: City of Tbilisi

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(2011-2020).” While the documents may seem very simplistic and with less information for research that is as long as this, they provide a fundamental impetus on how other sources related to green infrastructure may be adopted and analyzed. In addition, document analysis helped to determine whether research literature is being translated into practice. This forms an essential section of green infrastructure development to determine whether the documents are within the scope of the proposed policy. If this is not the case, then the ultimate results of green infrastructure may not be realized.

The analysis of the documents offered an adequate platform that allowed for a proper exploration of practice and policy influences that are meant to have a big impact on either the success or the failure of green infrastructure in Tbilisi, Georgia. The first document, “The Tbilisi Green City Action Plan (2017-2030),” covered 2017 to 2030, showing the measures that Georgia planned to institute to enhance green infrastructure. The second document, “Sustainable Energy Action Plan: City of Tbilisi (2011-2020),” covered the years 2011-2020 to show the way that Georgia has come and where it is at the moment as regards green infrastructure development in Tbilisi.

The researcher wanted to find out whether the documents were aligned with the expected output of the green infrastructure development in Tbilisi. Without properly instituted mechanisms of delivery, the researcher notes that it might be impossible for green infrastructure to progress in Tbilisi, Georgia. In this regard, there is value in the provision of a snapshot of the way in which green infrastructure is addressed in documents. The information from the documents helped in the improvement of the existing knowledge on green infrastructure development as well as its utility in landscape planning.

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The documents that were assessed dealt with policy, planning, and scoping study as well as the various strategies that are related to green infrastructure. The selection of the documents for use was based on certain criteria. One of the criteria that were used was that the document had to be accessible either in hard copy or electronic form. The documents that were not publicly available were not considered. The use of materials that could be available publicly was essential as it ensured that access to information was not limited and could be accessed at any time that it was required. The documents that were publicly available, especially in terms of Really Simple Syndication (RSS), were considered as they were essential in providing additional information on green infrastructure development. The other benefit that came with having publicly available information is that such documents offered the opportunity to compare and contrast as well as to cross-reference where necessary.

The analysis of the documents obtained took the form of content analysis. This was done by analysing various sources to identify common themes and concepts. To do this, the researcher had to perform an extensive reading of the sources, and this led to the development of a number of assessment categories. The creation of the different categories was archered on primary themes as well as the principles of green infrastructure either as a delivery mechanism or a policy. Therefore, the reading of the green infrastructure was seen as a means that entails aspects of landscaping as well as enhancing urban sustainability. The analysis of the documents was also meant to help the researcher review the different interpretations of the term green infrastructure better (Fajgelj & Ambrus, 2000). As mentioned earlier, the researcher was cognizant of the fact that green infrastructure is a recent term that has not gained wide usage in other fields outside academia and policy. Even in academia and policy, the word is not frequently used as many scholars are yet to come to terms with it. Thus, documents scrutiny and analysis were essential for

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the researcher to realize how different authors have explored the term as well as its related themes. The purpose of doing this was not merely to report about what green infrastructure is but to engage in a scholarly discussion about what green infrastructure entails as well as the associated themes.

### **3.5 Ethical Considerations**

During this study, the researcher ensured that ethical considerations were followed. One of the ways that this was done was ensuring that the data sourced from secondary sources was correctly referenced to acknowledge the authors. Since most of the data was freely available on the internet, the owners of the original data were acknowledged. The researcher also ensured that data could not be used to identify participants. For example, in the sources about the protests in Tbilisi, the author ensured that there was no way the information could re-identify a particular person as this could cause harm to them. For the data from Tbilisi government, consent was sought before it was used for this study.

### **3.6 Challenges of Data Collection**

There were few sources that discussed green infrastructure in Tbilisi. As a result, the researcher was not able to use a lot of sources that touched on green infrastructure in Tbilisi. Most of the sources for the literature review discussed green infrastructure from other countries but not Georgia. Despite this challenge, all the available data on green infrastructure in Tbilisi was analyzed in depth.

### **3.7 Context Section**

#### **3.7.1 Georgia and Tbilisi City**

Tbilisi is the capital of Georgia and is one of the largest cities in the country. It is located at the crossroads of Europe and Asia and this setting provides the strategic value to the city itself. The abovementioned marks Tbilisi as a suitable place for the development of infrastructure, trade,

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and other investment projects in the region (Deloitte, 2019). The city is the centre of economic, financial, education, and cultural activities. It covers an area of about 720 km<sup>2</sup> (EBRD, 2017) and is located between 380 to 770 metres above sea level (Rimple & Mielnikiewicz, 2019). The city is situated at the banks of Mtkvari River and is surrounded by hills on three sides which gives to it a humid climate. The population of Tbilisi stands at about 1.2 million people (Rimple & Mielnikiewicz, 2019). Some of the transport systems that are found in Tbilisi include road, rail, and air transport. The minibus is the most used means of transport in the city and contributes to the greatest percentage of air pollution (Rimple & Mielnikiewicz, 2019). The environmental legislation in Georgia is obsolete. The law has inconsistencies and gaps that cause compliance issues. They include lack of proper guidelines to aid in the development of green infrastructure, financing regulations which limit lending to organisations for infrastructure development.

Consequently, the city has only one treatment plant for wastewater. The plant is located at the Mtkvari River (Tbilisi City Hall, 2018). Domestic and industrial premises are connected to the sewerage system. However, the main challenge is that the city does not have a treatment plant. Due to the lack of a treatment plan, the sewerage system deposits wastes to small rivers and watercourses, leading to water pollution (Szalavetz, 2018). The Mtkvari River has high pollutant levels caused by run-offs from industrial sites and agricultural land. Air and water contamination prompted the development of Tbilisi's GCAP.

Georgia agreed to enhance sustainability in its cities hence it has shown the desire to safeguard the environment and prevent further destruction (EBRD, 2017). Georgia is in the process of meeting obligations to gain membership in the EU. In 2017, Tbilisi released its action plan for green infrastructure development with the help of the European Bank of Reconstruction and Development (EBRD) (EBRD, 2017). The document identifies the full range of environmental

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issues and addresses the techniques deployed to improve Tbilisi's ecological performance. The sectors defined are transport, building, industry, energy, water, solid waste, and land use. This research investigated the successes and failures of the GIP plan and its objective to develop green spaces in a bid to enhance sustainability.

The GCAP works on what the document lists as "State Indicators." These are meant to cover certain risks such as climate change, and quality of environmental assets. This shows the areas that have the biggest environmental risks and shows where the biggest environmental challenges are and how they need to be addressed. In the GCAP these are listed as the areas that require quicker attention. These include ammonia concentration in the Mtkvari River, the total suspended particles in the air, the green space per head population the economic damage caused by floods and earthquakes (Gont, 2017). The amount of the total suspended particles is considered to be very high and there is the need to ensure that these levels go down. The increased use of diesel fuel is considered a major cause for the high levels of total suspended particles (Gont, 2017).

The GCAP shows that the total area of green spaces in some of the major cities and towns in Georgia have significantly reduced in the past 15 years. This has resulted in increased heat stress especially during the periods that have hot weather. The report also indicates that the yearly greenhouse gas emissions per capita are low for Tbilisi. This has been so due to the fact that most of the electricity used in Tbilisi comes from hydro and this has zero emissions.

Mtkvari River is significant in Georgia as it acts as a major water source for both urban and rural areas. The river has muddy water as it passes through gorges and canyons. The river has also been polluted from waste that is dumped into the river. Besides the fact that Tbilisi, is located along the bank of the river the polluted water of the river makes it unsafe for use. Thus, it has to be treated beforehand.

The figure below shows the estimated population in various districts in Tbilisi. For instance, Samgori has 17% of Georgia's total population and is the one that is mostly populated together with Gldani. The least populated is Krtsanisi with 4% of inhabitants. The figures are essential for this research to show how the population of a place affects the implementation of green infrastructure.

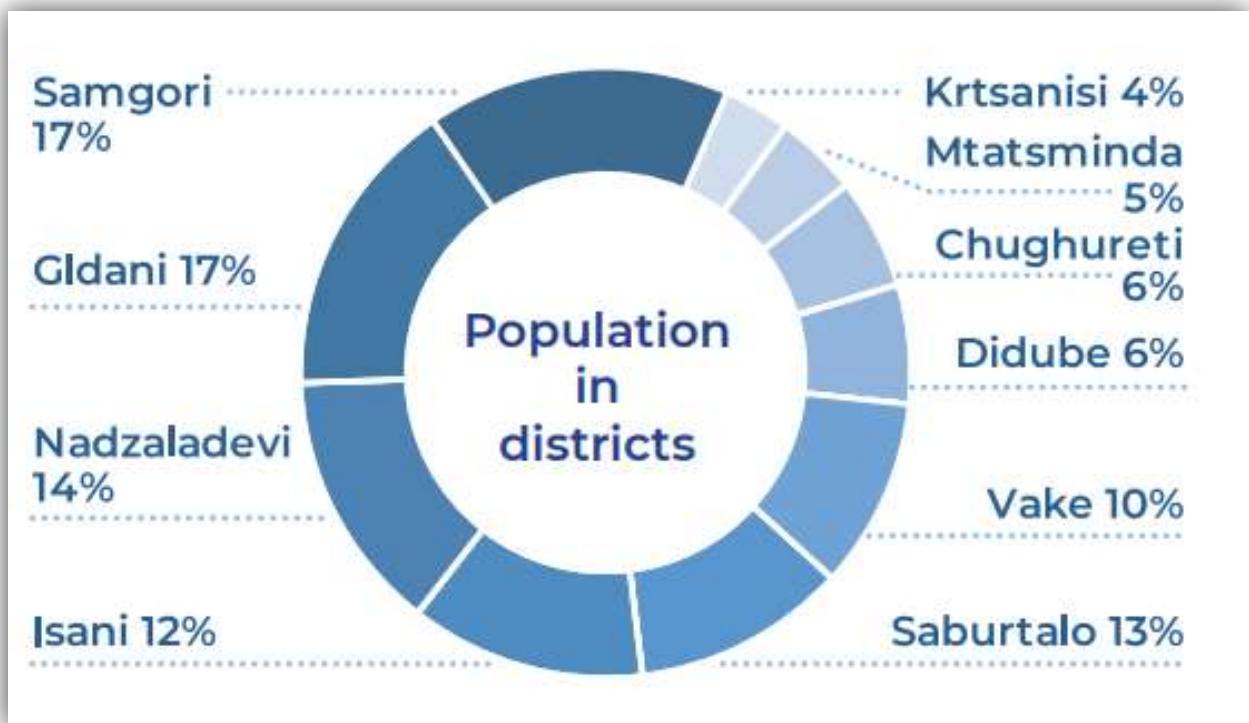


*Figure 3.1: Population Statistics in Tbilisi (Source: "Tbilisi City Hall," 2018)*

The figure below shows the map of Tbilisi. On one side there is the National Park of Tbilisi, and on the other side Tbilisi Reservoir is located. The Mtkvari River runs in the middle of the city and divides it into the right and the left banks. The mentioned elements are some of the features that the implementation of the green infrastructure targets.



**Figure 3.2: Map of Tbilisi. (Source: Deloitte, 2019)**

The map below describes the key infrastructure facilities in the Tbilisi **such as** airports, carriageways, and national parks. All these will have a great impact on the success of green infrastructure in Tbilisi because they will provide the necessary support and resources required in the implementation of green infrastructure.



**Figure 3.3: Map of Tbilisi. (Source: Deloitte, 2019)**

The administrative structure of Tbilisi is headed by a Mayor who is the highest-ranking official. Besides, the Mayor is the head of the Tbilisi Government. The administrative structure also consists of deputy mayors, heads of city offices, and governors. The roles of each of the administrators are essential in the success of the green infrastructure. The Mayor, for instance, as the head of the Tbilisi Government determines the kind of policies related to green infrastructure

that are to be implemented. The governors provide the needed support to ensure that the objectives of the GIP are properly met.

Tbilisi is important, not just as an economic and cultural centre for Georgia, but also as a major business hub for the region. 42% of Georgia's total Gross Domestic Product (GDP) comes from Tbilisi (Deloitte, 2019). The GDP forecast for Georgia is as shown below.

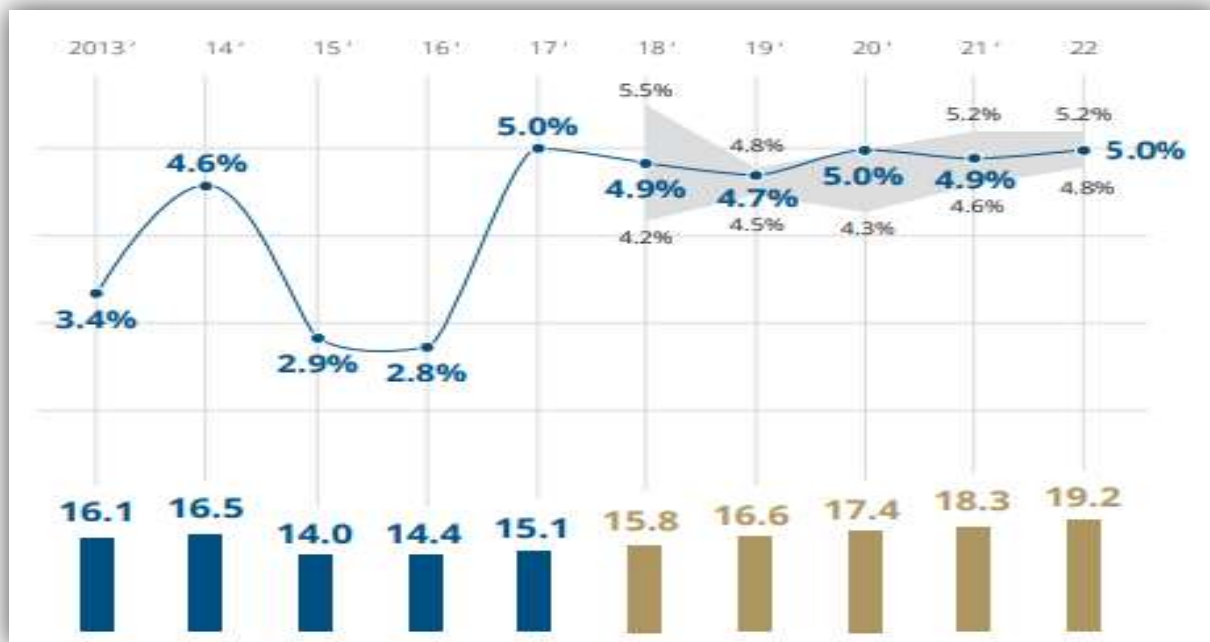


**Figure 3.4: Georgia GDP forecast, USD bln. (Source: Deloitte, 2019)**

### 3.7.2 The Green City Action Plan in Tbilisi, Georgia

While a city such as Tbilisi is above the national average in terms of the innovation index, most of the other regions are usually below the national average (Gont, 2017). The differences in these are rooted in various factors such as infrastructure, education, as well as knowledge generation capacities in these regions. Considered cumulatively, the level of innovation in Georgia is low (Gont, 2017). **There is lack of skilful manpower** to come with innovative measures to deal with some of the problems that **affect** the country. For example, countries that have the innovative power to make vehicles have designed models that produce fewer fumes while others have even

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attempted to make electric cars. Besides, innovation can also be applied in developing better ways of addressing air pollution.

Gont (2017) stated that there are efforts to make Tbilisi a green city under the European Bank for Reconstruction and Development (EBRD) **plan**. The major aim of this **plan** is to make Tbilisi a secure, clean, and safe city for the citizens. The GCAP is already in the implementation stage, and a great number of citizens are set to benefit from the change of their city. Policymakers and developers are keen on transforming Tbilisi to a modern city that is both safe and secure for the citizens under the guiding principles of green infrastructure. Although there have been several problems that are being experienced, the stakeholders are confident that they will overcome them and transform the city for good.

Gont (2017) listed a number of things that the authorities have planned on fulfilling. As Gont (2017) noted, some of the plans include measures to make better areas such as local industry development, solid waste management, water, and wastewater services as well as energy efficiency, among others. Transport and energy efficiency are also part of the plan, and the authorities are keen on addressing these issues as soon as possible. **When these issues are** addressed, it will lead to a better city that is safer and cleaner.

Part of the driving force towards Tbilisi's transformation is the role it serves both to the residents and outsiders. As Gont (2017) noted, Georgia obtained independence in 1991 following a referendum held on 31 March 1991, and since then, it has been attracting a high number of visitors and the number has continued to surge year in year out. Some of the tourists' attraction sites in Georgia include the diverse architecture and Soviet Modernist structures. As such, the authorities found it better to transform the city to make it a safer tourist destination.

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Gont (2017) observed that in 2013, Tbilisi registered around 400,000 cars, and out of these, 74 per cent were more than 15 years old. While this may not sound alarming, it needs to arouse the concept that the older the car, the more toxic the fumes it is likely to emit (Salata & Yiannakou, 2016). This shows that with the rising number of old cars being registered in Tbilisi, the higher the pollution arising from car fumes. The whole world is struggling with reducing emissions from vehicles by either using alternative sources of fuels or registering newer cars and doing away with the older cars. However, this seems not to be the case for Georgia, the more the reason for the implementation of the GCAP.

### ***3.7.3 Tbilisi Land Use Master Plan (LUMP)***

The Tbilisi Land Use Master Plan (LUMP) was approved and made several recommendations that should be followed toward ensuring that the city is made more habitable. Some of the recommendations include the specification of construction and non-construction areas that need to be considered, the need to define landscape areas and the addition of the Forest Zone, the need to select territories such as the city park to help in the implementation of the Green Infrastructure Policy (Tbilisi City Hall, 2019). The master plan also enlisted the need to update the Development Regulation rules. The rules stipulate how green infrastructure should be implemented and the areas to be given priority.

## **3.8 Conclusion**

In the development of the GIP in Tbilisi, there were several factors that were considered such as the Tbilisi Land Use Master Plan which pointed out the areas that need to be considered first in the implementation of green infrastructure. Besides, major issues affecting Tbilisi such as fumes from cars have been brought into context as the city has around 400,000 cars, and out of

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these, 74 per cent were more than 15 years old (Gont, 2017). The old cars are major producers of fumes which cause environmental pollution in the city (Gont, 2017).

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## CHAPTER 4: FINDINGS AND DISCUSSIONS

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This study sought to determine the successes and failures arising from the GCAP implementation in Tbilisi, Georgia. The researcher looked into secondary sources as well as documents that have information related to the green infrastructure topic, especially in the urban centres in Georgia such as Tbilisi. The data obtained revealed several factors for the planning of green infrastructure in Tbilisi. The Green Action Plan document showed that the major need for the green infrastructure is to convert Tbilisi to make it a green city. This is by reducing pollution and making it more habitable. Emissions from vehicles, coupled with those from industries, are major factors that lead to air pollution in Georgia. Currently, the project is in the middle of implementation stage.

Tzoulas *et al.* (2007) noted that implementing the GCAP in Tbilisi will lead to an improved ecosystem. It gives a new lease of life to human beings, trees, and wildlife in the cities. Thus, the benefits of green infrastructure are present in almost every other sector. Mell (2009) revealed that implementation of green infrastructure would lead to city sustainability. Green infrastructure is bound to promote access, strategic planning, and connectivity of essential elements in the towns. Therefore, green infrastructure in Tbilisi will lead to a changed city that is more habitable.

While the green infrastructure is an essential project, it has an equal share of strengths and challenges. Gont (2017) identified strengths such as timing, favourable policies, among others, as being very beneficial to the project. The Green Action Plan is being rolled out at a time when Georgia needs to think seriously about reducing air pollution within the city (Gont, 2017). Therefore, the plan could not have come at a better time than this. Some of the challenges faced by the implementation of the GIP include lack of adequate money to finance the project to completion, community resistance, and lack of enough space within the city, among others. The

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completion of the entire process requires a lot of money to implement. Thus, the government might be forced to take loans before the project is complete or partner with private organizations to ensure that the project does not stall due to a lack of adequate funds.

#### **4.1 Strengths and Weaknesses of the Green Infrastructure Project in Tbilisi**

Like any other project, the GCAP in Tbilisi, Georgia, experiences both strengths and weaknesses. The strengths are the **fundamentals** of the project, and they push it to completion while the weaknesses are those factors that delay the implementation of the project. Some of the major strengths identified in this research are what can be referred to as the building blocks of GCAP in Tbilisi.

Quintero (2012) noted the importance of updating local laws as well as codes and setting up a maintenance workforce to help sustain the GCAP. The most important building blocks help the municipalities, communities as well as the individuals to pursue green infrastructure installation opportunities.

##### ***4.1.1 Policies and Codes as Strengths***

It is essential to note that the success or failure of a project of the magnitude of green infrastructure can be determined by the federal, state, and local laws and regulations. As such, projects such as GCAP need to be protected by policies and codes to ensure that they are budgeted for during the country's financial budgeting. For example, the use of water is one of the main factors in GCAP development. In such cases, the use of water in Tbilisi has been regulated by prior appropriation laws so that GCAP cannot be seen as using water illegally or more than agencies are supposed to use.

Quintero (2012) stated that antiquated local zoning, as well as building codes can delay the installation of GCAP. To cover this, the local authority in conjunction with the government has

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developed a mechanism that allows the implementation of GCAP to change some of the existing infrastructure such as the street width **as long** as doing so enables the concerned parties to implement the GCAP in a better manner. Before commencement of the mentioned plan development, there were some zoning reforms that were conducted in a bid to make it easier to implement the GCAP favourably into modern developments. There are policies that allow for the mentioned plan to change the use or status of certain lands without changing the current zoning significantly. These policies ensure that the extent of pollution in the city is limited.

It is also worth noting that Tbilisi's city environmental regulation can either support GCAP or discourage it. In the past few years, the Tbilisi's city authorities have developed effective management strategies that are aimed at ensuring that the implementation of GCAP can involve the best practices that allow for its implementation.

However, recent policies related to GIP indicate that green infrastructure as a replacement or supplement to aid in the control of the already overloaded traditional storm water piping system (Gont, 2017). Since green infrastructure is seen as a project that comes to save an existing challenge, it is supported greatly.

#### ***4.1.2 Financing and Fees***

For any project to be successful, it needs enough funds to cover for all the processes. Mega projects such as green infrastructure are expected to take a huge share of the national budget, and this calls for proper preparation. Mecca (2019) noted that the highest number of projects that never live to see their actualization are as a result of insufficient funds. Thus, to ensure that green infrastructure does not fail halfway, there are well developed structures to help in its funding.

The GCAP in Tbilisi receives funds from both the city and the national government and this makes it easier to carry it out. The gross investment needs for energy efficiency under National

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Environmental Education Advancement Project (NEEAP) are estimated at USD 8.3 billion from 2017 to 2030. An additional USD 10.6 billion is also needed for energy efficiency, non-energy related Greenhouse Gas (GHG) emissions among others (World Bank, n.d.). Other than this, there are also funds from private institutions which are aimed at ensuring that GCAP becomes successful. There are also efforts to ensure that materials used in the actualization of the plan are not sold as expensively as they would cost if one was buying the materials for personal use (Zuniga-Teran et al., 2019). This has been witnessed through actions such as provision of technical assistance to homeowners, especially those that are interested in installing their rain barrel, rain garden, or any other green infrastructure technology. This gives people the **motivation** to install green infrastructure in the properties, and this means a lot in the achievement of green infrastructure goals.

There have been proposals to institute stormwater and sewage water tax, which is meant to make storm water and sewage control a personal responsibility. This is meant to ensure that individual people take the necessary responsibility to ensure that such water is maintained and controlled accordingly. While this plan by the government is meant to ensure that there is proper water control and management by individual people, there have been dissenting voices regarding the same. Water that is free from pollution also ensures that the air quality is good. For example, sewage water that is not properly treated produces a foul smell that affects the quality of the air people breath.

#### ***4.1.3 Collaboration with Major Government and Private Entities***

The designing, planning, and implementation of the GCAP in Tbilisi comprise experts from both the government and the private sectors. Several offices are represented, and this collaboration brings expertise, skills, and revenue on the table that is necessary for a successful

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implementation of the GIP. For example, the Deputy Mayor, representatives from the Economic Development Office, representatives from the Ecology and Green Spaces Department, and others have collaborated to boost the success of the GIP (“Green City,” 2017).

Other than the above mentioned ones, there are also representatives from the Ministry of Energy, representatives from the Ministry of Economy and Sustainable Development of Georgia, representatives from the Ministry of Environment and Natural Resources Protection, representatives from the National Environment Agency, representatives from the Agency of Protected Areas, representatives from the City Institute of Georgia, representatives from the Institute of Earth Sciences and National Seismic Monitoring Centre, representatives from The Regional Environmental Centre for the Caucasus, representatives from the Caucasus Environmental NGO Network (CENN), representatives from Georgian Chamber of Commerce and Industry, representatives from the Georgian Employer’s Agency, representatives from the Land Transport Agency, representatives from the National Statistic Office of Georgia – Geosat, representatives from the State Security and Crisis Management Council, representatives from Municipal Development Fund and others from the TSU University, Tbilisi (“Green City,” 2017). These representatives are properly selected to ensure all the aspects that are involved in the GIP are covered. The various ministries are empowered by the government to provide direction while the academic institutions provide the knowledge and skills that are required for the success of the project. The advantage of having such a huge collaboration is that there is an increased workforce and cooperation that also enhances exchange of skills. However, the con is that coordinating all the teams may be a challenge as conflicts may arise.

Municipal organizations, as well as private organizations are also incorporated in this project. These include the Tbilisi Transport Company, Tbilservice Group, AO TELASI, Georgian

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Water & Power, KDV GEORGIA LLC, Housing Association “Grmagele Village 15” and Housing Association “Vazha – Phshavela 5th district” (“Green City,” 2017). These municipal and private organizations are important stakeholders as they help in funding some of the projects and sensitizing the community about the need to positively embrace the project.

#### ***4.1.4 Mandatory Car Testing***

Transport is a major factor for strategic development in modern cities. There is no city that can develop without investing in its transport system. Despite this being an important sector in the development of cities, it is one of the major contributors of pollution and poor air quality. Zuniga-Teran *et al.* (2019) found out that the transport system within a city leads to air pollution and noise pollution which can have an impact on the social inclusion and economic growth. The GCAP reports that the transport system in Tbilisi is an amalgamation of different elements. These elements include road vehicle fleet such as private cars, minibuses, heavy duty vehicles and buses. It also includes the transport infrastructure such as roads, walking areas, cable railways as well as metro. The other elements are passenger expectations and experiences which include transport management including the parking policy.

Data shows that more than 90% of the air pollution in the city is as a result of the transport systems especially the diesel-powered vehicles which dominate the transport sector in Tbilisi and the larger Georgia (Green City, 2017). With this in mind, the GCAP was instituted to reduce the air pollution in Georgia. So far, the green infrastructure in Georgia has been successful in reducing the percentage of air pollution through the improvement of traffic flows in Tbilisi. This is proposed to be done by reducing the number of vehicles in the city centre. As much as the government of Georgia supports the idea of as many citizens as possible owning vehicles, it is imperative for them to understand that the higher the number of vehicles within the city centre, the higher the levels of

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pollution and congestion (Zuniga-Teran et al., 2019). As such, the government, through the GCAP is working on a policy that will ensure that the pollution rates in the city centre will go down to favourable and internationally recommended levels. The implemented level of green infrastructure so far has not been able to reach these levels.

To be able to ensure that this is possible, the GCAP developed a vision, strategic objectives as well as a list of specific measures that are designed to address some of the most rampant environmental challenges for transport. Developing this required collaboration with several stakeholders among them the Tbilisi Transport Company, National Environmental Agency, Ministry of Environment and Natural Resources Protection, Land Transport Agency as well as international and local experts, and Non-Governmental Organizations (Ahern, 2017). This was a sure way to ensure that the levels of pollution are reduced in Tbilisi.

## **4.2 Weaknesses of the Green Infrastructure Project**

One of the main weaknesses facing the GCAP in Tbilisi is the adaptation to climate change. Climate change is a serious phenomenon and urban centres are considered some of the major contributors to it (World Health Organization (WHO), 2017). This arises from the increase in human activities in the cities as well as increase in the production rates in the industries as well as the transport sector. It is to be noted that as green infrastructure seeks to reduce pollution through reduction of vehicle emissions, some equipment such as the tractors that are used for levelling purposes and construction of parks that still contribute to climate change. The emissions from these tractors and other related machines add to the fumes that the GCAP seeks to capture. As such, there is the notion that green infrastructure should lead the way by ensuring the usage of equipment that does not contribute to climate change. However, this is a very difficult task to achieve at this time when all the tractors will produce fumes when they are in use. This is a major challenge for

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the GCAP actualization as it seems not to live up to its campaign of ensuring that fumes from vehicles are reduced as much as possible.

Research from WHO has identified the emergence of Urban Heat Island (UHI) (WHO, 2017). This is a concept that explains that the cities are usually warmer and more polluted than other areas away from town (WHO, 2017). This shows the difference in balance between the natural ecosystems and human activities. As a result, a significant number of people tend to be cut off from valuable ecosystem services. This then results to a range of consequences including the inability to adapt to climate change or seek ways of mitigating the effects of global warming. Due to the environment that exists in urban centres, these areas are regarded as the best loci that can be utilized to change the effects of climate change and the creation of a sustainable future.

#### ***4.2.1 Role of Civilians in the Implementation of the Green Infrastructure Development Plan***

The conceptual framework identifies civilians as a group that can disrupt the implementation of green infrastructure especially if they do not understand the objectives of the project. In Tbilisi, the civilians had a great role to play in the implementation of the green infrastructure development in Tbilisi, Georgia. The civilians are considered the primary people that interact with the project on a daily basis, and they are the ones to feel the greatest impact. In the drafting and implementation of the project, it is inescapable to consult the civilians and address their needs. There are some cases in the urbanization process where the civilians become the greatest impediment especially if they are not consulted and briefed on the issues that are happening.

In the drafting and implementation of the GCAP in Tbilisi, the civilians provide the required services. This is one of the greatest roles that the civilians have and they have to be a part

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and parcel of the ongoing process. In fact, they are supposed to be involved in every process of the plan.

The major resource for city related activities such as construction, architecture, design, and urban planning was sourced from some of the largest universities in Georgia. One of these universities is Georgian Technical University (GTU). This university has various departments but there are those that have traditionally been known to produce different specialists to be used in urban planning, architecture and related activities (Harrison et al., 2016). These two departments are civil engineering and architecture, planning and design. However, employees in the other sectors do need to have the requisite education or technical skills. These can be used for any activities in the urban planning which do not require special skills.

The civilians are also essential in the identification of areas that need to be addressed in the process of the GCAP. This is so because the civilians are best placed to know which places need to be addressed. The civilians are also the watchdogs of the resources used in the green infrastructure development process. In the green infrastructure development process, there are many resources required ranging from tractors, vehicles among others (Mecca, 2019). When the working day is over, some of these resources are not returned to the warehouses or stored properly but are left at the place of their last use for the following day. During such times, it is the civilians who take care of them and protect them from being stolen or vandalized by thugs. This is one of the major reasons that the community must be sensitized about the project so that they pave the way for its implementation by providing assistance and a conducive environment.

Harrison *et al.* (2016) noted that communities have the role of ensuring that the project is successful especially if community trust has been built. It is to be noted that without the community trust, the local residents might frustrate the efforts of implementing the project. The installation of

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green infrastructure requires both public and private land. While the government can utilize the public land comfortably, it will need the consent of the locals to install green infrastructure on private land.

Some of the land is owned by individuals, groups, and organizations, and the government needs to have a proper working relationship with these groups to ensure that they can install green infrastructure on the private land (Mecca, 2019). This is to be understood from the background that the installation of green infrastructure is not just for the public space but also for private space that is within or near the urban centres. Since this is an inclusive process, it is necessary to have it installed in all relevant spaces, whether private or public. This study found out the need for the government to motivate the individuals and private owners of lands to cooperate in the whole project of implementing the green infrastructure. It is also possible for groups and agencies to work together with the residents to install private green infrastructure by financing them favourably.

As da Silva *et al.* (2012) noted, the civilians are also essential assets when it comes to the performance of acts such as planting of trees and the maintenance of local rain gardens. Such activities as planting of trees might be a very expensive process for the government if it were to do it without involving the residents. One, the process would take a lot of time to fulfil, and secondly, the residents may revolt. The residents are more likely to accept indigenous trees within their compounds but reject trees that they are not conversant with. This work is also likely to be easy especially where the residents work jointly. Two hundred residents can plant 1000 trees within less than one hour in a case where each resident plants five trees. This is a task that can take two government employees more than two weeks to fulfil. In Tbilisi, the government engaged people in planting of trees in the city.

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While the civilians can provide an enabling environment for the success of green infrastructure, **this is not always the case**. Da Silva *et al.* (2012) noted that there is the need for the residents to perceive the responsibility of the green infrastructure as their own, and this aids in the prevention of damages that would have otherwise been easily addressed. It is thus the responsibility of the government, authorities, and relevant agencies to inform the residents about the need to collaborate with the government in the maintenance of the GIP although this has not been properly done by the Georgia government (Chorgolashvili, 2017). This way, the residents will take immediate action where needed, such as watering of trees, taking care of local rain gardens, and reporting cases that they cannot handle such as leaking **sewerages**, among others. Projects such as green infrastructure in Tbilisi are meant to help the local community and improve their relationship with the government.

The relationship between the government and the residents in Tbilisi **has had some challenges**. To be able to ensure the success of GIP in Tbilisi, normal lives of the residents have been affected, it has brought a lot of resistance (Chorgolashvili, 2017). To confirm how dire the situation is, there have been reported cases of revolt and protests around the City of Tbilisi with the residents refusing any attempt to change their city or affect their daily life routine. For instance, in 2017, activists in Georgia protested against the city government of Tbilisi citing that the city was not committed towards fighting the air pollution (Tvalavadze, 2019). The protestors claimed that all the activities that the government engaged in under the banner, green infrastructure, was not doing anything to solve this problem.

An article by Tvalavadze (2019) showed that protestors in Tbilisi did not understand what the proposed GIP entailed. The steering committee behind it did not take enough time to explain to the residents what the project is all about and the accompanying benefits. According to the

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conceptual framework created earlier in this study, the local community participation was identified as a major factor the success of any government project. Due to the inability of the steering committee to involve the local community, the project suffered a setback especially when the people had to protest to refuse its implementation.

#### ***4.2.2 Institutional Barriers in the Implementation of Green Infrastructure Development Plan***

Despite the concerted efforts by various agencies to ensure that green infrastructure is realized in Tbilisi, Georgia, the major hindrance to this is lack of enough space for expansion. The Green Action Plan in Tbilisi utilises the zoned land instead of development of the green infrastructure on new land spaces (Zuniga-Teran et al., 2019). Importantly, the city has a high population residing and working in the area. Also, there are dense structures within the city. It would be a herculean task to be able to determine which structures to demolish and what to leave.

According to Zuniga-Teran et al. (2019), the planning of green infrastructure for cities should be determined by a spatial dimension. The spatial dimension is shown below:

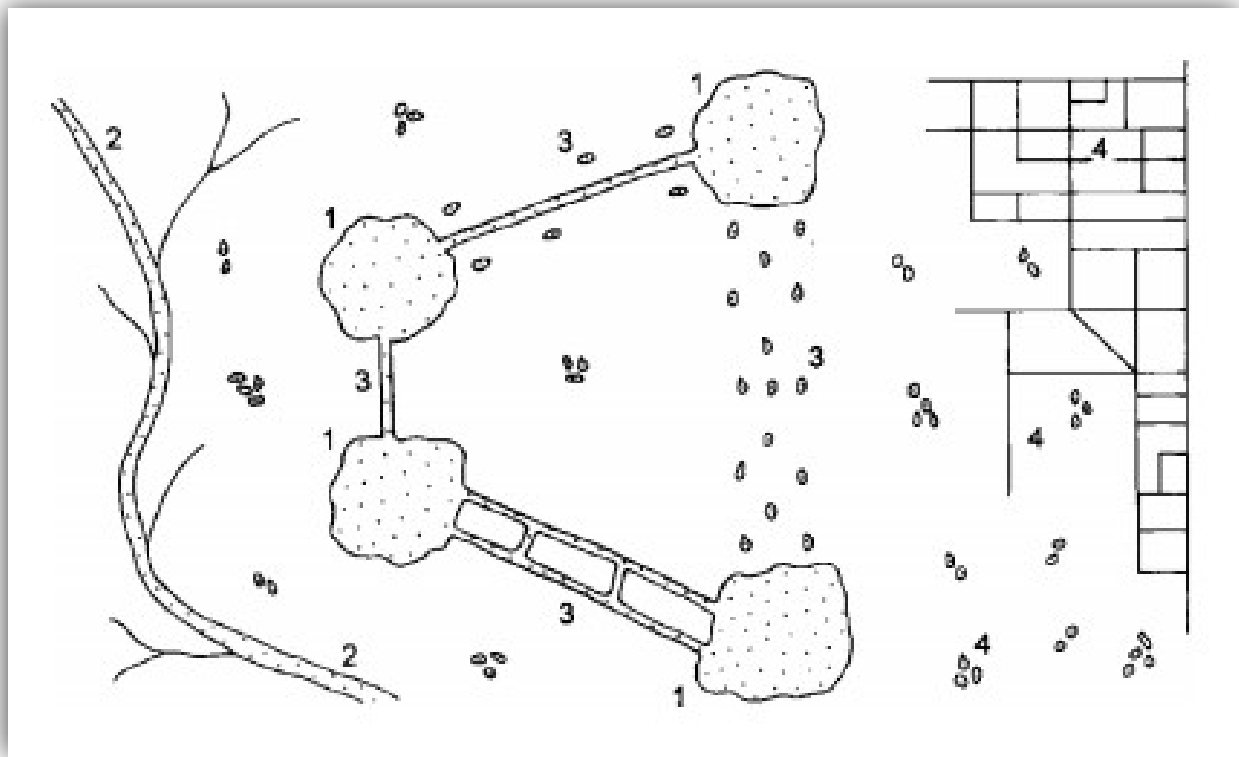


**Figure 4.1: Green Infrastructure Spatial Dimension. (Source: Ahern, 2007)**

In the figure above, 1 represents the large patches of natural vegetation, 2 represents a river or a stream corridor, 3 denotes connectivity between stepping stones and patches, while 4 denotes some bits of nature. This dimension is considered a major factor in green infrastructure planning. The principles of the spatial dimensions need to be applied successfully in landscape and urban planning.

It is essential to mention that for green infrastructure to be successful there is the need to have a supporting landscape to anchor sustainable patterns and processes, which make it possible to employ a protective strategy. This strategy explains an optimal or eventual landscape pattern which is protected from change while the landscape around it may change (Zuniga-Teran et al., 2019). To get a desired goal, this strategy utilizes planning knowledge, regulation as well as land acquisition strategies.

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There is a high rate of unemployment and poverty in Tbilisi. These could make it harder for the green infrastructure planning to be actualized. The poverty levels in Georgia, especially in the capital, are so high that the government had to think about the welfare of the people before implementing the GIP. Besides, it might become difficult for people to accept the funding of green infrastructure while they are not employed themselves. Therefore, this raises the need for the government to develop a mechanism of addressing such issues before they become an impediment to the development of the GIP. High levels of poverty among the people saw the government divert some of the funds to meet the basic needs of the people leaving very little for the running of the project (Zuniga-Teran et al., 2019). Additionally, high rate of unemployment in Tbilisi saw the government put in hard place between deciding whether to initiate projects such as green infrastructure in the city of provide employment to the people through the construction of industries. The high levels of poverty have been the cause of protests from the local community and this slowed down the implementation of the project.

Some of the people who consider themselves employed provide unskilled labour and usually receive very low salaries. Income inequality in Georgia remains high, especially in major cities such as Tbilisi. The level of inequality for money income in Georgia is comparable to highest inequality countries of Latin America (Gini equals 0.6) (Tvalavadze, 2019). The wealthy, as well as the socially vulnerable, are found in all districts of the city. The low income and high rate of unemployment means that people do not engage in high end investments and therefore may not find it necessary to have a changed face of the city (Tvalavadze, 2019). Additionally, the unemployed may demand to be incorporated in the restructuring process of the city and lock outsiders from being given jobs. This may be problematic, especially where skilled labour is required, and the locals are not able to provide it. What this shows is that there are more urgent

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needs that should be tackled in Tbilisi such as providing employment to the people so that the benefits of green infrastructure can be felt by all.

As a result of the complacency by the government, residents are of the perception that the GIP will not do anything substantial until the government declares itself ready to fight for the public spaces by all means possible. While these issues remain unaddressed, the success of the GIP still remains uncertain as without the confidence of the residents and the local community, it might be very difficult to have a successful project.

#### **4.3 Role of Green Infrastructure in Reducing Air Pollution**

As indicated earlier, air pollution is a major challenge in many urban centres and Tbilisi is no exception. Air pollution has affected the quality of air in Tbilisi making it difficult for people to live due to associated illnesses. Based on the results obtained from the GCAP and textbooks, green infrastructure has the role of reducing exposure to urban air pollution. Tbilisi's GCAP has done a lot to improve the quality of air in Tbilisi. This has been achieved by the creation of greener spaces where people spend most of their free time to relax instead of hopping from one car to another which increases the emissions that cause air pollution.

In addition, green infrastructure offers a variety of other benefits such as increased biodiversity which make urban life more habitable. Green infrastructure improves the air quality not mainly by removing pollution by deposition but by effectively controlling its dispersion thus reducing public exposure (Tvalavadze, 2019). Through the plantation of vegetation in the urban centres, the air filtered by the vegetation thus making it better than it would have been without the trees. This way, the concentration of the polluted air is decreased.

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## CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

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### 5.1 Conclusions

This study has revealed various observations about green infrastructure, especially in Tbilisi. Green infrastructure is a natural environmental management approach that entails the protection and restoration of the natural environment. The study has found out that some of the techniques employed for strengthening green infrastructure include planting trees and restoring wetlands. Planting trees is an effective means of restoring the natural water cycle instead of temporary techniques such as building a costly water treatment plant. Tbilisi is one of the cities seeking to implement green infrastructure due to the deteriorated ecological conditions. GIP has aided in providing protective functions that include enhancing the climate of urban areas and restoring the aesthetic nature of Tbilisi City.

One of the major findings of the study is that green infrastructure reduces air pollution. The implementation of green infrastructure helps in the reduction of air pollution levels which ensure better health for the people (Tvalavadze, 2019). The implementation of green infrastructure in Tbilisi is faced by numerous challenges which may affect its success. The study has found several challenges such as limited space for expansion, community resistance, lack of adequate funds and high rates of unemployment among others. There also exist high rates of poverty, unemployment and high incomes in Tbilisi. These could make it harder for the GIP to be actualized because most of the funds and attention is dedicated to means of alleviating poverty.

Regarding the question as to whether green infrastructure in Tbilisi can promote urban sustainability, this research concludes that green infrastructure is a viable system for achieving positive environmental change as well as sustainable development. The research questions were responded to as addressed in the findings and discussion section. Thus, the study concludes that

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green infrastructure is a strong tool for the mitigation of climate change effect, social equity and urban development and all of these are important in the promotion of the underlying principles of sustainability. Although resistance is high, the benefits of green infrastructure are many.

The implications of these findings and conclusions are that green infrastructure remains an area that has numerous benefits that it comes with. Green infrastructure is one of the surest ways of reducing air pollution especially in cities and other urban centres. The failures identified in the implementation of GCAP in Tbilisi can be addressed if there is enough information about the implementation process of green infrastructure. Thus, the findings of this study provide a solution to Tbilisi and other cities about the means to resuscitate the urban centres for sustainability.

## **5.2 Recommendations**

Following the findings of this study, it is evident that there are some things that need to be done in Georgia to ensure that the green infrastructure planning is successful and that the residents are able to enjoy the benefits that come with it. One of the policy implications for the study is the need to devise policies that support green infrastructure. There is a need to realize that each of these areas is essential in addressing the targets that green infrastructure should achieve. The developers need to take into account the health, social inclusion, and service provision to ensure that the long-term viability of urban renewal goal is achieved. This plan can also be used for other regions across the globe that are concerned about green infrastructure.

It is also recommended that other researchers address the implementation of green infrastructure in small towns. Most of the research tends to concentrate on green infrastructure in cities. It would be plausible to get findings on the benefits and challenges of green infrastructure

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in small towns and determine how they compare with cities. This is a research gap that future researchers should address.

The study highlighted the challenge of community resistance that could hinder the success of green infrastructure implementation in Tbilisi. Cognizant of this challenge, this study recommends that the task force for the implementation of the project incorporates the residents as stakeholders to the project. This could also be done by forming forums to educate the residents about the importance of the project and how it will benefit them. For example, the residents need to be taught about air pollution affects their health and how green infrastructure will address this challenge making their life more comfortable and safer. This may help to deal with the resistance of the residents.

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## Appendices

### Appendix One: Ethics Clearance Certificate



#### SCHOOL OF ARCHITECTURE AND PLANNING HUMAN RESEARCH ETHICS COMMITTEE

##### CLEARANCE CERTIFICATE PROTOCOL NUMBER: SOAP087/06/2020

**PROJECT TITLE:** Green perspectives for grey sustainability  
**INVESTIGATOR/S:** Tavdgiridze Ann (Student No: 2371485)  
**SCHOOL:** Architecture and Planning  
**DEGREE PROGRAMME:** Master of Urban Studies (MUS UM)  
**DATE CONSIDERED:** 05 August 2020  
**EXPIRY DATE:** 05 August 2021  
**DECISION OF THE COMMITTEE:** Approved

**CHAIRPERSON**  
(Dr Brian Boshoff)

**DATE:** Signed under lockdown: 10.8.20

cc: Supervisor/s: Tsepang Leuta

#### **DECLARATION OF INVESTIGATORS**

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to endure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

#### **Signature**

School of Architecture & Planning  
University of the Witwatersrand  
Private Bag 3 Wits 2050  
Johannesburg South Africa  
www.wits.ac.za

T +27 11 717 7623  
F +27 11 717 7649

#### **Date**



## Appendix Two: Title Approval Letter from the Faculty



Private Bag 3 Wits, 2050  
Fax: 02711 7177009  
Tel: 02711 7177007

Reference: Ms Olga Ndlovu  
E-mail: [olga.ndlovu@wits.ac.za](mailto:olga.ndlovu@wits.ac.za)

04 August 2020  
Person No: 2371485  
PAG

Ms A Tavgiridze  
5 central street  
Houghton estate  
Gauteng  
South Africa

Dear Ms Ann Tavgiridze

### Master of Urban Studies: Approval of Title

We have pleasure in advising that your proposal entitled *„Investigating successes and failures of implementing green infrastructure as a way to enhance sustainability „ The case of Tbilisi, Georgia„* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

A handwritten signature in black ink, appearing to read 'Yaseen Stoffberg'.

Mr Yaseen Stoffberg  
Faculty Registrar  
Faculty of Engineering and the Built Environment

## Appendix Three: Plagiarism Declaration

Faculty of Engineering and the Built Environment

Private Bag 3, Wits 2050, South Africa \* Telephone (011) 717 – 7007 \* Fax: (011) 717 7009 \* Email: f\_eng@wits.ac.za



### PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Ann Tavdgriridze (Student number: 2371485) am a student  
registered for the degree of Masters of Urban studies in the academic year 2020.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature:  Date: 02.03.2021