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SUSTAINABLE CITIES

Eric Pollock (ed.)

Sustainable Cities

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Preface

The graphic design work begins with the most important understanding of timely coordination and effective planning. Time and quality of the work are pivotal. The proper decision at the right time is the key. Editorial decisions of reject, revise and accept set up the basic platform. The graphic design and editorial works have been mainly guided by the editor Mr. Eric Pollock. We have drawn upon our experiences of our work as editors, authors, and reviewers. It is likely to be particularly beneficial to scholars at the early stages of their profession.

The role of the graphic designers has been largely advisory, but also included the design of the cover and authors page. The graphic designers and the editor have always carefully reviewed the text together. The mindset has always been positive which not only motivated the team but also set the right tune for the large group of authors which made this book complete and worth reading within the limited course of time. Nonetheless, the eyes were always focused on any possible flaws and further improvement of the work.

For the student graphic designers, the job was challenging but also very rewarding. The experience gathered is enormous. The privilege of responsibility for the graphic work filled our hearts with unspeakable joy. We began with the pristine idea of putting together the vast knowledge and experience of our authors under the title ‘Sustainable Cities’.

Groups were made for different chapters based on interest and previous expertise. To support a culture of timeliness, we encouraged the authors to make a timely decision on accepting the review invitation and, importantly, a responsible commitment to provide the written drafts on the agreed timeline. A set of academic guidelines was provided to the authors mentioning all the instructions for their writing. Periodical reviews were done in the presence of the authors and our Lecturer Mr.Pollock. Moreover, a template in Adobe InDesign was separately given to all the authors in the beginning. The template was utilized to make the layout of the book. The vision was to make the book more interesting and readable for the authors.

We started at the beginning of January 2018 and were able to finish in early May 2018. Courtesy of the intense motivation of the authors and endless cooperation of our team, this has been possible beyond our expectations. The editor and graphic designers worked in close cooperation with the authors constantly. We were to able to finish the work with the desired quality because of proper planning and efficient coordination. The sole interest in the book by all made our vision come true at the end. In future, we aspire to grow upon our experiences and continue being involved in the noble job of editing and graphic design.

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Metropolia University of Applied Sciences
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Helsinki, May 2018

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Introduction - Making cities sustainable

The Construction and Real Estate Management program is a 4 semester master degree given jointly by the Metropolia University of Applied Sciences, Helsinki, Finland and The Berlin University of Applied Sciences HTW-Berlin, Germany. The case studies course in the second semester follows up on the sustainable development course of the first semester. The students wanted to make a publication on real sustainability questions in todays' urban world. Many students need to participate in academic research publications for future doctoral studies. Director Mika Lindholm encouraged us to go for a full publication, in both print and digital form, and to apply to research conferences.

When undergraduates of architecture and civil engineering begin their Master of Science studies in Europe, their lives and their future careers undergo a quantum change. They have come from around the world to study in Europe, to start their professional lives in the design and construction of the built environment. They have come as individual students, but very quickly learn teamwork, to survive in academic works and student life. The Finnish language is difficult, but the City of Helsinki quite easy to get to know, while life in Berlin is full of opportunities, but usually requires some level of German language skills. The Finnish construction market is quite small but very well managed using advanced IT technology, in contrast to the huge German market, more oriented to built-in-situ production. The students chose their own groups, including four editors, and fixed their deadline for completion. They have worked independently, and although some have more academic writing experience, teamwork in the groups produced five very good chapters on sustainability in cities around the world.

The lecture series began with polluted cities: air, land and water pollution in urban areas. Next was traffic planning: road networks, railways, waterways and bicycle/pedestrian paths. In aging Infrastructure, developed nations like USA and Britain have a tremendous repair deficit for bridges, tunnels and highways, and nations depending on railways like India have failures far too often. In the High-rise housing lecture, Western nations have a century of experience, but fast-growing nations in the Middle East and South America have a different middle and high-rise housing crisis of their own. Finally, in the Off-Grid Housing lecture, rural areas are obliged to find their power locally, use their fresh water wisely and recycle their wastewater. The students are from all corners of the world, so it was easy to get comparisons of sustainable development from major cities on many continents. The basic goal of the whole publication is to look at the 17 unsustainable development goals (SDGs) of the 2030 Agenda for Sustainable Development that became official on 1 January 2016. With the new goals that apply to everyone, nations can mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change.
(http://www.un.org/sustainabledevelopment/cities/)

In particular, goal 11 states, "Make cities inclusive, safe, resilient and sustainable. Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically. However, many challenges exist to maintaining cities in a way that continues to create jobs and prosperity while not straining land and resources. Common urban challenges include congestion, lack of funds to provide basic services, a shortage of adequate housing and declining infrastructure.

The book is divided into five chapters, according to the groups chosen by the students.
A major city is the case study for each, with students from that country who know the language, culture and history. They are also motivated to show they can offer some real alternatives for

change. In the groups, all with mixed backgrounds, has led to some good discussions, and has brought them together as authors and researchers. Cities are the most complicated things humans have ever built. With climate change (the biggest threat our species is facing) the word sustainability has achieved more relevance than ever. As the majority of the world's population living in the urban environment, the sustainable city is the thought of today. Courtesy of the broad diversity of the authors, the book has been able to make justice to the title.

The topics of sustainable cities have been covered by an interdisciplinary approach. Emphasis has been given to the urban and physical processes shaping our future cities. The human impacts on the cities and vice-versa are analyzed. Each topic is discussed through case studies, which are selected from the hometowns of the authors and discussed in the field of their professional expertise and experience. The experienced team of professionals combining architects and engineers brought their expertise into this book.This book offers an intuitive understanding of our future cities to the reader. The book can also be used as sustainable coursework related to cities in an undergraduate curriculum. The authors were encouraged to back up their views with evidence and reasoning. Nevertheless, the issues covered in the book are of timeless value and would undoubtedly appear relevant for our future cities.

In the first chapter, city planning is discussed in the context of Cairo, Egypt. Historical and political references have been drawn. Energy production and settlements are reviewed. The sustainability city goal is further discussed in the housing context.The second chapter deals with sustainable housing agendas in Santiago. Critical and contemporary questions have been raised and comparatively analyzed based on policies, politics,design, and statistics. A proposal for policy intervention is made for sustainable development.Sustainable transportation is the central theme of the third chapter. Cities have flourished around transportation. Rapid urbanization and growing connectedness of the world generate paramount importance for the field Global cities of Delhi and Berlin are analyzed. Small cities of different context, Helsinki and Pune, are discussed for better understanding. Issues were researched in sustainable transportation among the cities. Policies were investigated and suggested for future cities.

In the fourth chapter, the issue of infrastructure is discussed through comparative case studies of Delhi and Singapore. Infrastructure namely roads, railways, and parks are reviewed. Design considerations and sustainable strategies are proposed. Moreover, drainage and electricity are discussed.The recommendation is proposed by the authors following the critical analysis derived from the case studies.

Off-grid renewable energy is analyzed globally in the last chapter. It includes small and mediumsize case studies from India, New Mexico and Jordan. Many ideas and hope for future sustainable cities can be derived from this section. Most importantly, it emphasizes on the principle of green energy from renewable sources. Our cities are offered sustainable innovation by the case studies discussed. A thorough analysis of the case study relates to the central theme of sustainability.The main purpose of the book is to give the reader a sense of the major issues related to sustainable cities. The authors have not hesitated to jump across centuries of development to explore urban development of cities, with thought-provoking ideas and contemporary debates. I am confident we will hear from them in the future as sustainable developers.

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1. CITY PLANNING, Case Study: Cairo
Local and regional planning, strategies and crisis management

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Abstract

The Greater Cairo Area (GCA) is the largest metropolitan area in Egypt and the largest urban area in Africa (Demographia, 2009). On the regional side, it is considered the third largest urban area in the Muslim world after Jakarta and Karachi. In the world figures, it is recognized as the world's 16th largest metropolitan area (R.I. Forstall, 2010).

The greater Cairo Area (GCA) consists of multiple cities/areas, including all the cities in the Cairo Governorate, as well as Giza, 6th of October, Sheikh Zayed City in the Giza Governorate, and Shubra El Kheima, and Obour in the Qalyubia Governorate. It has a total area of 1,709 km2 (The Evolving Urban Form: Cairo, 2012). Its current population is estimated to count 19,846,000 inhabitants. In the year 2030 the prognosticated population will be 24,5 millions, making it the top city in the world in terms of population increase, above other high population cities such as Shanghai, Manila, Jakarta, Beijing and Karachi (the-newkhalij, 2017).

The aforementioned population figures and other reasons raise some issues that need to be addressed effectively to successfully deal with the encountered challenges. This research chapter discusses number of main topics related to the principal challenges and proposes possible solutions.

Keywords: Greater Cairo City, City Planning, Sustainable Development, City Infrastructure

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The First Cairo: Memphis

The history of Memphis and the other Pharaoh cities in the old history of Egypt – which was written in hieroglyphic language- became known after the famous discover of the Rosetta Stone in the Nile Delta city of Rosetta in 1799 during the campaign of Napoleon in Egypt. The Rosetta Stone- now located in the British Museum- contained the same decree in three languages: ancient Egyptian, Demotic, and Greek.

The history of Egypt extended back to 5000 years BC. The oldest archives show that it was divided into two kingdoms. The Upper Egypt was located in the south align with the Nile towards Aswan, and the Lower Egypt was located in the north along with the Delta branch of Nile river. The site of today's Cairo is located in between these two kingdoms. In 3100 BC, the great Egyptian king Menes succeeded to invade and conquer the Delta and unify the two kingdoms into one strong empire. Therefore, he became the first Pharaoh of Egypt. On the left bank of the Nile and thirty-two kilometers south of the Nile branching, Menes located his unified capital, which became the site of Memphis (Alsayyad, 2011).

According to (Alsayyad, 2011), the historical knowledge of Egypt is credited to Khaemwaset, Manetho, and Herodotus. Khaemwaset was one of the sons of king Ramses, and is considered the first Egyptologist. Manetho was a priest born in a small town near Delta, in 280 BC he wrote about the history of ancient Egypt in Greek. Herodotus was Greek and visited Egypt in between 460 to 455 BC, "He characterized the Nile as the regulator and predictor of Egyptian life and the maker of a unique Egyptian culture" (Alsayyad, 2011).

Some neighborhoods of the city were named after particular ethnic groups who came to Egypt, such as "the Field of Hittites" and "Phoenicians". Thousands of years after Menes was an era of flourishing which had the establishment of administrations, courts, and temples (Alsayyad, 2011).

At the end of the Old Kingdom, after Thebes became the new capital and Pharaoh took it as the religious capital, the importance of Memphis was decreased due to political and social circumstances. During the Ptolemaic Period, Memphis recovered its universal position. The Greek changed the name to Memphis, the original being "Men-efer". Today ruins are still to be found at the original site of the city (Alsayyad, 2011).

The Memphis region has witnessed a great construction during the Old Kingdom. Ancient Egyptians believed in the afterlife, therefore they built their tombs before their death and collected all their belongings with them in the tomb. The more powerful in the society, the greater the tomb would be. The Pharaoh of Egypt used to build a pyramid as a tomb, Djoser was the first king who did it, in 2600 BC he ordered his architect "Imhotep" to build him the first tomb from cut stone instead of traditional mud bricks. After the sixth revision of the design of the pyramid, the final version was chosen to be a pyramid consisting of six steps in Saqqara (Alsayyad, 2011).

Circa fifty years after the innovation of archetypal pyramids, King Khufu built one of the greatest buildings in the known world; the Great Pyramid of Giza is 147m high and contains 2.3 million limestone blocks, of an average weight of 2.5 tons each. The same site of Great Pyramid was used later by King Khafra and Menkaura to build their pyramids in addition to the Great Sphinx (Alsayyad, 2011).

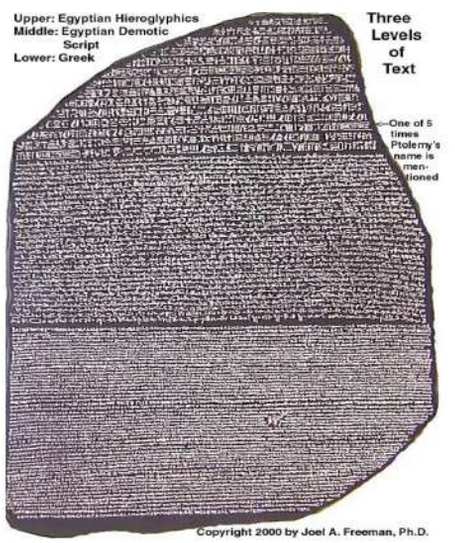


Figure 01: The Rosetta Stone. *Source: freemaninstitute, n.d.*

Figure 02: King Menes, unifier of Egypt. *Source: Crystalinks, n.d.*

Figure 03: The Pyramids of Gizah. *Source: Ricardo Liberato, All Gizah Pyramids, 2006*

Roman, Byzantine, and Coptic Cairo

Tourists visiting Egypt are advised to visit the Coptic district in Cairo, where the Coptic Museum is located as well as the remains of the fortress of Bablyon. “The words Copt and Egypt are most likely derived from the ancient Egyptian hi-ka-Ptah, which means “the house of the spirit of Ptah”; Ptah was the god of the ancient Egyptian city of Memphis. Prior to Alexander’s invasion, the Greeks may have pronounced Hikaptah as “Aigyptos,” which ultimately became “Egypt.”(Alsayyad, 2011). After the Arab conquered Egypt, they referred to the Egyptian as Al

Qibt by the time. After the expansion, they used the word settlement or “Misr”.

In 331 BC, Alexander conquered Egypt and ordered to build a new city on the Mediterranean sea which would be called “Alexandria”. According to the historian Diodorus Siculus, “Alexander himself specified the layout and orientation of its streets. He then ordered that Alexandria be developed according to a mix of Egyptian traditions, local knowledge, and distinctively Greek features” (Alsayyad, 2011).

After the death of Alexander, Ptolemy Soter - one of his generals - ruled Egypt. Alexandria continued growing to become one of the most powerful cities in the Mediterranean Sea at that time. When Cleopatra ruled, Alexandria was the only city in the Mediterranean Sea which was able to compete with Rome. This led the Romans to conquer Egypt in 30 BC. The Roman military positioned itself in three different cities in Egypt, Alexandria in the north, Thebes in the south, and in Memphis in a fortress called Babylon. It is believed that the Emperor built Babylon fortress in 98 and the name came from “Bab-li-on”, which mean “The gate to On” (Alsayyad, 2011).

After the deterioration of the power of Rome, a new empire had been born in the Mediterranean Sea. The Byzantine Empire took Constantinople as a capital known nowadays as Istanbul. In 313 Christianity was legalized by Constantine, which helped spread Christianity all over the world. At the same time, Egypt was a main center for Christianity.

“The dispute originated in 325 in Nicaea when an Egyptian presbyter, Arius, declared his thesis that God, the Father, was divine, eternal, and without beginning, and that Jesus, the Son, was simply his begotten human extension, born in time and place. Influenced by Athanasius, another Alexandrian theologian, the Nicaea Council rejected Arius’s doctrine and declared that Jesus was of the same substance as God. Athanasius’s view was eventually adopted as orthodoxy by the Christian Church and led to the consolidation of orthodox Christian views in the Nicene Creed” (Alsayyad, 2011).

The Egyptian Church split from the Byzantine Church as a result of this discord. Christians in Egypt divided into two groups. Malekites who followed Constantinople and accepted the idea of one god in two natures, and the Copts who followed Alexandria. Copts were later persecuted under the Byzantine Rule.

While Christians were suffering under the Byzantine rule because of high taxes and religious persecution, Islam was born which changed the entire region. In summer of 640 Caliph Omar sent Amr Ibn al-As to conquest Egypt. The Islamic army reached the Babylon fortress and offered three options for the Byzantine governor: accept Islam, religious freedom with taxation or continue in war. Seven months later the Byzantine governor accepted the religious freedom with taxation (Alsayyad, 2011).

Figure 04: Mosque of Amr Ibn al-As in. *Source: Ulama, n.d.*

Fustat-Misr: Capital of Arab Islam

“The birth of Islam occurred in Arabia in the early seventh century. Out of the wilderness of the desert and in a small town called Mecca, Prophet Muhammad began preaching against a culture of pagan belief. He called for the worship of one god—Allah. His fundamental teachings included the belief that human beings must submit to God and observe five specific tenets. These were the Shahada, a declaration and acceptance of the oneness of God; the Salat, the five daily prayers; the Siyam, fasting during the month of Ramadan; the Zakat, the giving of alms; and the Hajj, the one-time pilgrimage to the Kaaba in Mecca” (Alsayyad, 2011). After the death of Prophet Muhammad, there were successors or caliphs and the Islamic Empire extended significantly. Islamic empire took over Egypt and Syria from Byzantine empire and Iraq from the Persian empire.The caliph was moving from China in the east to Al Andalus or Spain in the west (Alsayyad, 2011).

During that period, new cities were built on the Islamic architectural style, such as Basra and Kufa in Iraq, Cordoba in Spain, and Fustat in Egypt. When Amr Ibn Al-As conquest Egypt, he choose Fustat to be the new capital. Amr Ibn Al-As’s mosque was the first building where the new capital waslocated. Fustat City started growing fast as a political and administration center for the new empire, and from there the Islamic empire started spreading to the west until the border of France. The design of Fustat was reflecting the typical Arab and Muslim cities, the mosque, governor’s residence and square at the center (Alsayyad, 2011).

Figure 05: Mosque and University of Al-Azhar in Cairo. *Source: Fraternites, n.d.*

Al-Qahira Fatimid: The First Name of Cairo

After the weaknesses of the Abbasids in Baghdad a new movement in Tunisia was growing. This movement reached its peak at the time of Al-Mahdi, who establish the Shi'ite caliphate or Fatimid caliphate. Al-Mahdi had the intension to extend to the east towards the Sunni Abbasids. In the year 969 the Fatimid Caliph Al-Mu'izz ordered Jawhar al-Siqilli to lead a campaign towards Egypt. By then Egypt was ruled by the Ikhshidi dynasty. The Fatimid defeated them and took over Fustat (Alsayyad, 2011).

Immediately after they took over Egypt, Jawhar began looking for a fortress for the Fatimid army; finally he decided to build a new capital on what Al-Mu'izz envisioned and to be as a competitor of Baghdad. First, Jawhar started building a boundaries wall and the most two important buildings, the palace and the mosque. Jawhar named the new city al-Mansuriya. Four years later, Al-Mu'izz arrived in Egypt and changed the name to Al-Qahira which translated to English as Cairo. Then he declared Cairo as the capital of his caliphate. Fatimid Cairo was an impressive city and was growing significantly. Over the time and the expansion of the city, Fustat and Cairo became one metropolitan city (Alsayyad, 2011).

Figure 06: Citadel of Salah Al-Din in Cairo. *Source: My little adventure,2016*

Salah al-Din: Fustat and Cairo, One City

While Egypt was under the Fatimid suffering from religious persecution as a result of not accepting Shi'a doctrine, the Crusaders were able to occupy a number of Muslim cities, including Jerusalem. In 1171, Nur al-Din the ruler of Syria wanted to overthrow Fatimid and unify Egypt and Syria to be able to recover Jerusalem. Nur al-Din selected one of his best commanders to this mission, Salah al-Din, who would change the course of the war with the Crusaders (Alsayyad, 2011).

In short time Salah al-Din took control over Egypt, Immediately fortified Cairo by building a fortification wall surrounding the two cities Fustat and Cairo. At the highest point in Cairo, Al Muqattam Hills, Salah al-Din ordered to build a citadel. This kind of citadel was not common in Egypt that time it was spreading in Syria where Salah al-Din originally from. Because the citadel was close to both cities, Cairo and Fustat, it was not difficult to supply it with resources (Alsayyad, 2011).

After Salah al-Din established a strong army in Egypt, he still had to achieve the dream of the Muslim nation to free the Holy Land from Crusaders after the corruption they established in Jerusalem. In 1187 a great battle ocurred between Muslims under the leadership of Salah al-Din and the Crusaders under the leadership of England, France, and other European leaders. The Muslim army defeated the Crusaders. As a result, the Crusaders surrendered and handed over Jerusalem to Muslims (Alsayyad, 2011).

The Mamluks:The City of the Slave Sultans

Figure 07: The Battle of Ain Jalut between Muslims and Mongols. *Source: Mapmasters, 2011*

"The Mamluks—which means "those who are owned"—were valued for their horsemanship and fighting skills, and trained as guards for the Ayyubid rulers of Egypt. Given their indispensable military role, their social status was subject to change over time. From slave soldiers, they could become free men and court favourites, holding important political positions whether as viziers or commanders of army battalions." (Alsayyad, 2011).

Sultan Qutuz was one of the Mamluk leaders who ruled Egypt after the family of Salah al-Din. In 1255, and after Genghis Khan unified the Mongols, his brother Hulagu led a campaign to invade the world. Passing through China, Russia and reaching as far as Vienna in Europe finally they invaded the Middle East and destroyed Baghdad, the Capital of caliphate. Syria, Palestine, and Egypt were the next. In 1260, Sultan Qutuz decided to confront the Mongols before arriving Egypt. The two armies faced each other in Ain Jalut, north of Palestine. Sultan Qutuz's army was able to defeat the Mongols and protect not only the Muslim nation but also the rest of the world.

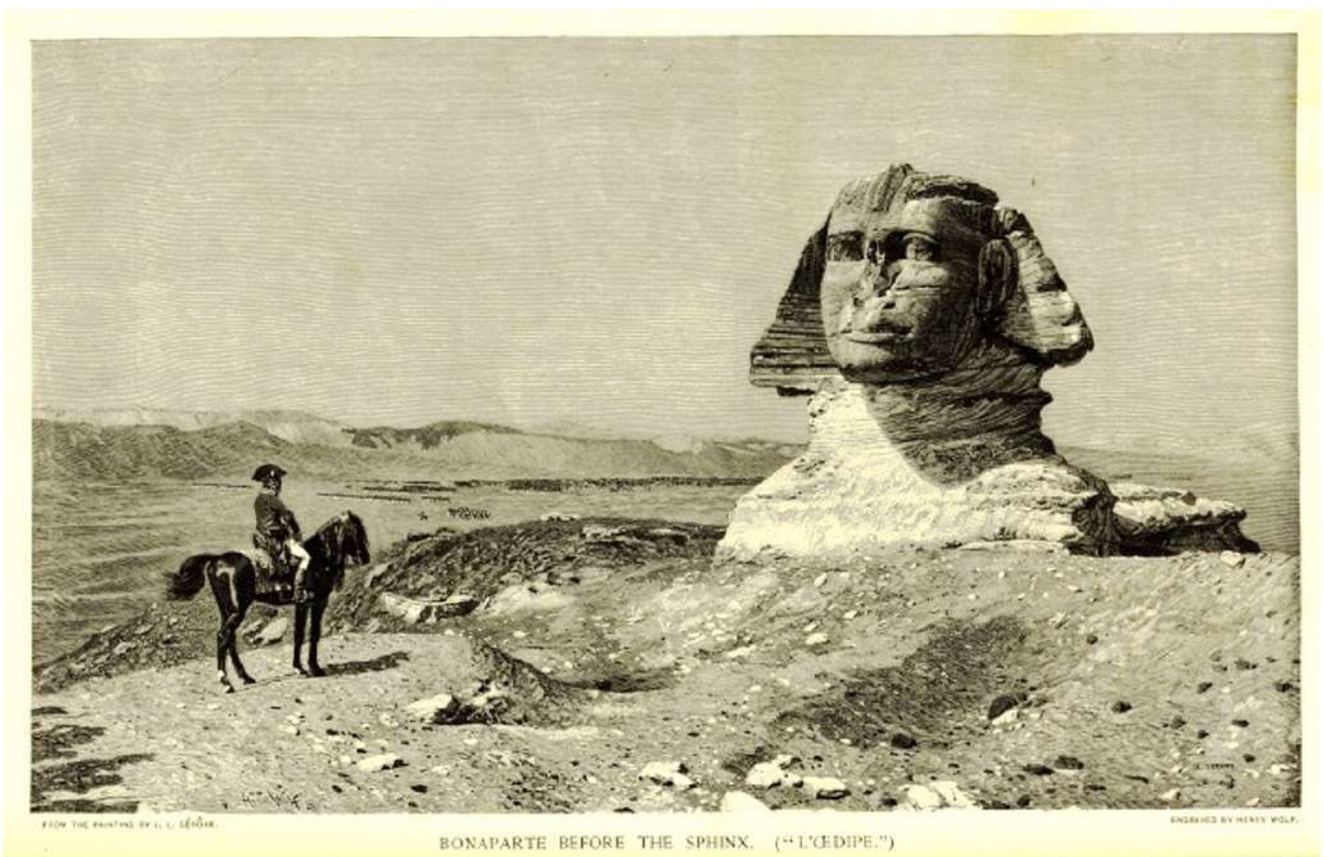


Figure 08: Napoleon Bonaparte Before The Sphinx during the French campaign on Egypt.
Source: Mimuw, n.d.

Ottoman Rule, Napoleon, and Muhammad Ali

After the fall of Abbasids caliphate, the Mamluks ruled Egypt and Syria as one state. In 1517 the Ottoman Sultan Selim decided to add Egypt to the Ottoman Empire and he succeeded to defeat Mamluks. After the control of Ottoman on Egypt, the centre of Islamic world shifted from Cairo to Istanbul. The Ottoman ruled Egypt from 1517 until the French campaign in 1798. Despite the stability of the economic and political situation during this time, there were no significant changes in Cairo during the Ottoman dynasty (Alsayyad, 2011).

In 1798, Napoleon Bonaparte occupied Cairo in search of colonial expansion.Trying to deceive the Egyptians, Napoleon called himself the servant of Allah and the Ottoman Empire. The French built many defensive structures connecting many roads. The resistance for colonization was increasing, and in 1800, Suleyman al-Halabi, a young Syrian was able to assassin the commander of the French troops Kléber. One year later under the pressure of resistance and the Ottomans, French troops were forced to withdraw and leave Egypt (Alsayyad, 2011)

Figure 09: Muhammad Ali Pasha. *Source: Noonpost, n.d.*

When the Ottoman took over Cairo, there were still Mamluks living in Egypt. After the withdrawal of French troops, they regrouped and regained power. Muhammad Ali, was an Albanian born in Kavala, a Macedonian city located in today's Greece; he came to Egypt with the Ottoman forces fighting against the French. After the withdrawal of the French army, he could control the government of Egypt but the Mamluks were an obstacle in his way to the throne. In 1811 he disposed of the Mamluks by a famous massacre in the Citadel.

Inspired by the industrial revolution, Mohamed Ali transformed Egypt to a modern industrial state and enhanced its military power; he also gave attention to agriculture and irrigation and

built many structures on the Nile and major infra-structures (Alsayyad, 2011).

Modern Cairo: Railway and Suez Canal

After the death of Muhammad Ali, the rule of Egypt was given to his sons. The economy was growing during this time due to the cotton industry. Abbas, one of Muhammad Ali's successors, continued to build the city and one of the most significant works he did was the railway in 1854, the first railway connecting Cairo and Alexandria.

Four years later the second railway between Cairo and Suez was finished. Sa'id, the next ruler after Abbas continued in the develop-ment of the city: one of the most important project he provided for Egypt was his agreement with de Lesseps to drill the Suez Canal. The Canal connected the Red Sea with the Mediterranean Sea for first time and changed the global trade routes (Alsayyad, 2011).

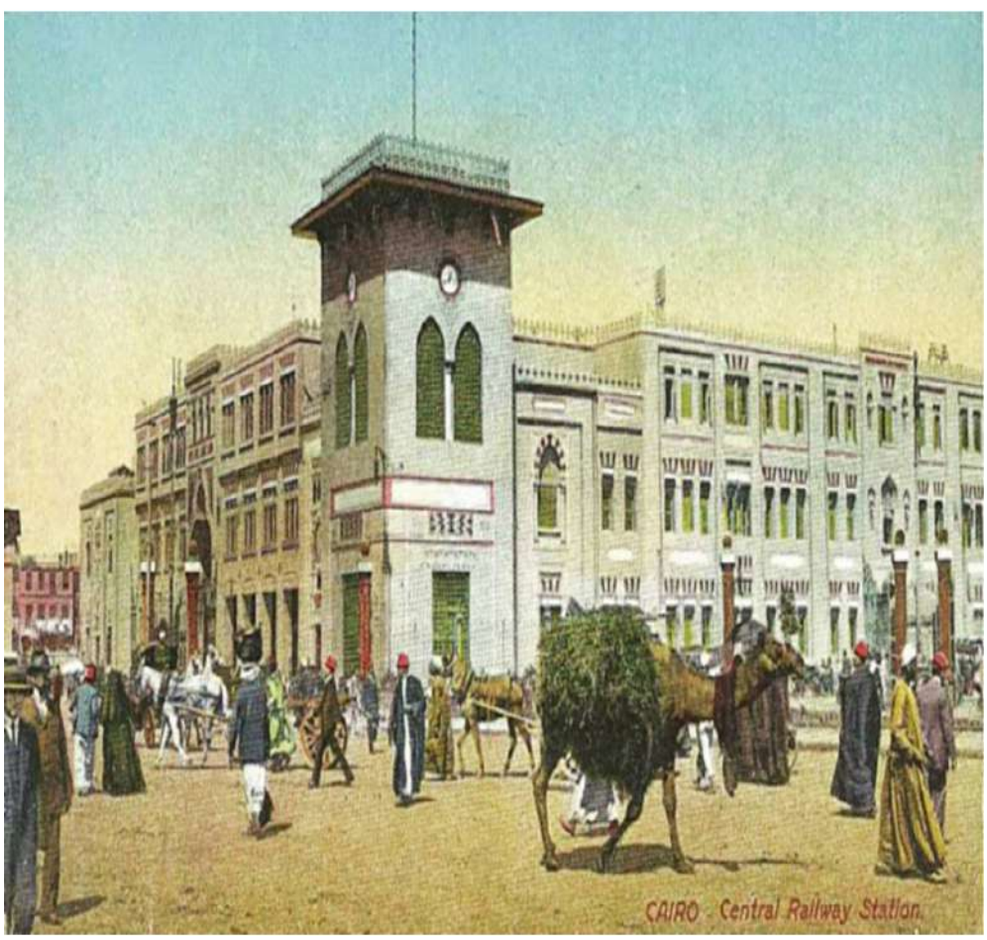


Figure 10: Cairo Central Railway Station. *Source:* Sawyertravel.blogspot

In 1882, because of the British Colonial creed and the deterioration of the economic situation in Egypt, England was able to defeat the Egyptian army and occupied the country. The British occupation effected the development of Egypt and reduced Egypt from a leading country to a state under occupation for nearly 70 years. After the pressure and resistance of Egyptians against the occupation, independence was regained in 1952.

Egypt was still occupied domestically by British military rule, which destroyed the way of life, politically, economically and socially.Cairo has witnessed great changes during Ismail's rule; he founded the ministry of public works and the Cairo Water Company to supply freshwater to inhabitants to install the streetlights. After attending the Exposition Universelle in France and the inauguration of Suez Canal, Ismail decided to build the Modern Cairo on the Parisian Style.

Ismail hired two French engineers for this mission; Piere Grand as civil engineer for Cairo's street network and Baril-let-Deschamps as an architect. As a result of the inauguration of Suez Canal and spending the country's money for building palaces and gardens for European visitors, Egypt was drowned in debt and Ismail was forced to sell his shares in Suez Canal to the British in 1875 (Alsayyad, 2011).

Figure 11: One Avenue of Cairo, 1920. *Source: Organization, n.d.*

Most homes in Cairo have access to electricity; however, the increasing demand is problematic, especially during the summer months (Economis Intelligence Unit, 2011).

Fossil Fuels

Egypt, in cooperation with the German company Siemens, built the biggest electric power plant in the world. This plant just 110Km away from Cairo, had a construction time of three years and uses the combined cycle of natural gas to produce 14.4 GW, providing electric energy for 45 million people, half of the Egyptian population. Even though this plant uses fossil fuel to produce electricity, its combined cycle technology allows a higher efficiency to reduce the energy loss in Egypt, saving about 1.300M USD yearly and producing less contamination than traditional fossil fuel plants (Notimex, 2017).

Egypt lacks significant coal reserves, which are estimated in 20 million short tons and mainly used for heating on rural housing. Most of the coal consumed in Egypt is imported (Comsan, 2010).

In 1986 the New and Renewable Energy Authority (NREA) was created to introduce renewable energy technologies in Egypt. In 2007 it established a plan to cover 20% of the total electricity production using renewable energy by 2027 (Comsan, 2010).

Hydroelectric power

Hydropower in Egypt takes advantage of the flow of water through the Nile river and its branches to produce electricity by using turbines, however, this resource is limited in the amount of locations where the construction of plants is feasible and most of them are already in use, as the next table describes (Comsan, 2010).

Year	Installed power (MW)	Hydropower plant
1926	5.8 (abandoned)	Several mini plants in Fayoum Oasis
1960	345	Aswan-I
1967	2100	Aswan High Dam
1985	270	Aswan-II
1995	90	Esna
2008	64	Nag-Hammadi
2009	40	Assiut
Feasibility	20	Damietta branch
Feasibility	10	Rosetta branch
Feasibility	3.5	Zefta
Feasibility	2.5	Tawfiki head regulator
Total	2945	

Table 1: Hydropower electricity generating plants in Egypt. *Source: Comsan, 2010*

Wind power

Wind energy is a clean, renewable source currently in development. Present wind farming technologies are still not able to compete against coal or fossil fuel energy in the bulk electricity market (El-Sayed, 2002).

A study by (Shata & Hanitsh, 2006) found that wind farming along the Mediterranean Sea coast area of Egypt has great potential, given the historical wind speed and air density data by the Meteorological Authority and the cost analysis of wind turbines.Private sector wind farming has been possible thanks to the Egyptian regulation policy. In the year 2022 a 200 MW farm is planned to run on the Ras Banas site, with a wind energy density of 1000 kW/m2; and at the East-of-Oweinat site with a wind energy density of 400 kW/m2 (Comsan, 2010).

“The total power that could be generated using wind farms along the Red Sea coast approximates 20 GW.” (Comsan, 2010)There is a 600 MW wind farm planned in Za’afarana, 200km southeast of Cairo (El-Sayed, 2002). Half of the capacity is financed by low interest loans for environmental protection from Denmark, Germany, Japan, and Spain; the remaining half is funded as “Build, own, operate and transfer” (BOOT) financial system in Egypt.

In comparison Turkey built their first wind farm in 1998, since then they have increased their wind power generation capacity as the next graph indicates (Turkish wind energy association, 2017).

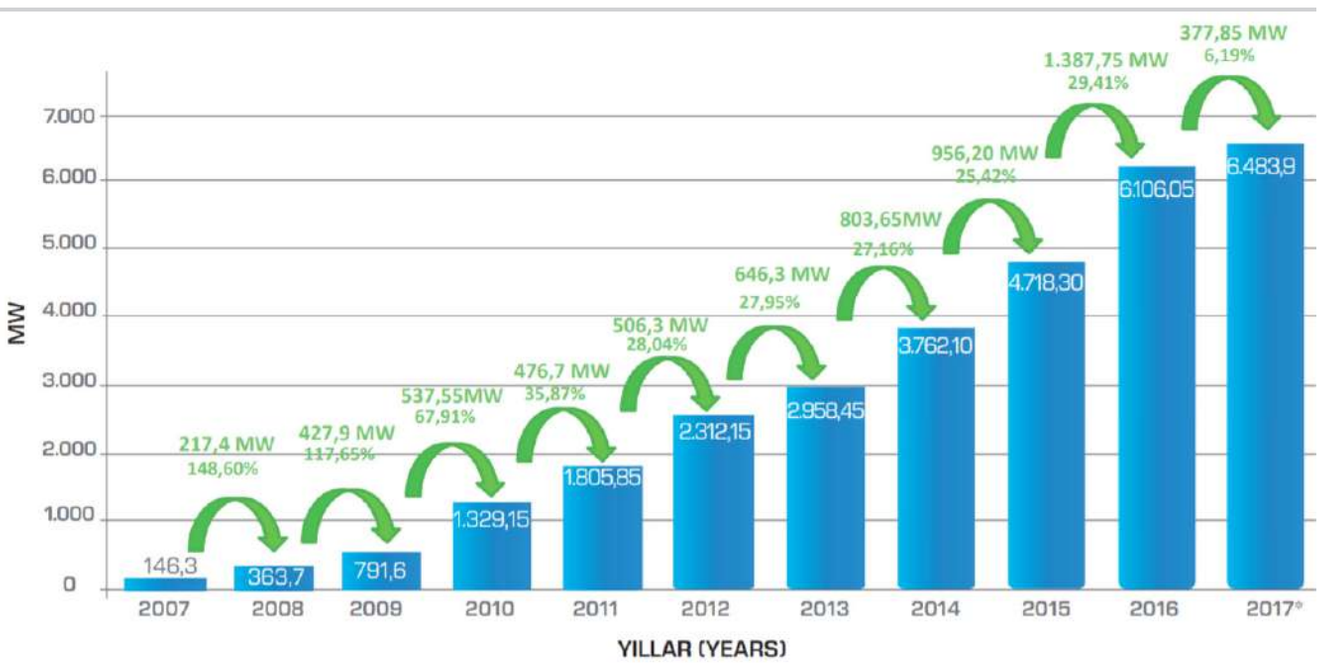


Figure 12: Cumulative installations for wind power plants in Turkey. *Source: Turkish wind energy association, 2017*

In 2017, The Ministry of Energy and Natural Resources launched the YEKA project (Acronym for “Renewable energy resource areas” in Turkish) aiming to build wind farms in 5 regions of Turkey, amounting to 1.000 MW of capacity, and able to produce 3 billion kWh; covering the demand of approximately 1.1 million homes, and reducing carbon emissions by 1.5 million tons annually. For this project, the estimated investment is 1 Billion USD and the contractors were given 10 years for research and development (Hürriyet.com.tr, 2017).

Solar power

Egypt is located in the global sunbelt, giving this country a favourable potential to harvest solar energy. The solar atlas issued in 1991 shows that Egypt has 2900-3200 hours of sunshine and 1970-3200 kW h/m² direct normal energy density per year; which indicates a potential production of 73.6 PW h (1015 Watts per hour) (Comsan, 2010).

Egypt, in cooperation with the United Kingdom and private investors, is building the biggest solar energy complex in the world, the Benban solar park in south Egypt. This facility is expected to have 1.8 GW power output. This project is part of the national plan to mitigate the dependency on fossil fuel, which now provides 90% of the total electric power of Egypt (EFE, 2017).The leading countries in solar energy capacity are located mainly in Asia (China, Japan) and Europe (Germany, Italy).

Turkey is located north of Egypt, just across the Mediterranean Sea, and in similarity with Egypt, enjoys the sunshine of the global sun belt. The Turkish Government declared specific targets for 2023, the 100th anniversary of the foundation of the Turkish Republic; one of them being to install capacity of at least 3000MW solar power (United Nations Development Programme), this goal was already met by 2017 with a solar power capacity of 3.402,8MW (TÜRKİYE ELEKTRİK İLETİM A.Ş., 2017).

Among the solar power plant facilities built in Turkey the solar tower at Mersin deserves a special mention, not because of the total capacity it generates but rather its innovative nature. It is a concentrated solar power (CSP) project built in 8 months in the municipality of Toroslar, with a power of 5 MW. 120 companies were involved in the design and construction, and the total cost for the project was $50 Million (Benmayor, 2013).

Figure 13: Mersin CSP field. *Source: Kohsman, File:Mersin CSP field.jpg, 2013*

Figure 14: Greenway Mersin CSP field solar tower. *Source: Kohsman, File:Mersin CSP Tower.jpg, 2013*

Nuclear Power

“Contrary to oil and gas reserves which are considered depleting resources, nuclear fuel has an extended life time. With appropriate nuclear fuel cycle technology, the life time of nuclear fuel may extend to several thousands of years.” (Comsan, 2010)

Meeting the estimated future energy demands from the Egyptian population relying on national fossil fuel resources is not feasible. In the Egyptian context, the introduction of nuclear power production can prove useful to meet future energy demands (Comsan, 2010).

On December 11th, 2017, the prime ministers of Russia and Egypt met in Cairo to sign a series of contracts in order to begin the construction of the first nuclear power plant in Egypt. The plant will be located on El-Dabaa, north of Egypt and construction time estimation is 12 years (EFE, 2017).

Figure 15: Russian President Vladimir Putin, left, and Egyptian President Abdel-Fattah El-Sissi, shake hands during their meeting in Cairo, Egypt, December 11, 2017. *Source: Zemlianichenko, 2017*

Cairo, Egypt's capital is the largest city of the country. Its current population is estimated to be 19,846,000 inhabitants. In the year 2030 the population will be 24,5 millions. This refers to 'greater Cairo' or the so-called metropolitan population. With a population density of 19,4 persons per square meter, Cairo holds 37th position in global comparison . Cairo is the 17th largest metropolitan area in the world ranking. In the Egyptian context Cairo has a unique status due to the fact that Alexandria (Egypt's 2nd largest city) reaches only up to 30 per cent of the size of Cairo.

Figure 16: Satellite view of Cairo, showing different kinds of settlements.. *Source: wallpapers people.com*

The UN states at 95 per cent of the urbanisation in the next ten years will take place in developing countries. But for Cairo neither the actual challenge of urbanisation is solved contenting nor is the future of this phenomenon yet organized and managed as that it reaches up to the sustainability development goal (SDG's) defined by the UN.
SDG No. 11 sets the framework and goals for 2030, like this:

- Adequate, safe and affordable housing with basic services → upgrade slums

- Access to safe, affordable, and sustainable (public) transport systems for all

- Promote inclusive and sustainable urbanization with included participation, problem and future directed sustainable human settlement planning and management

- Reduction of deaths and damages caused by disaster, specifically water-related, in particular for poor and vulnerable people

- Reduction of adverse effects of air pollution

- Promotion of eco-socio environmental links between urban, peri-urban and rural districts through strengthened development planning

- By 2020 integrated and adapted policies for inclusion, resource efficiency, reduction and reaction to climate change and disaster resilience and management via implementation of the ‘Sendai Framework for Disaster Risk Reduction 2015-2030’

- Development for/of financial and technical assistance to build sustainable and resilient buildings, best of all through utilization of local and sustain-able material.

Informal settlements

Informal urbanization can be seen as a result of the combination of a rapid and centred urbanisation, high population densities compared with the inability of authorities to provide appropriate land and, or housing (or to tackle the situa-tion/phenomenon somehow else), which matches the needs of the urban population, specifically that of the lower income (and median) segments (Ar-andel & El Batran, 1997).

Abdelhalim explains informal settlements (housing) as a normal occurrence which associates

Figure 17: Satellite view of Cairo. *Source: Nasa. Earth Observatory*

with rapid urbanisation, when the formal housing market is unable to cope with the massive demand of housing (by the low and median income sector), as general, understood by experts. “Informal areas occur when planning, land administration and housing policies fail to address the needs of the whole society” (Abdelhalim, 2010, p. 2).

The informal sector is the, the low and middle income wage earners, who cannot find a housing solution which matches their demands (Khalifa, 2015). The private sector did not respond to the low and middle income levels, so informal housing is the only affordable (and all comprehensive optimal) option (Malterre-Barthes, 2016).

Brief history of Cairo’s informal settlement

In 1950, according to David Sims ‘Understanding Cairo’ informal settlements in Cairo were not existent and started to emerge only in 1960. Back in the 1980’s there is a study claiming, that 77 per cent of all nationally housing units built in the timeframe 1966 – 76 are informal (El-Batran & Arandel, 1998), and in 1982 conducted study on informal housing states that 91 per cent of all built units in Cairo are informal (Arandel & El Batran, 1997). The UN Habitat report from 2016 (‘Egypt Housing Profile’) states that in the period from 1996 till 2006, 65 per cent of produced houses in urban area were informal and after the revolution in 2011 the informal housing increased exponentially (but mainly in already existing ones, not new settlements (Khalifa, 2015)).
Today, informal housing is the majority form of housing and building in Egypt (Khalifa, 2015).

‘Informal’ and the challenge of language

Unfortunately, in Cairo’s context, ‘informal’ is not defined (hence the precise content not clarified) and thus often interchangeably used with other vocabulary like ‘slum’, ‘unsafe’, ‘unplanned’ or specifically ‘illegal’ (Sims & Abd-El Fattah, 2016).One main reason why buildings are ‘informal’ is, because they are built on land, which is not designated as building plot, rather is illegal converted (self-owned) agricultural land into a building plot (Khalifa, 2015). Another one is that buildings are built on public state-owned land and built without building permission.

This tangle is not only encountered regarding informality and whatever it means and it stands for, unfortunately a general lack of conceptual clarity (not only in language also in other areas) is given - “Egypt’s Informal Areas: Inaccurate and Contradictory Data” (Kipper & Fischer, 2009, p. 029) Clarification (as the advent of progress) starts and demands a precise articulation, to establish common and exact understanding. This is an absolute prerequisite for further progress and development.

A retrospective projection

So, neither is the topic of informal settlements in Cairo a contemporary problem nor is it an exclusive problem of Cairo. Shawn O’Donnell names it a present urban ‘problem’ of the Global South or the urban challenge of the 21st century (O’Donnell, 2010). Abdelhalim refers to the informal housing phenomenon in 2010 in a broader perspective and points out, that Europe and USA, especially in industrial cities, encountered this phenomenon too, until the 20th century.
Taken this into consideration,it should help to understand that the stated ‘urban challenge of the 21st century’ is historically nothing new and, in its todays appearance, the challenge of the 21st century, as it was in its manner and appearance the urban challenge in the 20th century.

So, as it was mastered once, there is confidence, that it will be master again, even through the challenges are different.

Cairo on its way

In 1966 Egypt signed the 'International Covenant on Economic, Social and Cultural Rights (ICESCR)' and is thereby obligated to provide for everyone's right to adequate living standards, for the individual and his family. This includes (in particular) housing in general and the ongoing improvement of living conditions (article 11). The Egyptians Constitution from 2014 guarantees in article 78 a right to adequate housing (Sims & Abd-El Fattah, 2016).

Dr. Joan Clos, the UN-Habitat Executive Director says, if Egypt wants to meet its demands to provide adequate housing for the low-income households it needs to build daily 1,500 of such dwellings till 2030 (Clos, in Egypt Housing Profile, 2016). Sims D. depicts it in the 'Egypt Housing Profile' report (2016) as a total amount and mentions that 8.2 millions new building units are needed by 2030.

The past has proven that the solution is not 'just' building houses , Egypt and Cairo have the phenomenon of an outstanding high level of vacancies, "gross vacancies in Cairo Governorate reached 28 percent" (Sims & Abd-El Fattah, 2016, p. 27) and some temporary government housing projects have vacancy rates above 50 per cent.

The UN addresses under the Sustainable Development Goal (SDG) No. 11 'Cities' explicitly the challenges of congestion, lacking funds for basic services and shortage of adequate housing together with declined infrastructure.

The UN-habitat report 'Egypt Housing Profile' 2016 recommends among others the following issues to develop a national housing strategy:

Issue 1: Unsuitable and remote locations for government housing
Issue 2: Housing and social mixity
Issue 3: The feasibility of sites and services
Issue 4: Micro-credit for housing
Issue 5: Informal housing
Issue 6: Urban upgrading of informal areas
Issue 7: Understanding and monitoring the housing sector
Issue 8: Need for a comprehensive national housing strategy
Issue 9: Need for better social housing design
(Sims & Abd-El Fattah, 2016, p. xxii).

Methodology

The problems of informal housing and inadequate housing conditions is a multi-complex topic with various causes, evident as soft ones which nonetheless have a strong influence. Thus, to present only one approach towards a specific detail in the whole complex seems to be inappropriate.

Cairo's Sustainable City Goals, in relation to housing

As argued and pointed out the main focus intra-context of housing is that of informal housing/ settlement. The two reasons call for this, one that informal settlements is the major form of housing (60 per cent) in Cairo (Malterre-Barthes, 2016) and on the other hand the housing conditions of informal settlements are those in greater need for upgrading to match the SDGs than those of the formal market .

In the following research results the main challenges to reach the SDGs are depicted, shortly explained and solution approaches named.

Vacancy

Vacancy of existing housing stock. Despite a huge demand for housing, there are a great number of vacant houses. In urban area 37 per cent of housing stock lay vacant in 2006 (Sims & Abd-El Fattah, 2016, p. xvii). 'Egypt Housing Profile' report allows for the inference that provided housing matches the needs such inadequate, that even after assignment of the housing unit people did not move there and this additionally led to a very high vacancy level, which surprisingly by no government was never assessed in its totality to clarify the reasons of this phenomenon. Lack of "effective public transportation" (Nohn & Goethert, 2017, p. 67) for outskirts is one reason therefor. Another is, that standard housing models do not reflect regional climatic and culture (Sims & Abd-El Fattah, 2016).

In the global context this phenomenon is not unusual, millions lack adequate housing while the stock of vacant housing increases continually (Clos, UN News, 2017).

Social Equality

Residents of informal cities are an effect of the problems which cause the situation of informal housing and its accompanying symptoms. Literature and science as well as vocabulary (like upgrading /integration, redevelopment, participatory development etc.) shows a general understanding and "paradigm shift" (Khalifa, 2015, p. 1153) towards this position and approach don't blame the symptom, solve the cause (which is the governments responsibility). Informal residents are not the problem , they are the 'victim', a cooperated development for a solution is needed, so that informal settlers' demands are met more appropriatly. This positive shift has commenced but has not yet reached out to a fully integration in all governmental institutions, policies and strategies or the providers of services (Khalifa, 2015). Kahlifa M. explicitly names the lack of "community participation in planning or implementation" (Khalifa, 2015, p. 1154) as an obvious deficiency of all the effort done by the 'Informal Settlement Development Program' (ISDP) over all the years from 1994~2004 and 2004~2008.

Participation is a vital component of 'Egypt's Vision 2030' , respectively Egypt's Sustainable Development Strategy' (SDS).Dr. J. Clos, Executive Director – UN Human Settlements Program (UN-Habitat), says that the 'SDGs' can only be achieved when housing contributes to socio-economic development wherefore the 'New Urban Agenda' lays down that housing policies must be at the midpoint of all national urban policies along with the strategic fight of poverty (Clos, UN News, 2017).
Who can better represent informal settlers needs as they themselves. This research has not discovered an informal settler's unity, where they associate to fight for and strengthen their

rights. Improvement and real participation can only take place when informal settler have a political voice.

Upgrading and Rehabilitation

After several failures of relocating (Sims & Abd-El Fattah, 2016) informal residents the potential of upgrading and rehabilitation of existing informal settlements is understood but how and to what extend upgrading can be realized must be further defined. A sound application of an advanced approach is needed. Worldwide there are many examples of successfully upgraded informal settlements, which solu-tions are adaptable in Cairo and should be examined.

Especially the unsafe areas (according to the ISDF's terminology and classification in 2009) should have for rank due to their high risk they pose upon its inhabitants.Upgrading attempts within the global realm have not shown the anticipated outcomes and since the 21th century the approach of integration become more the centre concept (while upgrading can be a part of integration).

Daylight and Fresh Air

Enable residents' access to (day) light and (fresh) air (air conditioning / ventilation). Use of daylight as natural light source leads to reduced energy consumption, if the building typology does not allow for direct access of natural light, light direction via mirrors and transparent doors should be considered.

The access to air and a certain ventilation rate within the edifice can (when a naturally circular ventilation is not feasible) done by ventilators and is highly recommend to prevent mildew. The major challenge is the general air pollution and hence, that fresh air (from outside) is not clean air.

Occupants modify and enlarge their units and buildings according to their needs, which results in "incremental expansion" (Nohn & Goethert, 2017, p. 67) partly leading to completely new rooms which in the original layout design haven't existed and ergo leads to unlit and unventilated rooms. The expansion can reach up to 50 per cent of the original space.

Energy

To avoid noise and further air pollution single energy generators are not a sustainable solution. Within the 'A²L-Mobilius' research project first ideas of a "Decentralized Processing Unit" (Hu, Follini, Pan, Linner, & Bock, 2017, p. 116) are developed to include the concept of energy collection, provision, use and production.

A fully established solution for energy generation and use for air conditioning is the "Solar-driven adsorption refrigeration for air conditioning in buildings" (Schlotter, 2017, p. 22). This system uses solar collectors (which are widely used in Egypt and already used to produce hot water) to drive the refrigeration machine for cooling . The system regarding its setup and components is, more or less, 'relatively' simple and can be locally planned, installed and maintained with some trained technicians.

Food and Agricultural land

Independent food supply (Hu, Follini, Pan, Linner, & Bock, 2017) must be encouraged and the elimination of agricultural land by informal settlements (Madbouly, 2016) needs to be stopped. By2025 Egypt will have lost almost half of its agricultural land to inhabitation through informal settlements (Khalifa, 2015).

Two improvements and compensations to gain food and agricultural land are roof gardening and vertical farming. The general concepts are not new and in Egypt well established too – e.g. 'Crowdfarming Egypt eZra3'. An implementation obstacle is that the investment costs (7000 ~ 15000 LE) exceeds low income earner's budget (Detrie, 2012).

Governmental support or 'start-up' credits could aid this, because according to Sherif Hosny, founder of the 'Schaduf' micro-agriculture initiative, about 300 ~ 500 LE per month can be generated by urban gardening. Meaning a small urban plant is amortised after about 2 years. The business model with a local grocery in the arear could help the producers to sell (what they don't use themselves) their products.

Figure 18: Roof Garden in Cairo. *Source: Cityfarmer.info, 2018*

Work opportunities

Work opportunities within reach or any ability to work and the optimized supply of food are important needs of informal settlers (Schlotter, 2017). Cairo's informal settlements are typological "brick-infill constructions" (Malterre-Barthes, 2016). This typology in combination with urban farming and the new building material 'mushroom- / mycelium bricks' contains much potential in several aspects. Local residents can profit from all positive effects of urban gardening, have a local opportunity for (additional) earnings and produce what is needed in a renewable and sustainable manner. The Technical University of Munich co-developed the innovative and local business model 'Decentral-ized Industrial Village' together with the 'Affordable and Adaptable Building System' and the 'Decentralized Processing Units' in the A²LMobilius project (Hu, Follini, Pan, Linner, & Bock, 2017).

A core problematic regarding work opportunities is, in the case of replacement, where residents often are relocated so distanced that they cannot retain their original income source (Sims & Abd-El Fattah, 2016), which actually worsens the situation and leads low income earners into poverty. Regarding this dramatic situation solutions are needed. Temporary relocation for redevelopment has shown success.Nohn & Goethert identified effective public transportation as crucial for successful resettlement projects "particularly transportation, which makes an important contribution to successful housing projects by connecting settlers with the city and with job opportunities" (Nohn & Goethert, 2017, p. 17)

Sewage

Full installation of sewage infrastructure and existing sewer improvement is necessary to reduce all negative and dangerous impacts such as malodorousness, health risks, ground water pollution and consequently drinking water pollution, rise of ground-water level, destabilization of subsoil, resulting in damage and even collapse (BEDI 6. , 2016 resulting from that source. According to scientific literature this problem at least nowadays for (greater) Cairo seems to be solved (Sims & Abd-El Fattah, 2016), except greater Cairo's districts Giza and Qalioubiya (Ahram, 2015).

Towards sustainability as next step should be in the context of disaster prevention which Cairo needs checked if the existing sanitation and sewage system can bear flooding. The UN 'New Urban Agenda' recognizes that urban centres worldwide and specifically in developing countries are vulnerable to impacts of climate change which among others flooding houses have backflow traps? How is the situation improved or better solved with the unsafe areas of grade/level 1, which are explicitly exposed flood-plain areas (Khalifa, 2015) In a case of flooding, will the sewage and the flood water intermingle?

SDG No. 11 target is set to be the reduction of death and to decrease losses done by water-related disasters, explicitly regarding poor and vulnerable people.

Secure Tenure

Secure tenure, residents living in informal housing do not benefit of a (complete) legal recognition (BEDI 4. , 2016). This causes a broad ramification of additional difficulties arising from it. Moreover, it seems as if there are contrary notions regarding this subject, the 'Egypt Housing Profile' report claims that informal areas enjoy relatively secure tenure whereas

Khalifa M. (2015) points out, that within the upgrading process (in the years 1994-2008 of the actions by ISDP) topics like secure tenure where neglected. Furthermore Shawkat Yahia presents how the Egyptian state - inter alia - via transforming public state land into private state land in cooperation with Real Estate investors gains tremendous profit, whereby the legal informality and the legal protection of numerous informal residents are defenceless extradites (Shawkat, 2016) . This goes hand in hand with the claim, that property registration needs to master seventy seven “bureaucratic procedures” (BEDI 4. , 2016, p. 3) and takes about 6 to 14 years.The current display is not sufficient as to state that the aim of adequate living in respect to (increased) tenure security is given in accordance with SDGs No. 11 access for all to adequate, safe housing.

The UN ‘Habitat III’ report mentions in several contexts how important the secure and “increased security of tenure” (UN, 2017, p. 13) is.

Informal housing is to 80 per cent built on (self) owned agricultural land (Khalifa, 2015), to at least possess some kind of ownership and right of property, even so the building’s erecting is (still) illegal. Ergo, the government needs to provide legal (and affordable) option for building plots to avoid the loss or alienation of agricultural land and establish legal options to help informal/illegal settlers out of their nebulous status. The implementation of social help centres (commenced and run by government) which helps informal settlers to get a legal and official registration is seemed to be necessary in consideration of the fact, that informal settlers mostly belong to the low income group which usually consist of the inferior educated people who might be afraid or simply be unable to cope with the situation and its challenges.

Redevelopment and Temporary Relocation

Temporary resettlement is successfully proved manageable when residents are only temporarily relocated for redevelopment and afterwards are again placed back in their former environment. This allows to keep their former or original income source which very often could not be maintained in the relocated area which was too far away from the original location. Also, it preserves the (good) living conditions of the residents as they remain in their used and entrusted surrounding. The Informal Settlements Development Fund has apprehended this and offers rent money affected residents for their temporary relocation (Sims & Abd-El Fattah, 2016).

Transformation, Clarification and Organization

Community transformation is a normal and permanent process which needs guidelines and legal framework to reach its optimum. These guidelines need to cover the causes as well as the symptoms – a “twin-track approach” (Payne, 2005). However, guidelines, policies and other instruments need to be coordinated by those responsible, but Khalifa M. could not find evidence for a sound coordination among the responsible actors (Khalifa, 2015). So Cairo wants transform its informal settlements clarification and organization must be further established. Ministries and authorities are established, coordination and cooperation needs to be optimized.

Miscellaneous

In acknowledgment of the size of the work and concomitant with the research findings following significant topics for the sustainable improvement of Cairo’s housing are listed in note form:

- Structural building standards need to be checked and improved, there are still people dying because of collapsing houses . “Contrary to what many think, the basic structural quality of informal production is good” (Sims & Abd-El Fattah, 2016, p. xviii). Every single person is one person to much even though the general structure of informal settlements is sound. Two main reasons are deterioration (no maintenance, people are too poor) or structural overload through additional illegal added floors (Sims & Abd-El Fattah, 2016).

“Occupants will seek options for improving their residential buildings according to their needs and preferences so that incremental expansions will take place” (Nohn & Goethert, 2017, p. 69).
- All inclusive and updated cadastre is needed – especially for the informal settlements – to facilitate their management, recognize incremental expansions (in all directions) which takes place over time nearly almost (Nohn & Goethert, 2017) and further to collect respective taxes (Malterre-Barthes, 2016). Consequently, upgrading the informal into formal settlements and full supply of public services.

- Community design is and thus should be an open and ongoing process, a temporary majority of informal settlements is the status quo and the beginning of the further design process. Monitoring instruments are needed and most helpful to direct the evolving process, Abdel-Kader & Ettouney recommend identifying “Actors, Actions and Acts/Interventions” (Abdel-Kader & Ettouney, 2017, p. 108).

- Prevention of the framework for the “grey economy” (Malterre-Barthes, 2016, p. 5), which is based on contractors and investigators who speculate with illegal and ‘secretly’ established real estate stock. These speculative Real Estate towers are no more typical informal structures and the “speculative one-off towers” (Malterre-Barthes, 2016, p. 5) are much bigger in their sizes and exhibit much higher building standards but are never the less completely illegal.

- Set and implementation of a holistic legal framework and its executive authorities to terminate informal settlements, especially in its speculative real estate stock version (Malterre-Barthes, 2016).

- Decentralisation, Cairo’s unique position should be limited through counteracts to the concentration on Cairo as unique pole.

- Broader focus for the future needs is necessary, current problem solving (urban issues) will not lead out of the problematic on the long run.

Conclusion & Action Plan

Informal settlements are the solution of its residents when they could not find housing in formal areas. This impetus still exists and is the driving force to the solution wherefore Egypt’s and Cairo’s governments have to provide a framework and channels to lead it towards matching the SDGs. The new inclusive and participatory upgrading and redeveloping approach (Abdel-Kader & Ettouney, 2017) seems to be auspicious but it must be citywide included into institutional policy reforms and not a separated single concept (Khalifa, 2015). The ‘New Urban Agenda’ should be integrated in Egypt’s policies and residents should unite and associate to become a politically voice and be able to protect their rights.

Individuals, communities, culture and consequently settlements are in a constant move/change to satisfy needs and improve conditions. The transformation in communities observed by Abdel Kader & Ettouney, 2017 demonstrates that over time some buildings are compensated by extensive high-rise building (real estate) developments. As positive as it seems, these changes must be observed with the focus if living conditions (for society and poor, vulnerable people) predominantly have improved. The investigations by Malterre-Barthes, 2016 and Shawkat, 2016 give rise to doubts, that only a local displacement is taking place, this would impair the situation more then it improves it. Thus, it is important to hold the set focus which is addressed towards the poorest and most vulnerable, those are the number one in the development agenda (Clos, UN News, 2017).

Egypt and Cairo need to shift out of the testing and experimental case phase into a stage of fully institutional implementation (Khalifa, 2015) with its executives, coordinating and controlling institutions.

In general the structural design of informal buildings is considered good. Those considerations did not allow to clarify if this is still true in cases of disaster. How has Cairo faced disaster in the recent past, where conclusions drawn from and implemented? Within the context of the SDGs for 2030 the implementation of the 'Sendai Framework for Disaster Risk Reduction 2015-2030' will have to clarify this and if necessary provide a remedy.

Egypt participates in international and intercontinental associations as well as in technical and educational programs and attains shared knowledge (Schlotter, 2017). The United Nations Development Programme (UNDP) supports Egypt and Egypt "requested UN-Habitat to prepare a Housing Sector Profile for Egypt" (Sims & Abd-El Fattah, 2016, p. xvii). Also a strong German-Egyptian cooperation has been established for many years now with plenty of success stories. Egypt and Cairo seem to feel responsible and willing to work out its solutions (not only) for improved housing and living conditions (but UNDP states that Egypt has not yet achieved the MDGs). The political will is one of the key factors, without this no real improvement can take place (Khalifa, 2015).

Historically, continuous political, economic and social changes and upheavals have contributed their pros and cons. Unfortunately, this did not allow for a pervasive improvement with and under the same concept/notion. Hopefully the current political situation will allow for necessary and demanded ongoing improvement to monitor, analyse, clarify, enact, coordinate and cooperate and finally maintain the implementation of the required actions to meet the SDGs not later than 2030.

Housing is a multi-related topic which is influenced by many ways and has impact on numerous aspects. Even so if there are general approaches towards sustainable cities and improved living conditions each city is individual and requests for its specific solutions. This chapter exhibited some problems and reactions as to how first tangible steps towards improved living conditions can be done.

Current Status

Cairo is divided into four regions and 37 administrative districts, four regions: northern Cairo, western Cairo, eastern Cairo, and southern Cairo, An extensive road network connects Cairo to other Egyptian cities and villages. On the outskirts of the city there are circular roads that surrounds Cairo. In the city, traffic is designed to be fast and efficient through overpasses and bridges (Embassy of the Republic of Korea in Egypt, 2009).

The main modes of transport in Cairo include buses, minibuses, taxis, subways and tuk-tuks.
- Bus: There are designated stops and system operated by the state, but the routes are few, the facility is old and they step at midnight.

Figure 19: Cairo Bus. *Source: Cairo Transport Authority, 2015*

Microbus: A small van of nine passengers available at an affordable price, but the risk of passengers is high due to aging facilities and wild driving. The name “micro” is attached to the fact that 14 people can ride a small van. Cities like Cairo are more popular than the big buses run by national transit agencies.

The large buses run along the main street as shown in the route table, but the micro buses run down to the deepest part of the town with small roads where large buses do not go. Passengers can ride anywhere they want. Even before you get on the van, you can go to the destination of your choice just by negotiating with the driver. The biggest advantage of Microbus is its 24-hour service. Microbus drivers usually do not depart until all 14 passengers have arrived. Then the passengers suggest that they pay a little more and they leave before the van is full (Embassy of the Republic of Korea in Egypt, 2009).

Trams: Cairo trams built from the early 20th century until 2014 are still in use. In the 1970s, the

Egyptian government preferred to make space for cars, removing more than half of the tram routes (Embassy of the Republic of Korea in Egypt, 2009)

- Subway: It has Line 1 to 3 and is the most efficient public transportation in Cairo. Rates are constant regardless of distance. It is very crowded during commute time and there is a separate section for women.

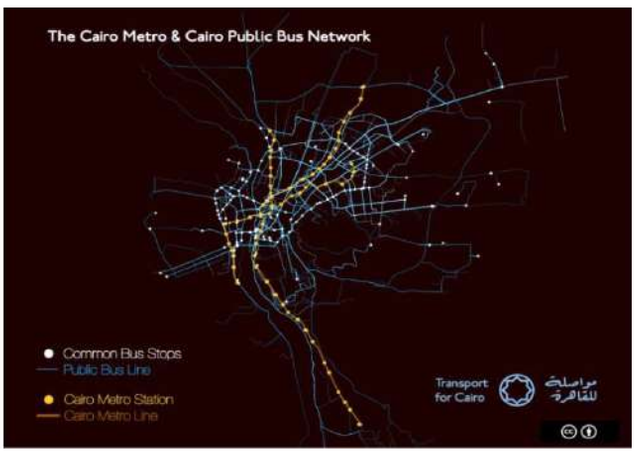
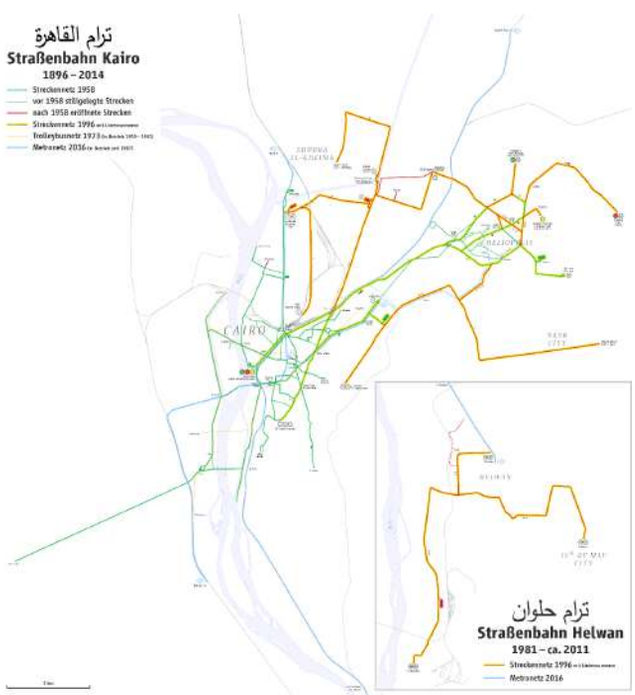


Figure 20: Cairo Metro & Public Bus Network. *Source: Cairo rom below, 2016*
Figure 21: Micro Bus. *Source: Korea Ministry of Foreign Affairs, 2009*



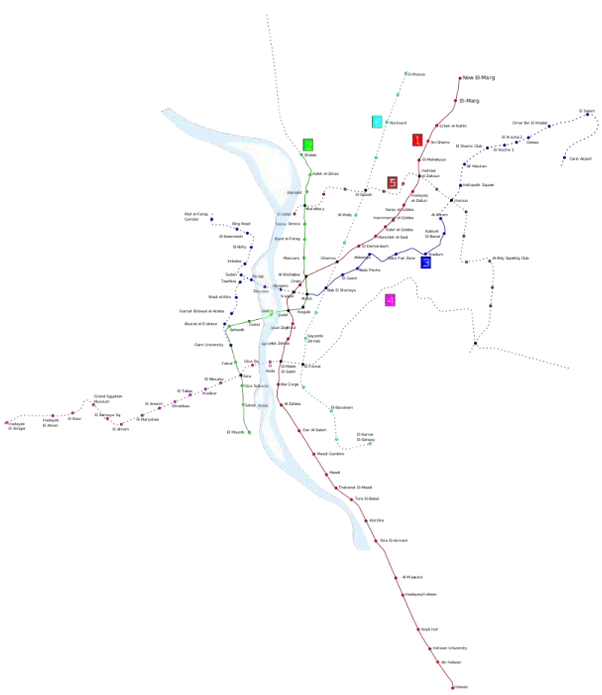


Figure 22: Cairo Tram Lines. *Source: Cairo rom below, 2016*

Figure 23: Subway lines. *Source: Cairo from below, 2016*

Tuk-tu: A small motorcycle-like car that operates similarly to a taxi, with no fixed fare, no restrictions on the driver.
Taxi: It is mainly used for long distance transportation such as airport.

Challenges

Cairo's high population density, automobile growth rate, low public transport utilization and poor pedestrian environment are causing severe traffic congestion, shortage of parking days, high

traffic accidents, air pollution, and noise. The share of means of car and taxi reaches 67.2% of the total means of transportation and the share of public transportation such as subways, buses and trams are only 32.8%. Traffic volume in taxis and cars is overwhelmingly over-shadowed by traffic congestion far exceeding the theoretical speed (Mi-Kyung, 2015).

Line	Destinations	Length	Stations
1(Red)	Helwan – El Marg	44,3 Km	35
2(Orange)	Shobra El Kheimal – El Mounib	21,6 Km	20
3(Green)	Attaba – Al Ahram	12,0 Km	9

Table 2: Cairo Subway Lines. *Source: Cairo from below, 2016*

Transportation	Trips/Day	Mode Share (%)
Subway	350.000	15.9%
Bus	250.000	11.4%
Taxi	650.000	29.5%
Micro Bus	110.000	5%
Tram, River Bus	10.000	0.5%
Personal Vehicle	830.000	37.7%
Total	2.200.000	100%

Table 3: Cairo Public Transportation Mode Share. *Source: Egypt Government, 2015*

Figure 24: Cairo Public Transportation. *Source: Egypt micro-bus strike in the greater Cairo area.*

Figure 25: Cairo Public Transportation. *Source: Daily News, 2017*

Case of Seoul

The city of Seoul has been continuously expanding its roads in response to the population growth of the city and the increase in the number of personal vehicles. The road extension in Seoul has increased by about 1.1% per annum over the past 40 years (1975 ~ 2013), and the total roadway has been maintained at 8,198 km and growth 22.3% as of 2013. The road growth rate in Seoul is high compared to 15.8% in Tokyo and 12.0% in Singapore (Korea Ministry of Land, Infrastructure and Transport, 2013).

In the 1960s, as the population of Seoul metropolitan area accelerated and the demand for traffic surged, the Seoul Metropolitan Government had implemented public transportation, especially bus - oriented traffic policies. However, the bus-based traffic system operation was not effective in solving the root cause of road traffic congestion, for the rapid expansion of the metropolitan area, the rapid increase of the traffic. As a result, the Seoul Metropolitan Government has steadily expanded its subway line since the opening of Subway Line 1 in 1974. Moreover, the subway's share has been ahead of other means of transportation in 1997 (Korea Ministry of Land, Infrastructure and Transport, 2013).

However, the urban railway is capable of high-speed transportation, but financial investment for construction and expansion are required, then it is difficult to immediately respond to the increase in traffic demand due to the long construction period. In order to maximize the linkage with the subway and get a synergy effect, the city of Seoul reorganized the bus system on July 1, 2004 (Korea Ministry of Land, Infrastructure and Transport, 2013).

Therefore, the number of bus routes connected to the subway has been expanded to form an integrated public transportation network, and the utilization rate of the traffic card has increased so that the management of the bus transportation income has become more transparent than in the past. The restructuring of the bus public transport system has shown improvements in air quality, speed of bus traffic and safety improvement. The Seoul Metropolitan Government's efforts to improve public transportation continued to receive international prizes for its innovative technology and policy making efforts (Korea Ministry of Land, Infrastructure and Transport, 2013).

The various transportation policies implemented by the Seoul Metropolitan City have made a great contribution to make Seoul a smarter city. Especially, it was possible to obtain speed, accuracy, transportation efficiency improvement and bus operation cost reduction by expanding the traffic information terminal of the bus stop and opening the central bus road system.

In addition, the Seoul Metropolitan Government made efforts to use smart cards in earnest, and the introduction and operation of the new transportation card system in Seoul, which has a population of more than 10 million people, is regarded as a successful reform of the transportation system in the world. Furthermore, a common service system for passenger cars using smart phones is suggesting a new model of smart transportation system implementation. More-over, high-speed WIFI is available free of charge in all public transportation.

Water Management

According to the UN, global demand for fresh water will surpass supply by 40% in 2030, as a result of numerous reasons from human activities, population density and climate change. As reported by BBC, Cairo is the fourth out of eleven cities to run out of clean water by 2025 (titled, 11 February 2018). To understand the reasons behind "water Scarcity' in Egypt as a city, we should study them in Egypt as a country.

The present available water resources in Egypt are 55.5 BCM/year from the Nile River which consist of around 97% of the renewable water supply in Egypt (Hussein I Abdel-Shafy, 24.09.2001), 1.6 BCM/year from rainfalls on the northern cost of Mediterranean Sea, 2.4 BCM/year from non-renewable deep groundwater, and 6.5 BCM/year from shallow groundwater. Which cumulatively compose 66 BCM water supply in Egypt. On the other hand, the total demand for fresh water is 79.5 BCM/year (Omar MEDM, 7.3.2016). The gap between supply and demand is 13.5 BCM/year, which is retrieved by recycling agriculture drainage water and wastewater in official or unofficial ways. In addition, Desalination is used to provide domestic clean water along the Mediterranean and the Red Sea coast areas (Ibrahim-El-Assuiti, 2005).

Requirements

Agriculture

Crop choice by ranchers has an explicit effect on water utilization. The water consumption differs significantly for each crop.

Crop	Delta	Middle Egypt	Upper Egypt	
Sugar Cane		7167	9109	Cubic m/ fed
Rice	4961	4691	5359	Cubic m/ fed
Cotton	2818	3541	3881	Cubic m/ fed
Corn	2251	2310	2370	Cubic m/ fed
Wheat	1608	1996	2195	Cubic m/ fed

Table 4: Crops Water Requirements. *Source: Ibrahim-El-Assuiti, 2005*

Table 4 explains the water requirements for each crop per area, when government gave the farmers the choice of choosing the crops type. As a result, rice production doubled, and agriculture water share almost used 1/5 of delivered water from the Nile River (Ibrahim-El-Assuiti, 2005).

Domestic

Average water production for domestic use was 5.3 cubic km/year (Irrigation, January 2015). These percentages came from Nile systems and ground water sources. The domestic water supply serves urban and rural suburbs and some industries. The challenge lies in the distribution system, some pipelines have as low efficiency as 50 % (Ibrahim-El-Assuiti, 2005) and sometimes less.

Industry

A survey made by general authority for industry revealed that water requirement for industrial sector was 7.5 cubic km^3/ year during 1995/96 (M. A. Ashour, March 2009).

In some cities, an important amount of treated or untreated process water returns to the system or flows directly to the sea creating greater environment problems.

Navigation

The Nile River is used for goods transportation and for the Nile touristic cruises in Luxor and Aswan. Ships experience great difficulty in January and February as the discharge decreases to meet other sector demands.

Hydropower

Since 1990, agriculture and land development were prioritized over hydropower. Therefore, hydropower has no exact share of water for production. Only the releases from agriculture, domestic and industrial purposes runs through the turbines at High Aswan Dam producing electricity (M. A. Ashour, March 2009).

Challenges

Egypt has reached a state where the amount of water is forcing limits to its financial growth. The individual's expenditure is increasingly decreasing. The current per capita share is under 1000 cm/capita/year (Sep. 2004), a number which in accordance with national standards represent "water poverty" limit. This share is predicted to drop to 500 cm/capita/year in the year 2025 (B.Attia, 2004).The principal challenge facing Egypt is the obligation to manage and develop its limited existing water resources, land and energy.

"Among these challenges are seepage losses from canal and drains, evapora-tion loss from water surface, evaporation losses so as infiltration losses from agriculture lands and aquatic weeds in canals. Moreover, the accuracy of water distribution operation, defect in control gates, number of pumps that do not deliver water to the stream ends, expansion of rice to sugarcane areas and exceedance of the permissible pumping rates of wells are counted among the challenges, in addition to lack of withdrawal control in deep groundwater, damage in drip irrigation system, installation of sprinkler, high distribution losses in drinking water network and lack of public awareness in domestic water sector" (Mohie El Din M. Omar, November 2015).

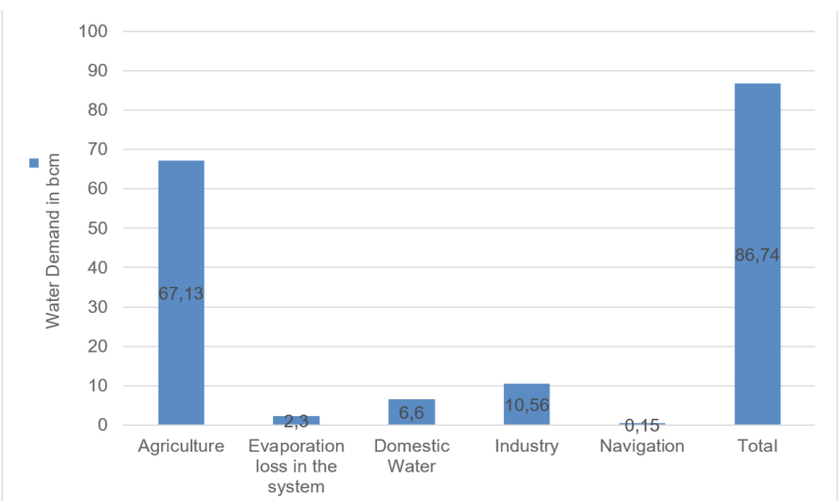


Figure 26: Water Demand for 2017. *Source: Ibrahim-El-Assuiti, 2005*

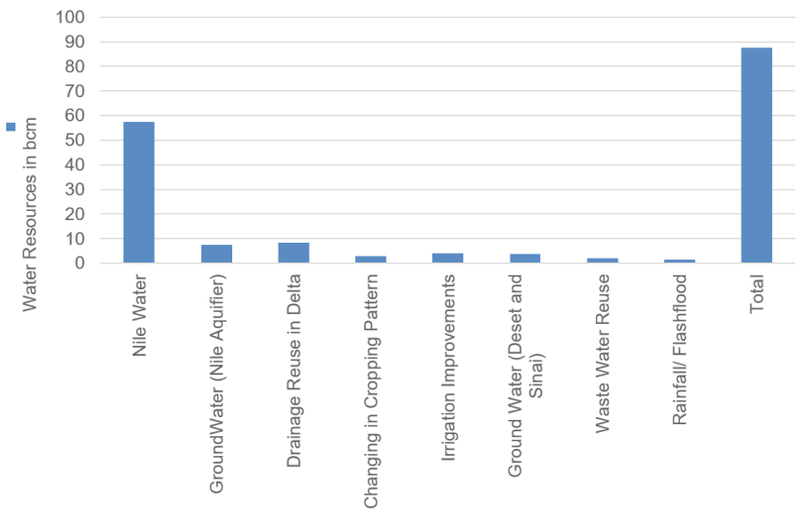


Figure 27: Water Resources for 2017. *Source: Ibrahim-El-Assuiti, 2005*

Egypt's population is rapidly growing. It has increased by 41 % since 1990. It is expected to grow from 92 to 110 million by 2025. The fast population growth duplicates the stress on Egypt's water supply due to more water necessities for household utilization and increased use of irrigation water to meet higher nourishment demands (Dakkak, 2017).
World Health Organization figures show that Egypt ranks high among lower middle-income countries in terms of the number of deaths related to water pollution.The pollution in the River Nile is caused by domestic and industrial waste and leakage of wastewater. The main industries in Egypt are chemicals, food, metal products, and textiles (Hamza, 1982). Untreated industrial waste discharge into the surface or groundwater causing major threat to the cultivated areas and food production.This leads to metal, ammonia, and lead existing in the water causing major risks on human health and food safety. In 1989, A study showed that in Helwan (south of Cairo) the industrial wastewater were around 45 million cubic m/year (RNPD, 1989), and in Shoubra El Khaima (north of Cairo) a large amount of untreated industrial wastewater are discharged into cultivation drains.

Water Management.
As Martin Hvidt (Hvidt, 1995) notes" there are two main ways one can match demand with supply: either by reducing demand or by increasing supply. In spite of the increasing scarcity of water, however, there are virtually no indications of attempts to reduce water demand in the three main water- consuming sectors".

A number of management actions and strategies should be taken to secure Egypt's Water demands (El-Nashar WY, 2017).
1. Eliminating rice and other water consuming plants from crop pattern or shifting to less water demanding crops (Kurschner, 2010)
2. Improve the surface irrigation system by converting small field canals from surface canal to pipes and improving the efficiency of existing public water supply. This will save 42% of water losses due to seepage and evaporation (Elyamany, 2016),
3. Using fixed furrow irrigation system to save more than 35% from water applied. This system will save 9.36 BCM (Ibrahim, 2010).
4. Using of modern irrigation systems such as sprinkler (Fig.4) and drip ir-rigation to reduce irrigation losses, this will result in saving about 8.8 BCM (El-Nashar WY, 2017).
5. Increase Water Taxes according to Individual's income.
6. Find alternatives water resources as: Reuse of drainage water and treated wastewater

(A, IWTC10 2006), Desalination of sea water in agriculture. (El-Nashar WY, 2017), Groundwater from drill water wells and the Nile aquifer (ICAR, 2011)., and construct water condensers (Fig. 7) next to severe evaporation places as coasts and cultivated lands (El-Nashar WY, 2017).

Figure 28: Sprinkler Irrigation System. *Source: The HIndu Times, New experiment: Sprinkler irrigation system: M. Srinath*

Figure 29: Furrow Irrigation. *Source: HoraceG, 2006*

Figure 30: Drip Irrigation. *Source: Borisshin, 2011*

Education System

In Egypt, 35 percent of the population represent young people under the age of 15, which means a lot of pressure on education in pre-school, primary, secondary, and higher education, the two Ministries of Education and Higher Education supervise the education system (EP-Nuffic, 2015).

Primary and Secondary Education

Education lasts for 6 years and at the end pupils take a centralized national exam, those who passes get the Basic Education Certificate, those who were unable to pass this exam, usually go for vocational education schools for 3 years. After completing this phase, pupils get Certificate of Completion Of Basic Education and Vocational Preparation. After this period, pupils can go to secondary school (EP-Nuffic, 2015).

Those who could not pass the exam of the preparatory education can go to technical secondary schools for 3 years in Industry, commerce or agriculture, and by the end of this study, pupils will be awarded of the Secondary School Technical Diploma. With a final grade of 70 percent and above, student can get an admission in Post-Secondary Program in similar field, or an admission in higher institute/University in the same specialization, Private schools are under the same system as the government schools, they can also provide admission to lower final mark but with limited number of students (EP-Nuffic, 2015).

The Al-Azhar system is the same system of the public one, it is supervised by Supreme council of the Al-azhar institution and the ministry of Education, It provides religious subjects of Islamic religion from primary to secondary schools, and the graduates will be automatically accepted by al-Azhar University, It also provides Arabic language and General Education (EP-Nuffic, 2015).

Higher Education

Higher Education in Cairo as well as the whole Egypt has two different systems; higher professional Education of 4 years duration, which is considered as a Bachelor's degree by the Council of Universities, second is the Universities, both government and private ones, most of the private universities are recognized by the Ministry of Higher Education, there is also Higher Professional Education institutes which most of them are private, they provide 4 years programs equivalent to Bachelor's degree (EP-Nuffic, 2015).

Admission to higher education is based on the grading, there is no entrance exam. Medicine, Dentistry, Engineering and Natural Sciences require the highest marks of final examination; however, Agriculture, Arts, Commerce and Law require lower marks. The Supreme council of Universities (EP-Nuffic, 2015) decides the number of available slots in each branch.

Assessment Systems

Secondary Education: 0 – 100 (a minimum satisfactory mark is 40 or 50, depending on the subject)
Higher Education: Marks are given in words, with a 'pass' being required for transition to the next year: excellent, very good, good, pass, weak, very weak

The system is different from one faculty to another:

Programme	In percentages	Description
Arts	90-100	excellent
	80-89	very good
	65-79	good
	50-64	pass
Dentistry	75-84	very good
Veterinary Medicine	65-74	good
Pharmacy	60-64	pass
Other faculties	85-100	excellent
	75-84	very good
	65-74	good
	50-64	pass

Table 5: Higher Education Assessment. *Source: EP-Nuffic, 2015*

Overpopulation

Cairo, with the current population of 19.8 million people, which influence negatively of all the aspect of living including education, because of the overpopulation in Cairo, the size of classes is bigger than it should be, which is not beneficial for pupils (TARALA, 2017).

Other issues of the educational system is the poor funding from the government, those two factors (poor funding and overpopulation) affect the educational system, and the government has yet to determine if decreasing the average number of children by encouraging families to have no more than two children per household (TARALA, 2017).

Other causes have been stated by Marwan Kamal, contributor, Egyptian-Streets.com, the subject is A to Z reasons why Egypt's education system is lacking:

-Some of the poor teachers do support courses outside the school, and some of them accept bribes because of the underpayment.

-No accountability infrastructure, schools and universities rarely report about numbers of students, or grades, there is a lack of communication.

-Grades based on repetition and not on understanding.

-Schools serve stakeholders and owners first

-Poor understanding by teachers, some teachers need to keep updated of the new curriculum.

-Other thing to worry about: some students prefer working than studying because of the lower income.
-Some lessons are politically guided and public schools still require tuition.

-Tuition fees are not based on income: Small fees does not mean it is affordable.

-Education spending focus on universities and upper secondary School: Government think that

those two types are more important than primary school and secondary schools.

-Polite Education is not practiced: Teaching kids to fear rather that to respect.

Health System

Health and safety are the most important factors for a nation's stability, and without these two factors, it is impossible to proceed to other fields like education.
The health system is divided into two categories, government sector which is sponsored by the Ministry of Finance, and public sector which receive some sponsor from MOF, both sectors are supervised by the (MOHP) Ministry of health and population (Organization, 2006).

Public Health Care System

The public system has four levels: Central, Health Directorates, Districts, and Providers (Organization, 2006).

At the central level, main functions occur, such planning, supervising, programme management and maintenance, reported directly to the Minister.

At the Governorate Level, Technical functions and Purchasing/Financing issues run for the MOHP but reported to Executive Council for day-to-day management.

At the district level, it is the same as the Governorate level but in a smaller scale, each district has a separate director.

Providers: make sure that purchasers respect the requirements of the MOHP.

Private Health Care System

"At the private hospitals, there are trained doctors and nurses as well as medicine and equipment, whereas the state-run hospitals do not have any of this" stated Dr Ahmed Saafan, who until recently was Egypt's assistant health minister.

The private sector seems to be more attractive for doctors because of higher incomes, but private sector also suffer from some deficiencies (Organization, 2006)

Challenges

According to the World Health Organization Agenda (May 2013), the challenges are:

- Mismanagement of the health body system
- Lack of effective intra and inter-sectorial collaboration
- "Existence of a high out-of-pocket expenditure on health and low government expenditure"
- Lack of basic health services and planning for human resources for health
- Lack of harmonization between international cooperation and the national health agenda
- Lack of leadership dealing with national and international partners
- Bureaucratic red-tapes for partnership
- Inadequate quality of health system

Strategies

Policies of the Ministry of Health to enhance the Private/Public Sector:

-Provide Training for physicians and nurses
-Integrate all the partners to participate in Planning.
-Integrate Quality Standards.
-Decentralize Planning and monitoring.
-Developing the financial System
-Implement the Family-Doctor culture.
-Liaise with Universities to enhance the quality of Education in Health Sector.
-Create a bridge between the Private and Public sector in term of Collaboration and Communication (Organization, 2006).

Even being an ancient city, Greater Cairo evolves a sense of a new renovated environment to the community often trapped between the complexities of the modern and tradition of four thousand years old city, and the gap between an ancient and a contemporary society, as if being located in arid and semi-arid regions was not enough.

The city has been modernizing itself towards slowly improving the environmental and social levels, and by that, it implies the hunger for green areas to create a more livable environmentally conscious community. Focusing only in the provision for green spaces, among the sustainable principles for a city, the climate itself for Cairo does not offer environmental friendly proposals as green spaces, but with landscaping techniques and urban planning the green spaces happen to be a sensation for recreation in Great Cairo.

Social and economic principles have not favoured the growth for much green space through the years, challenges in the local and national level have been compromised and new solutions have been created to aim for sustainable communities. However, that keeps being a challenge and a new strategic plan is under construction. After a com-prehensive literature review, this chapter remarks the main challenges and goals for green space allocation and creation that Great Cairo has been learning.

Challenges for implementing Green Space in Great Cairo

Implementing sustainability in any city leads to manage a widespread of challenges, amongst them are the population growth, land availability, housing problems, efficient transportation, and proper infrastructure, not to mention the social and economic aspects (Wanas and Samir, 2016). In Great Cairo, green spaces are already naturally scarce due to its arid environment, and the most remarkable challenge is for the region to find the importance for the provision and maintenance of green spaces to create environmental sustainable space (Nassar, 2013). The next table shows the incredibly low green space per person in Egypt.

Year	Persons' share in green spaces	Source
1870	15-25 m2/ person	Supreme Council for Planning and Urban Development
1954	8m2/ person	Supreme Council for Planning and Urban Development
1975	1.2m2/ person	Cairo government
1990	One footprint/person	Supreme Council for Planning and Urban Development
2004	.0308m2/ person	Aga khan, 2004
2007	1.83m2/ person	Cairo government
2008	1.5m2/ person	Supreme Council for Planning and Urban Development
2010	0.5 m2/ person	Cairo government

Table 6: Amount of existent green space per person. *Source: Wanas and Samir, 2016*

As table 6 displays, in Cairo, since 2010 the green space has been equivalent to 0.5 square meters per person, where areas in developed countries the average goes from 20 to 40 square meters per person, and 12 to 18 square meters for developing countries this shows the tremendous scarcity for green space in Great Cairo.

Public green space should be considered as important as any other city´s growth plan. Few of the most frequent challenges in Great Cairo through the years, according to (Nassar, 2013) are ¨Great Cairo municipality detached the garden fence. Garden maintenance has been ignored. Waste and garbage collection has been ignored. Phenomenal accretion of street vendors around the garden. In 2012, Cairo municipality allocated street vendors inside the gar-den to solve street vending activity chronic problem¨ (Nassar, 2013). In addition, these problems instantly lead to a confusion of having available land to be part of an environmental contribution in a city, especially like Great Cairo with millions of habitants.

Another example of lack of consideration for green spaces was the cut off in green space in El- Azbakeya Garden. The green area´s use narrowed to only 60% while the rest of the green space was retained for street vendors, infrastructure improvements, and street markets (Wanas and Samir, 2016).

Over the years, the population in Great Cairo has kept increasing, and therefore the need for globalization has aimed for public spaces where people could mix in society and culture. One of the main problems was that the government would not invest in green areas (Wanas and Samir, 2016) and the private sector, would rather create businesses such as shopping malls, coffee shops, and golf courses rather than public green spaces. Many problems in the city such

as the need for new infrastructure while overpopulation was the main topic, did not leave space for the creation of green spaces to be a priority in the list (Wanas and Samir, 2016) as a result, no green space was yet playing an important role for an environmental friendly city.

Great Cairo hungers for green space in terms of quantity, and quality. According to the Cairo Cleanness and Beautification Agency data, the city only counts with 3.85 % green area from the total urban fabric (Nassar, 2013) and the minimum percentage for green area in a City should not be less than 10% (Nassar, 2013). Awareness of the importance of having green public spaces has not yet been one of the priorities listed in the city´s growth. Through the history in Great Cairo, the green space has been neglected, eroded, and accommodated for different purposes by the political and economic sectors (Wanas and Samir, 2016).

During the period of Fatimid´s in 969 to 974, Great Cairo happened to be a great example for urban planning, and urban green space development, as it had the creation for royal gardens, and central green areas where military parades and religious gatherings happened (Kafafy and Al-Betawi, 2009). Later, along the years, Great Cairo city`s centre passed on to be of less importance for investors in developing the city, urban sprawl along with investment in the outer areas of the city lead to the deterioration of green areas in the centre, and development for new ones in growing areas seem to not be a priority (Kafafy and Al-Betawi, 2009).

The small percentages of created green spaces in Great Cairo have been losing land over the years in history; some places lost its cultural value, and therefore the land was taken to serve as the base for the city´s infrastructure. In other cases, the ignorance of the cultural wealth to preserve such areas led to the discontinuity for maintenance and care (Nassar, 2013).It seems that the urban development was forgetting a big role in its future; the integration of urban green space. Nowadays, in Great Cairo, the thin green space gap within the city seems to serve as a recreational space only for certain social classes, and to serve as part of new buildings, roads, and socio-economic mobility reasons (Wanas and Samir, 2016).

Growth for Green Space in Great Cairo

After mentioning the main challenges that Great Cairo has been facing over the years, here are some examples for green space development and restoration that the Egyptian government has implemented in the city´s development plan. The first one is the Al-Azhar Park in the Darb Al-Ahmar Project. The project aims for development and restoration for green space, and it provides examples for a great insight in the Great Cairo´s urban green space sustainability that should be evolved in the rest of the city.

Case Study: Al-Azhar Park and the Darb Al-Ahmar Neighbourhood.

The Park is located in Darassa Hill; its total area of green space adds 30 hectares of green lungs to the central region of Great Cairo (Kafafy and Al-Betawi, 2009). This is a great example for urban green space development and revitalization to the surrounding neighbourhood. It is also a restoration example of the 12th Century Ayubid Cairo wall in ancient Islamic Cairo, adding value to some of the most famous landmarks in the city, the Saladin citadel and the three mosques; Mohamed Ali, Sultan Hassan, and Al-Refa'ee. The conservative multi-purpose construction for Al-Azhar Park serves for the needs of the people, the environment, and the government (Kafafy and Al-Betawi, 2009).

The central part in the Park allows easy access to the city, providing great accessibility in its planning. The park also meets the criteria for quality since its friendly in its space design by meeting the needs for the community as well as in the guidance for its maintenance and management. The design of the park is also with multi-functionality to meet the needs for all people´s ages. The next figure displays the park before and after its development as a green area.

Figure 31: Al-Azhar Park before and after. *Source: Kafafy and Al-Betawi, 2009*

The location of the park before its substantial green development was a 500 years old waste fill that had to be excavated and cleaned (Kafafy and Al-Betawi, 2009). The strategy of picking the location for a green space development emerged to add value to the neighbourhood around.

The reality was that the Darb Al-Ahmar neighbourhood was rich in Islamic history and architecture unfortunately located in one of the poorest and polluted areas in the districts of Great Cairo (Kafafy and Al-Betawi, 2009). With the waste dump turned into a recreational green area, revitalization to the area would be given, and therefore a socio-economic impact would emerge to the Egyptian city.

Al-Azhar Park also served as an impulse to restore the Islamic cultural features around and add value for the region habitants and tourist in the City. Overall, the park nowadays is a case study for economic and urban revitalization for green space and restoration for ancient marvels of Great Cairo (Kafafy and Al-Betawi, 2009).

The problem now, is that Great Cairo does not have enough space to build green spaces in the inner city; more projects like Al-Ahmar neighbourhood are required to restore the balance for environmental friendly neighbourhoods.

Alternative Sustainable Solutions for Great Cairo

The Egyptian government agreed on creating a new capital for Egypt, not to replace the city of Great Cairo, but to aim for a brand-new capital complying with sustainability principles for the community. The so-called ¨New Capital¨ project of 714 kilometres square is full with green areas design to serve as an environmental friendly city and rank on the top listings for global sustainable cities. The main goal for this project is to build a new administrative capital with open green spaces that enable anyone living in there to balance ecological, economic, and social needs. This project was created with the world latest standards for ecological living principles (Cube Consultants, 2018). Figure 32 wraps an overall view of the proposed development for the New Capital.

Figure 32: 3D Development Plan for the New Capital of Egypt. *Source: Cube Consultants, 2018*

Green areas are one of the most efficient elements which have to be presented in the new administrative capital as a sign of cleanness, purity, freshness to suit all the Egyptians needs and wants to seek the quality of life attributes. To seek creativity and productivity, there is a need of having calm and fresh areas known as the most important attributes that drive the citizens to be productive at work and to be delighted with life as well. Therefore, designing a green fresh city is the goal of building a new administrative capital seeking the pleasure of every citizen and building his glistering future with this prosperous development¨ (Cube Consultants, 2018).

The design for a whole new city is to meet the needs for Egyptian people, and government. Just Great Cairo itself forecast is to increase its population from the current 18 million to over 40 million by 2050 (Cube Consultants, 2018) giving the need for livable space for the future residents, the new Capital seems to be a perfect response. The New Capital gathers in all the principles for sustainable prosperity for all the Egyptians, and it is aiming to global recognition

for using the latest world standards for eco-cities.

The new city is designed to be flexible to adjust for future changes, and the goal is to use a minimum in infrastructure. The Minister of Housing Dr. Mostafa Madbouly stated that ¨Cairo is known for its overwhelming congestion¨ therefore calls its need for a new space to live. The plan is designed to handle a new administrative district, a cultural area, and civilian area (Cube Consultants, 2018).

Location. The green, sustainable, walkable, livable, connected, smart, and business new city was decided to be built in between Cairo and the city of Suez; it is located 45 km east from the centre of Great Cairo, and 80 km east from the city of Suez. The decision for this location was with the goals of encouraging the long-term growth.

Figure 33: Location for the New Capital of Egypt, 45 Km East from Great Cairo. *Source: Cube Consultants, 2018*

The Masterpiece Plan. The strategy for the design of the New Capital is mainly based on an Oasis design, taking advantage of the land´s topography, every feature in the design is to be connected with green axes fed by the storm water collection system underneath. This new city is to have a Central Business District at the centre of the design surrounded by residential area, and each residential area has its own centre with recreation spaces. Universities, recreational centres, and industrial space is also in the design at the end of the project area (Cube Consultants, 2018).

The next figure shows the relation between the business district area selected in orange colour, and the residential neighbourhoods surrounding it selected in green. A water canal has been also proposed in the design that would gather all the water from the storm water collection flowing towards the end west side of the city (Cube Consultants, 2018).

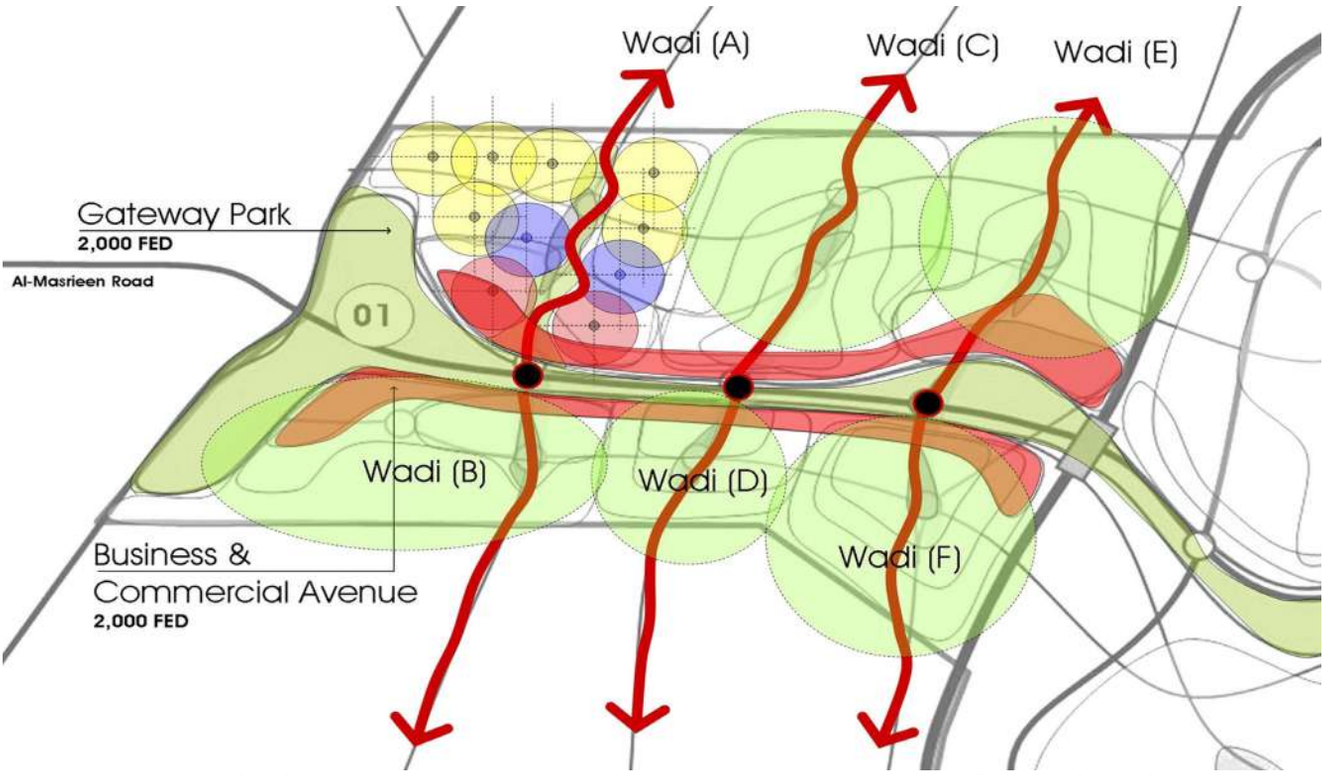


Figure 34: Design for Commercial Avenues and Residential Neighborhoods. *Source: Cube Consultants, 2018*

Taking advantage of the topography, is the design for 12 clusters, each is to be full of green space simulating valleys. Each valley is located in the centre for the residential neighbourhoods, and includes all the services and maintenance for green recreational spaces as shown in the next image.

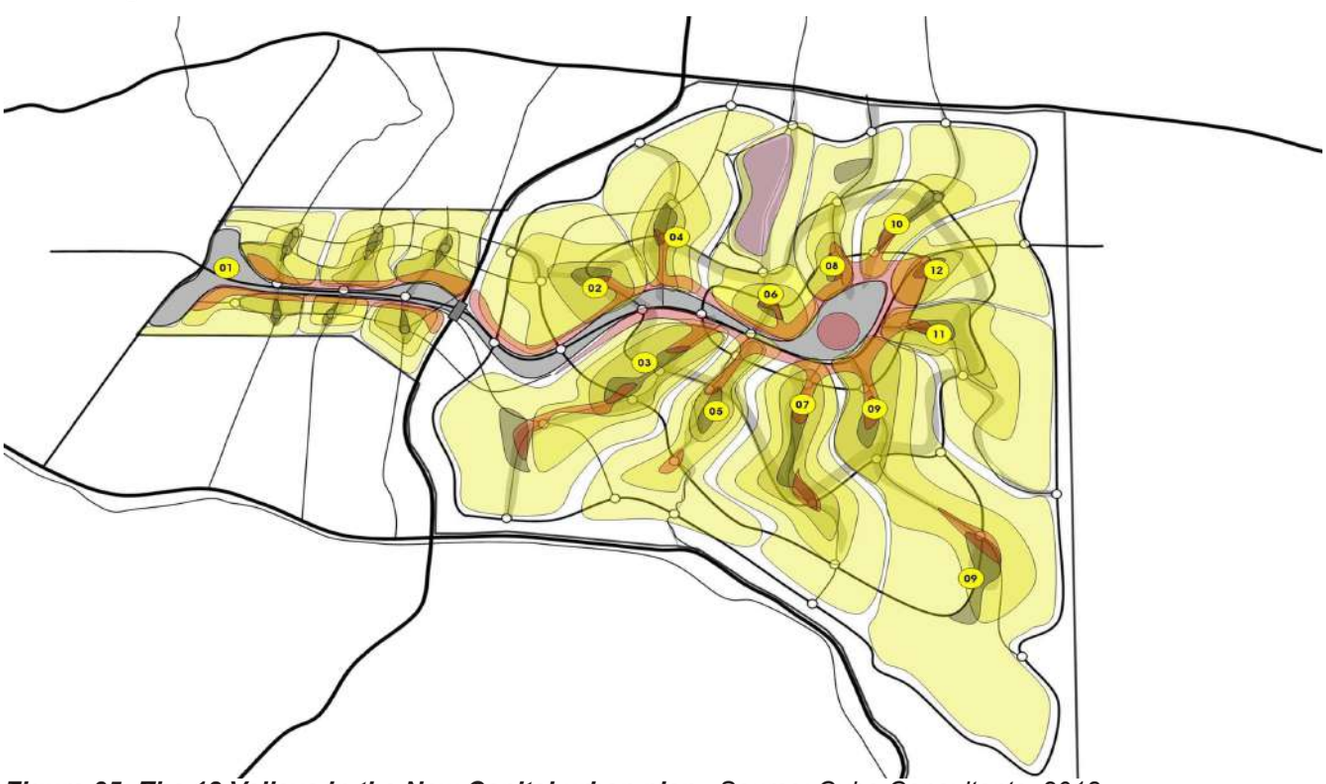


Figure 35: The 12 Valleys in the New Capital urban plan. *Source: Cube Consultants, 2018*

The total design includes residential neighbourhoods, a central business district, a green river, regional investment areas, aero city and international airport, mix-use areas, city´s main roads,

and green and open areas. The whole design is based on strategic functional road networks to attract development. The network is designed to alleviate translation for the city roads to easy access into the residential neighbourhoods. The city network properly links all the way to the city of Great Cairo. The network consists of mini buses, buses, metro lines, and train tracks, with the objective of linking all means of the city to the public (Cube Consultants, 2018). This Mega project is expected to be opened by the mid-year of 2019.

Conclusion

Overall, Great Cairo is continuously growing population claims more attention in where development and redevelopment agree. After literature review, it can be concluded that the City´s green space planning is not very relevant, as it should be compared at the international level. Great Cairo does not have much space to be taken for recreation, as it is decided to build it for housing, roads, or commercial purposes instead of green areas. The city has a perfect example for land use and neighbourhood sustainable revitalisation but, the Al-Azhar Park, but this park is not enough for all the habitants within the city (Kafafy and Al-Betawi, 2009).

Seems to be easier to create new cities from scratch to approach sustainability principles than to redevelop strategies to have sustainable existent communities, as it is the case for the New Capital planning strategy. Usually, the approach of not overcoming an existent problem, and just creating a new city would not be that sustainable, but in the case of Egypt it is because of its enormous estimated growth in population, as stated in this report, it is estimated to double by 40 million towards the year of 2050. New cities are needed to place that amount of people, as existent cities have already its own overpopulation problems.

The city has problems already in pollution, traffic congestion, waste management, education, and the need for green space, all of which can be solved more effectively if the overpopulation problem is solved first. Now, it is of perfect analysis to create new sustainable cities planned in high sustainable world standards. Integrating conservation of urban green spaces with urban development is perhaps an effective solution towards safeguarding and activating the remaining natural areas within the urban settings. For Great Cairo, this approach should also be considered in the conservation and revitalization for the existent neighbourhoods (Gholab and Shalabi, 2016).

Most of the problems arising in Great Cairo seem to be connected with the lack of unsustainable patterns in all aspects, and reversing the effect of unsustainable living, might take years. Changes in the city planning, and education for sustainable living are much needed to create an eco-friendlier city, and for that investment is required. It is a chain; is not just the need for more green spaces, it all circles in the sustainable principles for water and energy technologies, waste production, transport efficiency, and urban planning (Gholab and Shalabi, 2016). In the urban area, the principles of compact, high density, and mix used districts are key along with the creation and maintenance for more public green spaces.

Strengths	Weaknesses
• Historical Value • Available Space • Strategic Location • Investment Support Programs • Renewable energy power plants	• Infrastructure and Transportation • Construction Waste • Unsafe Buildings • Urbanization • Informal Areas
Opportunities	**Threats**
• Renovation and Reconstruction • Redevelopment and temporary relocation • Improve Transportation Systems • Recycling of Construction Waste • El-Dabaa Nuclear Power Plant	• Building Collapse or Partial Collapse • Traffic Accidents • Pollution and Health Problems • Lack of Green Areas

Table 7: SWOT Analysis. *Source: Own elaboration*

Finally, after studying the different aspects of Greater Cairo city planning, and discussing the current situation, challenges and opportunities for improvement and development, we can summarize the conclusions in the following points:

Energy Sectors:

In order to deal with the energy resources challenge, the biggest electric power plant in the world was built, producing 14.4 GW to meet the ac-celerating electrical energy requirements.

NREA (New and Renewable Energy Authority) implemented a renewable energy generated plant to cover 20% of total electric energy production by 2027.

Wind farming prospects are high based on the wind speed and air densi-ty data provided in Egypt.The wind farms output can reach approximately 20 GW.

Potential energy generated through solar power is high, due to country's location.

As a part of national plan to reduce the fossil fuel dependency, and col-laborating with UK and other investors, Egypt is building the biggest so-lar energy complex in the world, with an anticipated power output of 1.8 GW.

Nuclear power energy can help in meeting the future energy requirements.

The construction works started for the first nuclear power plant, located in El-Dabaa, with expected construction duration of 12 years.

Housing Sector:

Informal areas are a critical challenge for Greater Cairo city planning, that Egypt's and Cairo's authorities have to supply a framework and channels to meet the SDGs.

The new upgrading and redeveloping strategy must be citywide built into institutional improvements and not separated single concept.Some buildings are replaced over time by high-rise buildings (real estate development).

Displacement for some informal area residents would inflame the situation more than improving it.Overall informal buildings structural condition is evaluated as good, with the need to conduct further tests and studies of the buildings condition to determine the problems.

To improve housing and living conditions, government's determination and funding are the main factors, without which improvement cannot be reached.

Discussing the transportation system main issues in Cairo, population density, automobile growth rate, low public transport utilization and poor pedestrian environment cause the major traffic problems and air pollution.

Cairo's public transportation share of the total means of transportation is significantly less compared to car and taxi shares.

By discussing Seoul transportation case and how transportation challenges were encountered, the following can be concluded

Road extensions were done over the past 40 years in response to population growth.

Seoul Metropolitan Government regularly expanded its subway line; as a result, subway's share was at top of other transportation ways in 1997.

Integrated public transportation network formed, which increased the traffic card utilization rate, therefore, increasing the transportation income.

These improvements have positively impacted air quality and safety of the transportation system.

In Health and Education Sector:

Government should increase salaries in order to enhance the quality of public sectors and eliminate the corruption.

Boosting the quality of Education by encouraging the scientific research.

Encouraging the exchange programs with developed countries.

Chapter 1: Image Sources

Figure 1.1: The Rosetta Stone British Museum
Source: http://www.freemaninstitute.com/rosetta.htm, Copyright 2000, by Joel A. Freeman, Ph.D.
Figure 1.2: King Menes after unified Egypt
Source: http://www.crystalinks.com/narmer.html, King Menes, n.d.
Figure 1.3: The Pyramids of Giza
Source : https://commons.wikimedia.org/wiki/File:All_Gizah_Pyramids.jpg, Ricardo Liberato
Figure 1.4: Mosque of Amr Ibn al-As in Cairo
Source: https://en.wikipedia.org/wiki/Mosque_of_Amr_ibn_al-As#/media/File:Mosque_of_Amr_ibn_al-As.jpg, Copyright Mohammed Mousa CC By-SA 3.0
Figure 1.5: Mosque and University of Al-Azhar in Cairo
Source: https://en.wikipedia.org/wiki/File:Cairo_-_Islamic_district_-_Al_Azhar_Mosque_and_University.JPG#/media/File:Cairo_-_Islamic_district_-_Al_Azhar_Mosque_and_University.JPG CC, By SA - 4.0 Daniel Meyer
Figure 1.6: Citadel of Salah Al-Din in Cairo
Source: https://commons.wikimedia.org/wiki/File:Flickr_-_HuTect_ShOts_-_Citadel_of_Salah_El.Din_and_Masjid_Muhammad_Ali_Cairo_-_Egypt_-_17_04_2010_(4).jpg, CC, BY SA-2.0 Ahmed Al. Badway
Figure 1.7: The Battle of Ain Jalut between Muslims and Mongols
Source: https://neverfeltbetter.wordpress.com/2010/10/10/nfbs-decisive-battles-of-the-world-ain-jalut/
Figure 1.8: Napoleon Bonaparte before the Sphinx during the French campaign
Source: https://napoleonbonapartepodcast.com/2006/06/28/napoleon-7-the-egyptian-campaign/
Figure 1.9: Muhammad Ali Pasha
Source: http://www.wikiwand.com/en/Muhammad_Ali_of_Egypt
Figure 1.10: Cairo Central Railway Station
Source: http://sawyertravel.blogspot.fi/2015/03/ramses-station-some-history.html
Figure 1.11: One of Avenues of Cairo at 1920
Source: http://www.arabnewsblog.net/2014/07/08/for-a-day-with-bad-news-everywhere-a-bit-of-nostalgia/
Figure 1.12: Cumulative installations for wind power plants in Turkey
Source: https://www.researchgate.net/publication/305720791_The_prediction_of_the_wind_speed_at_different_heights_by_machine_learning_methods?_sg=rs50OFcnpmmtMOwTGjVfCeHnzd8pPOD7UMfVXI-qQMbSWTPMTRUT-s_w3kuYTRTTmSVABgIADg
Figure 1.13: Mersin CSP field
Source: https://commons.wikimedia.org/wiki/File:Mersin_CSP_Tower.jpg, CC, BY-SA 4.0, Kosham
Figure 1.14: Greenway Mersin CSP field solar tower
Source: https://www.protenders.com/companies/greenway-csp/projects/greenway-csp-mersin-solar-tower-plant
Figure 1.15: Russian President Vladimir Putin, left, and Egyptian President Abdel Fattah El-Sissi,Egypt, December
Source: https://www.usnews.com/news/world/articles/2017-12-11/russias-putin-and-egypts-sisi-discuss-middle-east-tensions-in-cairo
Figure 1.16: Satellite view of Greater CAIRO
Source: https://earthobservatory.nasa.gov/IOTD/view.php?id=85645
Figure 1.17: Satellite view of Cairo, showing different kinds of settlements
Source: http://wallpaperspeople.com/cairo/
Figure 1.18: Roof Garden in Cairo
Source: https://www.greenprophet.com/2011/07/urban-agriculture-egypt/, July 15
Figure 1.19: Cairo Bus
Source: https://commons.wikimedia.org/wiki/File:Cairo_Transport_Authority.JPG, Hancock 10
Figure 1.20: Cairo Metro and Public Bus Network
Source: https://cairofrombelow.org/2016/02/03/citizens-make-a-difference-together-at-transport-for-cairo/
Figure 1.21: Micro Bus
Source: https://commons.wikimedia.org/wiki/File:Map_of_the_Cairo_and_Helwan_tramways.png Creative Commons Attribution-Share Alike 2.5 Generic license.
Figure 1.22: Cairo Tram Lines
Source: https://commons.wikimedia.org/wiki/File:Cairo-metro-plans.svg, Open Street Maps
Figure 1.23: Subway Lines
Source: https://commons.wikimedia.org/wiki/File:Cairo-metro-plans.svg, Open Street Maps

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2. SUSTAINABLE HIGH-RISE BUILDINGS, Case Study: Santiago: Dense, high-rise buildings with green, low carbon solutions

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Abstract

Considering to the international relevance of sustainability, Chile has implemented several regulations related to this topic in the housing area during the last years through the Ministry of Housing and Urbanism. The goal of these regulations is to improve the performance of Chilean cities regarding three pillars of the sustainability (social, economic and environmental). Santiago, as the capital of Chile and focus of this research, has defined different methods to apply these regulations. However, this city still has challenges to implement them, such as the environmental pollution, the social segregation and the lack of economic and natural sources. There are different alternatives to overcome the challenges to implement the new sustainable housing guidelines in Santiago, one of them is to rethink the current density, high and sustainable solutions that the buildings have. The main objective of this chapter is to describe and analyse the situation of the housing in Santiago considering the density, high-rise buildings with green guidelines and low carbon solutions as analysis parameters. The methodology established to achieve this objective is exploratory-descriptive with the literature review technique. The partial results illustrate that despite the benefits that represent the incorporation of new guidelines related to the increase in density and high-rise and low carbon solutions in housing projects of Santiago, it is important to consider that not all of these are applicable to this city. Each territory has its features (weather, culture, resources and norms), which determine the requirements that the projects need and the real possibilities to implement changes.

Keywords: high-rise building, housing project, low carbon solution, green guidelines, Santiago-Chile.

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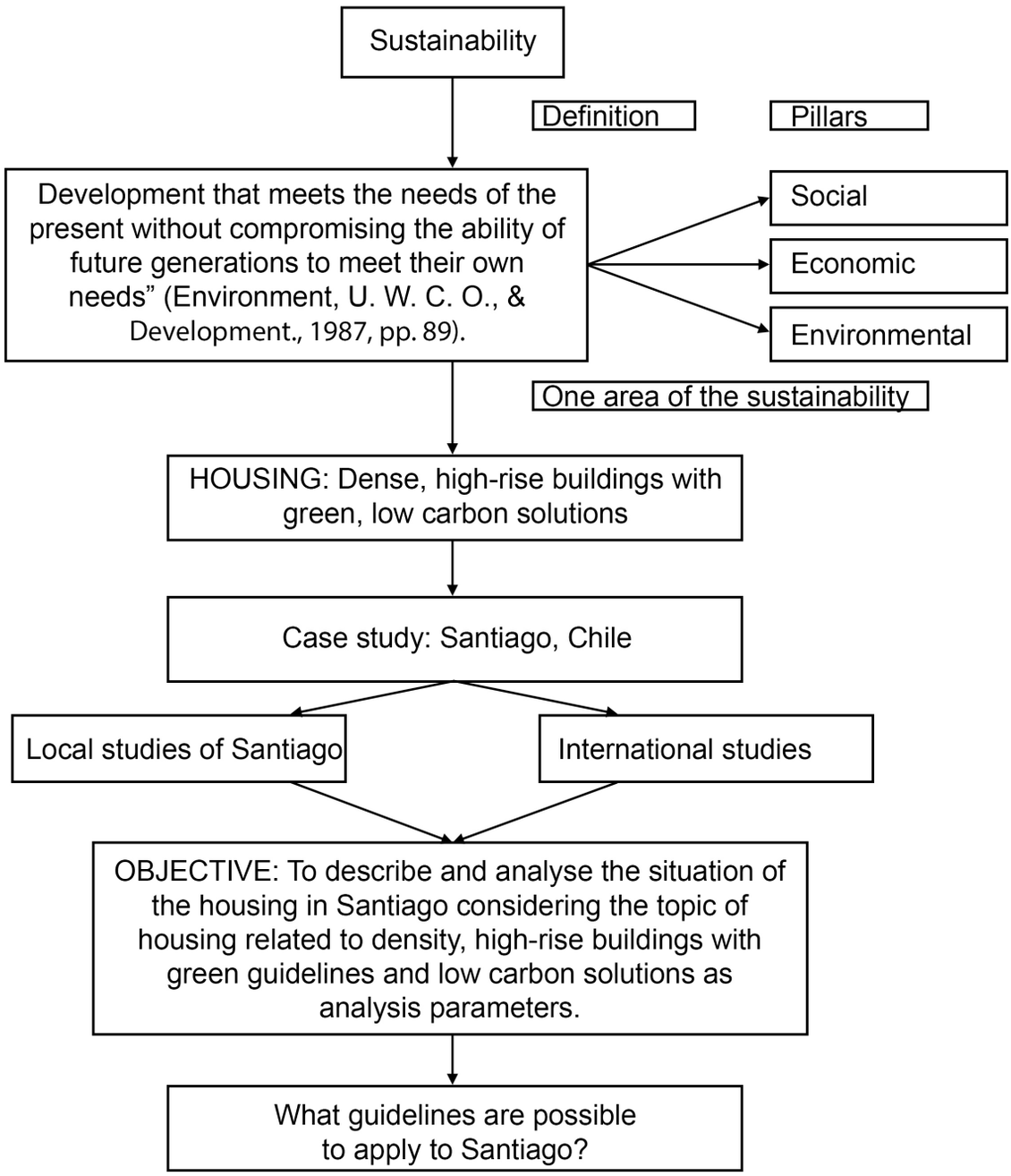


Figure 01: Flow of the chapter. *Source: Own elaboration*

Introduction

The sustainability is a significant concept in the Architecture, Engineering, and Construction (AEC) industry because it defines the guidelines that this business implements in its projects. The Brundtland Commission defined sustainability as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Environment, U. W. C. O., & Development., 1987, pp. 89). This definition was complemented by the Agenda for Development established by the United Nations (UN) in 1997 with the description of three pillars of this concept: social development, economic development and environmental protection.

GENERAL OBJECTIVE	SPECIFIC OBJECTIVES	SOURCES
To describe and analyse the situation of the housing in Santiago considering the density, high-rise buildings with green guidelines and low carbon solutions as analysis parameters	To define the key concepts of this research: density, high-rise buildings with green guidelines and low carbon solutions	- Academic papers
	To describe successful and unsuccessful examples of dense, high-rise buildings with green, low carbon solutions for housing considering the features of the city of Santiago	- Academic papers - Official information of the projects (architecture offices website)
	To describe the social, economic and environmental areas of the Santiago	- Official information of Santiago (governmental documents). - Academic papers
	To explore new guidelines, from the case studies analysed, possible to apply in Santiago to improve the current situation of the housings	- Academic papers - Official information of the projects (architecture offices website) - Official information of Santiago (governmental documents)

Table 1: Summary of the objectives and methodology of this research. *Source: Own elaboration.*

Internationally, there are two facts which illustrate the relevance of sustainability. First, the agreements established to define the sustainable goals for the future of the world. For example, the 17 Sustainable Development Goals (SDGs) of the UN (UN, 2015) and the Paris Agreement signed in 2015 (UN, 2016). Second, the new green certifications for building and materials. For instance, Energy Start, Leadership in Energy and Environmental Design (LEED), and Green Globes (WBDG, 2016).

Considering the international relevance of sustainability and the guidelines and certifications related to this topic, Chile has implemented three regulations in the housing area during the last years through the Ministry of Housing and Urbanism: The Sustainable Construction Code, The National Sustainable Construction Strategy and The Energy Rating of Housing (MINVU, n.d.). The objective of these regulations is to improve the performance of Chilean cities regarding three pillars of the sustainability. Santiago, as the capital of Chile and focus of this research, has defined different methods to apply these regulations. However, this city still has challenges to implement them (Santiago municipality, 2015). For example, the environmental pollution, the social segregation and the lack of economic and natural sources.

There are different alternatives to overcome the challenges to implement the new sustainable housing rules in Santiago, one of them is to rethink the current density, high and sustainable solutions that the buildings have. The objective of this work is to describe and analyse the situation of the housing in Santiago, Chile considering the density, high-rise buildings with green guidelines and low carbon solutions as analysis parameters. This research is descriptive exploratory, and the methodology involves a bibliographic review.

Figure 02: High rise buildings in New York City. *Source: Berkman, 2013*

Housing: dense, high-rise buildings with green, low carbon solution

Definition of the concepts

High-rise dense buildings

A high-rise structure is a tall working, instead of a low-ascent constructing and is characterized by its stature diversely in different purviews. It is utilized as a private, office building or different capacities including a hotel, retail or for numerous reasons consolidated; a private high-rise structure is likewise called tower (Ali & Armstrong, 2008).

Tall structures became conceivable with the innovation of the lift and less expensive building materials such as steel and concrete. Most North American style high rises have a steel outline, some are built of concrete. There is no certain contrast between a skyscraper and a tower, despite the fact that working with at least fifty stories is, for the most part, thought about as a skyscraper (Encyclopaedia Britannica, 2012).

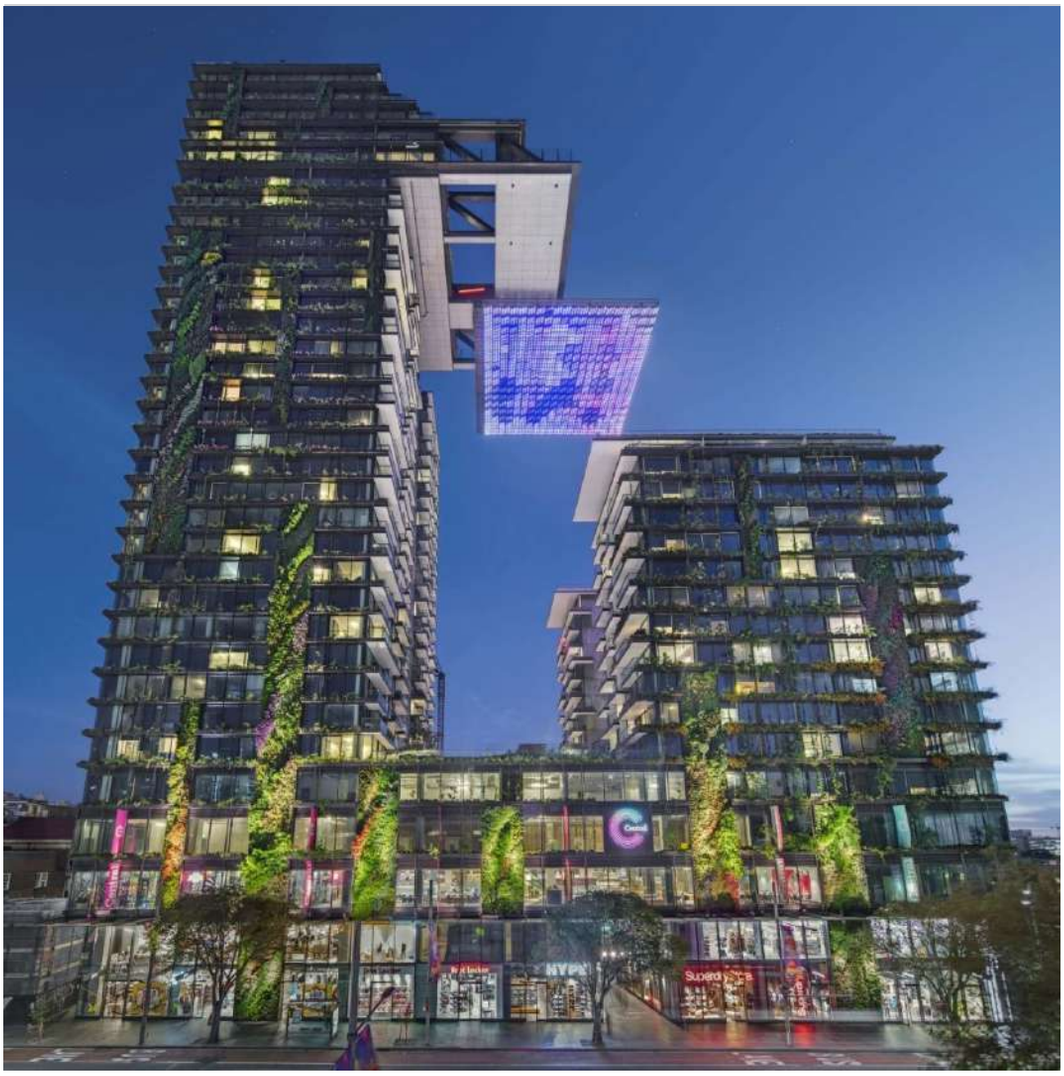


Figure 03: One Central Park building in Sydney. *Source: One Central Park, 2018*

Apartment structures have specialized and financially favourable circumstances in locations with high population and have turned into an unmistakable element of lodging settlement in practically all high population urban regions around the globe. Interestingly with a low-ascent and single-family houses, apartments suit more tenants for every unit of a region of land and decrease the cost of civil foundation; on the other hand, they will have disadvantages including effect on neighbours or higher technology needed in the case of fire or earthquake (Ali & Armstrong, 2008).

Green or sustainable low carbon buildings

According to Liu, Lau and Fellows (2012) “something is sustainable if it continues to exist, at the limit, forever (whatever that may be)” (Liu, Lau & Fellows, 2012, pp. 161). A building can be named sustainable when it has the scarcest troublesome impact on the environment.

Sustainability is fulfilling necessities of the human while concentrating on the earth. In other words, it is thought of human necessities with the view of essential environmental purposes of control. It will answer progression of countries to the best individual fulfilment (Du Plessis, 2007). It should be added that sustainability can be represented with a three-legged stool having a leg for environmental, social and financial responsibility. On the other hand, services

Figure 04: The Solaire building in New York City. *Source: GREENHECK, 2018*

or products that have less impact on environment and health can be named green. It is needed to add that buildings that have fewer carbon emissions are called low carbon buildings (Zhong & Chen, 2011).

Buildings are one of the major consumers of materials and resources. Development effects about 40% of ozone-draining substances and exhausts of the material in the overall economy. It expects an enormous piece of countries' economy and is responsible for making openings for work and money related change. Development has monetary impacts and also political, normal and social impacts (Williams & Dair, 2007).

The issue in creating the built environment is not just about construction or quick progression but also about natural and social concerns. It is principal in countries with quick progression to consider green low carbon methods in light of the fact that late action will bring biological issues lack of new resources (Du Plessis, 2007).

On the planet with obliged access to new resources and the sharp increase in population, green building is fundamental. Down to earth improvement requires upgrading sensible progression, which is required for each period of assignments. In green low carbon building, it should be endeavoured to use recyclable resources as opposed to new ones which will realize condition

protection (Zhong & Chen, 2011). Generally, advantages of low carbon green buildings have less impact on the environment use less energy and materials and have a higher quality of life. On the other hand, it has disadvantages including higher initial costs; a higher level of technology needed, and complicated equipment used in these buildings.The justification to consider high rise, dense, green and low carbon buildings as a possible alternative in AEC industry

Green low carbon building is essential for the future environment because of its advantages. Limited natural resources and also improvement of countries require new methods and techniques in construction project management in order to minimize the effects of construction. The attractive indoor environment of buildings, higher quality of life, renewable energy use, reuse and recycling of materials are substantial benefits of sustainable construction which makes the improvement of sustainability essential.

All in all, tall structures areone of the examples of high rise green building located in New York City's dense location which has low carbon effect is The Solaire. This building benefits from solar cells, intelligent water system with recycling and reusing systems, green roof, energy efficient facilities and high-tech cooling heating system. In the following , this building's features will be discussed in detail.

Successful international sustainable buildings

Considering the definition of the key concepts defined in section 2, this research analyses two successful international sustainable buildings with the objective to identify possible guidelines to implement in Santiago. The selections criteria of these buildings are based on in the existing similarities that the countries where they are located have with Santiago.

PROJECTS	SIMILARITIES WITH SANTIAGO
Sydney: One Central Park	Temperature, humidity and quantity of the population of the city
New York: The Solaire	Solar energy and temperature

Table 2: Similarities of the successful examples to Santiago. *Source: Own elaboration*

One Central Park

Similarities with Santiago

The aim of this research is to study the possibilities of implementation of best solutions to build and utilize sustainable residential buildings in Santiago, Chile.Climate patterns like average monthly temperature and average monthly humidity have a significant impact on achieving sustainable goals. The city of Sydney in Australia has got almost similar climate pattern with the city of Santiago in Chile. Figure 5 shows that the monthly average temperature in Sydney is almost near to the one in Santiago. Also, Figure 6 illustrates that the average humidity in Sydney is 71% whereas in Santiago it is 70%

The similarity between the population of both Sydney and Santiago cities is another reason to

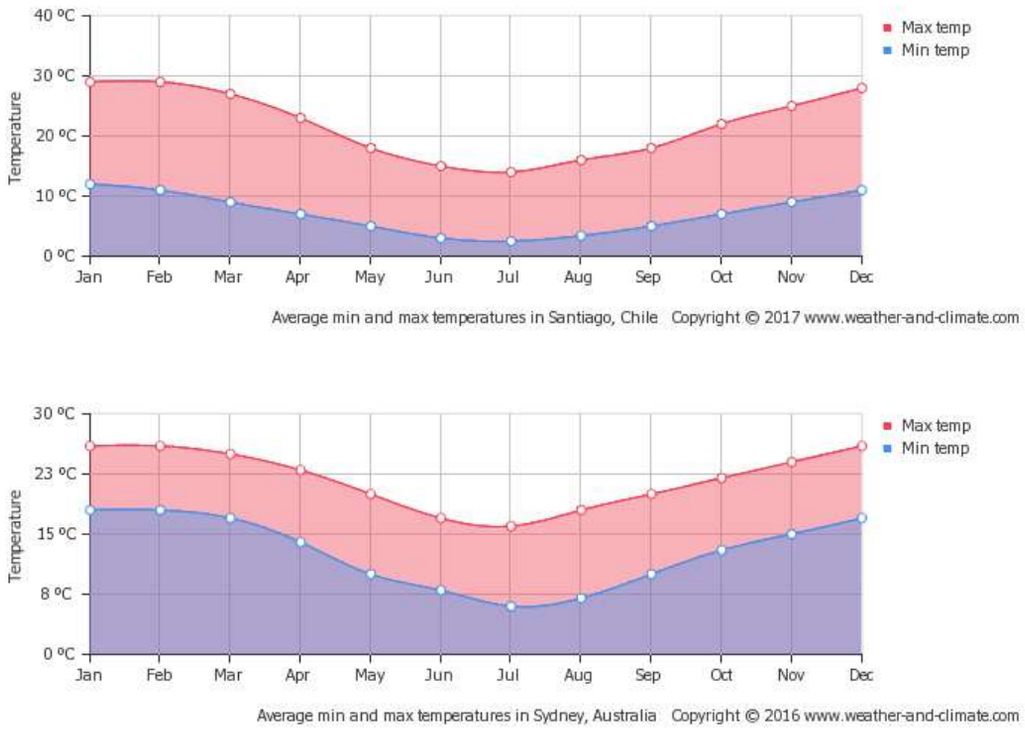


Figure 05: Average monthly temperature of Sydney and Santiago. *Source: Holiday Weather.Com, 2018*

choose the One Central Park building as a good example. The population of Sydney in 2017 was about 5.07 (The population experts, 2017), while the population of Santiago in 2016 was about 6.5 million (Santiago Population, 2017).

Introduction

The One Central Park building is a mixed-use type of building which means it integrates residential, commercial, cultural, and institutional and entertainment applications all in one stop. This building is placed in the suburb of Chippendale, Sydney, Australia. The building developed as a joint venture between Frasers Property and Sekisui House in 2012 and completed the constriction phase in December 2013. The building consists of two residential towers, an east, and west tower, where there are six levels of the retail shopping centre at the base of towers. The building was awarded as a 5 star 'Green Star Multi-Unit Residential Design v1' by the Green Building Council of Australia and it's the largest residential building which receives this award in Australia so far.

The area of the One Central Park is just under six hectares of land and it is designed for nearly 235,000 square meters for residential, commercial and retail space (Central Park Sydney, 2013). The building consists of 4 levels below ground and 34 levels above ground, and the total of 623 apartments as well as 625 parking spaces. The height of the building is 117 meters (One Central Park, 2018). The One Central Park is a well-known international unique building because of distinguishing features like vertical hanging gardens, cantilevered heliostat, low carbon tri-generation power plant and internal water cycling plant (One Central Park, 2018).

Green sustainable features of One Central Park

At Central Park, 'sustainability' is more than a buzzword. It is an attitude that requires an honest,

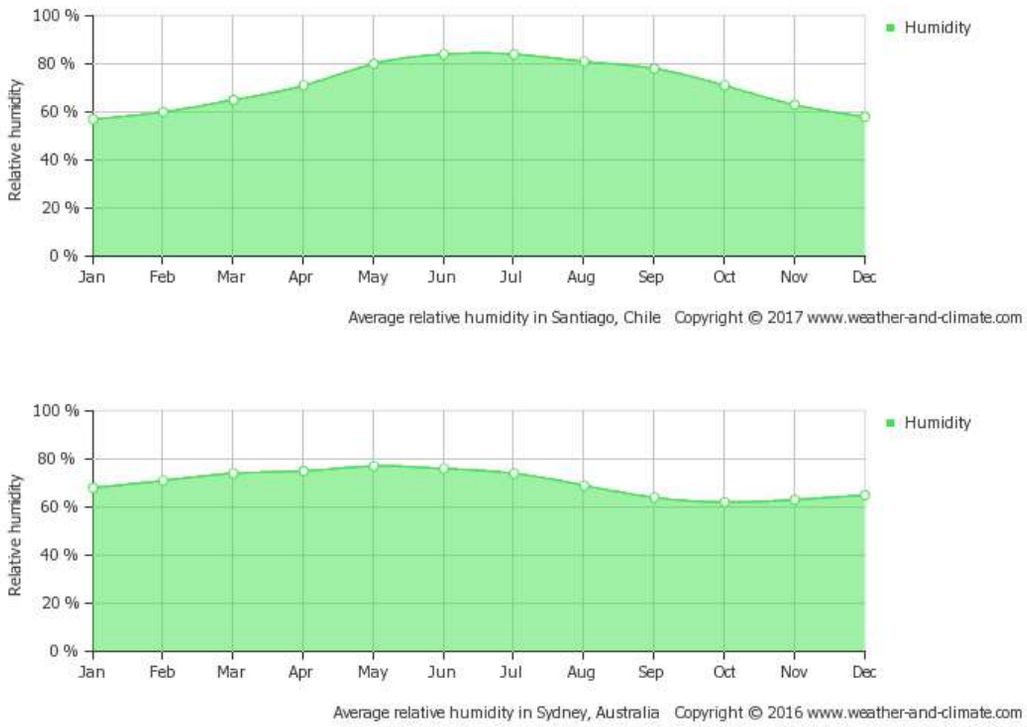


Figure 06: Average monthly humidity of Sydney and Santiago. *Source: World Weather & Climate Information, 2018*

thoughtful analysis of how we live our lives today, in order to create a better world tomorrow (Central Park Sydney, 2013).

The sustainable features in the One Central Park could be listed as follows:

1. On-site central thermal tri-generation plant
2. On-site water recycling plant
3. Vertical Gardens
4. Cantilevered heliostat

With the help of low-carbon natural gas power plant mounted in the One Central Park building, the energy for the residents as well as workers is produced. A two-megawatt (MW) tri-generation (producing hot and cold water and electricity) energy plant which is run by natural gas, provides 3,000 inhabitants and 65,000 sqm of retail and commercial space heating and cooling energy by producing low-carbon thermal energy. The power plant also supplies electricity to the Country Clare Hotel and mixed-use Brewery Yard building.

The tri-generation power plants are twice the energy efficiency with compared to coal-fired power plants. The reduction of greenhouse gas emission could be as much as 190,000 tonnes over 25 years by the two-megawatt power plant in One Central Park (Central Park Sydney, 2013).

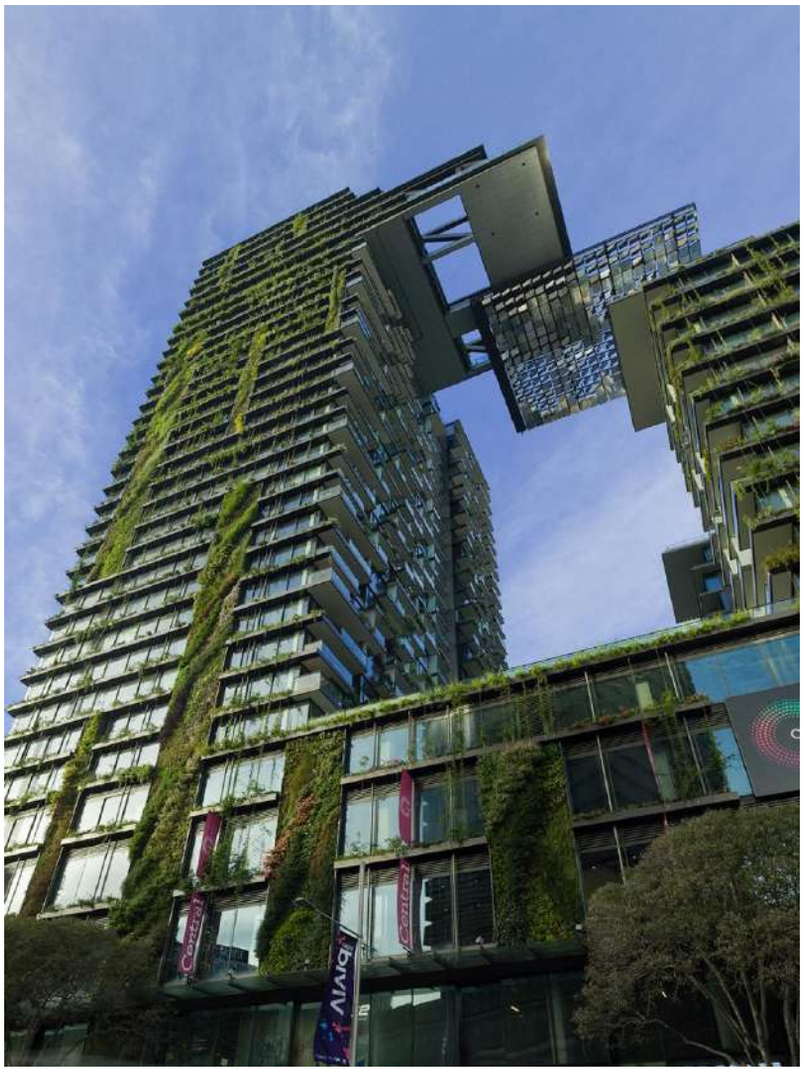


Figure 07: One Central Park building. *Source:Cardigan,2017*

On-site water recycling plant

The recycled water network is the most important sustainable element in One Central Park. “The One Central Park water will be the biggest Membrane Bioreactor (MBR) recycled water facility in the world” (Central Park Sydney, 2013). Thanks to Central Park Water, inhabitants use 40-50 percent less drinking water leading to saving money and drinking water supplies.

As it is shown in the Figure 9 the recycled water is provided after passing wastewater from waste water screening, anaerobic processing, aerobic processing, chemical treatment, membrane filtration, ultraviolet treatment, reverse osmosis and chlorination stages.

The recycled water network is supplied by seven resources including:

1. “Rain water from roofs.
2. Storm water from impermeable surfaces/planter box drainage.
3. Ground water from basement drainage system.
4. Sewage from an adjacent public sewer.
5. Swage from all buildings within the Central Park community.
6. Irrigation water from all green walls.

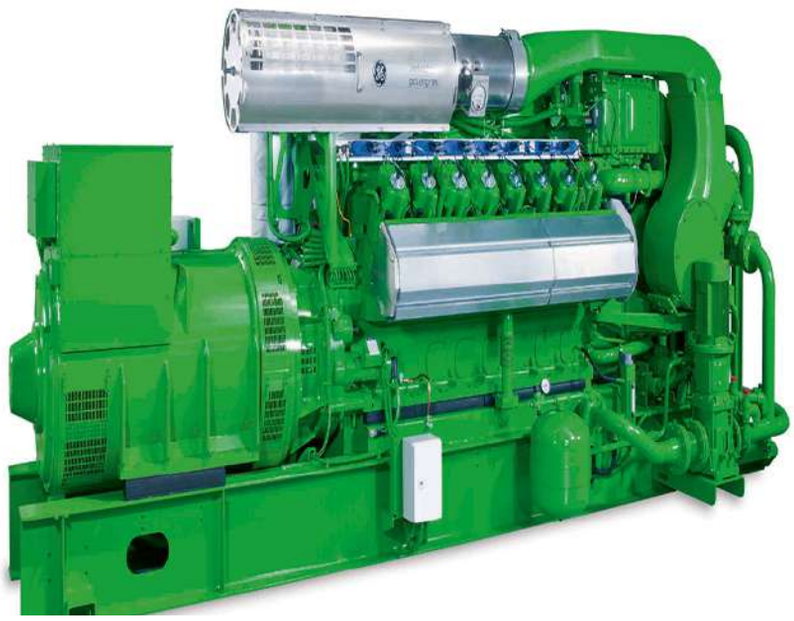


Figure 08: Thermal tri-generation plant. *Source: Diesel & Gas Turbine Worldwide,2016*

Vertical Gardens

Hanging gardens of the One Central Park are the tallest vertical gardens by over 50 meters high in the world. They have been designed by botanic and architecture experts. The individually designed planter boxes are supported by floor slabs. All environmental conditions of each slab are monitoring by building management system. There are 23 green walls including over 35,000 green wall plants in 350 different species, occupying 1,200 sqm area of the façade.

The plants are selected in such a way that they do not need soil to grow while they are watered by light carbon dioxide water and nutrients. To thoroughly maintenance the green walls, regular swing stage, checking the structure, monitoring plant health, pests and disease and also rubbish removal are necessary (Jean Nouvel, 2014).

The vertical gardens give a unique view to the building and they purify the air. They also provide a hedge against heat produced by sunlight and in cold months they provide an air gap to isolate the internal heat of the building sectors.

Cantilevered heliostat

The cantilevered heliostat is hanging from the 28th floor of the One Central Park east tower to not only illustrate a unique design element but also reflecting light to gardens and atriums below. There are a series of motorized mirrors mounted on the west tower rooftop which reflects the daylight to the cantilever.

There are 220 reflecting panels fixed in the cantilever and they bounce the light back to below spaces. There is a sky garden on the upper side of the cantilever. 2088 mounted LED lights on the cantilever deliver the work of international lighting artist Yan Kersale (Jean Nouvel, 2014).

Awards

One Central Park has received numerous accolades and awards that have recognized both its

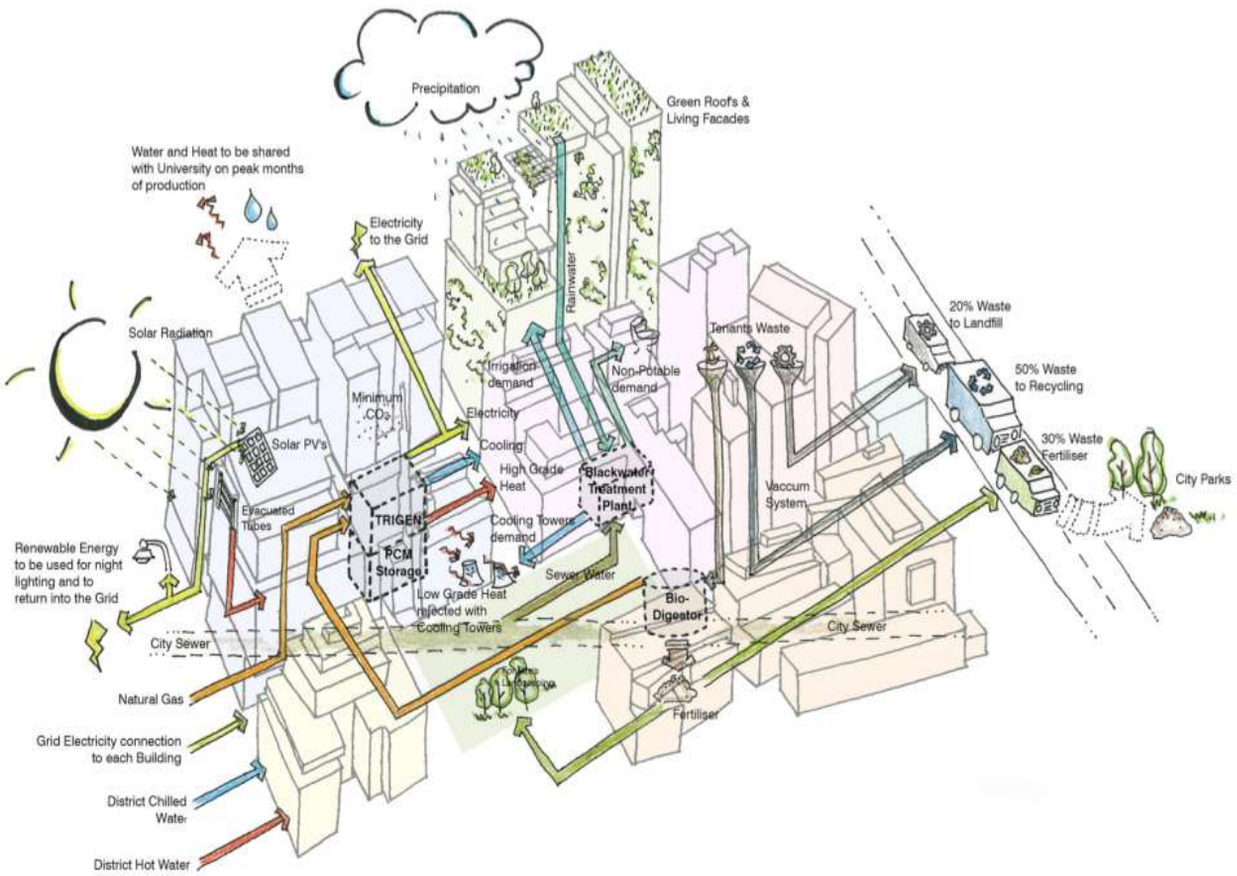


Figure 09: Water Recycling System Diagram. *Source: Finding Infinity - Finding a future based on infinite resources,2015*

structural ingenuity and sustainability measures. In 2014, the more noteworthy awards included:

-Winner of the Sustainability Award from LEAF Awards 2014 (global).

-Overall Winner of the LEAF Awards 2014 (global).

-Winner of the Best Cogeneration or District Energy Project from the Energy Efficiency Council 2014 (national).
-Winner of the International Green Infrastructure Award from World Green Infrastructure Congress 2014 (global).
-Winner of the Best Tall Building Worldwide from the Council for Tall Building and Urban Habitat (global).

In 2015, some of the more prominent awards it achieved included:

-Winner of the Best Interior Fitout Award from ASOFIA 2014/15 Interior Fitout Awards (national).

-Winner of the High-Density Development by 2015 UDIA National Awards and Winner of the Best Innovative Green Building (global) from MIPIM Awards 2015 (One Central Park, 2018).

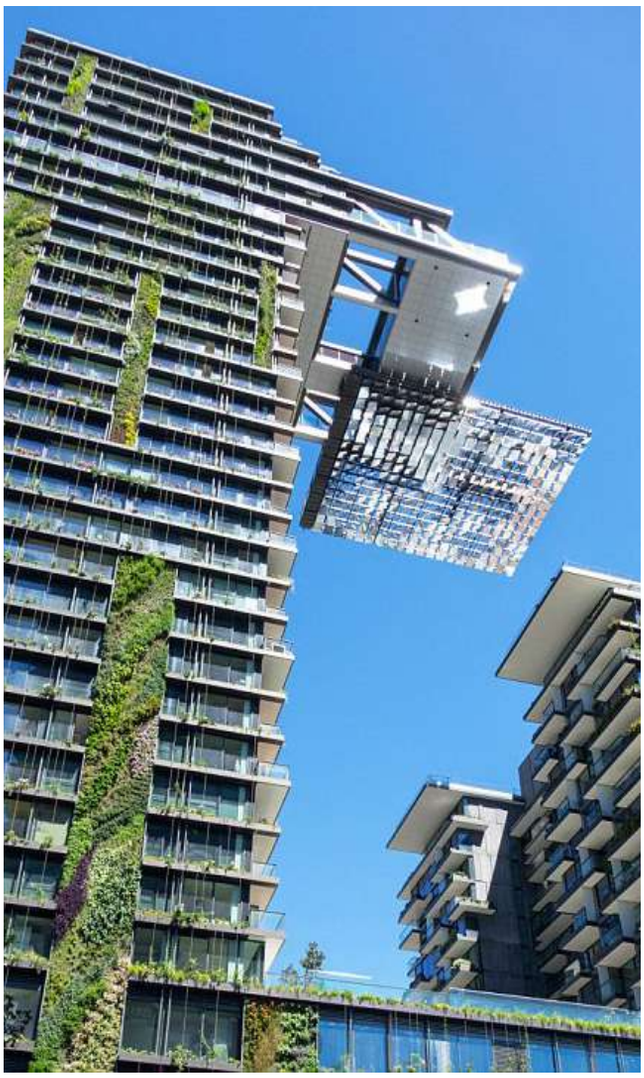


Figure 10: Vertical gardens. *Source: UK Home Daily Mail Online,2015*

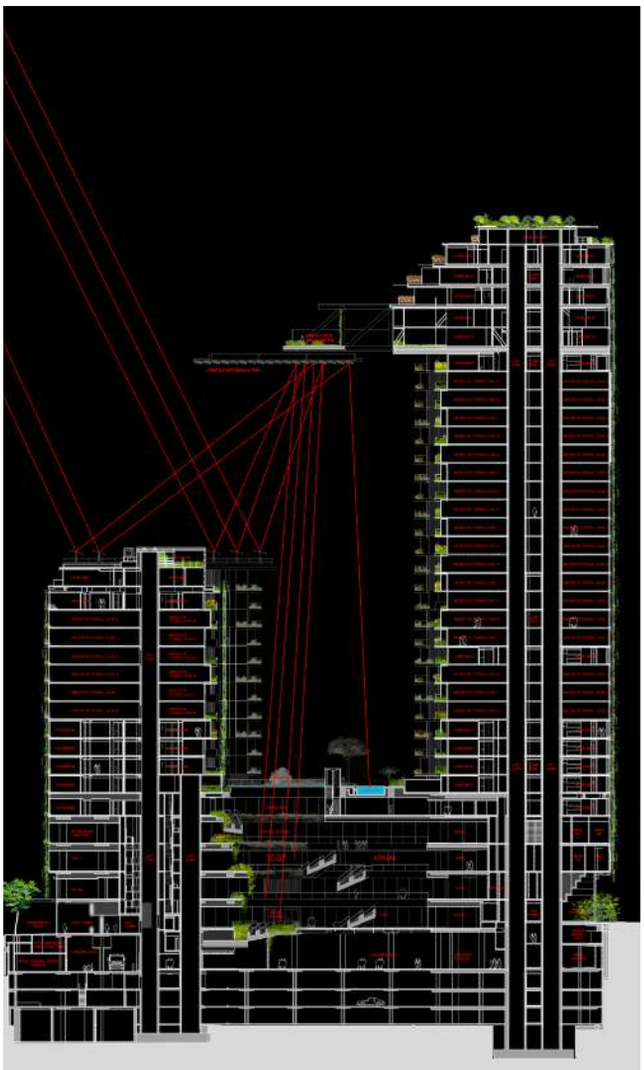


Figure 11: One Central Park. *Source: Ateliers Juan Nuevel,2014*

Discussion

Advantages of One Central Park

-Utilizing low carbon thermal tri-generation plant to provide the energy needed for entire building.
-Utilizing water recycle plant to minimize the water consumption by integrating high tech water recycling solutions.
-Utilizing light reflecting system to maximize the natural daylight leading to minimizing artificial light.

Disadvantages of One Central Park

-Implementing regular green façade maintenance which required accurate schedule and great caution regarding plant pests and diseases.
-Costly vertical garden maintenance.

The Solaire

Similarities with Santiago

Santiago is a city with sunny weather in which solar energy is beneficial to use like New York City. The Solaire's photovoltaic panels create a striking visual effect from the street, serving as reinforcement of sustainable principals. The Solaire is designed and engineered to use 35 percent less energy overall, and 67 percent less electricity during peak loads, which usually occur on hot summer afternoons (Tarnay, 2003).

Here a comparison between Santiago and New York City climate has been shown based on weather reports collected during 1985-2015. The hottest month temperature average in New York City is 25 °C while it is 21 °C in Santiago. In addition, the coldest month temperature average in New York City is 1 °C while it is 9 °C in Santiago. The average of temperature is very near in both cities. On the other hand, both cities have sunny weather which is an acceptable reason for using solar energy in these cities.

Introduction

Santiago is going to be a city of high-rises, dense, low carbon buildings with green features,A successful example of a building including these factor is the 250-unit, Solaire Apartments in Battery Park, New York,USA.The city's trend is to be reusable, sustainable, and efficient residential development. This specific development was a private-public partnership and is the first "green" residential high-rise building that incorporates advanced materials, energy conservation and water reuse in an urban setting. The development has adopted features that will become a must in the future as populations grow and water resources become limited (Ali and Armstrong, 2008).Green features of The Solaire are going to be discussed in following parts including energy, water, cooling, heating and solar cells installed in this building. In addition, advantages and disadvantages have been evaluated.

Energy

The 33.166 sqm Solaire also was designed to meet USGBC LEED® Gold requirements using strategies such as a black water/wastewater treatment plant; photovoltaics; efficient heating, ventilation and cooling systems; efficient windows and walls; efficient lighting and controls; green reef system and U.S. Environmental Protection Agency (EPA) ENERGY STAR® appliances in all units (Epstein, 2008).
Sustainability encompasses more than energy efficiency. The Solaire team walked a fine line, balancing energy efficiency with other aspects of sustainability. For example, making the windows at the Solaire smaller and inoperable would have reduced energy use, but also would have negatively impacted residents' living space. Additionally, reducing the number of fresh air changes and leaving the water treatment/reclamation systems out of the design would have lowered overall energy consumption, but at the expense of air quality and water conservation goals (Epstein, 2008).

The design team sought to use energy efficiently, while providing healthier indoor air quality, enhanced daylighting, and drastically lower potable water consumption. These goals have been supplemented with resident education on the benefits and daily components of sustainability, and behaviour reinforcing communications and operations protocols (Epstein, 2008).

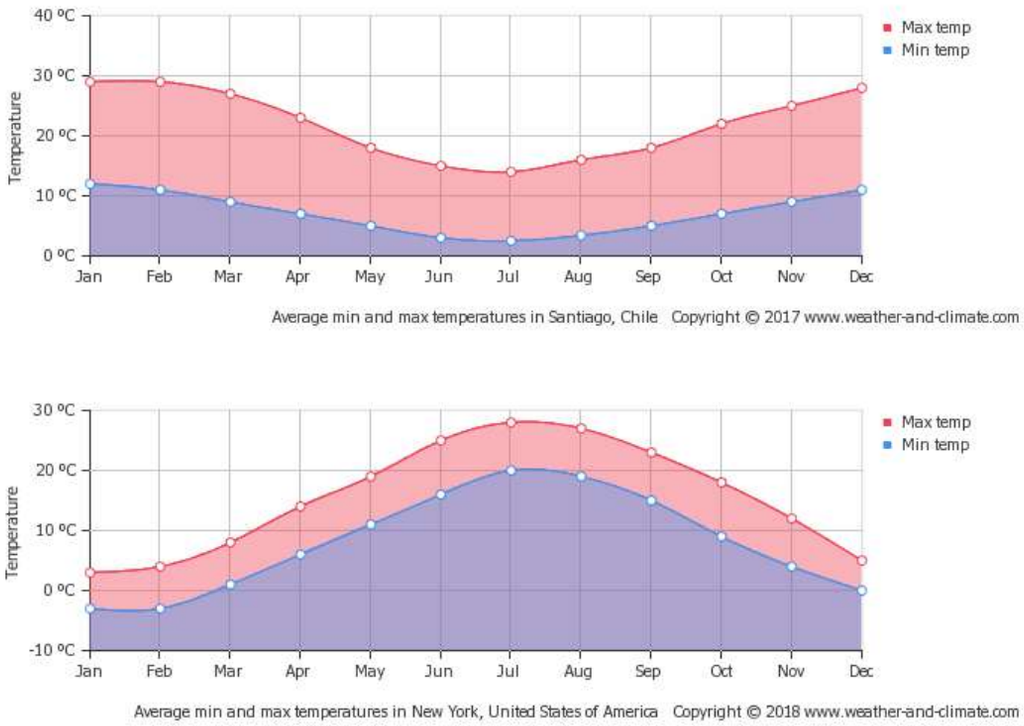


Figure 12: New York City and Santiago annual temperature average. *Source: World Weather & Climate Information, 2018*

As a result, informed tenants use less energy in their residences. Energy consumption by residents, as measured by actual submeter readings, is 24% less than New York State code as predicted in the model for a building of similar size. Building energy use, after almost four years of operation and annual recommissioning, also has decreased. Natural gas consumption has been reduced steadily each year by an average of 10% in each of the last two years. Consumption is almost 20% lower in the first four months of 2008 compared to the same period in the previous year (Epstein, 2008).

Water

The 25,000 gallons of product water produces per day (Gdp) (95 m³/d) onsite wastewater treatment, storage and reuse system is located in the building's basement and includes a series of common-walled, cast-in-place, concrete tanks. The first step in the process is a collection and settling tank where large solids are removed. The wastewater then flows to a bioreactor, which contains active bacteria used to consume or digest the biodegradable waste (SUEZ Water Technologies & Solutions, 2013).

ZeeWeed ultrafiltration membranes are immersed directly into the bioreactor, which eliminates the need to settle solids, and significantly decreases the necessary size of the treatment tanks. Permeate pumps are used to gently pull the wastewater through thousands of membrane fibres. Each fibre is filled with billions of microscopic pores that physically block suspended solids, bacteria and viruses from passing through—guaranteeing an exceptional water quality and clarity on a continuous basis (SUEZ Water Technologies & Solutions, 2013).

The treated water is then further disinfected by ultraviolet lights. Any remaining colour and odour are removed using an ozone generator that also provides a residual disinfection during water storage.

Figure 13: The Solaire building. *Source: America's Firsst LEED Certified Residential High-Rise*

The storage tanks serve as reservoirs for the treated water, which is used as flush water, make-up water for the cooling towers, and for irrigation (SUEZ Water Technologies & Solutions, 2013).

Cooling and heating

The Solaire's heating and cooling system were designed to be energy efficient, provide high indoor air quality, and conserve water. Heating, cooling and ventilation air is supplied to apartments and public corridors mechanically from HVAC units that humidify and dehumidify as necessary. This air also provides makeup air for kitchen and bathroom exhaust. Two direct-fired gas absorption chillers provide hot and chilled water to each unit (Tarnay, 2003).

All of the apartments include programmable thermostats that efficiently control four-pipe fan coil units providing heating and cooling all year. The fan coil units in the apartments also have MERV-12 air filters, which enhance the indoor environmental quality. High-efficiency, variable-speed pumps, fans, and motors circulate ventilation air and water throughout the building, and the high-efficiency absorption chillers run on natural gas instead of electricity. The cooling tower uses a combination of process water from the wastewater treatment plant as well as city water as its makeup water (Epstein, 2008).

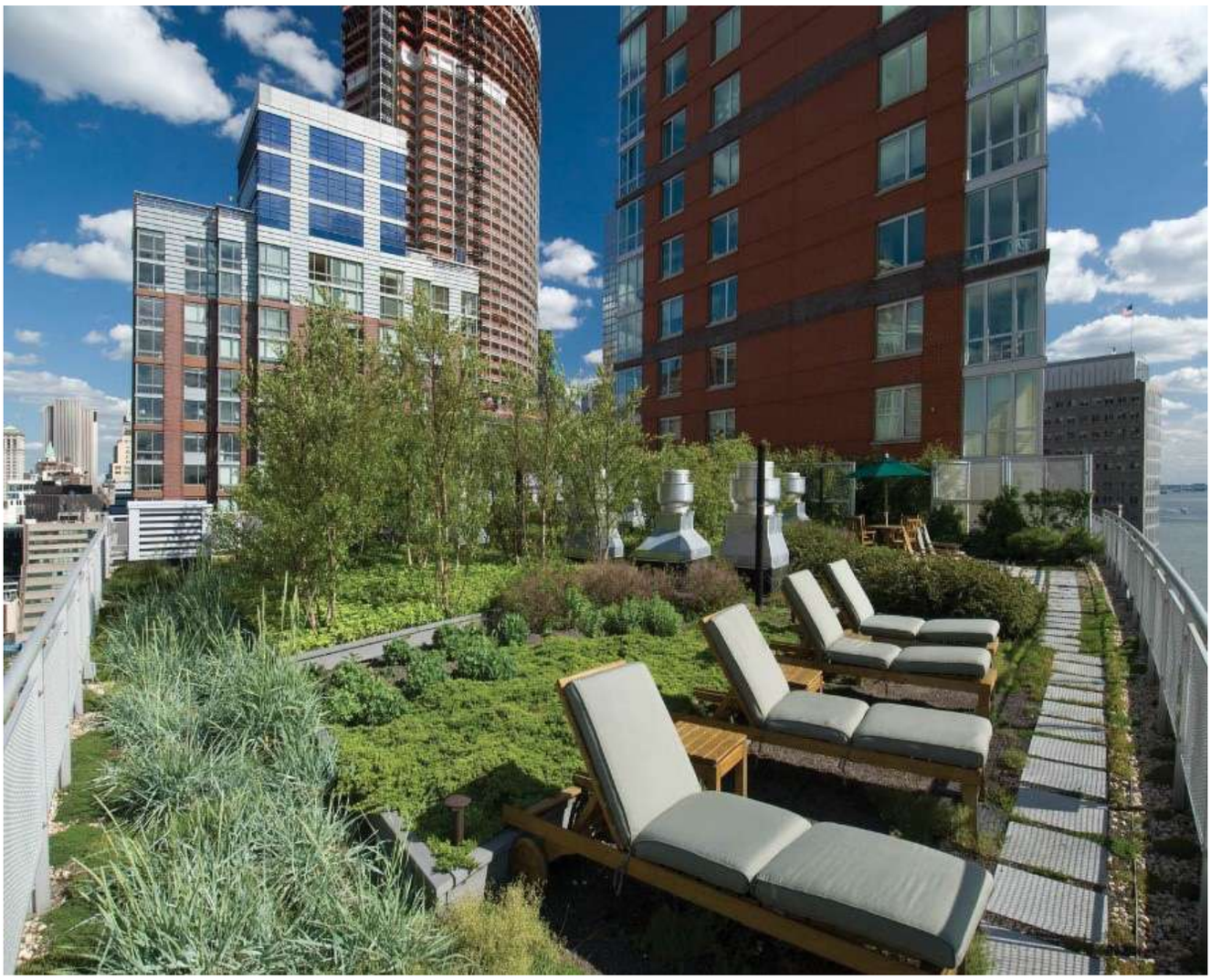


Figure 14: The Solaire building green roof. *Source: Epstein, 2008*

Solar cells

The Solaire's photovoltaic panels create a striking visual effect from the street, serving as reinforcement of sustainable principals. The west facing façade features 1,300 ft2 of photovoltaics with 76 custom panels. The total façade rating is 11 kW. The canopy above the main entrance is made of 151 ft2 of building-integrated photovoltaic panels sandwiched between two panels of glass, generating electricity and also providing shade and shelter from the rain. The total canopy rating is 662 W. At the top of the building are the bulkhead solar systems: 286 standard 75 W photovoltaic modules covering almost 2,000 ft2 of building façade mounted to the bulkhead west and south walls, which use an ornamental aluminium mounting system. The total rating of the bulkhead is 21 kW (Epstein, 2008).

Unlike many solar photovoltaic systems, this building-integrated photovoltaic project required a configuration of modules on the façade and canopy with custom sizes and shapes. As manufactured, the panels become the structure of the façade, replacing the use of brick or glass. Also, the solar cells that make up the panels on the Solaire were manufactured from recycled silicon, helping the building team reach its goal of using 50% recycled-content building materials, and the panels were manufactured less than 150 miles from the building site (Epstein, 2008).

Figure 15: The Solaire water system. *Source: SUEZ Water Technologies and Solutions, 2013*

To meet a requirement of the Battery Park City Authority, the solar electric systems are sized to meet 5% of the base building's non-residential electric load (common areas such as hallway lights and the mechanical systems). Since 2004, the photovoltaic system has been meeting or exceeding its production estimates. During 2005 and 2006, the façade system of 11 kW produced about 6,000 kWh of electricity per year (Epstein, 2008).

Advantages and Disadvantages

Advantages of the Solaire

-A well-insulated and sealed building envelope with an extra layer of exterior insulation and a separate vapor barrier.
-High-performance, operable spectrally selective low-emission glazed casement windows that limits energy usage and are environment friendly.
-Generous daylighting resulting in higher social level of residents.
-A centralized HVAC system that incorporates a double-action natural gas–fired absorption chiller, and variable speed pumps, motors, and fans.
-Centralized air filtration and seasonal humidity adjustment, with additional unit filtration.

Figure 16: Solar cells on The Solaire façade. *Source: Five ingenious buildings that put the style into solar power,2014*

-3,400 square feet (316 square meters) of building-integrated photovoltaic panels which decreases the amount of money paid by residents for energy.
-On-site water treatment and recycling of black water for cooling tower make up water and toilet flushing decreasing environmental impacts.
-A rooftop garden on the 19th floor and a green roof on the 27th floor to reduce heat island effect and water runoff, and to help insulate building, and give some social benefits.
-Storm water reclamation and reuse for garden irrigation.
-Energy Star® fixtures, lights, and appliances, with master shut-off switch.
-Programmable digital thermostats.
-Occupancy sensors in common spaces.
-Low-emission paints, carpets, and components.
-High-quality materials including locally manufactured brick, New York cast stone, Vermont slate and granite, ceramic tile, recycled-content aluminium, and sustainably harvested FSC-certified woods.
-50 percent of materials manufactured and delivered from within 500-mile (804-kilometer) radius.
-85 percent of construction waste recycled, and a storage area for 150 bicycles to fulfil social needs.

Disadvantages of the Solaire

-More initial cost which is estimated to be 17%.
-Systems used in Solaire including heating, cooling or water are high tech and need more cost to maintain.
-New residents need to be taught to efficiently work with some complicated equipment installed in this building.
-Some systems like humidification system consume more energy than designed.
-Indoor air quality decrease because of energy efficiency concerns.

Unsuccesful Example

Considering the definition of the key concepts defined in section 2, this research analyses two unsuccessful international sustainable buildings with the objective to identify possible guidelines to implement in Santiago. The selections criteria of these buildings are based on in the existing similarities that the countries where they are located have with Santiago.

PROJECTS	SIMILARITIES WITH SANTIAGO
London: Grenfell Tower Refurbishment	Weather and daylight
Missouri: Pruitt-Igoe	Existing social segregation in the cities

Table 3: Similarities of the unsuccessful examples to Santiago. *Source: Own elaboration*

Grenfell Tower Refurbishment

Similarities with Santiago

As per research, this Project was full of faulty construction design and unsustainable material usage which are very important for constructing a sustainable building. Apart from the designing problems this project has similar weather conditions as compared to Santiago. The façade work plays a significant role in terms of heating and insulation system for the city which has an adequate daylight amid an entire year. Aside from that this task comprises botch of mix-ups that prompt a calamity toward the end, so we are depicting every disadvantage of the venture here and it ought to be vital for designing high-rise structures in Santiago. The overall temperature of both the cities varies from 0°C to 22°C from winter to summer during a year. Hence for overcoming the effect of overheating and insulation problems, this project case study is very important for developing sustainable Santiago.

Introduction

In 1967, Grenfell Tower was planned by Clifford and Associates with the style of Brutalist. As a Lancaster West redevelopment, the construction work was completed in 1970. Advancement continued running from 1972-74 by Contractual workers an E Symes of Leyton, under the board lodging structure. The building contained 120 flats and one and two-bedroom apartment with an overall height of building 67.3m. The upper 20 of 24 stories had six living arrangements and

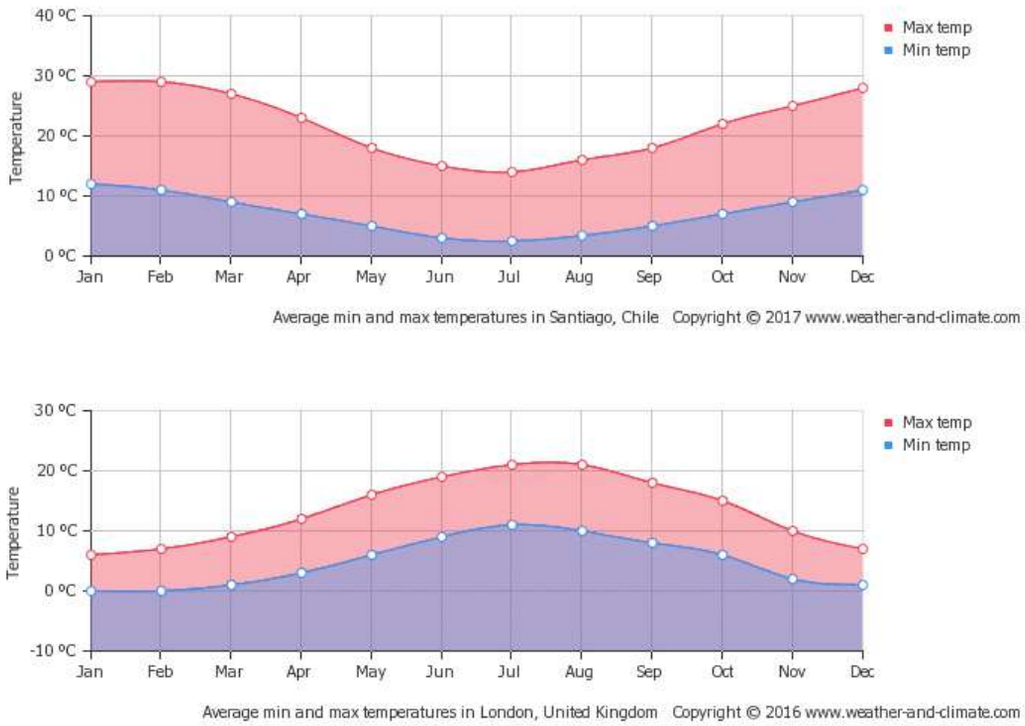


Figure 17: London and Santiago temperature. *Source: https://weather-and-climate.com*

10 rooms each. In the beginning, the lower four stories were utilized for non-private purposes, and then two stories were changed over to private use, bringing the total to 129 flats holding up to 600 people. Grenfell Tower had a single staircase, hence no provision of the fire escape that was the major drawback for the safety point of view (TMO, 2012).The point of this contextual investigation case is to recognize how, as a feature of the Grenfell Tower renovation plot, the present energy, and environmental comfort problems issues can be tended to, and how the picked solutions of refurbishment were excessively unsafe as far as security and sustainability (Max Fordham LLP, 2012).

Grenfell Tower deficiencies in terms of designing

1. The defective functionality of window: The essential issue for the refurbishment was the bad insulation level and airtightness between the walls and ventilated windows at Grenfell tower brought about extreme heat loss in the winter season. Due to safety concerns, the windows were restricted to open for only 100mm and for this reason in the summer season chronic heating took place. So, the building was facing heating problem all over the year. Hence the decision has been made that in the refurbishment process they have to be extra careful about overcoming this heating problem (Max Fordham LLP, 2012).

2. Insulation problem: The concrete walls were made of thickness 250mm and the 12mm insulation layer was provided over the concrete wall. Due to this the U-value of the concrete wall was found 1.25 W/m2 K after testing. This value should be less than 0.25 W/m2 K for the category of good insulation that means the existing level of Insulation was 5 times higher than building regulation limits specified for the residential buildings. Due to this, noise penetration from one flat to another became a common issue for the building. Hence the existing building wall insulation needs modification and alterations to fulfil the building regulation requirements. (Max Fordham LLP, 2012).

Figure 18: Grenfell Tower. *Source: Grenfell Tower, North Kensington,2015*

3. Energy wastage: Building has a shared bathroom extract system. Extracted warm air from the bathroom was at a rate of1.8 m3/s, hence during the whole year, it represents a sign of energy loss.

4. Overheating: In summer Grenfell Tower suffered from chronic overheating effect. South facing apartments were facing very high temperature during the summer. The apartments were not properly sealed and offered no solar control. Ventilation of flats was also bad because there was only single glazed window concept and that was restricted to open the only 100mm due to safety reasons (Max Fordham LLP, 2012).

5. Heating System: The apartments were using single loop hot water cylinder system for delivering the hot water to individual apartments. Due to hot water piping, those were gone concealed inside the floor or slabs of the flats resultant in overheating of flats. There was no automatic controlling system of hot water supply to help to reduce the overheating of flats whenever not required. The heating system technology was around 35 years old resulted in leakage and repairing work of floors tiling work (Max Fordham LLP, 2012).

6. Daylight Assessment criteria: As indicated by British standard code for setting them out

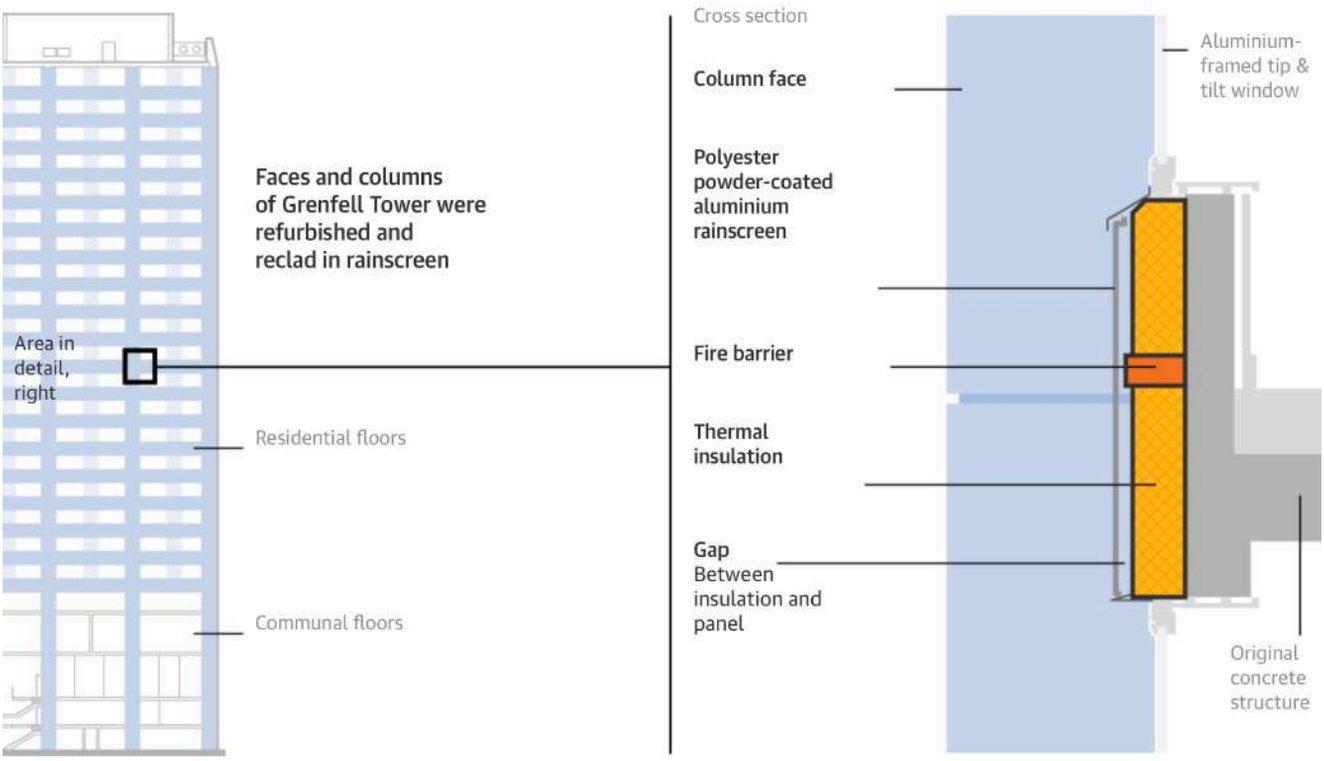


Figure 19: Details of the Renovation effect on the Grenfell Tower. *Source: Architects for Social Housing,2017*

the building orientation such as the minimum average sunlight should be following the British code criteria. Minimum Average daylight values are shown below. But in the Case of Grenfell Tower, this criterion was not fulfilled by most of inside flats (Max Fordham LLP, 2012).

ROOM	MINIMUM AVERAGE DAYLIGHT FACTOR (ADF)
Drawing room	1.5%
Bedroom	1.0%
Kitchen	2.0%

Table 4: Minimum Average daylight factor(ADF) o the rooms of the Grenfell Tower.
Source: Grenfell Tower Sustainability and Energy Statement,2012

7. No provision of Fire staircase: No fire staircase was constructed in the Grenfell Tower. During the Fire accident which was happened on 14th of June 2017, it was one of the real explanations behind life loss of numerous individuals since they don't have the best possible emergency exit arrangement.

8. An absence of fire alarm system: Fire alarm system which was one of the key factors in term of safety regulation was absent in the Grenfell Tower.

9. No provision of sprinkler: Sprinkler is the primary solution to getting rid of fire accident inside the building, was not considered as its installation cost was out of their tight budget in the Grenfell Tower. It seems the management, client and the designer absolutely under-evaluating the fire wellbeing controls which later on transformed into a major fiasco.

Figure 20: Fire accident in the Grenfell Tower. *Source: Lawyer Monthly,2017*

After facing all these issues, the management has decided to do some modification during the refurbishment to tackle the problems. In the month of July 2012, Designer had introduced the new cladding concept keeping in mind the budget for the renovation. Hence the renovation work was started in the end of 2012 and finished in 2016 (Max Fordham LLP, 2012).

Renovation effect on the Grenfell Tower

Refurbishment of Grenfell tower involved façade work as exterior cladding. This façade work has been fabricated as follows:

-Exterior cladding: Outer layer of Aluminium composite material (ACM) rain screen cladding was made of Reynobond PE material.
-Thermal Insulation foam sheet having thickness 150mm was made of Celotex RS5000; a material of Polyisocyanurate, fixed over the existing concrete wall panels.
-The cavity between the Thermal insulation and aluminium sheet is 50mm.
-Double glazed Window of unknown material classification was fabricated in the same plane of insulation (Architects for Social Housing, 2017).

On the 14th of June 2017, A fire started in Grenfell Tower inside a flat on the 4th floor and reached

to the 24th floor within 15 minutes. The reason for the fire was a short circuit in the refrigerator. But the major reason for the disaster was faulty designing and poor material consideration of Aluminium Composite cladding (ACM), which took 71 lives and many injured.

After the accident, several meetings and inspections were held, and inspection was all around, after the testing many reasons behind the cladding failure came out which are listed below:

The major reasons were the cavity between the insulation and the aluminium panels, and the usage of combustible materials in ACM cladding. The cavity and the blowing wind inside the cladding setup the chimney effect under which the fire reached to the terrace rapidly. Beside this 50mm cavity between insulation and panels, there were large voids present around the ten round columns due to the design of cladding, which helped the flames to move fast towards terrace as there was direct contact of these columns from the basement to the terrace. As these columns had a direct connection with each floor hence allowed the fire to move laterally on each floor as well.

On the other hand, Celotex RS5000; a thermal insulation foam sheet and Reynobond PE core between the aluminium panels were made from combustible materials. After the fire, a test has been conducted on both the polyethene aluminium cladding and Thermal insulation and both resulted out fail against fire-resistant property under the fire regulations system. Polyethylene has caused the worst problem as it has a very low melting point and due to its chemical property when it got the fire it was working like a candle and spreads the fire more effectively. After the fire safety test, it has concluded that the cladding was more flammable rather than fire resistant (Architects for Social Housing, 2017).

According to Arconic's website, a Reynobond PE was suitable for the building with height less than 10m and after that, the material should be used is Reynobond FR (fire resistant) or alternative non-combustible material because there is no provision of fire fighter's ladder to overcome the fire problem. After this fire, the supply of this material was stopped.

Discussion

Advantages of Grenfell Tower:

-Refurbishment had improvedd the acoustic view of the tower.
-Refurbishment had improved the heating system of the building.
-Refurbishment staff was able to save around £ 293,250 during the refurbishment by using cheaper aluminium composite cladding material for façade work.
-They have well utilized the podium space for the parking facilities.

Disadvantages of Grenfell Tower:

-The defective functionality of windows due to which an extreme heat loss in the winter.
-The insulation system of the building was very poor. The insulation losses were 5 times higher than the building regulation limits set for the buildings.
-Extracted warm air from the bathroom was at a rate of1.8 m3/s, hence during the whole year, it representsn energy loss.
-In summer Grenfell Tower suffered from chronic overheating.
-The heating system was very old fashioned hence there were many problems in distribution.

-Grenfell tower failed to address the daylight assessment criteria.
-There was no fire alarm system installed for the fire safety.
-No provision for the fire escape staircase in such high-rise buildings where it is difficult for the fire ladders to reach the top floors.
-No provision of the sprinkler in a 24-story building was well.
-Combustible materials used in ACM cladding during refurbishment and the thermal insulation material Celotex RS5000 got fire; it produces intense heat and emits harmful gases which are toxic and irritating.

Pruitt-Igoe Housing

Similarities with Santiago

The city of Santiago population continues to increase and expands vertically, so also the need for high-rise social housing. When a new urban development scheme is proposed, developers and city officials typically take three primary concerns into account. One; how the development will be financed, and in turn, what economic benefits it can bring, two; urban infrastructure's environmental impact and sometimes its own sustainability, three; how to gain the support of local stakeholders to implement the project. With the environmental, economic and governance dimensions of sustainable development considered, the social dimension is often a lower priority (Baldwin 2014). While organizations such as BREEAM and LEED that provide general concepts and guidelines to achieve environmental, economic and social objectives of buildings did not exist during the period of Pruitt-Igoe but now exist today, knowledge about the social challenges to sustainability for dense high-rise housing can provide more specific insights for planning new projects.

Inhabitants of Santiago face socio-economic segregation. Social segregation and physical fragmentation have existed for over half a century (Bosdorf, Hidalgo, 2008). This is parallel to the spatial segregation of St. Louis in the 50's where initially, white and non-white communities were kept exclusive of each other through segregation law (which was later abolished) and indirect socio-economic city fragmentation policies. Pruitt-Igoe's site plan was a manifestation of segregation practices.

The Santiago urban area is clearly differentiated according to family income. Higher-income groups are concentrated in six of the city's 34 municipalities (Dockemdorff, Rodríguez, Winchester, 2000). In St. Louis, Poor coloured people were restricted to the inner cities while whites inhabited suburban areas. The geographical, cultural/racial, and economic isolation of the inner city exacerbated living conditions of Pruitt-Igoe and the surrounding ghetto areas. Wealthy tended to congregate in the outer, non-industrialized areas, while the poor, especially African-Americans remained near the old industrial core (Lawson, 2003).

Introduction

In March 1972, after being deemed inhabitable, the start with the controlled demolition of the Pruitt-Igoe housing project in St Louis, Missouri was met different emotions. Some praised it and believed the demolition was long overdue, others were devastated that their dream for better housing was gone. To architects and city planners, and the Missouri state government, it was a revelation to how well-intentioned policies and solutions to social housing and public blight can go awry.

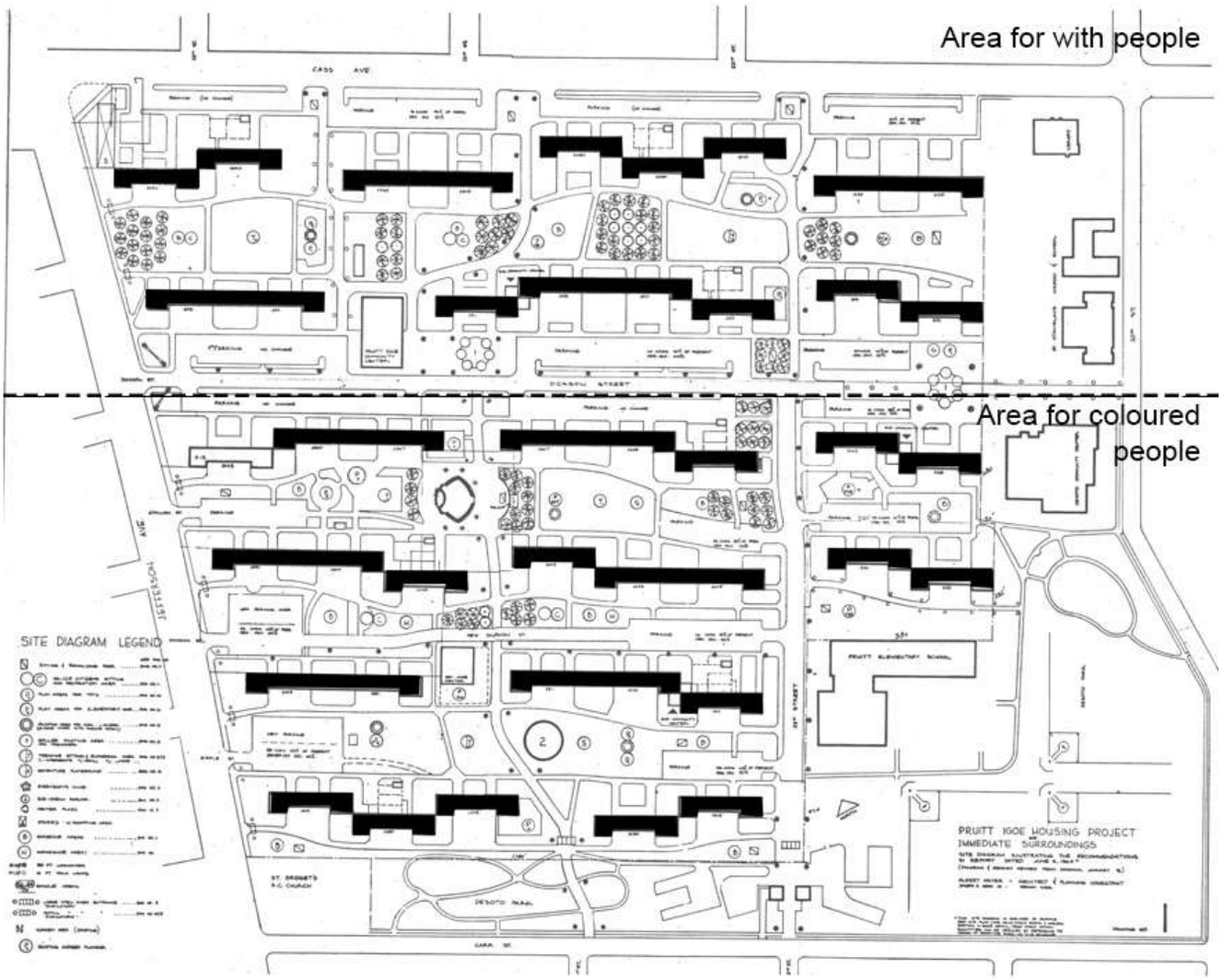


Figure 21: Site Layout of Pruitt-Igoe. *Source: Katharine Bristol*

The Pruitt-Igoe project was 33 buildings of 11 stories high residential apartments built across 57 acres of land. Once a symbol of a city's progressive housing ideologies through the adoption of modernist architecture and Le Corbusier's relatively new theory of city planning using high-rise buildings, came to be a good argument for opponents of dense high-rise building construction. Its progression from architectural monument to controversial status and finally to its eventual demolition foreshadowed the fate of high rise buildings across the nation (Henderson, 2000). In the following years, federal housing projects around USA abandoned the concept of dense high-rise buildings in social housing projects. The demolition of Pruitt-Igoe was the death of modernist architecture as argued by architecture historian Charles Jenks.

While there have been numerous studies with opposing results on reasons why the Pruitt-Igoe project failed, a common acknowledgment is that the costs of maintaining the buildings grew unviable. Fire outbreaks occurred often, elevators; waste management and plumbing fittings deteriorated during extreme weather, all making living conditions poor and unsafe.

Buildings can influence happiness, safety, health and prosperity of its occupants. Lessons from how the construction and operation of Pruitt-Igoe housing projects impacted on the social and economic welfare of its occupants are valuable in understanding sustainable dense high-rise how projects should be done. While there are numerous reasons why the project failed, this

Figure 22: Site layout of Pruitt-Igoe Housing. *Source: farm4.static.com*

chapter would only focus on construction details that contributed to the project's demise.

Pruitt-Igoe was designed by architectural firm Leinweber, Yamasaki & Hellmuth and sponsored by the Federal Public Housing Authority. The project was developed to provide better housing for an economically blighted growing population of slum dwellers who had migrated from other parts of the country. It was part of a bigger urban renewal effort in the 1950s, a period when St Louis was being transformed into a modernist city. Cochran Gardens and the St Louis arch projects started during this period.

Architecture and construction

Pruitt-Igoe was developed with the cheapest possible plan and not the most efficiency of life-cycle costs. Going against the initial designs of the architects, to maximize cost savings for the Federal Housing Authority, the buildings were raised to be constructed on 11 floors. Apartment floor areas were extremely restrictive, and kitchen and toilets were built small. 2870 one-bedroom apartments were crammed into 57 acres of space; this is approximately 50 apartments to 1 acre. The scale of the project itself would condemn it to its fate of not being sustainable. Without automation, the resources needed for maintenance activities and security for a project of its size was huge; more so, that it required rent collection at full occupancy levels to be able to raise enough funds for its maintenance. While much planning went into designing functional shelters using cost-efficient construction methods, a recurring theme is that these decisions failed to provide long-term safety and liveable conditions for the residents.

The site layout was designed to foster racial divide between white and black segregated areas. Blacks were concentrated into the Wendell Pruitt apartments and whites were concentrated into the William Igoe apartments. This promoted social inequality. 'After the White flight' by the white community to suburban areas, the buildings would eventually become occupied only

by poorer African American families. Despite legally banning segregation nationally, St Louis' spatial behaviour would remain segregated as 'After the White flight' by the white community to suburban areas; the buildings would eventually become occupied only by poorer African American families. Furthermore, through housing policies, poor families were indirectly restricted to the inner cities while white people inhabited suburban areas.

Fittings with poor performance were used to achieve cost cuts. With heavy use, they failed often, and frequent replacement became too expensive to keep up with. Sewage infrastructure was also not designed strong enough to cater to the high-density use by several apartments usually found in high rises. As sewage leaks became more frequent, it created the environmental pollution. Another problematic cost-saving decision was the use of Skip stop elevators.

Stopping at every three floors provided the opportunity for intimidation, harassment, and robbery in the corridors of floors where residents were forced to use staircases. In an interpretation of Oscar Newman's theory of defensible space, it can be posited that having a mixture of disadvantaged people and the buildings' layout encouraged crime and vandalism. (Rainwater, 1970) also argued that the violence and vandalism that occurred at the project were an understandable response by its residents to poverty and racial discrimination.

The project, modelled after Le Corbusier's 'Ville radieuse', green spaces and kids play areas typical of the model, needed for the purpose of achieving improved urban air quality, space for community interaction and heightened aesthetic appeal were never included.

Before its demolition, there were growing concerns over the longevity of the building structures (Duffy, 2015). The structures were built using exposed aggregate concrete and bricks. Exposed aggregate concrete can be used to achieve aesthetic looks at very low costs, it is not durable against long-term weather effects. Vandalism and moisture penetration which could affect the structural durability of the building made it prone to more frequent maintenance costs than other more durable options.

In the immediate years following the demolition of the structures, as narrated in the film (The Pruitt-Igoe myth, 2011), the Pruitt-Igoe buildings had developed such an unpleasant social reputation that African Americans who were associated with living in them faced prejudices or were excluded from social and economic opportunities in the city of St. Louis. While the building no longer physically existed, it still had great influence on the socio-economic welfare of its former residents.

It is important to consider the harmony of environmental responsibility, resource efficiency and social integration of people during design and construction, especially in high rise density buildings. the choice of design and building components as in the case of Pruitt-Igoe have, implications on the economic viability of the buildings during the operations phase of their lifecycle. Deep social segregation with bad housing policies fast-tracked the failure of Pruitt-Igoe's failure.

The architecture and value engineering and social segregation caused a dangerous chain reaction of events. Poor performing designs and building components led to expensive maintenance costs, which led to the gradual break down of the building and left in a state of disrepair, which led to social dissatisfaction among a socio-economically frustrated people, which spurred reproachable behaviour from its occupants towards each other and the building. Many people living in high rise buildings results in potential heavy social interactions among

its occupants and their collective interaction with the building. Lessons from Pruitt-Igoe directly brought to bear, social issues architects and city planners must consider when planning for the sustainability of dense high rise social housing and how they affect the long-term social welfare of its users.

Discussion

Opportunities of the Pruitt-Igoe

-Move value from engineering to life cycle costing.
-Adopting guidelines set by sustainable organizations such as LEED and BREEAM.
-Integrate social housing into the architectural façade of its host environment to avoid stigmatization.
-Minimizing cluster densities and having them more spread out to reduce overall environmental impact and improve natural resource circulation.

Disadvantages of the Pruitt-Igoe

-Cheap standard of construction.
-Poor facility services.
-Needed frequent and expensive maintenance.
-Not included in the main paper, but incinerators were used for waste management which causes greenhouse gas emissions, today we have reuse and recycling technology.
-Social segregation and concentrated poverty.
-Main structural elements of steel and concrete are products of severe environmental pollution processes.

Summary of this chapter

Green low carbon building is essential for the future environment because of its advantages. Limited natural resources and improvement of countries require new methods and techniques in construction project management in order to minimize the effects of construction. The attractive indoor environment of buildings, higher quality of life, renewable energy use, reuse and recycling of materials are substantial benefits of sustainable construction which makes the improvement of sustainability essential.

By studying successful projects around the world and analysing the utilized new techniques and technologies and implementing these in housing projects as well as studying the lesson-learned items of failed projects worldwide and avoid repeating them, the most effective sustainable projects can achieve. The following tables, summarise the two successful and unsuccessful examples of high-rise green buildings in two locations around the world with conditions similar to Santiago, Chile.

ITEM	THE ONE CENTRAL PARK	THE SOLAIRE
Location	Sydney, Australia	New York,USA
Similarities with Santiago, Chile	Average Monthly Temperature, Humidity, daylight hours and population	Sunlight
Description	Mixed-use building, two Towers -623 apartments, 235,000 sqm residential - 117 m Hight	250 units 357,000 ft2 area
Utilized Sustainable Technologies	On-site central tri-generation plant, one-site water recycling plant, vertical gardens and cantilevered heliostat.	Blackwater treatment plant, photovoltaics, efficient heating, ventilation and cooling system, efficient windows and walls, lighting and controls and green reef system
Advantages	Utilizing low carbon thermal tri-generation plant, utilizing water recycle plant and utilizing the daylight reflecting system	Integrated photovoltaic panels, well-insulated and sealed building envelope and centralized HVAC system On-site water treatment and recycling of blackwater and storm water reclamation
Disadvantages	Implementing regular green façade maintenance and costly vertical garden maintenance	High initial cost, high-tech systems high maintenance cost, implementing complicated equipment and less indoor air quality

Table 5: Summary of the successful examples. *Source: Own elaboration*

ITEM	GRENFELL TOWER	PRUITT-IGOE
Location	London,UK	St. Louis, Missouri, the USA
Similarities with Santiago, Chile	Climate condition and daylight	Existing social segregation in the cities
Description	120 flats, 67.3 m height	33 buildings of 11 story high residential apartments
Deficiencies	The defective functionality of window, Insulation problem, energy wastage, overheating, heating system, daylight assessment criteria, no provision of fire staircase, an absence of fire alarm system and no provision of sprinkler	Bad housing policies, Social inequality, lack of the architecture and value engineering, poor performing designs and building components
Advantages	Refurbishment had increased the acoustic view of the tower, refurbishment had improved the heating system of the building and well utilized the podium space for the parking facilities	Move from value engineering to life cycle costing, adopting sustainable organization guidelines like LEED and BREEAM, integrate social housing into the architectural façade of its host environment and minimizing cluster densities
Disadvantages	The defective functionality of windows, poor insulation system, high extracted warm air from the bathroom, suffering from chronic overheating effect in summer, old fashioned heating system and no fire alarm	Cheap standard of construction, poor facility services, frequent and expensive maintenance, lack of waste management, social segregation and concentrated poverty

Table 6: Summary of the unsuccessful examples. *Source: Own elaboration*

Figure 23: Municipalities of Santiago. *Source: Bombardeo Comunas de Santiago,2015*

Case study: Santiago, Chile

Santiago is the capital of Chile. It is located in the country's central valley. It consists of 32 independent municipalities referred to as Greater Santiago. Each of these municipalities are self-governing areas and operate their social services, political offices and fiscal policies independently.

Geography and climate

Santiago is a valley city located in the middle of Chile. It has an elevation of 520m. It is surrounded by the Andes Mountains to the east and the Chilean Coastal Mountains to the west. The Cordon de Chacabuco, a transverse mountain range from the Andes is north of the city and to its southern boundary is Angostura de Paine, where an elongated spur of the Andes almost reaches the Coastal Range (newworldencyclopedia, 2016).

Santiago has a population of 6.5 million people and as the population continue to migrate from other parts of the country in pursuit of better economic and social opportunity, the city expands at an average of 1.4% per year (Population.city, 2015).

Figure 24: Andes Mountain in Chile. *Source:Home Page - Worldfolio, 2014*

Summer and winter are the two main seasons in Santiago. The dry and hot summer months last from November till March with average temperatures of 35 degrees. The cold and humid winters last from June until August with occasional snowfall and average temperatures of 8 degrees.

Economics

Santiago is the commercial nerve centre of Chile. Santiago generates up to 50% of Chile's total Gross Domestic Product (GDP) (Trujillo, Parilla & Ramzillic, 2016). It is home to several Commercial, financial and industrial institutions which leverage in its economic assets, developed infrastructure and a well-educated workforce. The stock exchange, located in Santiago is one of the three major markets in Latin America.

Santiago is an international access point for Chile. There is a strong foreign direct investment in the city and many multinational companies now have their national and regional headquarters in Santiago.

Average standards of living and labour productivity are much higher today than they were in 2000. Manufacturing and exports of food, textiles, foot ware and mining industries is a growing

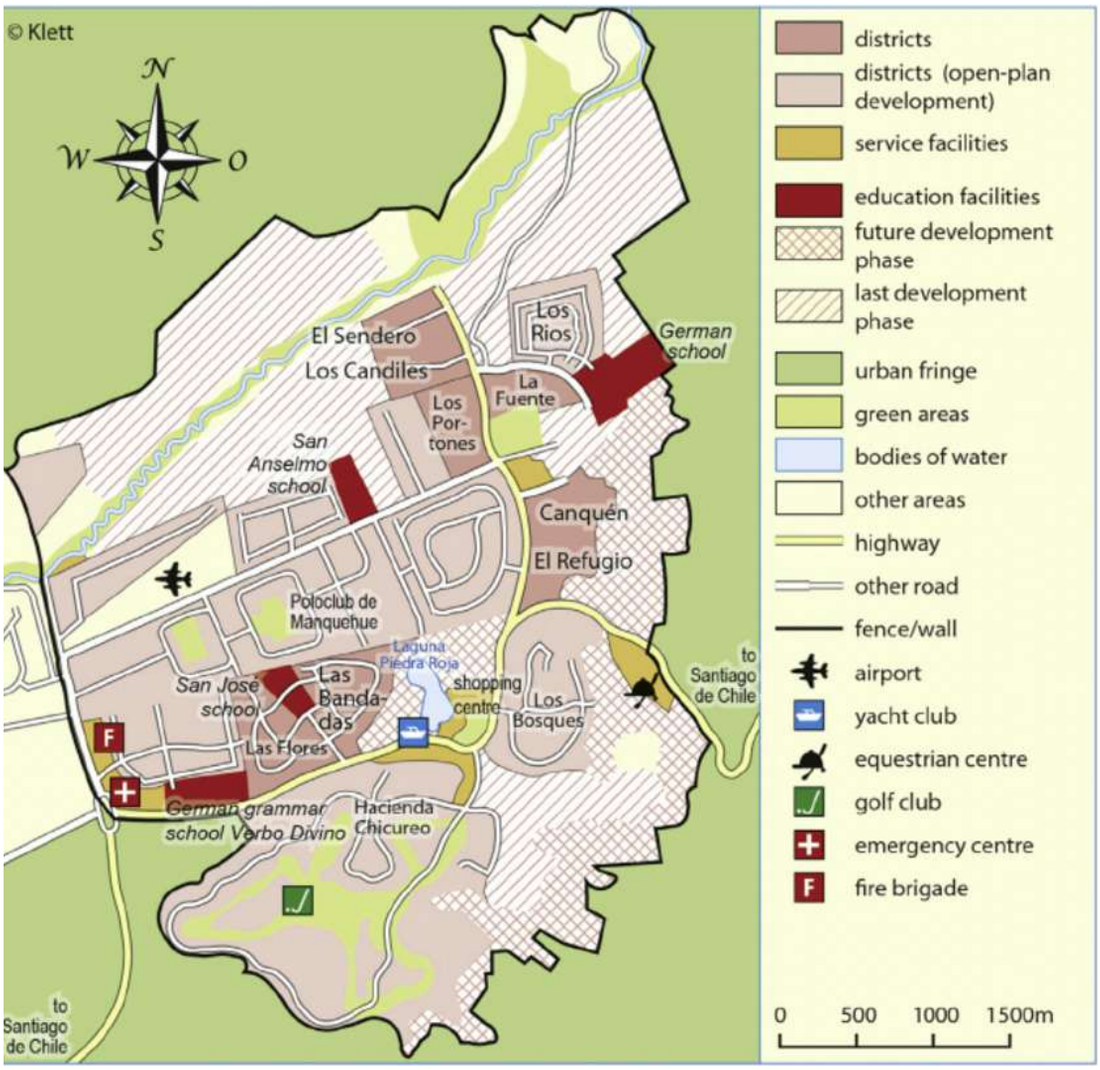


Figure 25: The gated city of Piedra Roja, north of Santiago de Chile. *Source: Borsdorf & Stadel, 2013*

and reliable source for foreign trade. Gains in output, GDP per capita, and output per worker outpace most of Santiago's peer regions (Trujillo, Parilla, Ramzillic & 2016). However, the city still has the problem of income inequality.

Social policy

Despite economic developments and rising income levels, through research, Santiago is believed to be a segregated city (De Mattos 2002; Sabatini, Cáceres & Cerda, 2003).

Evidence suggests that public housing policies are principally responsible for this segregation. The creation of private roads and motorways accessible only to privileged residents, of towns on a scale of medium-sized European cities that are out of bounds for the public, creates large self-sufficient ghettos that are taken out of the public space and the state as an institution. Bosdorf, Hildago (2008) & Tokman (2006) shows that in 2002 the biggest concentration of projects within Greater Santiago was located in Quilicura, La Pintana, Renca, Pudahuel and Peñalolen. Hence, isolated neighbourhoods inhabited by low-income households are located on the southern and northern boundaries of the city.
There exists segregation also on the on the basis of ethnicities and new migrants according to (Borsdorf, Coy, 2009). These groups were noticed be directed towards peripheral areas.

Figure 26: Rich and poor neighbourhood in Santiago. *Sources: INVITRO - Blog of Vivienda ofThe Faculty of Architecture and Urbanisem of the University of Chile ,2017*

At the International RC21 Conference 2013 Resourceful Cities in Berlin, (Link, 2013) presented further research that segregation in Santiago had caused urban fragmentation. Boundary areas were isolated from the rest of the metropolitan area in terms of connectivity, public services, public spaces, workplaces, etc. In this context, everyday life for residents of these areas is spatially limited. A derivative of this is that social interactions and personal networks are confined according to specific areas in Santiago.

Urban development

Santiago is one of Latin America's most sophisticated landscapes. Metropolitan areas, with extensive suburban development, dozens of shopping malls, and impressive high-rise architecture (new world encyclopedia). Santiago is a highly urbanized city with 70% of its land mass being built up area. The Central municipalities of Santiago Centro, Quinta Normal and La Cisterna, are fully urbanized while the suburbanized areas exist around the peripheral of the city. Santiago hosts 50% of the city's surface area is residential (Galetovic & Poduje, 2006). Santiago holds the tallest building in Latin America Santiago holds multiple skyscrapers which includes the 'Grand Torre'- the tallest building in Latin America. Several high rise residential buildings are scattered around the city.

Santiago has a highly developed infrastructure. Rail and road network systems link most parts of the city and also connects to other parts of the country. The city is also serviced by one international airport, three smaller domestic airports and two seaports.

Environmental

Santiago is one of Latin America's most polluted cities due to thermal inversion (Garcia-Chevesich P, Alvarado S, Neary D, et al, 2014). Thermal inversion causes high levels of smog and polluted gases to be trapped and concentrated within the Central Valley within which it is located. In 2001, shortly after the creation of Chile's National Environmental Commission (CONAMA), the science journal published Santiago as the second most polluted Latin American city. 2016 studies revealed PM2.5 has been reduced by 68% and the PM10 by 38% between 1989 and 2015.

This reduction is attributed to government policies such as controlled agriculture burning, eliminating lead gasoline, prohibiting open fires, the introduction of tradable emissions permits, the introduction of Transantiago to gradually phase out noisy and polluting buses and limiting the use of the private vehicle on days of emergency-level air conditions. (Mullins & Bharadwaj, 2014) assessed that the announcement of days of emergency-level air conditioning reduced particle matters in the atmosphere by approximately 20% on the day of implementation.

Other efforts adopted to reduce environmental pollution are compulsory wastewater management plans for all industries in Santiago and a move to renewable sources of energy. Ultimately, the judiciary has the authority to stop investments and projects on ecological and sustainability grounds (Klein et al, 2016).

Current situation of the housing

The planning goals are building dense urban areas and cities. In many different countries, dense construction policies consist of population growth and reduction of suburbanization. Although, building and population distribution in a city is a very difficult issue and can increase contradictions in it, at the metropolitan scale rising density rates may be a favourable planning goal. Due to social infrastructure are closer, density causes to enhance access to services, on the other hand, it may bring up neighbourhood problems and people dissatisfaction (Bramley & Power, 2009; Aquino & Gainza, 2014).

Aquino and Gainza consider that “these contradictions are further complicated in cities polarized along socio-economic lines. In Latin American cities (and in much of the non-Western world), density rates differ dramatically across areas and, as such, there are strong differences in mobility, accessibility and the use of social infrastructures and amenities” (Aquino & Gainza, 2014, pp. 5877).

History of Housing in Santiago

Residential architecture in Chile is as diverse history, culture and geography. In Chile’s urban history, between the period of the Late-nineteenth and the mid-twentieth century, many people migrate to the capital city (Santiago) from the rural and mining cities.

Figure 27 is depicted as the building of the workers’ building societies and its goal was to improve the life of workers and establish a community infrastructure for them (Larraín Bravo, 1911).Figure 28 is a simple continuous facade of the many housing in Santiago. Figure 28 is about the two-story buildings which have the central open space for middle-class families and the first type of these buildings is built in 1880 in Santiago. These create a private open space and provide a secure area for children to play (Parra Flores & Galleguillos, 1926).

This type of housing is as an accommodation for local residents and new migrants and then the municipality of Santiago redesigned it to provide social housing for low-income residents in the city centre which is shown in Figure 29.Furthermore, Figure 30 indicates Población Madrid that built in 1927 and now is a heritage as traditional zone.

In Figure 31, Villa Frei is a micro-city housing development. There are medium-rise apartment blocks, high-rise apartment building and open public spaces that prepare social and ecological value to residents.

Figure 27: The building of the workers' building societies and the community infrastructure. *Source: Mazo Arquitectos/ Santiago Chile,2017*

Figure 28: Continuous facade and the central open space in a two-storey cité for middle-class families. *Source: Begining, University Bernardo O'Higgins*

Nowadays, there are an important percentage of housing which consider sustainable design and efficiency energy in Santiago.

The density profile of Santiago

The Santiago Metropolitan Area has 6.1 million inhabitants in an urban area and it represents the 35% of the whole population of Chile (INE, 2012).

Figure 29: Neo-city San Francisco, Santiago. *Source: Architecture Platform*

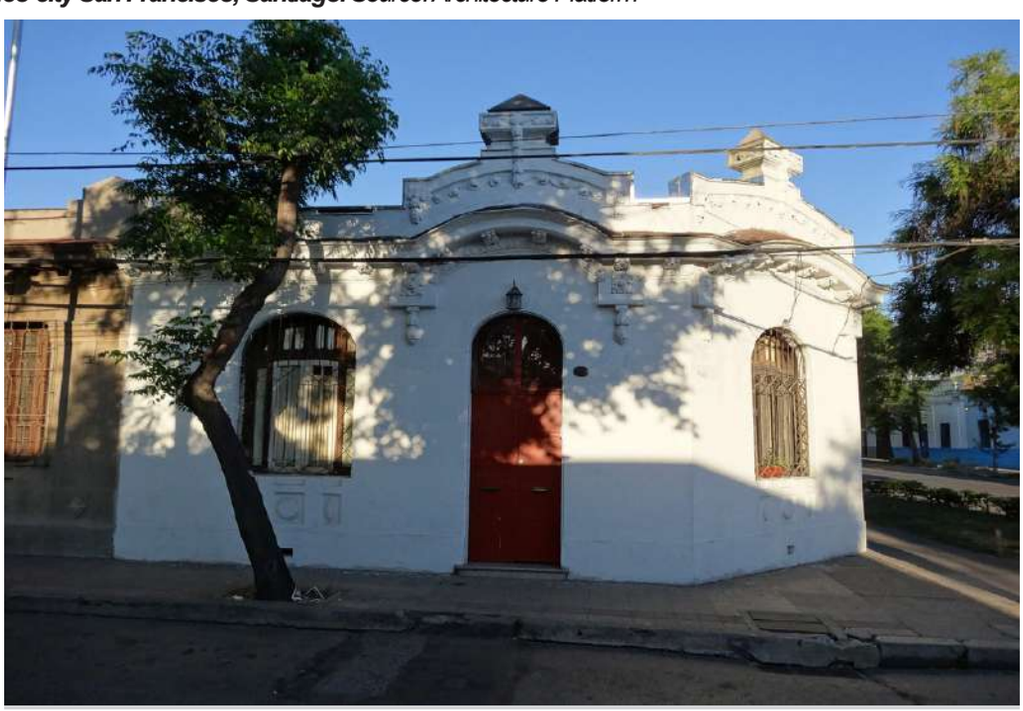


Figure 30: A common housing type such as Madrid housing development in Santiago. *Source: Luciano Kulczewski Garcia, 1927*

The density of residential within the built-up area is around 84 occupants per ha, which is medium based on international standards. In most cities which have market-oriented economies, density decreases with the spacing from the city centre (Aquino & Gainza, 2014).

The population in the cities of Chile has grown almost 107% from 1970 to 2002, going from 6,050,436 to 12,538,053 in that period. When comparing the data from the 1992 census with 2002, it can be seen that 26 cities had an explosive population growth, understanding this as an annual average growth rate higher than 4.2% (University of Chile, 2010). Figure 33 shows the urban development between 1920 and 2002 in the city of Santiago.

Figure 31: Villa Frei, Ñuñoa, Santiago. *Source: Villa Frei,2012*

Public spaces

Green areas include vegetation and natural elements that deliver multiple advantages to the population and the urban environment. For instance, the green areas bring social integration, physical activity, and a better quality of life for the inhabitants, moreover, it provides different environmental services, for example, carbon capture, improvement of air quality, urban temperature control, erosion reduction, flood control, noise control, and energy saving. The green areas are few in the large cities of Latin America (Reyes 2011 & Flores, 2011).

The Greater Santiago (GS) is separated into 34 sections where nearly 5.8 million people live with an average density of 93.3 inhabitants/hectare (Ministry of Housing & Urban Development, 2011).

As mentioned above, the availability of green areas of the Greater Santiago (GS) on average is below the standard of 9 m2 / inhabitants of the WHO (World Health Organization), with considerable inequality among the segments that include it. The National Environment Commission (currently Ministry of Environment) conducted a survey of the green areas of the GS in 2003, obtaining an average of 3.2 m2 / inhabitant. The poorest communes recorded values between 0.4 and 2.9 m2 / inhabitant, while the wealthiest parts between 6.7 and 18.8 m2 / inhabitant (Figueroa, 2008).

Recent studies conducted a perfect analysis of the green areas of Greater Santiago (GS) (Reyes, 2010; Figueroa, 2008), including all green areas available, as municipal with and without maintenance and private. Figure 34 shows that of the 34 parts of the GS, only eight exceed the 9 m2 / inhabitant recommended by the WHO (World Health Organization) and that the communes with higher incomes have a greater area of green areas per person than those with lower income. It should be noted that the part with the largest area per capita is Vitacura (56.2 m2 / inhabitant) and the one with the smallest one is El Bosque (1.8 m2 / inhabitant).

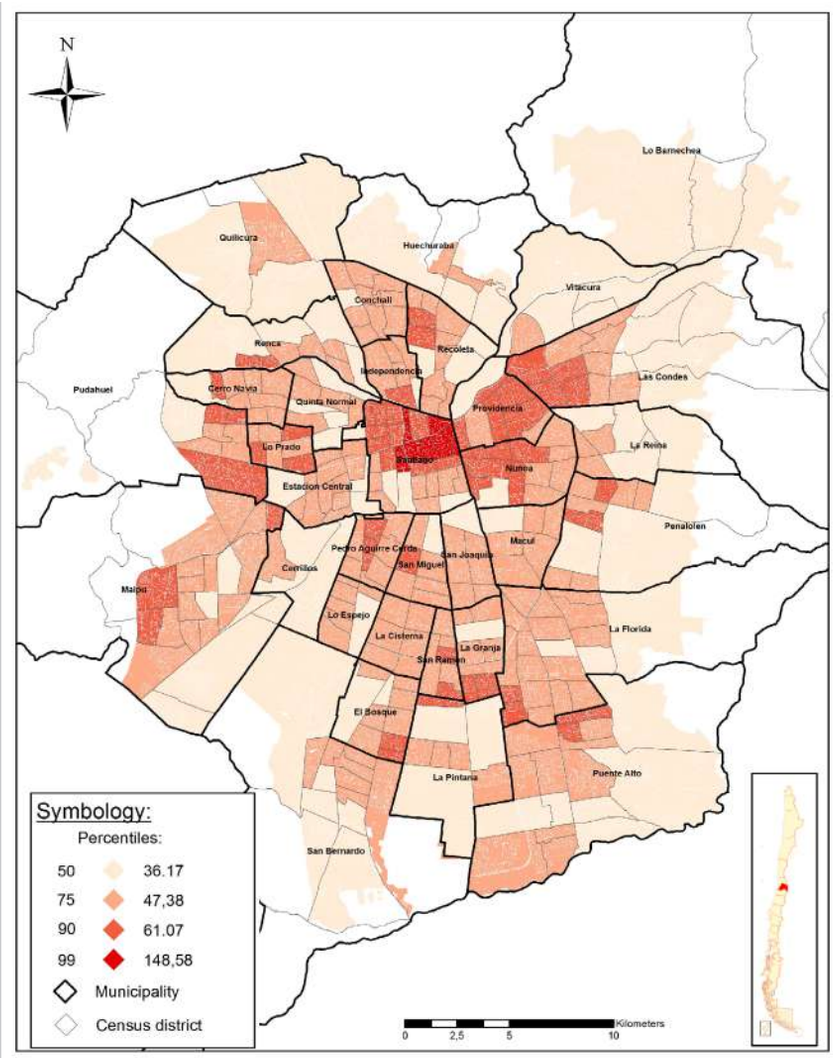


Figure 32: Dwelling density at the census district level, 2011. *Source: Aquino Gainza, 2014*

Housing in Santiago, Chile

The amount of housing in metropolitan of Santiago increased between 2002 and 2011. In Figure 35, the red line shows the boundary between Santiago and other communes.

According to Ocampo & et all 2009, the socio-economic groups and location of neighbourhoods is the criterion of the division in Figure 36. According to the uneven distribution of income in Santiago, the quality of life and housing standards are increasingly unequal in the different areas of the city. This division is affected by the income levels of its inhabitants for instance as it is indicated in Figure 36 that in the blue and dark green area, there are more facilities, houses, tall buildings, and public amenities, accessibility to urban goods and services, and also the people living in it have higher income levels in comparison with the red area. The lack of basic infrastructure to accommodate is one of the important reasons that blue zone has the massive population.

Furthermore, the green area of each person in the blue area is around 9 square meters per person but compare with other areas which are below less than 3 square meters.

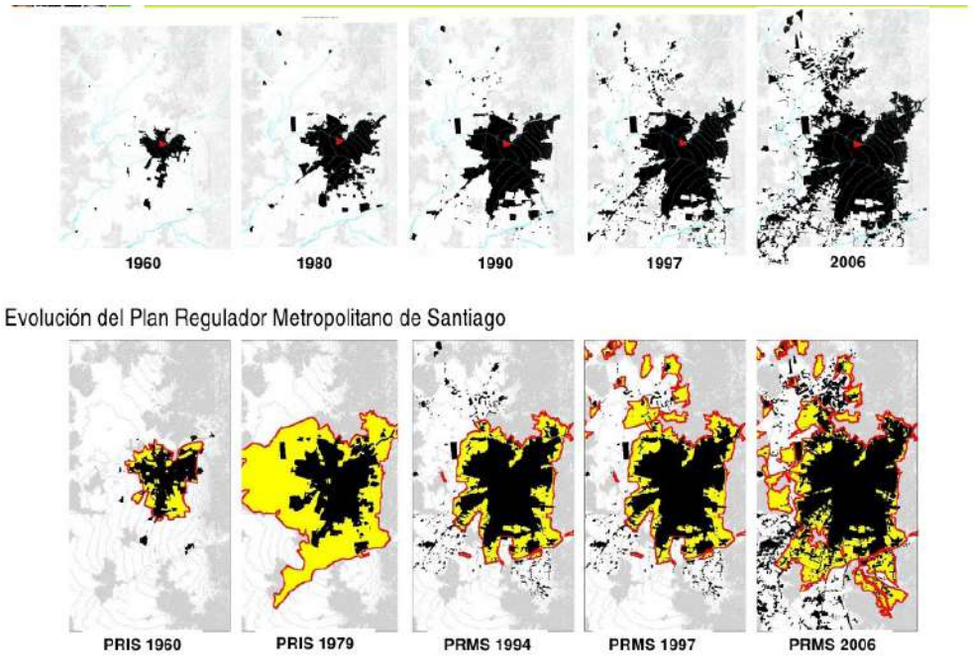


Figure 33: Urban growth in Santiago de Chile, 1920-2002. *Source: MINVU 2008*

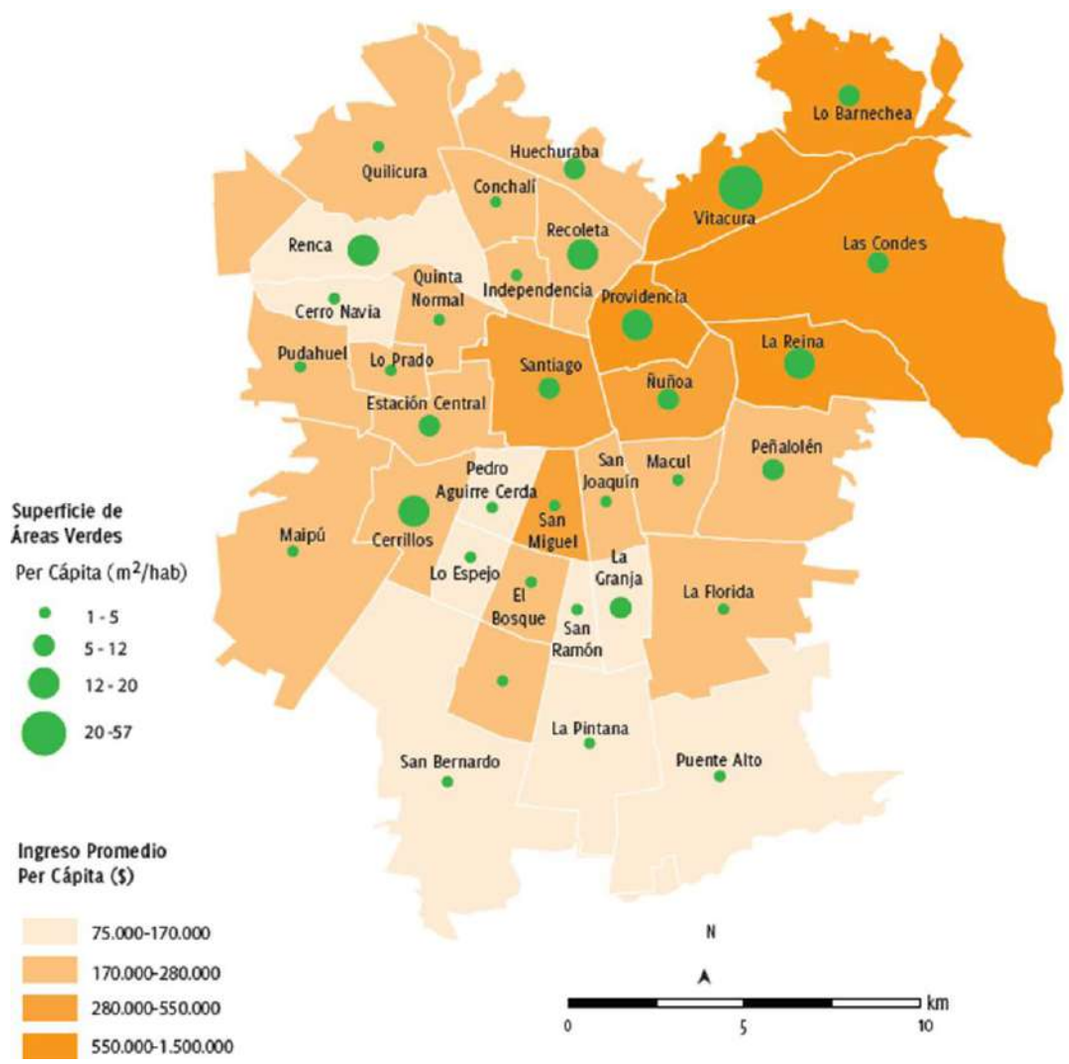


Figure 34: Green areas per inhabitant (m2/inhabitant) and average income per capita ($) in the communes of Greater Santiago. *Source: Figueroa, 2008 and Mideplan (CASEN Survey, 2009)*

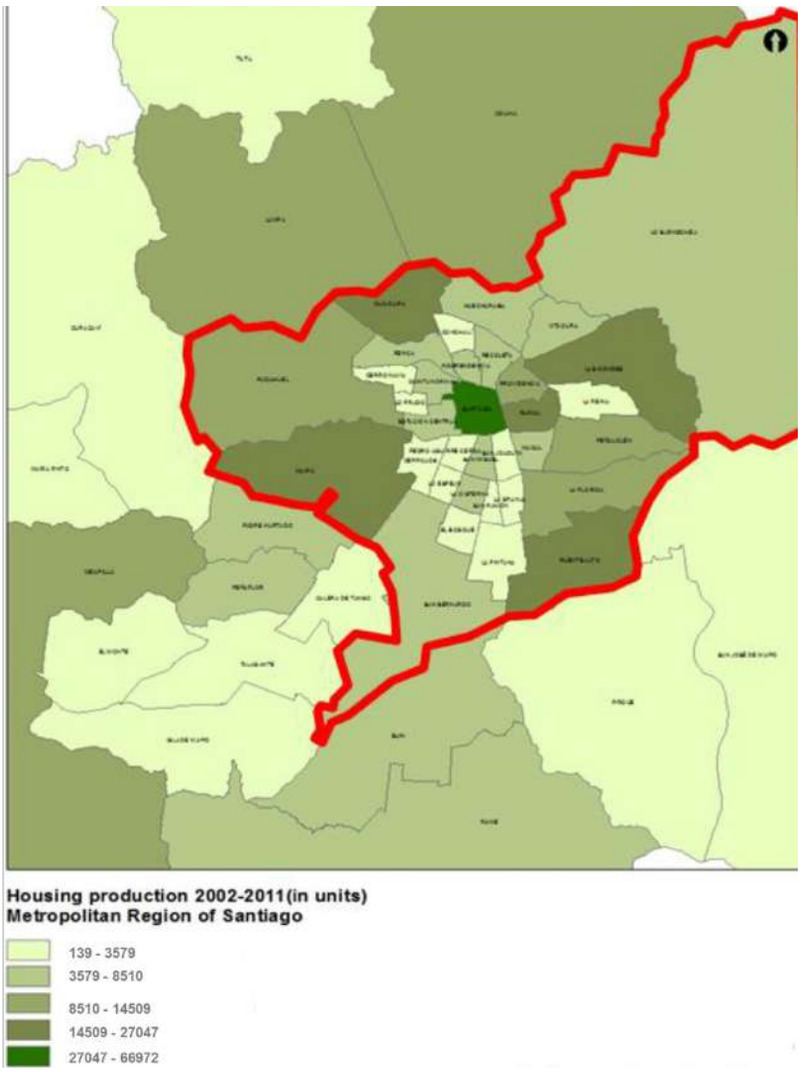


Figure 35: Housing in Santiago 2002-2011. *Source: Cáceres, 2014*

Housing development on peri-urban (OUTSKIRTS) communes of Santiago: a statistical analysis

According to the building permission for housing with the exception of apartments from 2002 to 2010, in the metropolitan region of Santiago, 30% of real estate activity was focused on peri-urban communes. The amount of distribution of housing (except apartments) permission among peri-urban and Gran Santiago is indicated in Figure 37 (Cáceres, 2014).

It is clearly evident that according to the number of building licenses issued, the high-income and low-income social groups are the main partners in the peri-urban communes in Santiago's real estate market.

The amount of distribution of building permission in peri-urban between 2002 and 2010 is depicted in Figure 38. The percentage of houses less than 50 m2 is around 35%, and the proportion of houses between 51 and 70 m2 is about 42%. Also, the number of houses 71-100 m2, 101-140 m2, and more than 140 m2 are 7%, 6%, and 10%, respectively.

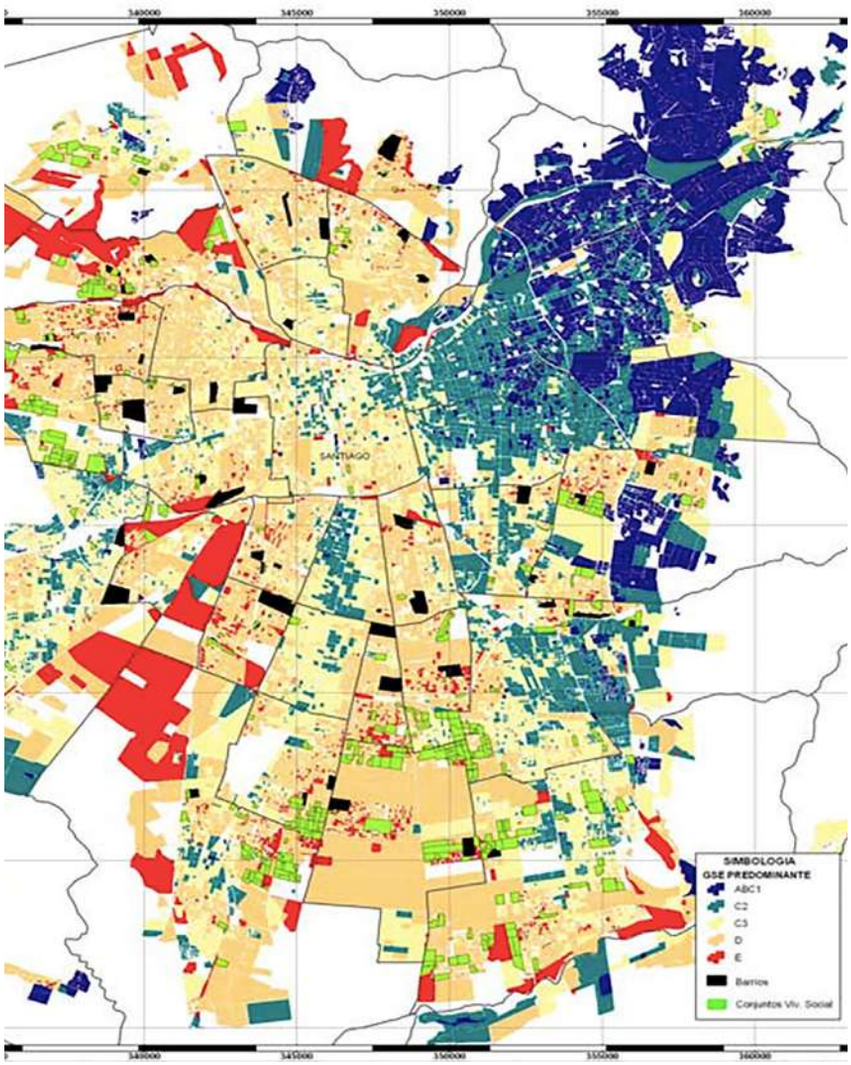


Figure 36: Socio-economic groups and location of neighbourhoods. *Source: FAU, U. de Chile.*

The urbanization process mostly was performed in nineteen and twenty decades and based on surveying the historical changes of peri-urban growth that is shown in Figure 39.

High rise buildings in Chile

According to the utilization of the high-rise buildings in Chile, these can be classified into two categories, residential and office buildings. The basic difference is based on spaces, for instance, occupant privacy spaces or large public open spaces.

Residential buildings:

The floor system is a flat concrete reinforced slab. The spans are around 5 to 8 m, and the thickness is 14 to 18 cm based on shear walls and upturned bars at the perimeter. The concrete walls are used for the vertical and lateral load systems.

Office buildings:

The floor system is flat post tension slab. The spans are 8 to 10 m, and the thickness is around 17 to 20 cm. The concrete walls and a concrete resisting frame at the perimeter are in order to

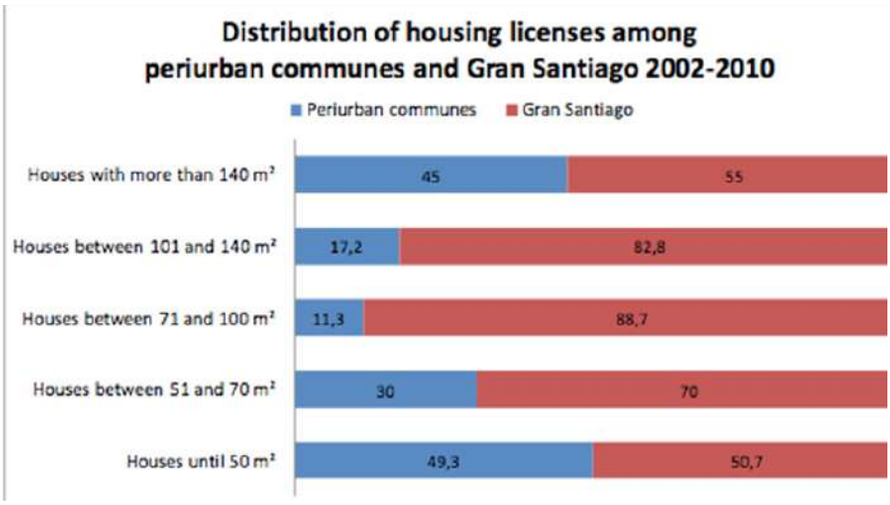


Figure 37: Distribution of housing licenses among peri-urban communes and Gran Santiago 2002-2010. *Source: Cáceres 2014*

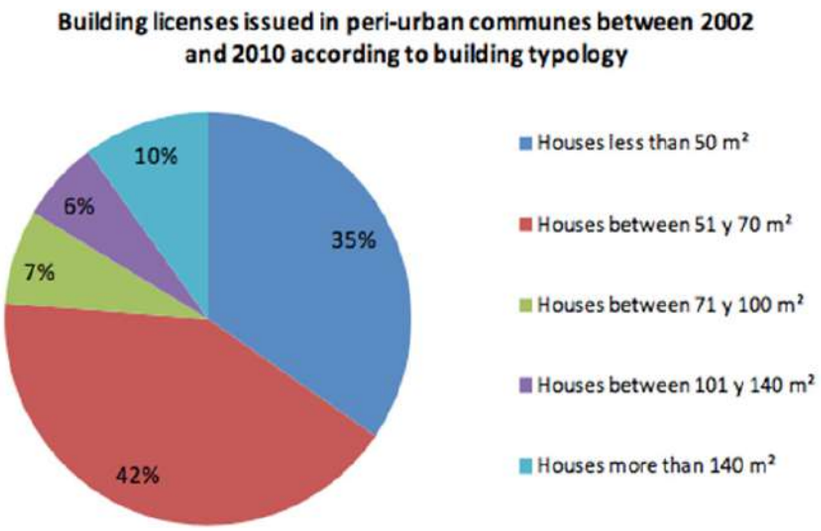


Figure 38: Distribution of building permission among peri-urban communes 2002-2010. *Source: Cáceres, 2014*

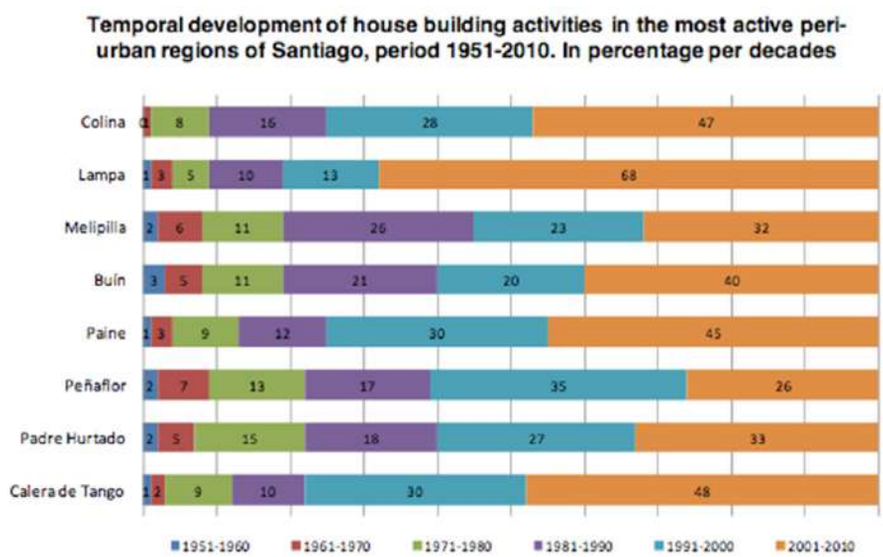


Figure 39: The development of house building activities in peri-urban region of Santiago between 1951 and 2010. *Source: Cáceres, 2014*

the vertical and lateral load systems.

Therefore, the basic difference is that residential buildings have taller wall length and thinner thickness than office buildings. Parking facilities in residential and office buildings are located below street level and it needs several underground levels of floor space and also it is 30% to 40% of the total construction area (Lagos & Kupfer, 2012).

Law and norms

The law and norms related to the housing have changed during the last hundred years in Chile. Nowadays the focus of the current National Policy of Urban Development of this country is to create Sustainable Cities and improve the Quality of Life of the inhabitants (Política Nacional de Desarrollo Urbano, 2014). This new policy considers important to rethink the density of the city and the structure of the urban planning because there are areas which do not have enough facilities or residential buildings to satisfice all the necessities of the population.

Apart from this policy, each municipality (34 in Santiago) has their own regulatory plans which define the existing requirements of each territory. Some municipalities allow building high-rise building and other prioritizing low density.

The criteria to define the density and the high of the buildings depends on the goal of the municipalities and the quantity of money that they have because these topics are related to available facilities that the territory has. For example: The Municipality of Vitacura (rich municipality) has the possibility to increase the density and the high-rise of the building because it has the m2 of green areas and educational, commercial, health facilities for more population, situation that is different in poor municipalities which have deficient services if they want to increase the quantity of the population. Currently, the municipalities prefer to increase the density and the high-rise of the building because they receive more funding from the private sector. The public sector in Chile is the responsible to build the residential buildings in Chile.

Comparison between sustainable buildings and non-eco-friendly buildings in Santiago

For describing the sustainable facilities after a brief research there are some examples in the Santiago which are eco-friendly in nature and dealing with the problems of housing deficit and articulation of the city. These buildings are sustainable in terms of designing, the technology used and protect orientation while taking consideration of climate conditions. The main focus is to highlight these facilities among the residents of the city and let the people aware that by simple cost adjustment, modification in design and having little knowledge of sustainable projects design and technologies we can construct a sustainable environment. Some of these Sustainable buildings in Santiago are listed below:

Exequiel González Cortés Housing complex

The construction of this project was carried out in the 1960s by the CORVI Housing Corporation. The project is well known as ‘Neighbourhood unit’ as the concept was to maintain the aggregation among the residents and the communal facilities. Designing was in such way that communal services such as buses, schools and hospitals all are just 5 minutes walking from the housing.

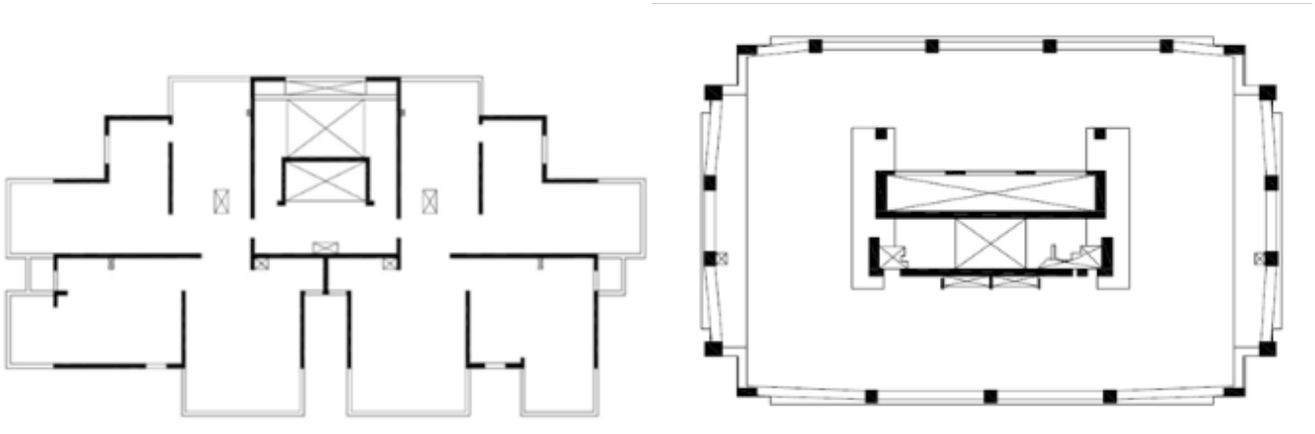


Figure 40: Typical residential building and typical office building. *Source: Lagos & Kupfer, 2012*

In 1947, the architects of Tau group had presented the advantages of Neighbourhood units by saying," with all the necessary services and amenities, separated from each other by green areas, but effectively linked to the civic centre by ways that do not pose a danger to anybody". And then, as a council, he told them: "Not many schools and few stadiums; not many stadiums and few homes; everything must be in close agreement with the real needs of the conglomerate " (Lara, 2016).

- The houses were designed according to minimum space criteria require for a person and the economy categories from low-income employee to medium class and decided to construct houses from 34 m2 to 84 m2 separated by the green area.
- The project was divided into blocks and restricting the access to all vehicles inside the streets to serve a safe walking access to the residents.
- There are three entrance gates for getting access to each block these are only 60 meters away from the entrance hence easy to control the movement of the people (Lara, 2016).

Amanda:

It is a 5-story residential building consisting total 79 flats. The project was designed while taking the consideration of excess temperature and bad pollution in the Santiago city.
It has various designing parts which make this project a sustainable one and we are describing these all here listed below:

- Super Insulation: This building has high-performance and superior thermal glass windows due to this superior thermal insulation system building have very minimum heat losses. It helps to keep the temperature high during winters and bring the temperature down in summers. For the same thermal comforts as compare to other projects, it requires 68% less energy consumption (URBES, 2016).

- Excellent environmental Quality: The superior air quality system renews the stale air into a fresh air all the time in the apartment. To improve the environmental quality of the apartment, air quality system helps to prevent condensation and odour by minimizing CO2 content in the interior. Clean air conditioning unit has converted the heat produced by residents into the cold and vice versa. Due to this recovered energy, residents are easily getting hot water and adequate room temperature all over the year.

- Easy access to roads and a wide range of services within no time due to excellent planning techniques while designing.

Figure 41: Exequiel González Cortés Housing complex. *Source: First Page Magazine,2016*

- Green area delivers a healthy environment to the residents of Amanda (URBES, 2016).

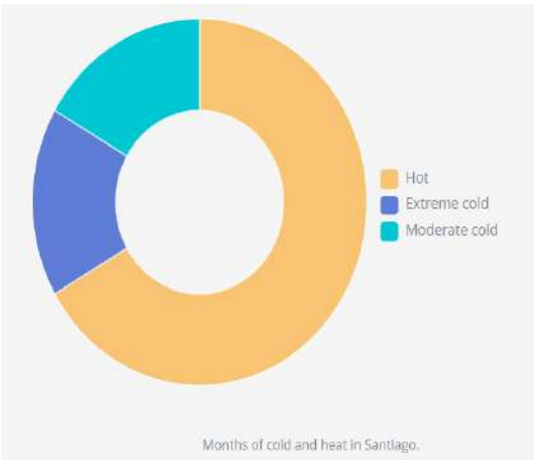
Non-Green Buildings

These are the buildings which are not eco-friendly in nature and are responsible for creating global warming, pollution and affecting project life cycle costing during the entire period of its service. Here is a description of such kind of non-eco-friendly building.

- Vertical ghettos: Building has 30 floors with 3000 apartments without any provision of public space. It seems local authority have fully neglected the rules and regulation while passing this building design as there were no space criteria for human space as well as for public space and liability and social concepts are totally missing in this project. The construction was carried out while putting the zonal aside because it has bad effect on surrounding (Emol, 2017).

There are some points which make this project unsustainable and these are listed below:

- There is no communal space provision.
- With the effect of the number of apartments, the landscaping or green area is negligible.
- Impropriate parking space.
- Santiago comes under high alert Earthquake Zone hence the height of the building in this zone puts the neighbourhood housing in danger as well.
- An acoustic view of the building is very bad.
- Limited Entrances and exits make this project worst.
- Very narrow pathway for the residents.
- Non-availability of natural sunlight and fresh air to most of the apartments makes it difficult to survive.
- High energy consumption for the fresh air ventilation and controlling heating system during the winter and summer time (Emol, 2017).



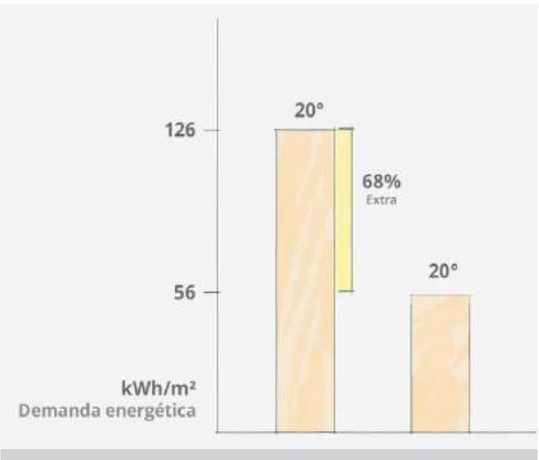


Figure 42: Months of cold and heat in Santiago. *Source: Urbes*

Figure 43: Energy demand. *Source: Urbes*

SWOT analysis of the current housing

SWOT Analysis is used to achieve an evaluation of the current situation of Santiago. This information will provide a better understanding of this city.

The Metropolitan area of Santiago accommodates approximately 35% of the population of the entire country (INE, 2012). It is the biggest city by population and provides up to 50% of Chile's total GDP (Trujillo, Parilla & Ramzillic, 2016). The city has expanded by 6.5 million people from 1970 to 2002 (University of Chile, 2010). The expansion was a process that proceeded through time and brought the construction of different varieties of buildings. These buildings provide a diversity of historical, cultural and architectural values.

The municipalities of Santiago are aligned towards high rise buildings. This is due to the funding provided by the private sector. The north-east part of Santiago is an example of high rise buildings, with high population and green areas density, which provide social and ecological value for their inhabitants. The parking system of the city is based on underground parking areas, limiting the above area necessary to provide this service (Ocampo, 2009). These standards are not achieved in the other Municipalities of Santiago. The lack of required green areas density and housing standards provided in these municipalities produce limited high-rise buildings which also do not meet the sustainable objectives.

The social and economic polarization of the city affects the urban landscape and the density distribution. The standard of housings such as dimension, localization, type of calefaction and quality of the design depends on the social and economic status of the inhabitants. The infrastructure is also, unevenly distributed in the different areas of the city. For example, the green area for a person is also affected varying from 9 square meters per person in the north-east area (rich sectors) to below less than 3 square meters per person in other areas (poor sectors).

The distribution of housing permissions in the peri-urban areas of the Great Santiago indicates

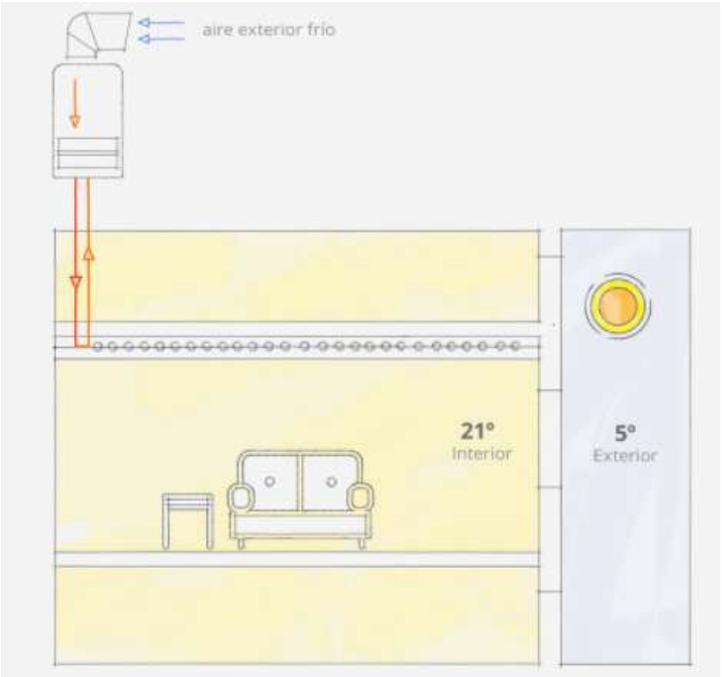


Figure 44: Energy performance. Source: URBES, 2016

the low density of middle-class residences in these areas. The lack of middle-class inhabitants contributes to accentuate the social differences in these areas (Caceres, 2014).

The inequality of distribution of the population based on social and economic status is a relevant issue of Santiago. The development of the dense areas populated by inhabitants with middle to low incomes in high-density areas, which provide better infrastructure, services and green areas for their population is a challenge faced to achieve sustainable goals for the city.

High standard buildings and infrastructure to the less wealthy areas of Great Santiago can only be provided through legislation and government initiatives. This would raise the wellbeing state of the city but is connected to political actions. The tendency of construction in the peri-urban area of Santiago is polarized between high and low surface residences, with a lack of medium size residences. This lowers expectations for a softening of the social and economic gap (Caceres, 2014).

Summary

In the last few years, sustainable issues have come to the forefront of the development of society in general and cities in particular. Based on population and economic strength, Santiago is the most important city in Chile. The study of Santiago based on the three pillars of sustainability provides the description of a segregated city.

The segregation affects Santiago, effectively dividing the inhabitants of the city based on social and economic status. The wealthy municipalities present communities with infrastructure, high-density areas, high housing standards and green areas within sustainable requirements. However, these parameters are not applied for the poorest municipalities.

The polarization of the city is a situation that remains and can be further observed by the number of building license issued in peri-urban areas. Statistics show, that apartments in these

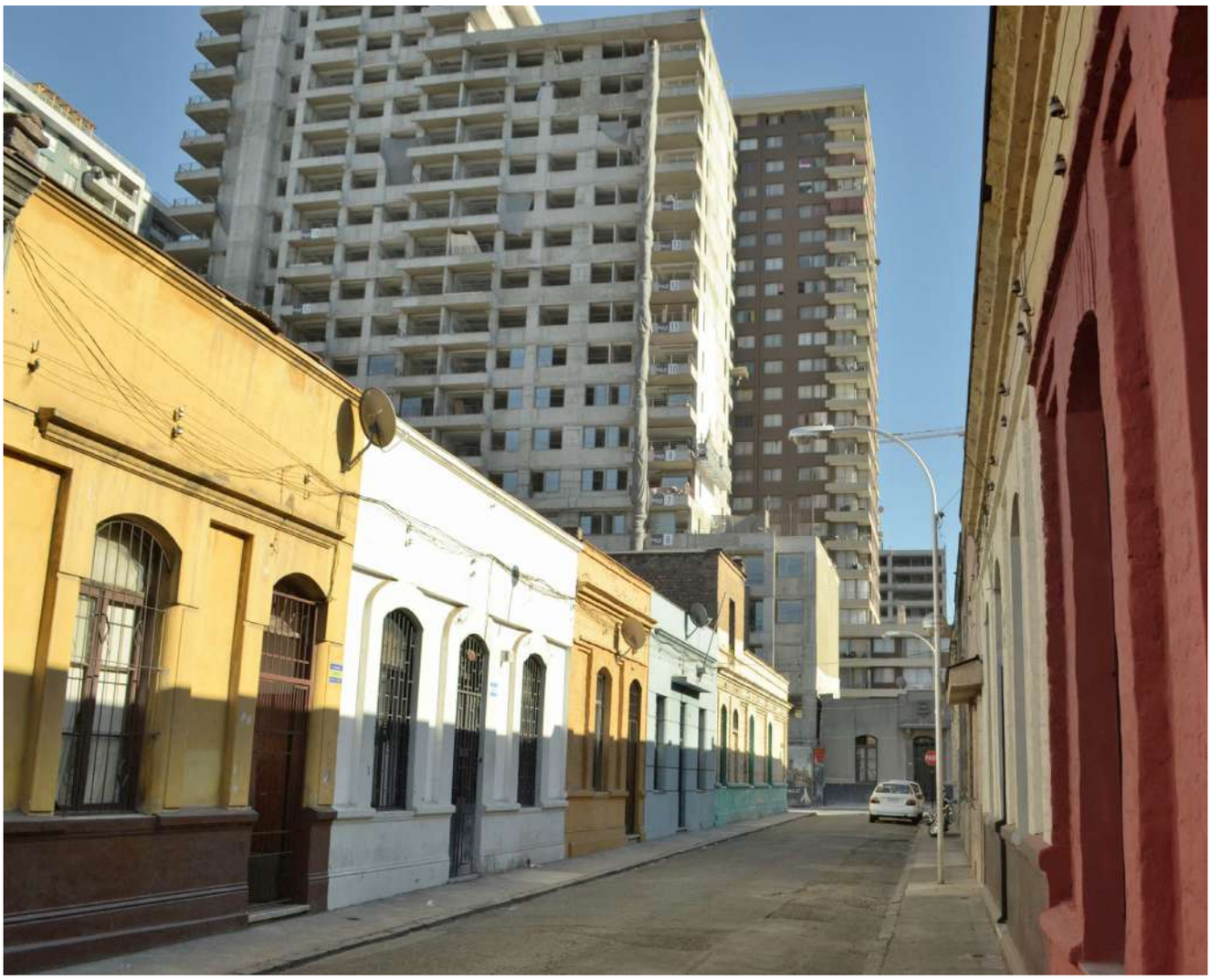


Figure 45: Non-Green Buildings in Santiago. *Source: World Bank Group - International Development, Poverty & Sustainability*

areas are constructed mostly for high-income citizens and low-income citizens.

Based on the existing issues, the government of Chile has provided guidelines defined by the National Policy of Urban Development (Politica Nacional de Desarrollo Urbano, 2014). The focus of these guidelines is shifting towards providing residential buildings to citizens with all the required necessities. The goal is to implement a strategy that will contribute to produce a cohesive housing situation for all the inhabitants of Santiago and to achieve the sustainable housing objectives.

Based on the existing situation of Santiago the Table 8 presents some examples of sustainable and not sustainable housing projects.

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
-Economic and development center for the country -Historical, cultural and architectural values of existing buildings -Existing areas with high rise buildings with social and ecological value. -Existing parking areas below the street level	-Social and economic polarization -Green areas distribution in different sectors -Standard of housing in different sectors. -Lack of infrastructure in different sectors -Low number of middle class population in peri-urban areas	-Build denser urban areas -Provide better infrastructure and services -Existing National Policy of Urban Development - Neighborhood unit concept	-Construction propensity peri-urban areas -Private sector construction tendency

Table 7: SWOT analysis. *Source: Own elaboration.*

	SUSTAINABLE EXAMPLE		NOT SUSTAINABLE EXAMPLE
Project Name	Exequiel González Cortés Housing complex	Amanda	Vertical Ghettos
Description	-Constructed in the1960s - Constructed by CORVI Housing Corporation. -Communal services in less than 5 minutes	-5 story residential building. -79 apartments	-30 story residential building -3000 apartments
Characteristics	-Houses from 34 m2 to 84 m2 separated by green areas -Safe walking access to residents. -Easy access to the entrance	-Super Insulation (requires 68% less thermal energy consumption) -Excellent Environmental Quality (reduced indoor CO2 emission). -Easy access to transport and services -Green areas	-Lack of communal space. -Landscaping and Green areas are neglected -Impropriate parking spacing -Impropriate Earthquake alert planning. -Limited acoustic isolation. -Limited entrance -Lack of natural sunlight and fresh air for most apartments -High energy consumption for ventilation and heating

Table 8: Sustainable and Not sustainable housing projects in Santiago. *Source: Own elaboration.*

Analysis: New guidelines to Santiago
Design (architecture and engineering)

New technologies

Below are significant and appropriate technologies for applying in a high rise building in Santiago that create sustainability.

A) On-site Tri-generation thermal system

Tri-generation technology produces clean power and energy for buildings. This technology works with natural gas. It is compatible in Santiago because of existing of natural gas resources. If the Tri-generation system is installed on site, it will supply thermal and electrical energy for residents; therefore, the electrical energy will not transfer from hundreds of kilometers away. Tri-generation technology is environmentally friendly because it reduces the greenhouse gases and increases air quality.

B) On-site water recycling plant

According to the weather and climate information of Santiago, the water recycling system is suitable to use, because of the considerable amount of humidity. The on-site water recycling plant is a significant environmentally sustainable technology. It provides the opportunity to use rainwater, groundwater, sewage water and irrigation water in a more effective way. In this way, it grants a solution for the lack of water resources in these days and also avoided a potential critical crisis in the future.

C) Solar panels

The weather and daylight statistics of Santiago justify the use of solar panels. These panels can be installed on the roof or on the facade of the building, to absorb renewable energy from the sunlight. Moreover, solar panels can generate electricity and also provide shade and shelter from the rain.

D) Rooftop Gardens

According to spreading the green area of Santiago, the rooftop garden is an appropriate solution to increases the green area. This technology reduces heat effect and water runoff. It also helps thermal insulation in the building and gives some social benefits for residents.

Energy Efficiency

In this part, for increasing energy efficiency different alternative methods can be used. These methods reduce non-renewable resources usage and provide more efficient and environmental solutions. The use of solar and gas energy is used to provide electricity and also improve the efficiency of HVAC system by using less energy. Using the waste heat through different systems to achieve heating and cooling efficiency. Moreover, using the appropriate sensors in different spaces to reduce the amount of energy by inhabitants.

Design Specification

Achieving sustainable goals is the international practice that has been followed by different states. The states have developed different sustainable guidelines for construction purposes. The implementation of guidelines such as LEED, BREEAM, iiSBE, Green Globes, and CASBEE have achieved ranged success in sustainable goals. These guidelines can be used as the main base to create the national specification for Chile.

Building life cycle consideration

The life cycle of the building must be considered to reduce the perception of the big initial investment of money necessary to implement new guidelines and the reduction of the energy during the complete life of the building. One of the main problems with life cycle cost of buildings is the emphasizes giving to the planning and construction process over the operation and maintenance process. The maintenance cost is at least three times more than initial cost (design and planning) (Source: https://www.wbdg.org/resources/life-cycle-cost-analysis-lcca).

Utilization of specific international standards for life cycle assessment like ISO 14040 and ISO 14044 offers an opportunity to establish life cycle cost as a requirement for construction projects.

Mixed-use building design

Implementing high rise mixed-use buildings as areas which provide not only residential spaces for the residents, but also commercial, cultural, and entertainment spaces. This enhances social interaction and provides the better social environment.

Urban policies

People education

Sustainability is a concept that is reaching a widespread the last few years. As a relatively new idea, it should be incorporated in the Educational system as a social concept. Students can understand it and later implement in society. Also, different educational programs within private companies and public institutions can provide lectures to develop the knowledge of the people.

New policies implementation

Social awareness is a key factor in understanding the benefits of achieving sustainable goals. The new guidelines can be realized, only if people have a complete understanding of the manner how the implementation of sustainable policies will improve their lives. The government should conceive extensive advertising campaigns to provide the population with an understanding of the impact of sustainability.

Private sector incentives

While the government produces policies related to construction requirements, the partnership with construction companies is essential to implementing them. Construction companies, as

private businesses are income oriented. A partnership can be reached if different incentives are given for achieving sustainable goals. These incentives can be in the form of beneficial loans, tax discounts or subsidies for implementing sustainable technologies.

Professionals knowledge

The development of new technologies provides tools to achieve sustainable goals. However, their usage is confined to the possibilities and abilities to implement them. The process of implementing and maintaining these new technologies over the life cycle of the buildings can be feasible, only if there are specialists, capable of implementing the new technological systems and are capable of maintaining them.

Society integration through the design of the cities

The main problem in Santiago that affects its capabilities of achieving sustainable goals is segregation. This problem can be challenged, through striving towards integration and social cooperation. High rise buildings can provide social apartments. This helps integrate people with different social and economic capabilities or background with each other. Also offering more common spaces in buildings for residents is needed.

DESIGN (ARCHITECTURE AND ENGINEERING)					
New technologies	On-site Tri-generation thermal system	On-site water recycling plant	Solar panels	Rooftop Gardens	
Energy efficiency	Non-renewable resources usage reduction	Solar and gas energy usage for electricity	HVAC system efficiency improvement	Waste heat utilisation for heating and cooling efficiency	Sensors use for reducing energy consumption
Design Specification	International sustainable goals	Sustainable guidelines for construction	International guidelines implementation such as LEED, BREEAM, iiSBE, Green Globes, and CASBEE	National specification guidelines for Chile	
Building life cycle consideration	Money reduction for initial investment	Energy reduction for building life cycle	Operation and maintenance planning	International standards for life cycle assessment	Life cycle cost as a requirement for construction projects
Mixed-use building design	High rise mixed-use buildings implementation	Social interaction and social environment			
URBAN POLICIES					
People education	Sustainability in the educational system	Educational programs in private and public sectors			
New policies implementation	Social awareness	Advertising campaigns for impact of sustainability			
Private sector incentives	Public and private partnership Projects results improvement	Incentives such as beneficial loans, tax discounts			
Society integration through the design of the cities	Social apartments in high rise buildings	People integration	Common spaces		

Table 9: New guidelines to Santiago. Source: Own elaboration.

Conclusion

During the last years, the AEC industry has included several sustainable guidelines in the building of housing. Nowadays, these new strategies have improved housing design and housings, their sustainability performance and the quality of life of the inhabitants. Considering to these improvements in the housings and the relevance of discussing and analysing the density, high-rise and low carbon solution for them the conclusions are structured as follows.

- First specific objective: “To define the key concepts of this research: density, high-rise buildings with green guidelines and low carbon solutions”. Nowadays, there are several innovations and new material which allow the construction of high-rise and dense buildings decreasing their cost. These new alternatives represent a real possibility to re-think about the design of buildings, specifically housing projects because there are more opportunities to plan and develop cities. Another important parameter is the current advance of green solutions for buildings which not only contribute to reducing the environmental impacts but also to improve the health of the inhabitants and limit of economic expenses during the life circle of the buildings. In summary to discuss and define the appropriate density, high-rise and low carbon solutions for the housing projects of a city is crucial to analyse the current performance of the buildings and the quality of life of the people from this city and the sources available to make changes.

- Second specific objective: “To describe successful and unsuccessful examples of dense, high-rise buildings with green, low carbon solutions for housing considering the features of the city of Santiago”. Considering the examples analysed, the possible guidelines to apply to Santiago are diverse. These contemplate technological innovations, vertical gardens, mix-uses, energy efficiency according to the local characteristics and bioclimate design. Nevertheless, all these projects show disadvantages such as difficult and expensive maintenance and investment, errors in the design and execution and ignorance of the inhabitants on how to use the new technologies. These weaknesses are important to overcome if the goal is to reply the guidelines of these buildings to other housings complex. For example, it is required to improve the knowledge of the professional and inhabitants in these areas to avoid mistakes during the design and maintenance, incentivize the private sector to invest in housing projects, strengthen the local norm and regulation and incorporate the sustainability guidelines and behaviours as part of the daily life.

- Third specific objective: “To describe the social, economic and environmental areas of the Santiago”. The city chosen has a strong economy and a variety of landscapes and natural resources and several sustainable construction laws and urban regulations, however, the distribution of wealth is unequal, a situation that is reflected in housing projects. For this reason, this city is considered a suitable case of study because the current situation of the guidelines to build and design housing can be improved through the analysis of the performance of other residential buildings.

- Fourth specific: “To explore new guidelines, from the case studies analysed, possible to apply in Santiago to improve the current situation of the housings”. The guidelines (architecture and engineering) examined contribute to understanding the existing variety of possibilities to design better housing complex and also the necessity to discuss the policies that support these guidelines. The political, social, an economic context of the city, in this case, Santiago, determines the guidelines possible to apply, since the current law allows (on not) to consider new technologies and architectural strategies; the perception and the education of the inhabitant

contribute to increasing the demand for environmentally friendly housing projects, and the resources of the city define the investment that it can make.

These four specific objectives contributed to achieve the general objective of this research: “To describe and analyse the situation of the housing in Santiago considering the density, high-rise buildings with green guidelines and low carbon solutions as analysis parameters”.
In summary, despite the benefits that represent the incorporation of new guidelines related to the increase in density and high-rise and low carbon solutions in housing projects of Santiago, it is important to consider that not all of these are applicable to this city. Each territory has its features (weather, culture, resources and norms), which determine the requirements that the projects need and the real possibilities to implement changes.

The future research topics are the methods to implement and evaluate the new guidelines proposed to Santiago because it is relevant to study the feasibility to modify the current situation of this city and the availability of resources to do it. Without these studies, these guidelines only contribute to generating an academic discussion but not to change and overcome the housing deficiencies of Santiago in a practical manner. Another topic to deepen is the effects that the new regulations of Santiago such as The Sustainable Construction Code, The National Sustainable Construction Strategy and The Energy Rating of Housing, can produce on the configuration of the city and housing.

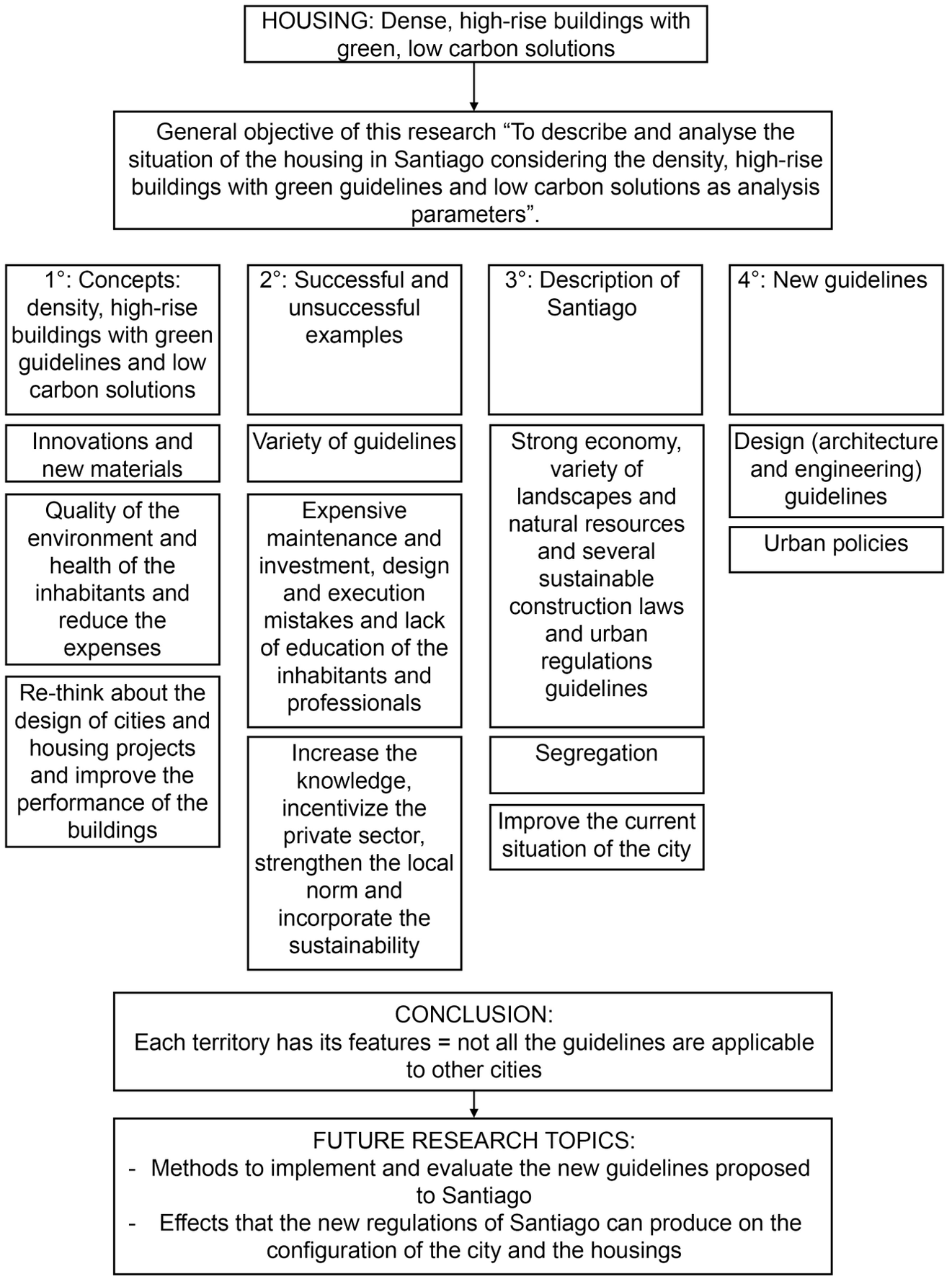


Figure 46: Conclusions. *Source: Own elaboration*

Chapter 2: Image Sources

Figure 2.1 : Flow of the Chapter
Source: Own elaboration
Figure 2.2 : High rise buildings in New York City Source: Ali and Armstrong, 2008.
(Ali, M. M., & Armstrong, P. J. (2008). Green Design of Residential High-Rise Building in Livable Cities. Green Rsidential High-rise Buildings, pp. 1-18.)
Figure 2.3 : One Central Park building in Sydney
https://arcspace.com/feature/one-central-park/
Figure 2.4 : The Solaire building in New York City
Source: GREENHECK, 2018. (https://www.google.at/search?q=The+Solaire+building+in+New+York+City+GREENHECK,+2018.&tbm=isch&source=iu&ictx=1&fir=PQN1ZKyYE9_2IM%253A%252C1pD3as348zUeNM%252C_&usg=__zl43aCABlBs0ewS3zla68Ol43VM%3D&sa=X&ved=0ahUKEwjksMqN4ozbAhXFA5oKHY2yD_QQ9QEIODAB#imgrc=PQN1ZKyYE9_2IM:)
Figure 2.5 : Average monthly temperature comparison between Sydney and Santiago
Source: http://www.holiday-weather.com/sydney/averages/
Figure 2.6 : Average monthly humidity comparison between Sydney and Santiago
Source: World Weather & Climate Information, 2018.
Figure 2.7 : One Central Park Building
Source: http://cardiganrow.com/architecture/sustainability-framework-one-central-park-sydney
Figure 2.8 : Thermal tri-generation plant
Source: https://www.centralparksydney.com/explore/a-sustainable-habitat
Figure 2.9 : Water Recycling System Diagram
Source: https://www.centralparksydney.com/explore/a-
Figure 2.10: Vertical gardens
Source: https://www.archdaily.com/551329/one-central-park-jean-nouvel-patrick-blanc
Figure 2.11: One Central Park
Source: https://www.archdaily.com
Figure 2.12: New York City and Santiago annual temperature average
Source: https://www.timeanddate.com/weather/dominican-republic/santiago-de-los-caballeros/climate
Figure 2.13: The Solaire building
Source: https://www.suez.com/en
Figure 2.14: The Solaire building green roof
Source: Epstein, 2008.(Epstein, K. (2008). NYC's Living Lesson. High Performing Buildings, pp. 56-65.)
Figure 2.15: The Solaire water system
Source: https://www.suez.com/en
Figure 2.16: Solar cells on the Solaire facade
Source: Epstein, 2008.(Epstein, K. (2008). NYC's Living Lesson. High Performing Buildings, pp. 56-65.)
Figure 2.17: London and Santiago temperature
Source: https://weather-and-climate.com
Figure 2.18: Grenfell Tower
Source: https://www.thesun.co.uk/news/3823836/grenfell-tower-was-over-insulated-with-flammable-cladding-that-went-over-and-above-regulations-to-avoid-a-repeat-job/:
Figure 2.19: Details of the Renovation effect on the Grenfell Tower
Source: https://architectsforsocialhousing.wordpress.com/
Figure 2.20: Fire accident in the Grenfell Tower
Source: http://www.telegraph.co.uk/content/dam/news/2017/07/08/TELEMMGLPICT000131886332_trans_NvBQzQNjv4BqC9PogZUtSpqAqO-tnweStQt3tN9Ddv3cHZNIEmYP14g.jpeg?imwidth=1400
Figure 2.21: Site Layout of Pruitt-Igoe
Source: Katharine Bristol.(http://farm4.static.flickr.com/3052/5810154674_d676f85826_o.gif)
Figure 2.22: Site layout of Pruitt-Igoe Housing
Source: http://farm4.static.flickr.com/3052/5810154674_d676f85826_o.gif
Figure 2.23: Municipalities of Santiago
Source: https://www.thinglink.com/scene/593601507614523393
Figure 2.24: Andes Mountain in Chile
Source: https://www.pinterest.com/pin/377809856221806150/
Figure 2.25: The gated city of PiedraRoja, north of Santiago de Chile
Source: Borsdorf&Stadel, 2013. (Borsdorf, A., & Hidalgo, R. (2013). Revitalization and futurization in the historical centre of Santiago de Chile. Journal Cities, 31, pp. 96-104.)
Figure 2.26: Rich neighbourhood and poor neighbourhood in Santiago
Source: http://www.viajeros.com/destinos/santiago-de-chile/3-que-hacer/barrio-paris-londres and https://invi.uchilefau.cl/por-que-en-mi-barrio-no-las-zonas-rojas-como-forma-de-retraccion-institucional-en-santiago-de-chile/
Figure 2.27: The building of the workers' building societies and the community infrastructure
Source: Larraín Bravo, 1911.(http://www.academia.edu/23501707/Emblematic_residential_projects_that_transformed_Santiago)
Figure 2.28: A simple continuous facade of housing and the central open space in a two-storey cité for middle-class families
Source: Parra Flores and Galleguillos, 1926.(http://www.academia.edu/23501707/Emblematic_residential_projects_that_transformed_Santiago)
Figure 2.29: Neo-cité San Francisco, Santiago.
Source: Iván Theoduloz, 2014.(https://www.pinterest.co.uk/pin/703756168464386/)
Figure 2.30: A common housing type such as Madrid housing development in Santiago.
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Figure 2.31: Villa Frei, Ñuñoa, Santiago
Source: LarrafnEcheverrfa, Jaime LarraínValdés and Diego Balmaceda, 1969.
Figure 2.32: Dwelling density at the census district level, 2011

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3. SUSTAINABLE TRANSPORTATION, Case Study: Berlin, Helsinki, New Delhi and Pune

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Abstract

If one comprehends a city as a human body, then transportation would be its arteries and veins. It makes mobilization possible. In the age of rapid globalization transportation does not only concern with a single city but transportation deals on a global scale today. The paper would focus on comparative analysis of four cities in terms of the different transportation methods and how new sustainable transportation concepts can be applied to make our future better. The critical issue of transportation would be studied globally. The discussion would include a vast range of possibilities of our future sustainable cities in transportation. The research would be done from environmental to technological aspects. Politics and policies would also be inspected. Cities flourish, develop and revolve around transportation. Our future sustainable cities would be no different. We need to approach transportation from all the three aspects of sustainability e.g. – social, ecological, and environmental. We have chosen our cities for case studies on a broad range in various scale ranging from scarce density in Helsinki to very high population in Delhi. The rapid growth in transportation has remarkably increased the carbon footprints of the cities. While planning for our future cities making transportation sustainable is of paramount importance. To understand the issue of transportation for our sustainable cities we should discuss the present state of transportation globally. We would also critically analyse the issues in these cities. Courtesy to the diversity of knowledge, origin and expertise of our co-authors we would discuss and analyses transportation in major cities such as Berlin, Delhi, Helsinki and Pune. .

Keywords: Berlin, Helsinki, Delhi, Pune, Transportation policies, Sustainable Transportation.

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Introduction

A majority of the world's population is living in urban areas today. We already have world urban population more than ever before. It is inevitable that transportation is going to grow more critical in our future sustainable cities. Looking at history we would find the major cities on the face of earth have developed around mobility routes. For instance, the operation and growth of ancient Rome was related to major arterial roads Cardo Maximus (North-South) and Decamanus Maximus (East-West). They have different functional aspects and provided connection in and around Rome. These ancient developed systems can explain the famous proverb "All road lead to Rome".

Urban transportation is the single most important component instrumental in shaping urban development and urban living. While urban areas may be viewed as engines of growth, urban transport is, figuratively and literally, the wheel of that engine. The test of urban governance depends upon the quality of life the city or town offers. Since transport is one of the prime determinants of quality of life, it is for the government to articulate the need for mobility and facilitate it through an appropriate mechanism. In fact, the efficiency of cities greatly depends on the development of transport systems; as urban transport is a catalyst for overall development. However, the cities in India suffer from the absence of a cogent urban transport policy. Urban transportation problems in India are manifest in the form of congestion, delay, accidents, energy wastage and pollution.

In Berlin, the population is nicely managed by the city authority, well organized, fast, integrated and precise in timing. It has a huge network, different modes of transportation, and numerous directions in transportation lines to manage the high scale demand of the city transportation. The transportation system is faster, walking distances are comfortable. It has well-organized ticketing system. Moreover, the transportation system is integrated which is essential for our future cities which are expected to grow based on mass-transit-development. In general, Berlin transportation is well accessible, different modes of stations are close in walking distance. There is almost no delay in commuter transport whatsoever. Even in a large-scale city like Berlin the transportation system has a dedicated cycling and pedestrian. The technologies are well developed and properly maintained. Though it is high class, the current transportation is developed from the old system.

Berlin

Berlin is one of the European cities with a well-developed public transport network. Its quality and efficiency are comparable to the quality of German life in general. Buses, trains and taxis will enjoy a smooth and convenient transport from Berlin. Comfortable, safe and affordable to Berlin's sights: use the extensive network of city and metro trains, as well as buses and trams. The Berlin map is divided into three sections ABC, where the transport network covers all parts of Berlin which have two types of trains S and U BAHN operates throughout the day from 4:30 am to 1:30 pm and continues holidays throughout the day without Stop. As well as buses and trams. It should be noted here that the waiting periods between the bus / train / tram and the following are extended and shortened according to peak times and other times. For example, a bus starts at peak times from one point every 5 minutes while off-peak hours depart every 10 or 20 minutes. The waiting period between the train / bus / tram and the following is usually up to 30 minutes for the train and 60 minutes for the bus after 10 pm for some lines and at 12 pm for other lines. This information is posted on bulletin boards at train stations and bus stops and must be considered.

Fare Zones

Berlin is divided into three areas A, B and C. Area A is based on a variety of aspects. They represent the area in the middle of the city. Area B represents the city and Area C boundaries representing the surrounding areas on the airport and the surrounding areas of Berlin. The main reason for this division is to know the ticket prices because the cost varies from one region to another.For example, trains run continuously in the city centre.

Figure 01: Travel Zone Berlin. *Source: Visit Berlin,2018*

Tariff zones and network maps

Berlin is divided into three tariff zones: AB, BC und ABC. Tariff zone AB includes the urban area to the city boundary. Zone ABC additionally includes Berlin's surrounding area and Potsdam Haupt Bahnhof(Main Railway Station)

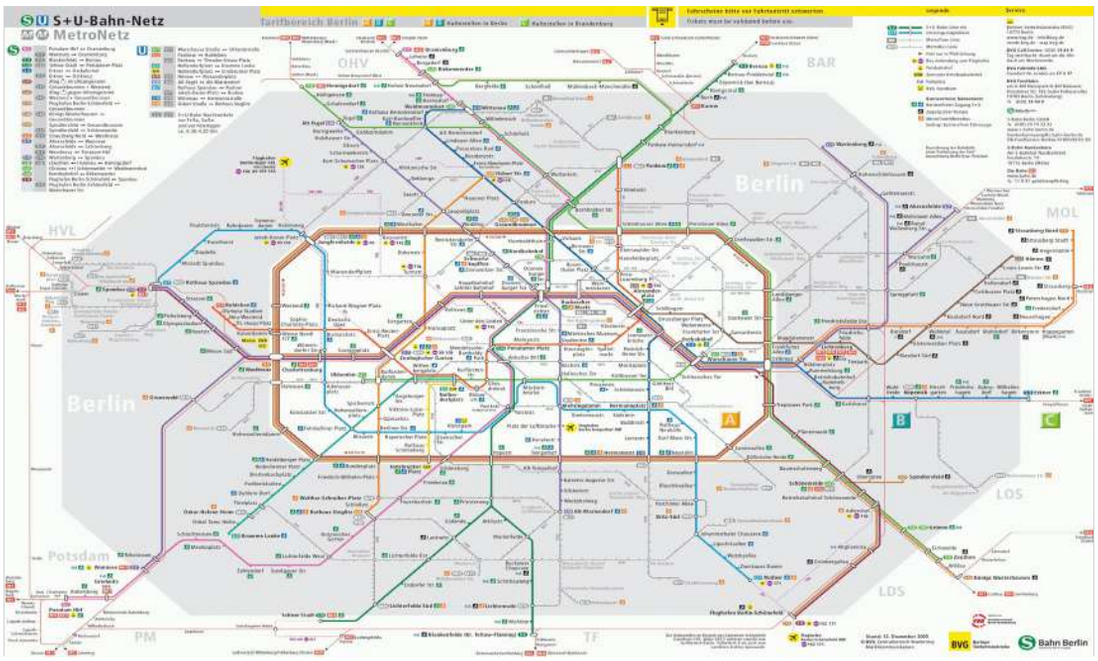

Figure 02: Transportation Map in Berlin. *Source: Visit Berlin 2018*

S-Bahn Ring / Ringbahn train

The so-called Ringbahn train runs around Berlin's city centre on a route of about 37 kilometres. It stops at 27 stations and needs approximately 60 minutes to circle around the city. Many stations of the Ringbahn have links to S-and U-Bahn lines running to the city centre or outskirts of Berlin. Important junctions of the Ringbahn are the stations Westkreuz, Gesundbrunnen, Ostkreuz and Südkreuz. The Ringbahn consists of the S-Bahn lines S41 and S42: S41 moves clockwise, the S42 counterclockwise. The trains run throughout the day, during the rush hour in five-minute intervals, in the evening in ten-minute intervals.

Tram and Metro

If you look carefully at the map of Berlin you will find that the trams trains are very much available in East Berlin. Consisting of 22 lines 9 of them operate 24 hours and the remainder at regular times.

Timetables for Tram

Tram and Metro lines run on different schedules. Furthermore, Metro tram lines operate during the night even on weekdays.

Metro Tram

The BVG Metro tram system has nine lines (1 to 17) which are supplemented by 13 tram lines (12 to 68). The lines of the Metro are marked with an "M". On daytime these lines run at least every ten minutes. At night (from 0.30 a.m.) they run in 30-minute intervals.

Buses and Bus Routes

In Berlin there is a very sophisticated system of buses in the city. It mainly covers roads that are not covered by other means of transport. It also acts as a link between train stations. In Berlin, buses do not operate from one area to another within the city. For buses, it is the slowest public transport but it is a sufficient way to take you to almost any area in Berlin. The double-decker busses stop in each lane, while the express buses stop at the main stations only. You can visit many of Berlin's tourist attractions through a few bus routes, something every tourist should do.

Night Buses

Well most buses in Berlin work throughout the day nonstop. The distinguishing feature of these buses is the letter N located at the front of the bus. These buses operate the metro at night where it connects the metro stations in the city during the stop.

Delhi

Delhi is an ancient city situated on the banks of river Yamuna, founding its first mention in mythologies of Mahabharata, as the capital city of Pandavas then known as Indraprastha dating 3000 BC. In anno domino years the city was ruled by various kings and dynasties such as Tomars, Chouhans, Slave dynasty(Qutbs), Khiljis, Tuglaqs, Sayeed's, Lodhis, Mughal, Marathas and British. Post-independence, Delhi serves as the capital of India. It has an area of 1483 sq km and has a radius of approximately 50 kms.

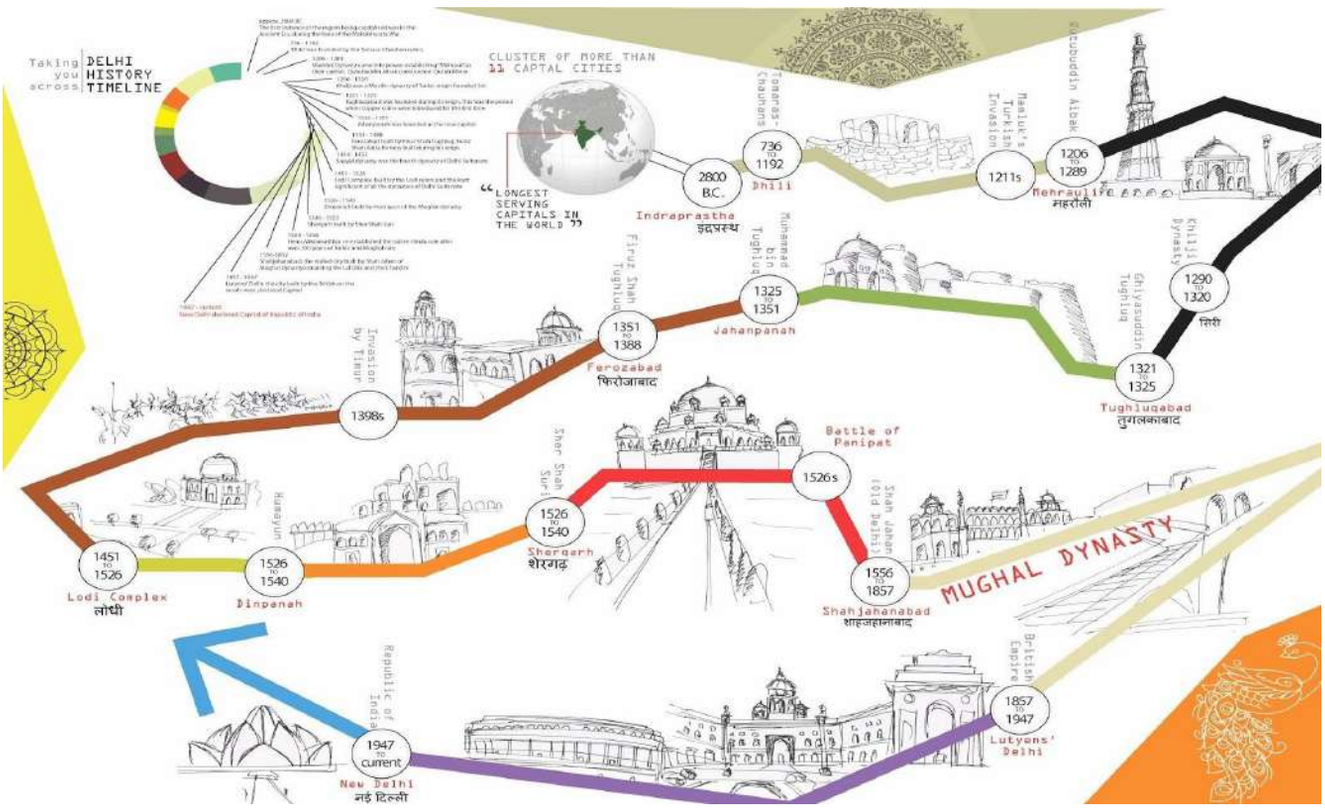

Figure 03: Delhi City. *Source: Anurag Arch 2013*

Delhi has one of the robust transport systems among Indian cities. Driving on the town plan of Architect Edward Lutyens, Delhi finds it has radial road networks. Being an ancient Mughal capital, it has a rich cultural heritage to bestow. In terms of transport system, there are several high points which the city feels proud of, but still it lacks on certain grounds which give scope for ample improvement in future.

Figure 04: Skyline of Delhi City. *Source: Anurag Arch 2013*

Background

Getting around the city has seen a significant transformation after the arrival of the Delhi Metro network. Delhi metro has been one of the major transport success stories not only in Delhi but entire India. The same concept is now being adopted in other metropolitan and two-tier cities (some in association and others in consultation with DMRC-Delhi Metro Rail Corporation). Besides Delhi metro,for decades DTC (Delhi Transport Corporation) bus transport system has served as the backbone of Delhi's transport system.

Now, primarily public buses thrive in the capital after abolition of private buses in early 21st Century. DTC is the world's cleanest public transport bus system running exclusively on CNG (Compressed natural gas). Broadly the intra city transport system can be classified into following categories:

1. Delhi Metro (DMRC)
2. Delhi EMU ring rail network (Indian Railways)
3. Buses (DTC) – Air Conditioned and Non-Air Conditioned
4. Auto-Rickshaws
5. Taxis
6. Cycle-Rickshaws and E-Rickshaws (battery operated)

Figure 05: Delhi Ring Railway. *Source: Delhi United 2018*

Delhi Metro service as well DTC buses are well connected to satellites town of Gurugram, Noida, Greater Noida, Ghaziabad, Faridabad and Bahadurgarh. This complete region comprises the term Delhi NCR (National Capital Region).

Acceptability of transport system

"If you have a car, you are treated like a king. If you come by bus or metro, then you are a second-grade citizen." Despite Delhi's evolving transport system, the financially effluent classes are reluctant to use public transport like in other parts of the world. Although Delhi metro only accounts for 2.76 million riders per day, but this basically consists of people earning less than 1200 Euro per month (98% of the total ridership). Travelling by personal car or taxis gives people last mile connectivity which is often found missing with a metro ride. Harsh extreme climate, pollution worries and safety concerns also play a role in people opting for car rides. But lately, government as well as private institutions have been working hard to spread awareness regarding need for acceptance of public mode of transport system. Car free week was largely advertised in recent year as part of this campaign.

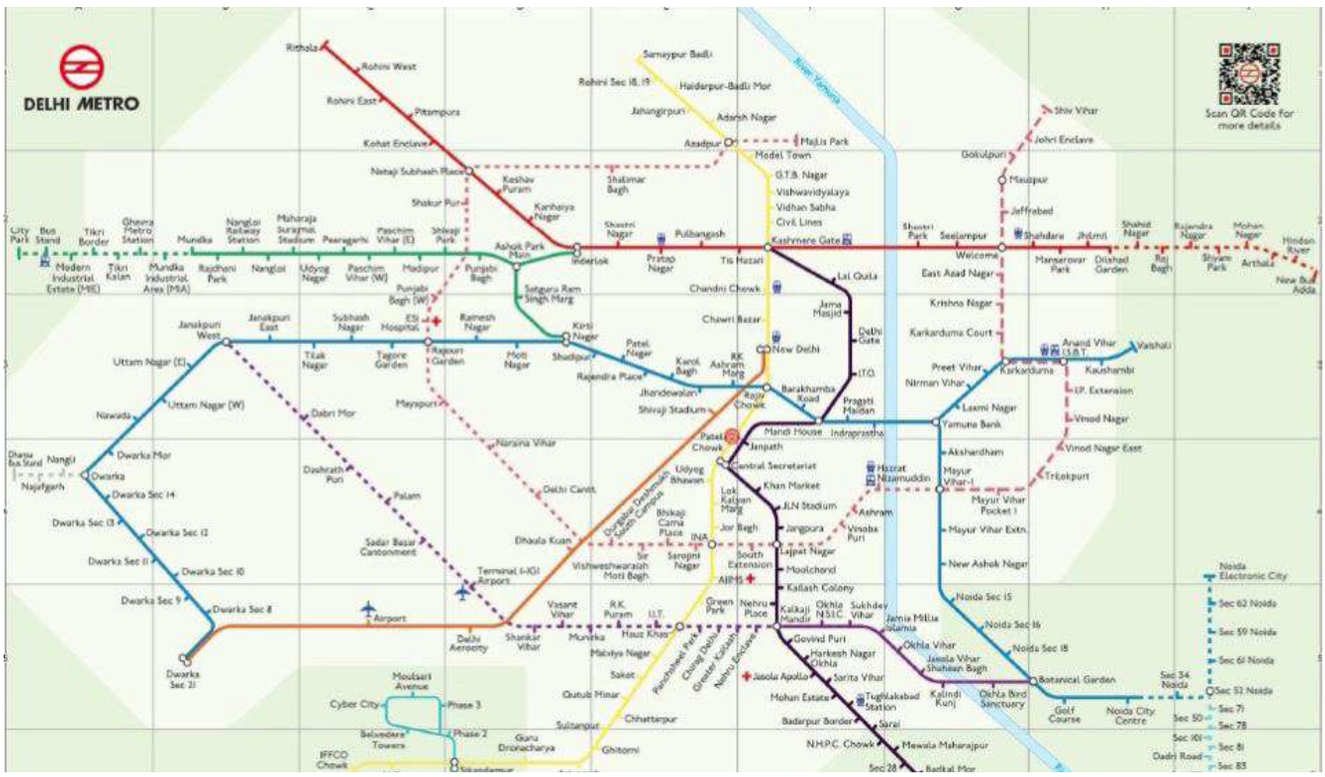

Figure 06: Delhi Ring Railway. *Source: Delhi Metro Rail 2011*

Real estate around stations

There are primarily two models of metro and real estate relationship. For instance, in Mumbai, metro stations were built first and extensive markets started to build up on both sides of the stations. The station became the focal point of any sub-region in the city. The influence is so large that for example areas got named as Malad (east) and Malad (west) owing to its direction on the either side of the rail station. And this phenomenon is seen in all stations of Mumbai city.

On the other hand, city of Delhi got Metro rail installed long after the establishment of core areas be it retail or residential in nature. The last 15 years of metro engagements has greatly influenced the real estate market of the nodal areas. There has been sharp increase in property prices in vicinity as well as notable distances of the metro stations. It has not been restricted to commercial or retail sector but also impacted the residential commodities. Due to better connectivity, the employments in all areas have thrived giving way to demand for housing. This has seen positive developments in residential sector.The FAR (floor area ratio) also have been increased in transit corridors.

This paved the way to new developments over the existing structures as well as vacant lands. Property prices in western area of Dwarka rose from Rs. 5000/Sqft in 2009 to Rs. 9000/Sqft in 2017. This kind of rise was seen in all areas of Delhi as well as its satellite towns.Ownership of land in Delhi is a mix of private and central government. But for the development of infrastructure and transport, the government acquires land using the “Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR)” which has recently replaced redundant “Land Acquisition Act of 1894.”In Delhi all auto rickshaws have been converted into CNG fuel operated mode. This has helped in reduction of PM10 emissions.

The recent addition is E-Rickshaws which serve as feeder for last mile transport from metro stations. They contribute to low emissions operating with 250W battery which runs for 50 kms on charging it for 4-5 hours. Invalid source specified. Despite various public transport options, majority of Delhi's population still prefers to travel on their personal vehicles such as car, taxi, auto-rickshaw and two wheelers. These roads are also instrumental in carrying freight on daily basis. The major roads to support this transit are as follows:

Figure 07: Delhi Major Highways. *Source: Google Maps 2018*

Intra City Transport

Owing to its national importance as capital of India and its central location, the city is well connected to the rest of India with efficient transport system of:

1. Rail
2. Road
3. Air (Domestic and International)

Figure 08: Delhi Major National Highways. *Source: Maps of India 2018*

Class system in railways

Indian still adopts the inherited class system in railways from the British's colonial mind-set. There have been several voices suggesting the unification of varied classes in the railways, but this will mean adopting a common rail fare that will be average of existing fare systems. This might not be necessarily acceptable to the masses especially the weaker sections. Depending on the financial capacity of the user, one chose the class of travel. In general, the class system in Indian railways (long distance) can be divided into following categories.

S. No.	Class	Reservation	AC/Non - AC	Type
01	General class	Non-reserved	Non-AC	Sitting
02	Sleeper class	Reserved	Non-AC	Sleeper
03	3 tier AC	Reserved	AC	Sleeper
04	2 tier AC	Reserved	AC	Sleeper
05	1 tier AC	Reserved	AC	Sleeper
06	Chair car 01	Reserved	Non-AC	Sitting
07	Chair car 02	Reserved	AC	Sitting

Table 1: Railway Class system in Delhi. *Source: Own Collaboration*

Inter-State Bus Depots:

1. Maharana Pratap ISBT in Kashmiri Gate (North Delhi)
2. Swami Vivekananda ISBT in Anand Vihar (East Delhi)
3. Vir Hakikat Rai ISBT in Sarai Kale Khan (South/East Delhi)
4. Dwarka ISBT (West Delhi)

Airports:

1. Indira Gandhi Airport T1 (Domestic operation)
2. Indira Gandhi Airport T2 (Domestic, Taj and freight operation)

3. Indira Gandhi International Airport T3 (Domestic and International operation)
4. Terminal 4, 5, 6 (To be built in phases by 2024)
5. Taj International Aviation Hub, Jewar (Under Conception) Invalid source specified.
6. Safdarjung Airport (Private and Government use)
7. Palam Airport (Used by Indian Air Force)
8. Rohini Helipad (Private and small commercial usage)

Issues in Transportation

Delhi's transport system has evolved over the years trying to meet up with its ever-increasing demographic structure.There is constant pressure on existing metropolitan cities like Delhi. Influx of population from other states leads to challenges the transport system. Although there have been fewer success stories like Delhi Metro, but still a lot needs to be done in Delhi Metro and especially so in other sectors of transportation.The roads of Delhi are primarily good only for use of cars. It has almost no consideration for pedestrians, bicycle users and even motor bike users. In most places there are no separate lanes for each and non-car users struggle to find their voices heard. Pedestrians are not respected by the car users and in most cases are threatened by the vehicles on the road. There is constant threat to life of the pedestrians. Bicycles and motor cycles also run in highly vulnerable circumstances and often meet fatal accidents.

A majority of the traffic lights have no signals for crossing the roads. Rather pedestrian bridge or underpass is built across the busy road. That means the on footer is expected to spend more energy by him to cross the road to make sure that traffic runs smoothly. Failure of BRT: Delhi bus rapid transport system(BRT) inaugurated in 2008 ahead of 2010 commonwealth games failed to live up to its expectation. It was scrapped and dismantled in 2016 by the state government. The BRT failed due to poor implementation, people violated the lane system by entering into bus lanes thereby defeating the purpose of the system. Moreover, there were other challenges such as accessing the bus stops and long waiting time in traffic signals (as long as 180 seconds).

The flyovers built in last three decades have started to weaken and major faults are being observed in a few of the flyovers due to soil settlement and temperature variations. 8-inch gap was observed in Lajpat Nagar flyover on the ring road which was later retrofitted. Pressure on Airport infrastructure with increasing ridership: With cheap flight tickets and rising middle classes, air ridership has seen a sharp increase. But the airport infrastructure has not been able to cope up with the same pace. Major airports and the state government are facing this challenge to upgrade the infrastructure as per recent demands of the consumers.

Transport all over India and especially in Delhi finds the challenge to provide adequate safety for women. Although the Delhi metro the condition has seen an uplift but still teasing and groping are major challenges in buses and pedestrian areas. Delhi government promised to install cameras in all DTC buses and provide marshals but the concept is still in pipeline even after 3 years.CNG vehicles (public and private) and Delhi metro helped in curbing city's pollution to a certain extent but due to ever increasing number of private vehicles.

Transportation issue are:

1. Last mile connectivity
2. Trucks bypassing the city
3. Traffic Jams

4. Old vehicles and Road accidents
5. Parking Vows

Recommendations:

1. Promoting regional economic zones
2. Promotion of use of public transport
3. Providing varied options of public transports
4. Making existing system more efficient
5. Optimal ticket pricing or free public transport
6. Transport networking and coordination and Car pooling
7. Banning old vehicles and Diesel vehicles
8. Stringent norms for emission and vehicle maintenance standards
9. Demand side and supply side management
10. Sustainable approach
11. Public awareness
12. Efficient transport and government institutions.

Helsinki

Helsinki is a compact well-planned city on the gulf of Finland and it grows due to internal and external immigration which cause its metropolitan area to extend rapidly; currently it covers 14 municipalities, spreads in a total area of 3700 km2 with 1.8 million inhabitants (Touru, 2016) and this cause, the main problem in transportation system, which is the low density of people.

Figure 09: Helsinki Metropolitian Area. *Source: HSL 2016*

The Helsinki Region Transport Authority (HSL) was founded in 2010 and it takes responsibility of managing the transportation system and developing transport plans (short and long term). HSL service covers cities of: Helsinki, Espoo, and Vantaa, Kerava and Kauniainen and the municipalities Kirkkonummi, Sipoo, Tuusula and Siuntio. (HSL, 2016)

Management and planning

Integrity and good public transport connections are the main goals of HSL policy, so the various transport means operates to insure a seamless journey. HSL transport management system based on hiring contractors to operate the various public transport means as per the schedule below:

Commuter trains	VR
Tram	HKL
Buses	• Nobina • Pohjolan Liikenne • Helsingin Bussiliikenne • Transdev • Savonlinja • Tammelundin Liikenne • Åbergin Linja • Korsisaari
Ferries	HSL
Metro	HKL

Table 2: Transportation operators. *Source: HEL 2016*

Ticketing

There are three types of tickets: single ticket, day ticket and travel card, you can issue or recharge your ticket via ticket machine, sms, mobile ticket or direct payment. No gates in ferry, metro or commuter train stations; that means the rider does not need to show ticket unless it is required by a conductor, if the rider has no ticket, rider will be fined. In buses the rider needs to show up the ticket to the driver.

Trip planning

HSL provides a comprehensive IT solution that works on electronic devices to facilitate the journey. The trip planner tool enables users to determine nearest point to reach public transport and guide him/her to the bus,tram or metro until the rider reaches destination.

Metro

Helsinki Metro consists of 25 stations (six stations lie in Espoo), six of these stations runs below ground, while others are at street level. All the stations aligned in two lines: M1 (Vuosaari – Matinkylä) and M2 (Mellunmäki – Tapiola). Tracks - of total length equal to 35 km (City of Helsinki, 2015)- run in two directions - east to west and vice versa.

Figure 10: Helsinki Metro Stations. *Source: HSL 2016*

Construction of the metro started in 1969 and the first official service operation was in August 2, 1982 and metro trains ran from Itäkeskus to Hakaniemi. From that time until now the line extended to the east and west. The last extension was to the west towards Espoo and opened to the public in November,2017, the final route as shown the figure below.

Figure 11: Helsinki Metro Route Map. *Source: YLE 2018*

The figure shows the metro station in Helsinki before the last extension in the orange colour and last extension in green colour and the future in stations in light green colour. Importance of metro line comes as it is the main public transportation mean that crosses Helsinki from east to west and vice versa. The fact that metro is the fastest means to transport inside Helsinki (City of Helsinki, 2017); metro has many other features that attracted more than 127 million passengers in 2015 (City of Helsinki, 2016). The most important feature is the connectivity of metro station to other transportation means, for instant there is bus station or at least bus stop at each metro station which enable passengers to continue their trips smoothly.

Also, there is a metro station in the Central Railway Station which gives passengers the chance to travel to northern parts of the city or to the nearby cities. Other features are that metro allows bicycles and pets in its trains and it offers continuous free Wi-Fi internet in the stations and in the trains. Metro starts first journey at 05:00 am and last one at 23:20 pm with headways varies from 2.5 min. to 10 min. depends on time and location.

Trams

First proposal to construct tram in Helsinki was in 1888 but due to electrification issues public transport launched using horse-drawn omnibus in 1890 with two lines (Museum, ND), thirteen years later in 1901 the Helsinki electrified tram started its operations with single track in four lines, and in 1908 conversion to double-track started and continued until 1910. Tram network started to expand in 1913 until it reached the apex in 1930s as 168 motorised trams and 147 trailers were in traffic. By 1939, there were already 61 million tram trips annually.” (Museum, ND). During the period 1940s to 1950s tram service suffered from the negative effects of the WWII and then in 1960s request for tram service decrease due to the increase of cars ownership and because of bus and commuter new lines.

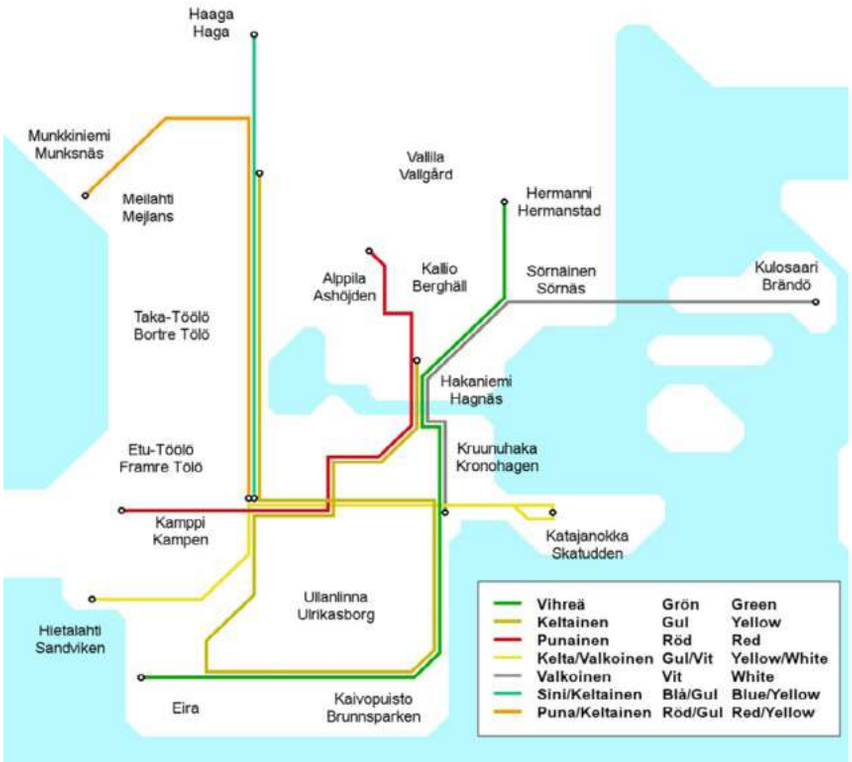

Figure 12: Helsinki Tram Network in 1920-1922. *Source: Map of Helsinki 2008*

From 1970s until now, tram networks expanded several times until it becomes as it appears in figure 13; eleven lines with total length of 100 km (Sandi, 2017) operating from 5:30–23:20 and daily used by 200.000 passengers in week days (City of Helsinki, 2017) and nearly 57 million passengers per year (City of Helsinki, 2018).

Figure 13: Tram Route Map, Helsinki. *Source: HSL 2018*

The Tram network has 293 tram stops, 226 of them with roof (City of Helsinki, 2017), most of stops has electronic timetable showing the estimated arrival time of next trip. Trams do not automatically stop at each stop, so tram rider needs to press a button to express his desire to get off, so far awaiting people at the stops also need to waive for the tram to stop by them.

Buses

Helsinki has about 120 bus routes in addition to multiple routes linking the city with surrounding cities in the metropolitan area. (City of Helsinki, 2017). These routes serve as feeder to metro and train stations inside the city and its suburbs and metropolitan area.

With 3000 pairs of bus and tram stops inside the city, 2000 bus stops in Espoo and Vantaa and total of 9000 stops in the metropolitan area (HSL, 2015); buses form a reliable and solid form of transport infrastructure that minimize the walk distance and integrate other means – metro and commuter- to insure smooth, easy and seamless journey.

Frequency of buses is about every 10-15 minutes, and in peak hours are less frequent at the busiest lines (Shanon, 2015). Buses do not automatically stop at each stop, so bus rider needs to press a button to express his desire to get off and so far, awaiting people at the stops also need to waive for the bus to stop by them.

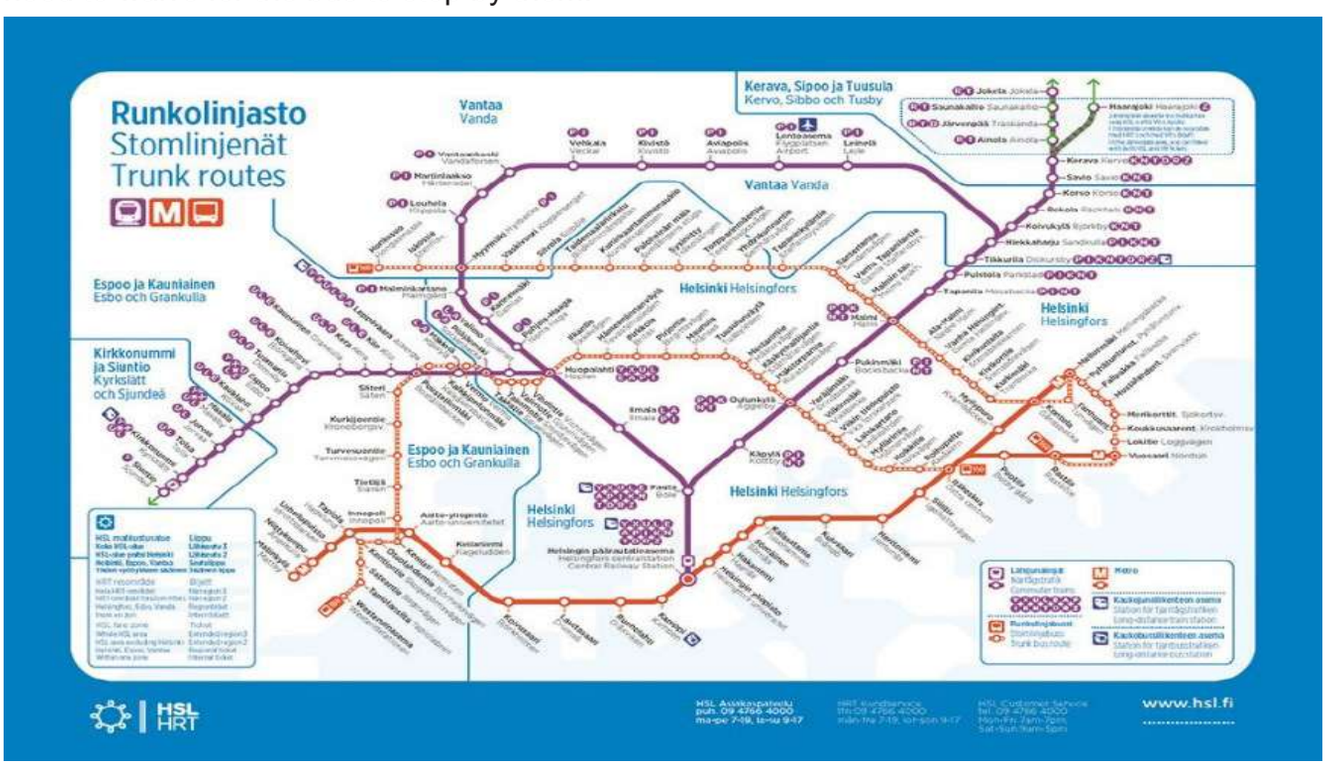

Figure 14: Helsinki Trunk Routes. *Source: HSL 2018*

Ferris

Two Ferries - Suomenlinna I and Suomenlinna II- link Helsinki to Suomenlinna Island, departure point located in the heart of Helsinki at Kauppatori (Market square) and arrival point is main pier of Iso Mustasaari Island. Ferry runs its trip between the only two stops year-round 1-4 times per hour even when the sea is frozen! (Suomenlinna, ND)

Commuter trains

Commuter rails network composed of 14 lines connecting Helsinki city with its suburbs and surrounding cities in the metropolitan area, four of these lines continue to connect metropolitan

area with some other cities to the north and west of Finland.
“The HSL area commuter trains operate on the main road between Helsinki and Kerava, on the beachfront between Helsinki and Kirkkonummi and on the Ring Road between Helsinki and the airport.” (Junakalusto, 2016)

Figure 15: Commuter Train Service. *Source: HSL 2018*

All these lines are terminated at the central railway station and Pasila at the heart of Helsinki. These lines pass through 70 stations in the greater metropolitan area, 14 of them are distributed in Helsinki and rest of the stations cover the surrounding cities -especially Vantaa and Espoo- and integrate with other public transportation means to form a solid coherent network. To insure flexible and smooth traffic journeys, six sub main stations distributed through the HSL metropolitan area allow commuter riders to change between lines. Total length of commuter lines is 99.2 km and average speed of trains is 54 km/h and the weekday’s traffic is about 194.500 trips (junakalusto, 2016). Pets are allowed in train for free and bikes also allowed outside of peak hours (Shanon, 2015).

Cycling
Most of Helsinki streets have a bike lane, and there are several bike stations attached to metro stations and many other places, bikes also allowed in metro and commuter trains. HSL has its city bikes, which are available for common share during summer period and can be borrowed

by residents or visitors via special ticketing system. These bikes are in 225 bike stations, 150 stations in Helsinki and 105 in Espoo. (City of Helsinki, ND). HSL policy aims to increase the use of bikes and make it as a lifestyle especially for those who care about their health and travel time (City of Helsinki, 2017), also to benefit from the sustainability of bikes rides where neither carbon emissions nor noise.

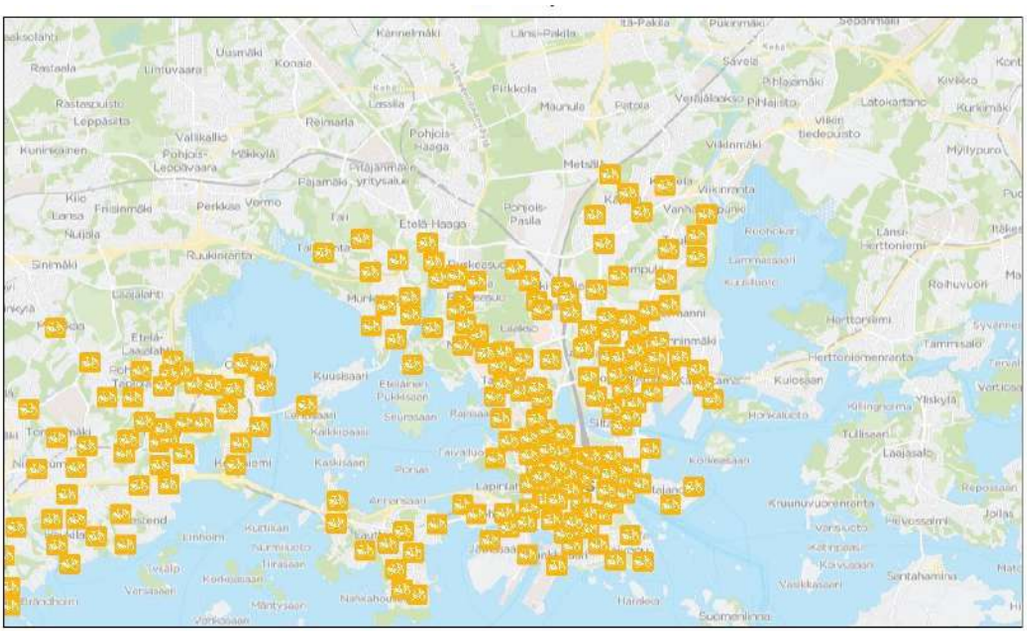

Figure 16: City Bike Stations. *Source: HSL 2018*

Walking

Helsinki policy aims to minimize the walking distance needed to reach public transport means and walkers have the priority not only in the road crossing but also in city planning. Pedestrian footpaths are paved well and illustrated by traffic sings and lines in addition to zebra crossing. There are many separate elevated pedestrian crossings in addition to footpaths attached to car and truck bridges, Elevated pedestrian crossings are constructed from reinforced concrete, steel or wood. Pedestrian paths in heart of Helsinki are usually underground or at ground level and they link shopping malls with each other and connect these malls with the main real way station and nearby metro stations.

Private cars and taxis

Streets and highways in Helsinki are well-planned and provided with traffic lights in most of the intersections, street markings and traffic safety lines in addition to speed limiting tools – speed limit in inner city is 30 to 40 kmph- (City of Helsinki, 2017) to guarantee a safe drive. Bridges and tunnels provide drivers a good and smooth trip and as a result there are less terrific jams even in rush hours. Taxi car service is provided by three private companies under supervision of HSL, in addition to Uber service. Taxis can be hailed from streets or ordered by phone calls, mobile apps or from Taxi stands which are in different points in the centre of the city (my Helsinki, ND).

Airports

Helsinki airport HEL: located in Vantaa and connected to the city via commuter train ring road, trunk bus lines and airport taxis.The Helsinki Malmi airport HEM: located at Malmi district, it used to be the main airport of Helsinki but it will be closed in 2019 (Malmi airport, ND).

Pune

The city of Pune is the second most growing metropolis in the state of Maharashtra after Mumbai. The urban sprawl of the core city is situated on the Deccan plateau on the banks of river Mula and Mutha. It has an area of almost 243.84 square kilometres. This city has been the land of administration since its establishment in 18th century by the great Maratha warrior “Chhatrapati Shivaji Maharaj”. The land has been the political centre and was ruled back then by the “Peshwas”. So, the city has a strong influence of planning and administration over the last four centuries. However, with the increasing footprint is not able to cater the norms. Mumbai is the economic and financial capital of India situated 150 Km apart, this makes the city of Pune more commutable and accessible. The city is a major contributor to economy, which is western part of the state. It is one of the most populated cities of India, with over 8 million residents. The rapid modernization, setting up of international IT companies, migration of skilled labour from other states, world-class educational institutions and a good standard of living are among few factors, which make Pune a preferred city to live in. The city is transcending from last decade to achieve this kind of world-class amenities and status.

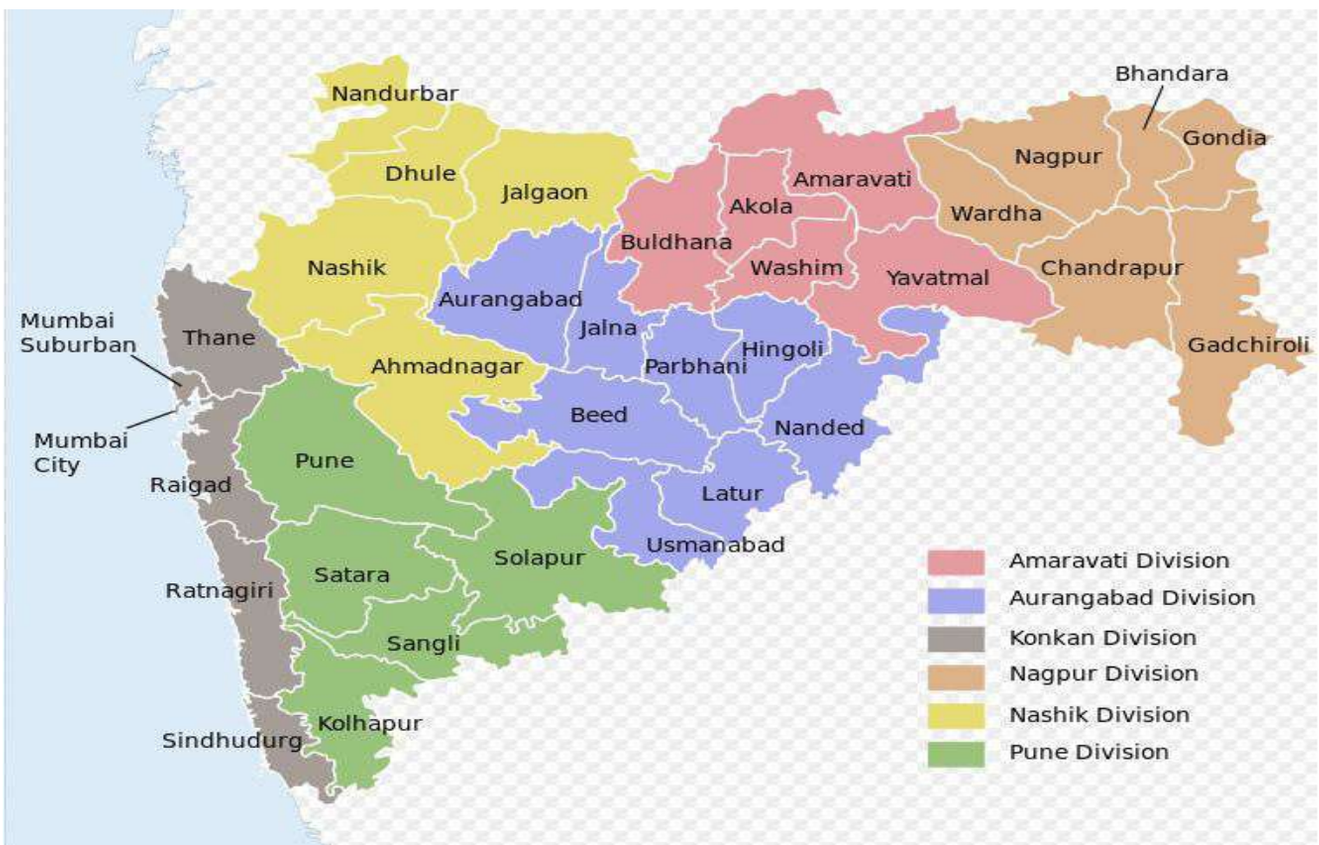

Figure 17: Map of Maharashtra Regions. *Source: Maharashtra Map 2018, User:PlaneMad derivative work: Kaajawa*

There is a proportionate growth of sectors in infrastructure, business and transportation. Hence, there is an increasing demand for public transport for the mobility of people, which is termed as inter-city and intra-city connection. However, the research areas for this chapter are only focused on intercity transport and would be focusing more on latest updates and changes in transportation policy in the city of Pune. The research focus in only restricted to three major public transportation sectors and one sector of pedestrian pathways and cycle tracks.

1. “PMPML”– Pune Mahanagar Parivahan Mahamandal Ltd. (BRT System)
2. “Maha Metro” – Pune Metro Rail.
3. “Streets of Aundh, Pune” – An Initiative to promote cycle and pathways.
4. “Feasibility study of HyperloopOne” – Case Pune and Mumbai in 20 minutes”

Figure 18: PMPML Bus Depot. *Source: Indian Express 2011*

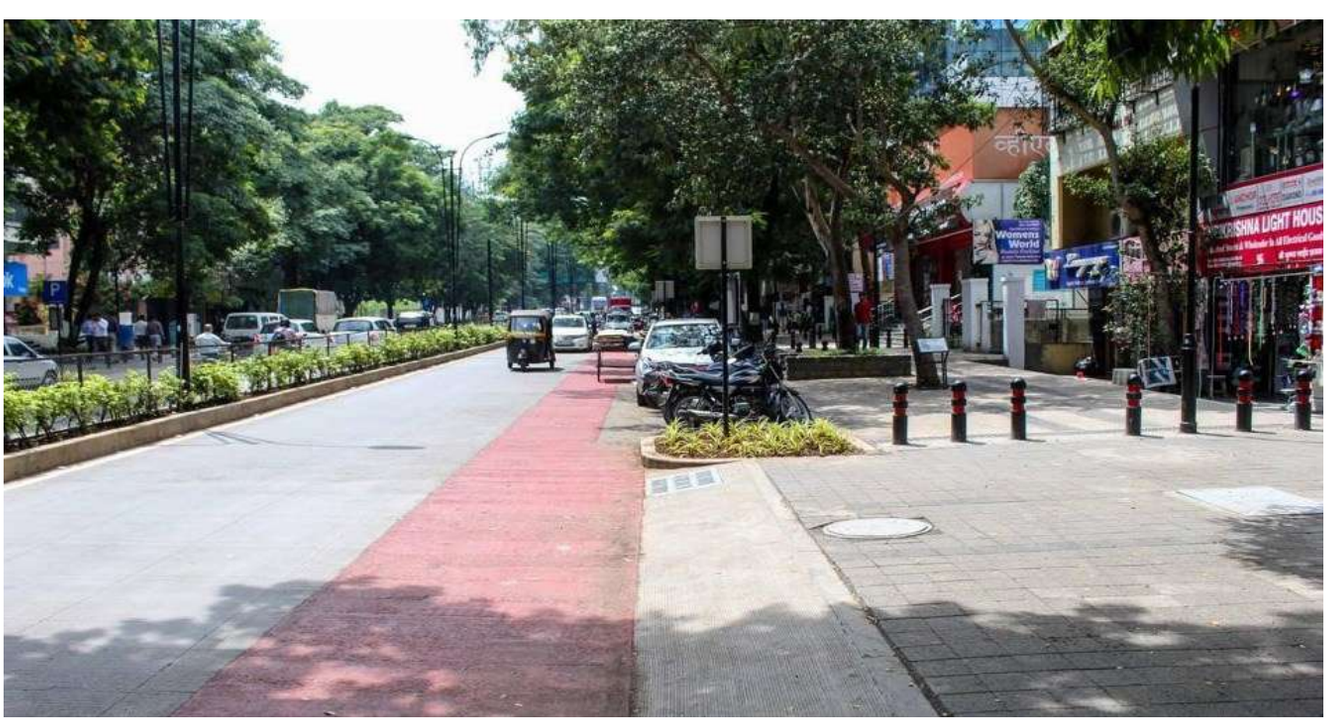

Figure 19: Streets of Aundh Pune. *Source: Hindustan Times 2017*

We are already in the age of revolution of transportation industry. One such example is HyperloopOne. Although the concept has reached in testing of wind tunnels the start-up which was founded by visionary “Mr. Elon Musk” has taken a sudden take off in last two years. The company has gone from 3 people to 100 people working on the design and feasibility study. The company has made so far eight MOU (Memorandum of understanding with the specific country’s Governments) for understanding the feasibility of the project. One of the routes on which it focuses is Pune – Mumbai in 20 minutes. This is a revolutionary idea in the field of transportation and if implemented for these two cities then it changes the concept of commute time for every transport. The feasibility study is being carried out by Indian railway ministry and the company.

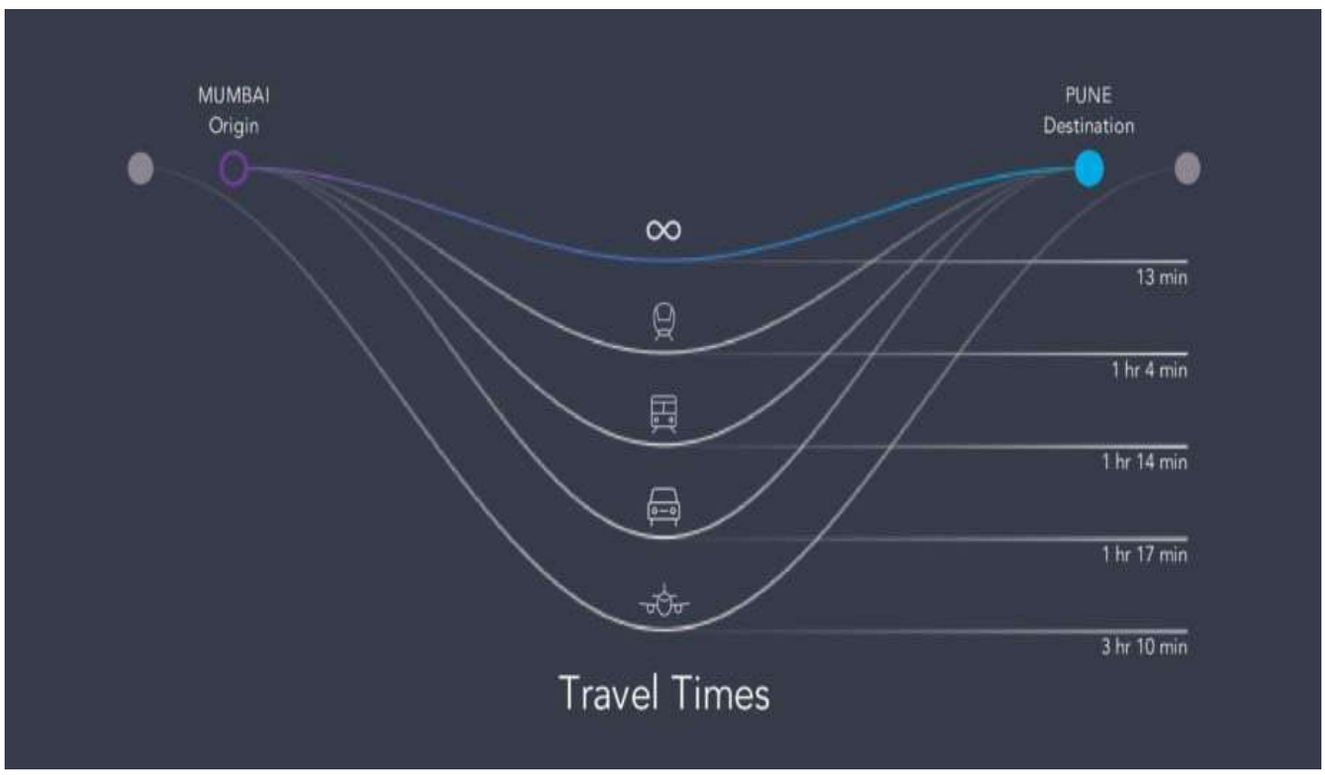

Figure 20: Travel Time With HyperloopOne. *Source: HyperloopOne 2018*

Transportation Systems

“PMPML - Pune Mahanagar Parivahan Mahamandal (BRT System)”
Most of the residents of Pune commute by personal vehicles such as bikes, scooters, cars, bicycles or privately-owned vehicles such as, taxis and auto-rickshaws. Few people commute through the company buses arranged by their employers. There are various inter-state buses run by private operators.

The ground transport vehicles such as buses, two wheelers, cars, autos, etc. are the most frequently used mode of transport in the city. Even the commercial carriers of goods prefer trucks and similar vehicles for their operations. Maharashtra State Road Transport Corporation (MSRTC) offers bus services for the people travelling between Pune and other cities of Maharashtra.

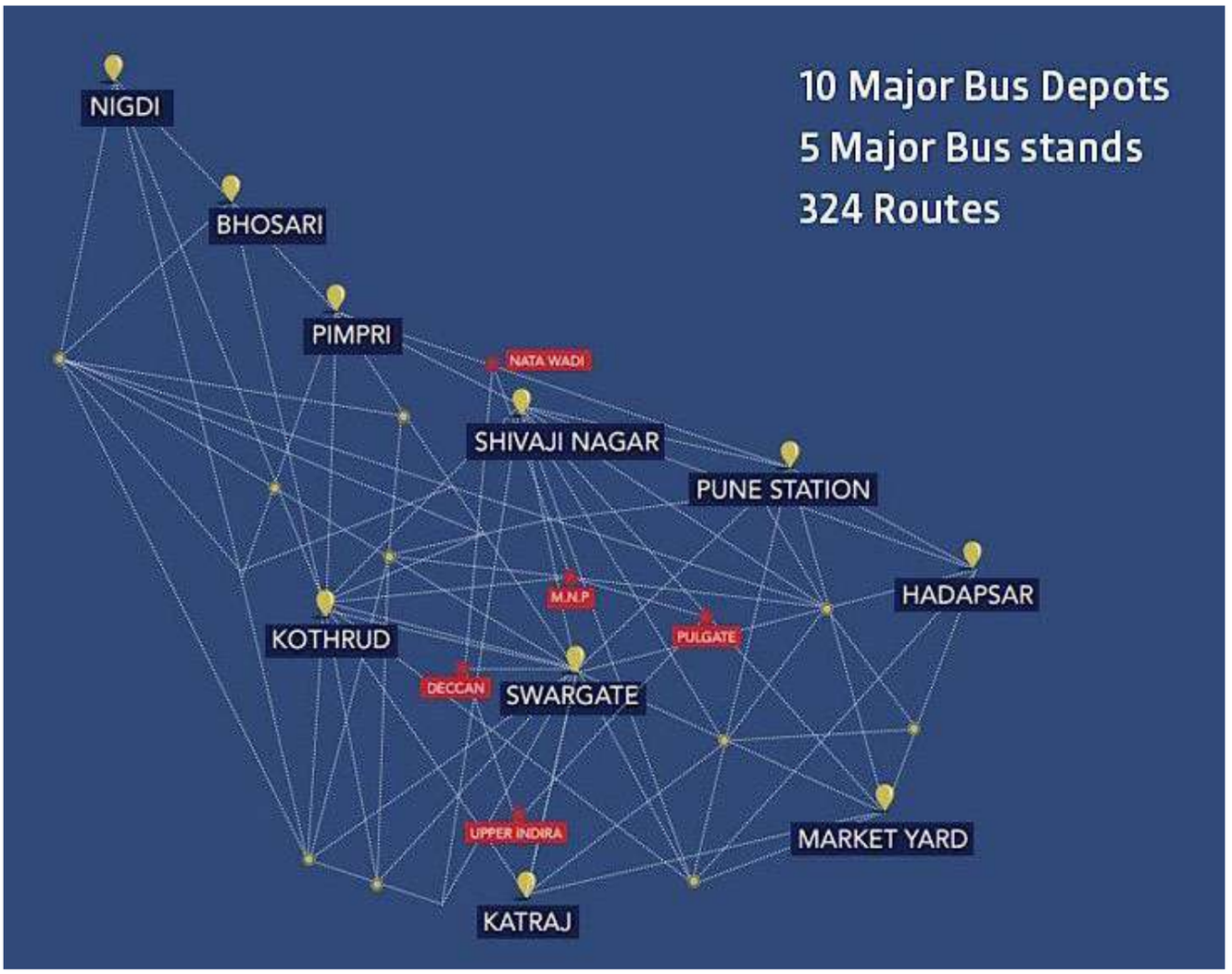

Figure 21: Pune PMPML Major Bus Routes. *Source: Rane 2012-14*

Managing and Planning

Pune Mahanagar Parivahan Mahamandal Ltd (PMPML) offers bus services in the Pune municipal region (PMC), Pimpri, Chinchwad Municipal Corporation (PCMC) and Pune metropolitan regional development authority (PMRDA). They together form the region of bus transport. PMPML falls under the control of Pune Municipal Corporation (PMC). The Pune region consists of 10 major bus stops. Currently, there are 10 operational bus depots that PMPML offers: Swargate, Nerveer Tanaji Wadi, Kothrud, and Katraj, Hadapsar, and Market yard, Pune Railway Station, Nigdi, Pimpri and Bhosari.

The maps made above are developed in 2012 on occasion of “Bus day”. However, a major revamp over the years was needed for these maps to update. 3 stages of maps were developed and updated but it’s difficult to manage with those maps, as they are huge in scale and the bus frequencies are approximately based on thumb rules. The following can be seen through maps below. (Rane, 2017)

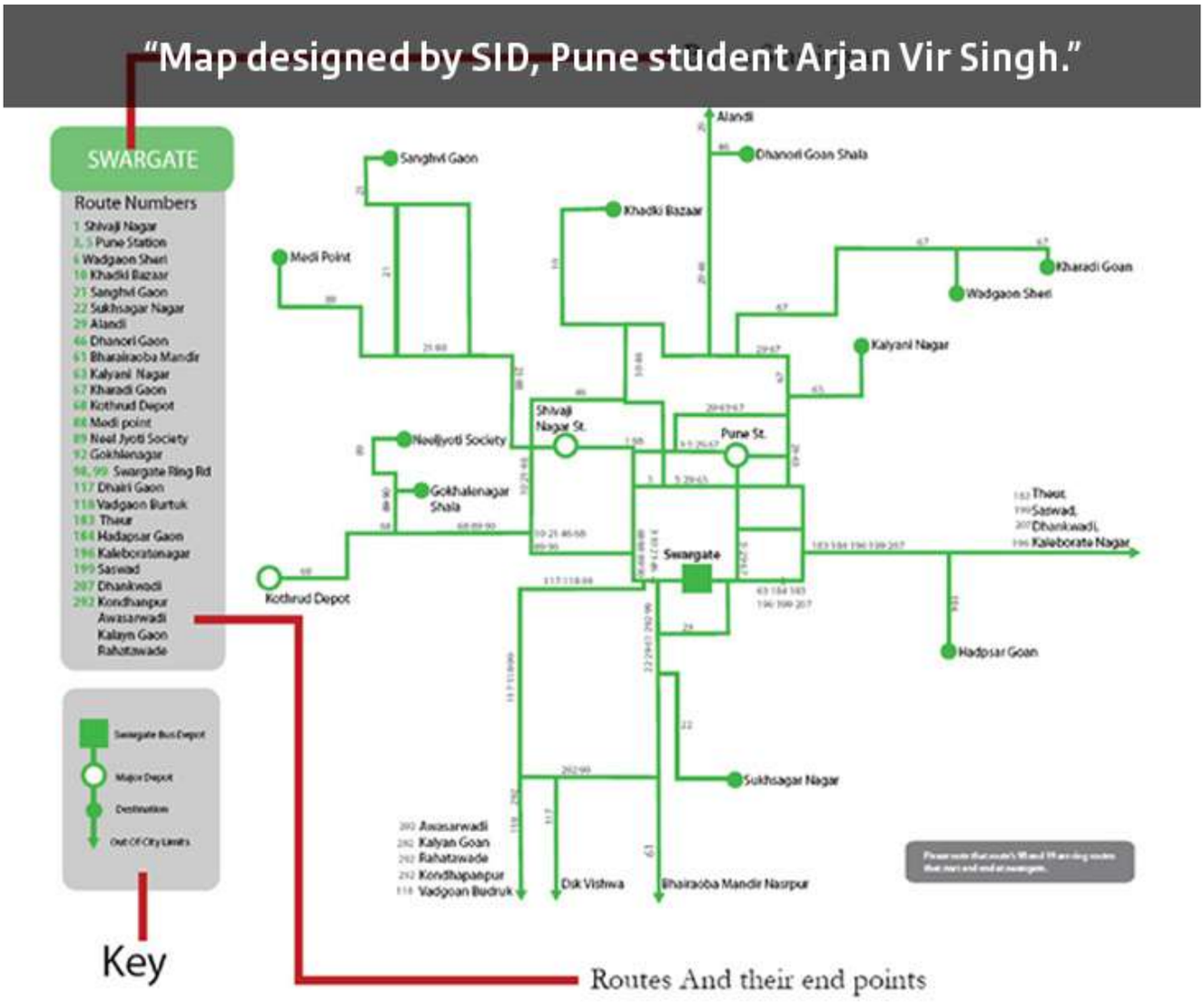

Figure 22: Design Bus Routes. *Source: Rane 2012-14*

Figure 23: People Searching For Bus Stops. *Source: Rane 2012-14*

Bus, Ticketing and Bus Depots

The buses are in abhorrent conditions. This is one of the reasons that people avoid using public transport. The city is one of the major market sellers of bikes and cars, since 83% of people own a personal bike. (Rane, 2017) The migration of young generation is huge from small towns around they form the floating population of the city the floating population is almost 1.5 million on monthly basis, hence this adds up to the footfall and pressure on the public buses. The buses don't have drivers lending ticket to the customers but everyone must buy their own ticket in the bus from the conductors a person who is already in the bus for lending tickets. The tickets cost around 10 – 50 cents for the entire one-way journey. The fine charged is around 15 euro if found guilty. The intercity bus charges around 60 - 100 euro's maximum for a journey of 350 – 800 km one-way.

Figure 24: Swargate Terminus. *Source: Rane 2012-14*

The bus depots are as abhorrent as the buses are. No segregation of bus routes, dividers, grade separator and lack of discipline in the public realm. "People in Pune prefer to travel on own two wheelers, which is more convenient than the unreliable public buses. The current survey says that there are 75.3% people who prefer to use two-wheeler for commuting in the city and only 0.8% people use public buses. There are various reasons, first is unavailability of buses on time and second is biggest confusion at the information deprived bus stands. People get into wrong buses and after half their journey they realize that they are in a wrong bus. This is the very reason people avoid going by public transport, unless they have no option. There are very few people who can easily travel by bus but, they say that they have adjusted themselves and are used to the transport system as they cannot afford to travel by private vehicle and due to ever increasing gas prices". (Rane, 2017)

Pune Metro Rail – "Maha Metro"

The much-awaited Pune metro has begun its construction (excavation and foundation phase) from last two years, since its thought of building a metro for the city in the year 2000. The project has been conveyed under managing dire—ctor "Mr Brijesh Dixit" of "Maha-metro". The metro suits the city since the average travel time in city is more than 100 min per person. The table explain the demand of metro for the city.

The proposal has 3 metro lines two in PMC area and one in PMRDA region. Total numbers of stations proposed are 53. The metro is being elevated at 23 stations and will go underground at 5 stations. Since land acquisition is a critical part for setup the metro got escalated for the city of Pune. The estimated date of completion for line 1 and line 2 is around the year 2021. The total area covered would be 54.58km. The PMC region is 31.25 km long while the PMRDA is 23.33 km long. The total estimate for the project is 845 million Euros.

Another project which recently got appreciated related to street streets development in an urban setting is the streets of Aundh; it was developed with the help of public participation and was designed by urban designer "Architect Prof. Prasanna Desai". The project aimed at developing a breather space on the heavily occupied traffic region for the residents. The pedestrian walkway stretches to 3M in length having cycle tracks of 1.5M. The street has an end to end connection, hence is used to full potential by residents.

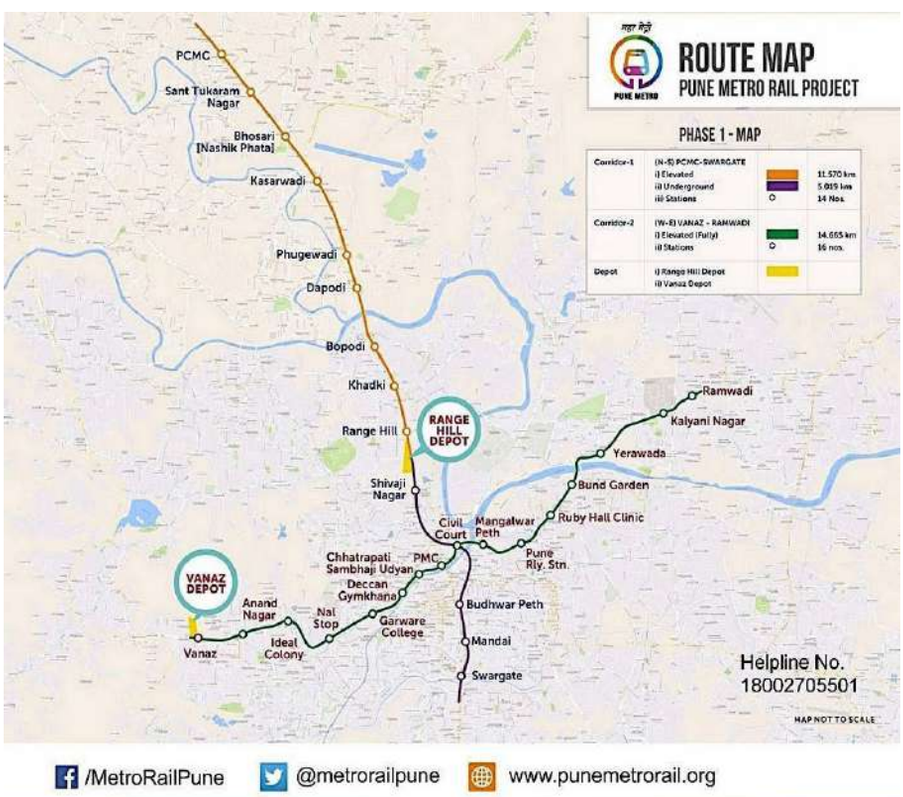

Figure 25: Pune Metro Route Map. *Source: Pune Metro Rail 2018*

The fare collection would be done on an automated system which would have a smart application. The estimated service of day is around 19 hours/day. The estimated travel speed would be 31Km/h to 33Km/h.The maps developed for the routes relate to the main stops and a comprehensive mobility plan has been developed for the same.

According to surveys and urban experts the TOD (Transit oriented development area) would boost the real estate sector since there are high chances of FSI (Floor space index) to be raised to 4. This figure is lucrative and a lot of debate is happening around the urban policy makers on what could be the solution.

The metro is to be built on BOT (Build operate and transfer) basis with a maintenance contract of 35 years. The companies involved in such projects are ILFS, IRB and Tata-reality Siemens. However, appropriate the infrastructure and figures sound; in terms of usability it can be determined only when users use the facility to its full potential.

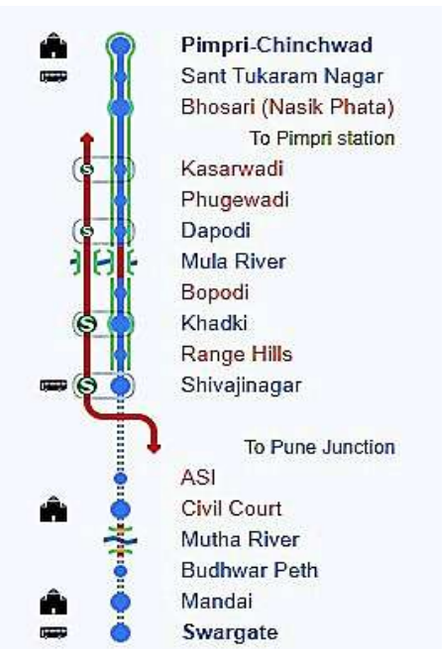

Figure 26: Pune Metro Route Map Line 1, *Source: Pune Metro Rail 2018*

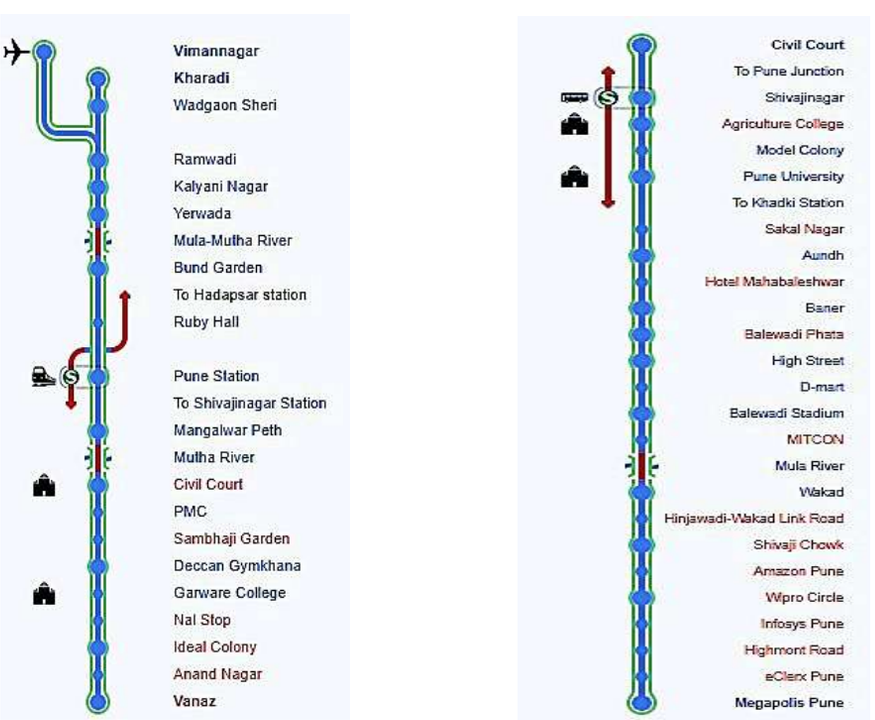

Figure 27: Pune Metro Route Map Line 2 and 3. *Source: Pune Metro Rail 2018*

The success of the metro will be determined based on the users experience in terms of time commute and fare prices. A comprehensive report for mobility has been developed by the regional municipal authorities for efficient implementation of systems of transport.

Comprehensive Mobility Report- Published PMC

"The CMP seeks to make public transport facilities available to all residents within a reasonable distance from their homes, work places and other destination points. It also seeks to encourage greater use of non-motorized modes by making their use safer. Recognizing that Pune is a rapidly growing city and travel demand will continue to grow, there is no escape from having to decongest some of the highly choked areas and intersections in the city. This is being suggested because long idling of motor vehicles at crowded junctions and corridors adds to pollution and unnecessary use of an imported fuel as also global warming. Measures have also been suggested to discourage the use of motor vehicles and attract a large part of the growing travel demand towards public transport and non-motorized modes" (Pune Municipal Corporation, 2018) The above strategy is sought to be implemented through the following broad approach:

1. Identification of several trunk mobility corridors along which high capacity public trans port systems such as BRT/Monorail/LRT/Metro, etc. would be considered based on a scientific and detailed alternatives analysis.
2. Enhancing the capacity and quality of the public transport so that people are willing to use it instead of moving towards personal motor vehicles.
3. Providing alternative routes for those having to enter the core city area even when their journey does not begin or end in this part of the city. For this purpose, ring corridors have been suggested to enable the core city area to be bypassed.
4. Providing bypass routes for long distance commuter and truck traffic so that they do not have to travel through the city roads.
5. Identifying feeder systems that connect different pockets and wards in the city to the most convenient point in one or more of the mobility corridors.
6. Providing a network of dedicated cycle tracks, footpaths and pedestrian crossings.
7. Pedestrian zing important portions of the core city area and linking them with strategic parking places to encourage people to walk in such areas
8. Providing flyovers in a few heavily congested junctions/intersections to reduce idling traffic.
9. Introduction of physical and fiscal measures that would discourage the use of personal motor vehicles.
10. Reform and strengthen the institutional arrangements for managing and regulating the transport system in the city.Based on the mentioned framework of the plan and the strategy for achieving the vision, Mobility plan action items are summarized as follows:

Mobility Corridor Plan,Traffic Management Plan,Public Transport Plan,Non-Motorized Transport Plan,Passenger and Commercial Terminal Plan, Flyovers and Bridges Plan, Travel Demand Management Plan,Road Maintenance and Management Plan.

"The public transport plan is supplemented with an extensive bi-cycle network that is both interconnected and continuous that reinforces and feeds into the public transport corridors. As it is assumed that every road must have a walkable and usable footpath no separate footpath plan is provided.

For efficient passenger dispersal system from the public transport corridors at-grade/grade separated pedestrian crossings are planned. To improve the mobility of the corridors and pave

way for the public transport corridors an effective parking management plan that complements the corridor plan is identified. The parking plan in addition to freeing the right of way for the public and non-motorized transport would also act as a demand management tool. A strong and reformed institutional framework is identified to help achieve the mobility plan and the vision."

Figure 28: Aundh Main Road Pedestrian and Road Connection. *Source: ITDP 2016*

Figure 29: PEDL Bicycles at Aundh. *Source: Whatshot.in Pune n.d.*

These individual plan elements are detailed in the subsequent sections". (Pune Municipal Corporation, 2018). Additionally, there has been initiative of strongly promoting bicycling in city. An association with a car rental company "Zoom car" and PEDL have made it possible to rent bicycles on hourly basis. There are cycling hot spots set around the areas of city. It's just 15 cents per hour thus by promoting the cycling experience in city.

Figure 30: Artefacts and Installations. *Source: ITDP 2016*

2.4.6 Streets of Pune

The urban streets of Pune are being developed in major areas of city.

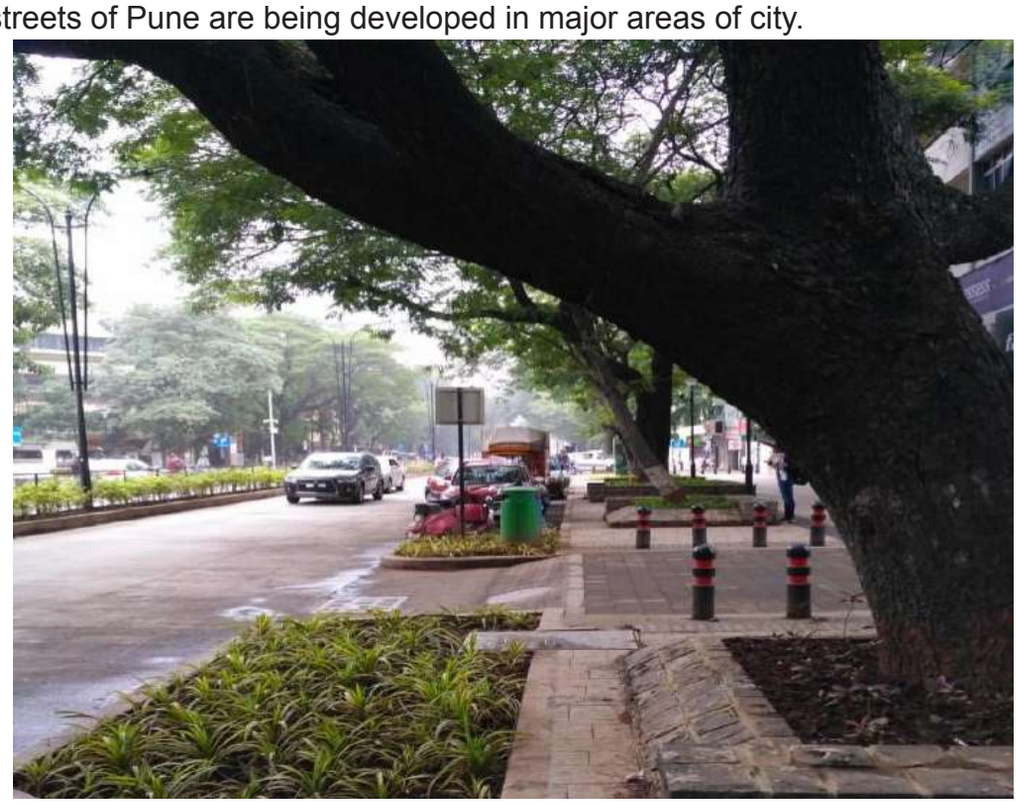

Figure 31: A Busy Street in Pune. *Source: ITDP 2016*

Figure 32: Cycle and Pedestrian Pathways, *Source: ITDP 2016*

The increase of the population in the 20th century is 220 million to 2.8 billion. According to the UN statistic, by 2050 6.9 billion people will be living in the urban areas, almost the 70% of the global population.

Due to this increase of population, the number of journeys inside the cities also increase. The transportation systems in all urban cities must grow in a sustainable and responsible way. But, for the transportation system to work efficiently, other actors must be involved. The planning of the cities, the policies, and the new technology must work together.

Asia will be the continent with the major increase in the road traffic levels and it is also the one who has the 1/3 of the global population. Nevertheless, the increase will be considered around the world and its one of the problems that every urban citizen suffers every day.
Since the world begging to talk about sustainable transportation, six cases or stage were presented to a city to be considered friendly to the environment based on the United Nations

Reports of Sustainable Development

1. Reducing greenhouse gas emissions
2. Improving air quality / reducing noise
3. Improving transport safety
4. Improving Access / Reducing exclusion
5. Reducing Congestion
6. Creating wealth / supporting the economy

The data will analyse the cities of Delhi (India), Pune (India), Berlin (Germany) and Helsinki (Finland) and show the most important issues at transportation.

Delhi – India

The transportation system in Delhi, the city with a population of more than 26 million persons, is now chaotic for the mismatch between urbanization, poor infrastructure development, and poor urban planning. One of the biggest problems is the vehicular congestion. Since 2012 the private vehicles registered in the city has increased in 24.7% (77.85 to 97.05 lakh), the DTC buses have decreased in -26.2% (5.445 to 4.020) and the road accident increase on 6.3% (6.937 in 2012 to 7.375 in 2016).

The city is taking the opposite direction to be a sustainable city. The public transportation has not increased in the last few years and the new residents have convenient to get a private transportation.The results are problems like traffic jams, increase in CO2, poor air quality and accidents inside the city.

Pune – India

One of the biggest problems of Pune city is the vehicle density of 753/1000 (Vehicles/Persons). The infrastructure of the city is acceptable, with highways of 6 lanes, but the resistance can be in the traffic jams between 3 to 4 hours per day in peak hours.The causes of this traffic jams are the improper planning of city development, unknown of the new traffic norms, an inadequacy of traffic police, VIP movement cultures, narrow roads, illegal parking, the higher purchasing power of the public, and the improper lane management.A 10 million population growth is expected in 2030, and the government is very concerned about it, but unfortunately, the new ideas to solve the problems have not been in use yet.

Berlin – Germany

As the capital of Germany and the former division of West-East, Berlin has improved all the systems of the city to be at the forefront of other cities like Paris and London. In the planning, Berlin created the urban renovation plan of Potsdamer Platz unknowing that the wall was going to fall in 1991. The Haupt Bahnhof (Berlin Central Station) was built on empty space where are building a new apartment building is in under construction in the middle of the city (15 mins away from Brandenburg Gate). All the innovation and new ideas of transportation are implemented in the city and works “good” according to the size of the city and the population (4 million approx.) The traffic jam is not as big as other countries. One problem is the connection time between metro lines (S-Bahn and U-Bahn), the average time waiting it is between 2-8 minutes. Also, the punctuality of the buses, trams, and metro are not “precise”. One big problem is the new airport outside the Berlin. It is already done, but the fire protection and alarm system are not functional according to the European laws. The government is fixing the problem, but when the airport will be open, the capacity will be short to the growing necessities of the city.The Tegel airport must remain in service.

Helsinki – Finland

Since 1991 the City Council adopted a transport policy in the development of public transport that works well.The development occurred in connection with trams, metro and train to the closest cities as Espoo and Vantaa and the airport. Electric transport allows the footprint of CO2 a minimum against other transportation systems. Also, the buses are using natural gas and the company begins to use new technologies as biodiesel and new renewal materials to replace the traditional diesel fuel.One problem should be the extreme weather that happens in Helsinki. After a big snow storm, the city can suffer for hours and the trams and buses can be late or cancelled.

The population of Delhi has 4,3 times the population and 2,75 more density that of Berlin. In the airport Cargo Tonnage, it is a big contrast. Delhi is almost 18 times Berlin capacity. In train both cities have almost the same number of stations; Berlin has more lines (15 to 6) and the system length is longer (327 km to 213). In the metro, both have the same number of stations, almost same lines, but in length, Delhi has 80km more than Berlin. Berlin has a tram and Delhi no. For the quantity of population, Delhi has more trips per day than Berlin.

The population of Pune has 3 times the population and 2,4 more density that of Helsinki. In the airport, the passenger movement in Helsinki its 2,65 times Pune journeys. In Cargo Tonnage it is a big contrast, Helsinki has 5,44 times Pune and 3,52 aircraft traffic. In train Sub - Urban, Helsinki has 15 lines against 2; 70 stations against more and daily ridership Helsinki move 2 times more than Pune; Pune that has Bus rapid transit with 6 lines, but unfortunately, the project has been a disaster.

Having a sustainable transport system in any city involves a complex coordination. It comprises of having an adequate infrastructure, planning, logistics and information to effectively manage the movement of buses, airplanes, trams, trains, and metro. A rounded and adequate transport system in the 21st century does not come overnight; it involves effective city planning, financing, and proper implementation. It is however important for such sustainable transport system to possess an international dimension such that there is an effective harmonization within and with neighbouring cities and or countries. Despite the international disposition of transport, cities and countries differ considerably in the method used to combat transportation issues. Physical and geographical conditions, however, are factors responsible for most of these differences.

Over the years, it has been discovered that problems that low-density cities face are different from the problems that high-density cities have. Also, the economic growth and income of high-density cities have more emphasis on the environmental impacts of transport than low-density cities. To effectively address these problems, it is imperative for the government of a city to create better opportunities for planning and the implementation of long-term transportation works, taking into consideration economic and population future projections. It is also important to have functioning, flexible and workable transportation laws and policies for citizens to follow. In extension, this policy becomes a standard practice for short and long-term purposes.

Generally, transport systems include the following; the transport means, transport infrastructure, the transport users and the goods being transported plus the transport organizations involved. On the other hand, transport policy is the measures taken to promote national competitiveness and economic activity of the transport sector and maintain or increase the well-being of citizens. In the development of a regional and community structure, transport policy must be implemented alongside with the transport system and other functions of the society. Adequate and sustainable and functioning transport system is imperative for people’s everyday life. Transport connects activities within a society together, as such; the quality of the system affects the well-being of people in the economy.

This section focuses on how politics and policies have shaped public transportation in the metropolitan cities of Helsinki, Berlin, Pune, and Delhi and to analyse how far these cities have come towards achieving an effective and sustainable public transportation system.

Berlin – Germany

Berlin aims at a more sustainable transport system than it currently has; the goal is to have safer transport routes, more mobile and more climate-friendly transport. Berlin is growing, and a more sustainable transport system can only be achieved and maintained if there is a success in all forms if mobility – that is, bus, trams, rail, bicycle, pedestrian traffic. Pedestrian movement, bicycle, and public transport are crucial because these types of mobility are resourceful in their use of space.

Berlin mobility act

In 2018, the Berlin Senate approved the draft of the first mobility law in Germany. The mobility law is aimed at increasing the efficiency of a holistic transport system to manage the traffic of the growing city. The Berlin mobility act will create a platform in the law for all interest to thrive. (Senate Department for Environment, transport and Climate protection, 2018)

The primary aim of the Berlin mobility is to ensure that people arrive at their destination at ease within the best travel time and in a way that it has little or no environmental impact. The act addresses further that an individual should be able to reach any destination irrespective of one's physical limitation or form of transportation. In general, the act aims to enhance the effectiveness of transportation. It also plans to implement the 2050 Berlin senate target to have motorized transport system neutral. Additionally, another long-term objective is to lessen the number of road traffic facilities and fatal injuries to zero. Measures are in place to redesign dangerous bends and junctions to facilitate bicycling along main roads. Key components of the Berlin mobility act include all modes of transport, ensuring that individual components take shape over time.

These components should demonstrate transport mobility that is future-driven. The basis of the Berlin mobility act was launched in the spring of 2017; this, however, saw the creation of a mobility committee, to which active members of the German political system belong. They include Senate administration department, Berlin parliament party representative. (Senate Department for Environment, transport and Climate protection, 2018) stated, that the departmental arm of the Senate for the environment, transport, and climate protection, in collaboration with Volksentscheid Fahrrad (a civic cycling organization), German cyclist association and parliamentary parties created the key features of the bicycle traffic element. This collaboration produced the first legislative draft that was presented in August 2017. After careful study and suggestions, the draft was further amended to a final one through the support of stakeholder representatives. (Senate Department for Environment, transport and Climate protection, 2018)

Benefits of the mobility act

According to (Senate Department for Environment, transport and Climate protection, 2018), one of the advantages of the Berlin mobility act is that there is a legally binding basis for urban growth and development for Mobility and transport and supporting strategy. Not only will the city's public transportation be cast in stone, it also creates an opportunity for the pedestrian plan, bicycle traffic, and integrated commercial transport model to thrive. A section of the mobility act advocates a barrier-free design of stops and stations for public transport route. Furthermore, the mobility act will make provision for priority transport routes for public transport. These routes will include a network with important public transport provision or networks with high level. As such, passenger demand is taken into deliberation properly when other forms of transport are being planned. The Mobility Act will also forge footing for expanding the cycling infrastructure of Berlin. This includes safe, fast and seamless cycling network on all road routes (major and minor) not leaving out better bicycle parking and safe storage facilities.

Berlin is a growing city; the city is expected to enjoy more urban influx in the coming years because of urbanization. The aftermath of Brexit will see Germany as a major European leader, which will translate to increase in economic growth and urbanization. It is, however, most crucial for the Berlin government to implement promptly all the content of the new mobility policy.

Delhi – India

In 2001, the Indian ministry of urban development launched a vision to transform Delhi into a clean and dynamic serving city through its Master Plan Delhi (MPD-2021) initiative by the year 2021. The government aim is to provide secure, environmentally friendly and cost-effective forms of public transportation within a multi-connected transportation network. The processes of creating a sustainable transport system in a hastily urbanizing developing city like Delhi are entirely different. Delhi has however made strides towards sustainable transportation by the introduction of Delhi Transport Corporation (DTC) buses and success with the Metro system.
The City of Delhi is characterized by high population density in small areas and low population density in large areas (Dinesh M. et al, 2008). Additionally, road traffic congestion is the order of the day coupled with decreasing air quality and rising figures in road accidents. The primary aims of the Delhi government through the MPD-2021 is to minimize traffic congestion, upgrade transportation facilities, improve air quality by reducing vehicular pollution and enhancing travel safety for commuters. (Indian Ministry of Urban development, 2001) However, the draft master plan for Delhi by the year 2021 is centred on widening roads, providing more road infrastructures like expressways, grade separated junctions and a more efficient Metro system. However specific provision for better pedestrian infrastructure and bicycle movements were not included in the draft. Unfortunately, due to societal perceptions, car and road system seem to be the desirable mode of transportation.

Challenges

Reports indicate that the situation is likely to deteriorate due to the rapid increase in economic growth and population of the city. From the year 2001, population growth of Delhi is presumed to grow from 138 million to 230 million by 2021. (Indian Ministry of Urban development, 2001) As such, demand for public transportation is expected to also increase from 139 million in 2001 to 279 million commuter travels by 2021. To achieve this, the Delhi government must put conscious efforts into upgrade the current state of the city's road infrastructure, traffic management processes and corresponding amenities. Various features are responsible for existing road congestion, air pollution, and road safety. The principal cause being the disparity in the type of passenger vehicles and traffic caused by diverse transportation means of transportation. (Indian Ministry of Urban development, 2001). Low capacity vehicles characterized by two wheelsers and cars are the most popular modes of transport in Delhi.

The government of India in 2002 disclosed its new Auto Policy aimed at making India a global competitor in the automobile industry. This level of industrial growth certainly has a clear connotation for structuring Indian transport and traffic policies. (Dinesh M. et al, 2008). The economy of Delhi grew in double figures in the past which however has influenced vehicle ownership; mostly cars and motorcycles. The economic growth has seen a 15% increase in the number of vehicle ownership. The complexity of this situation is that modern high-speed cars and motorcycles compete for space on the same roads. This level of complexity was never faced by European nations during their development phases. Cheap automobiles are readily available for use and purchase daily, leading to much more road cluster and competition for street space in Delhi. These so-called cheap vehicles contribute negatively to public health, energy use, and air pollution.

Policy

The objective is to achieve a balanced model transportation mix and dampen the desire for personalized transportation. Additionally, the government intends to achieve a sustainable transport system by financing and increasing of public transportation options by providing sufficient, available and affordable transport models like buses, bicycles, completed by a network of its already existing Metro system. The need for an adequate metro system is imperative. In October 2017, there was a discussion centred on the proposed increase in fare prices by the Delhi Metro Rail Corporation (DMRC) due to increase in the cost of producing the service to commuters. However, the APP government was quick to react by placing a hold on the hike that was scheduled to start in October 2017. The APP lead government advocated that Delhi Metro should be more concerned with how to develop effectiveness rather than increase fares. This sole decision, however, is not enough to solve the transportation issues in Delhi. During the hike, data showed a decrease in the ridership of the Metro; (Singh, 2017) argued that for Delhi Metro to thrive further, the Metro system must offer last mile connectivity from all stations. However, since the begining of 2018, Delhi Metro has recorded an upward rise in average ridership; averaging 2.7 million commuters per day (The Hindu, 2018)

Mass transportation

To achieve balance with the modes of transportation, a wide-ranging, sustainable and effective rail, metro and bus system must be attained and maintained. In this light, the government plans to extend Delhi Metro network to 245 km by 2021. Despite this, sustainable transportation can only be achieved not only by investing in rail and metro but also by an equally effective bus transport system. The Delhi Transportation Corporation Buses (DTC) which is a close substitute for Delhi Metro suffered gradual decline since 2011. Buses these days are packed out (Singh, 2017). He further stated that reports indicated that the number of DTC buses available for commuters within 2001-2011 was 6000 and that saw a rapid decline to 4,300 by 2016. Although the Delhi government is in the process of procuring additional 2,000 buses, (Singh, 2017) argued that this will still be insufficient to meet the city's current bus needs. The rapidly growing population will require about 11,000 buses to make appreciable progress.

However, in accordance with the Master Plan MPD 2021, the government is improving the city's bus mode of transportation by procuring CNG buses, high capacity bus system buses, and Electric Trolley Buses. The later will yield many benefits towards the reduction of pollution; light rail transit is also being planned.

The policy also expects Intermediate Public Transport system (IPT) to play an important role; serving as links from some pre-designated areas to mail transport lines. According to (Dinesh M. et al, 2008), the National Urban Transport Policy in India stated that "Travel in Delhi city has become riskier"; which has taken its toll more on the poor as many of the road accident and injury cases recorded are experienced by pedestrians, cyclist, and pavement dwellers. In general, construction of pedestrian routes, flyovers, and bridges are underway in various parts of the city. The new road network is being constructed and old ones are widened.

For Delhi to achieve sustainable transport system, it is important for the government to follow through on implementing the Master Plan MPD 2021 goals and explore eco-friendly modes of transport and leverage on learning from the success of developed cities like Berlin and Helsinki. It will also be of adequate benefit to introducing contemporary and sustainable transportation technology. The following points are however recommended.

1. Support and introduction of adequately planned cycling routes across the city.
2. Encourage commuters further to use the Metro lines rather than committing to individual automobiles by controlling fare prices.
3. The adequate connection of major public bus corridor stops to all Metro terminals.
4. Although plans are in place to change the phase of intermediate public transport, it is not sustainable.
5. Initiate adequate measure to control urban influx and rapid population growth.

Finland - Helsinki

The Finnish ministry of transport and communications in spring of 2007 put together a report on a new transportation policy; led by former Prime Minister Matti Vanhanen. The modus operandi of the government was that they present a transportation report to the Parliament at the beginning of the electoral phase. The report contained a comprehensive transport facility investment schedule for short and long-term infrastructural development. This report further highlights the adoption of possible financing formats for transport facility investments which will be used to complement budget funding. Another important objective of the Report is to create a 10 to 15-year plan of a more sustainable transport policy. The ministerial faction for the transportation policy was thorough to discuss the report on eleven occasions.

The transport system is a vital economical feature in Finland because of the Finnish widespread area and long transport distances. Industrial and residential growth is dispersed all over the country. According to report, the vision and transport objectives of the Finnish government by 2020 is to have a “Long-term and sustainable approach in transport financing” (Ministerial working group on transport and communication Finland, 2008). The plan is to always, prepare reports on transport policy at the commencement of every electoral period. This will guarantee better budget planning and a steady supply of necessary finance for public transport development. The government also make it imperative to support regional economic development through public transportation. Additionally, the Finnish government aims to see increase travelling figure by 2020 but decrease in car travel figures. To support this course, an additional goal of the government is to make public transport system an attractive alternative. (Ministry of Transport and Communications et al, 2012) Highlight Issues confronting the Helsinki transportation policy; including:

1. Increase in urbanization and growing urban centres
2. The need to accommodate the changing operational environment of Air transportation
3. Management of trans-European transport network, improving sea route via the Baltic Sea to Tallinn and planning adequately towards the proposed Helsinki Tallinn underground rail project.
4. Offering solutions to climate change through sustainable transport modes.

Further, strengthen transport safety by managing issues related to speed limits and road accidents.

Sustainable transport in Helsinki

Helsinki region is made up of a sustainable modal mix of public transportation. The system is designed to rely on rails and buses. The latter serve as feeders for the former. Road transportation constitutes the highest number of transport pollution cases and accounts for the largest number of energy consumption. The City of Helsinki aims to achieve sustainable public transportation, by the encouraging walking, cycling, use of public transport i.e. Metro, Trains, Busses, Trams), car sharing and driving economically. (City of Helsinki, 2017) Additionally seeks to

locate jobs and services within a proximity reach to dwelling units in other to limit dependency on car transportation.

The Helsinki Region Transport (HSL) oversees managing and planning transport system and network within the Helsinki region. They are also responsible for public transport organization and public transport expansion. To achieve sustainable transport, it is important not only to allocate policies but also to educate commuters on the consequences their choice of transportation may have on the environment. (City of Helsinki, 2017) argued that, dwellers in Helsinki become more open and aware that walking, cycling, and public transportation are the most efficient forms of transportation. Dwellers with personal cars are also encouraged to choose energy efficient vehicles, participate in car sharing scheme by the HSL. The government has also taken an initiative of building free commuter parking facilities as a comfortable way to avoid traffic jams at the city centre. public parking spaces are stationed near stops and stations making it interestingly possible to park and continue travelling by bus, trams, metro or train.

Pune – India

The transportation issues that confront the city of Pune are relatively the same for most developing cities. “Pune is at the crossroads in its urban development journey” (PG Patankar, 2006). The decisions implemented will be instrumental in the determination of the city in the future. Pune metropolitan region is also facing an overwhelming challenge of implementing a balanced transport modality within the region. The daily travel of people between Pune and its regions and the city’s deficiency in sustainable public transport system have resulted in the precipitous rise in private vehicle ownership. Like the case of Delhi, the situation is similar. (PG Patankar, 2006), highlighted that Pune is expected to grow into a large megapolis in the next five decades. As such, there is a need for a present strategy in achieving a sustainable public transportation. Unlike Delhi, the current population figures recorded in Pune is relatively conservative and easier to manage; this calls for an urgent solution and implementation of policies within the metropolis.

The Indian Ministry of Urban Development formed the National Urban Transportation Policy (NUTP) in 2006 with the primary aim of transforming Pune’s public transportation system into a safe, sustainable, effective and convenient system. The result of this led to the adoption of “Comprehensive Mobility plan” (CMP) to tackle and proffer solutions to the transportation problems faced by the city. The policy set by this plan centres ease of mobility for people rather than vehicles; giving priority to the Non-motorized mode of transport, pedestrians and Public transportation modes (Pune Municipal Corporation, 2008). With this mobility plan, the city can address traffic growth of all modes of transpiration on the city’s grid and suggest a mix-modal transportation system for Pune. According to (Pune Municipal Corporation, 2008), four objectives were highlighted.

1. To organize adequate forecast necessary for an adequate public transportation model by studying the present date traffic situations
2. To have an idea and sustainable transportation template for Pune
3. To recognize policies and procedures to confront traffic growth problems
4. Prepare a financial timeline for the implementation of CMP

Bus rapid transit

Currently, Pune Municipal Corporation (PMC) has a Bus Rapid Transit system (BRT). However, (ITDP India, 2018) reported that the flagship initiative suffered negative promoting by the media and resulted in poor patronization by the public. The project was however found to be deficient

in design, construction, and execution. The Institute for Transportation and Development Policy (ITDP) was consulted at that time to proffer solutions to the system and to develop a sustainable plan for a detailed and comprehensive BRT road network system. Important features such as dedicated BRT lanes, effective administrative process, aggressive branding, and excellent service delivery were put in place. The BRT system covered a 160km bus network and is a link between the municipalities, Pune Municipal Corporation PMC and Pimpri Chinchwad Municipal Corporation (PCMC). Additionally, the BRT system is characterized by feeders, direct service links, and trunk routes.

Transit oriented development

Pune has a strong technical support from ITDP professionals making sure that the new BRT system embraces the features of a complete BRT system. Adequate procurements were made to enable ticketing, electronic pre-board, and alighting and passenger routes and information. (ITDP India, 2018) argued that BRT system along with the necessary features will reduce passengers' average waiting time by 50%. Furthermore, development of adequate pedestrian access to BRT stations was also initiated. In a bid to capitalize more on the BRT system, Transit-oriented development (TOD) was adopted along all BRT corridors making Pune one of the first cities in India to adopt this approach. Most importantly ITDP was responsible for organizing participatory workshop and seminars to increase awareness of the TOD initiative with public officials and other stakeholders.

Street design and landscaping

Apart from the BRT initiative, urban street designs have been put in place towards the realization of a sustainable public transportation Pune. An urban guideline was drafted with the aim of margining pedestrians and cycling routes for the city. Cycling is an important feature in a sustainable transport setting; it basically improves transportation safety and comfort to have clear-cut paving for bicycles. Generally, ITDP is working closely with all necessary corporation, media and stakeholders on a campaign to discourage motorization in other to encourage pedestrians and cyclist within the city.

Conclusion

A modern city runs on its mobility. In today's world, metro or railways are essential in the daily life of citizens. Metro is one of those basic infrastructures on which common people heavily depend. The Delhi Metro is the lifeline of the citizens. It connects the big city from its one part to another. The basic purpose of public infrastructure like Metro is to serve the public a safe and convenient transport. The policy makers must not forget that Delhi metro is also keeping the pollution and the traffic of the city in control.

The population and management of transportation system is of high importance in cities like Delhi and Berlin. Smaller cities like Helsinki provides a nice modular mix of transportation without dedicated lanes for pedestrians and bi-cycles. In Delhi plan, auto-rickshaws are widely used. The accident rates are also high among people travelling in these transportation modes where the traffic density is not accommodated at all by the narrow road lanes. There is a need for remarkable improvement and proper integration of mixed transportation in Delhi. The Delhi Metro is one of the few good examples the city provides for future sustainable cities.

The Pedestrian safety should be given prior importance in sustainable development of transportation. In older cities pedestrian lanes is where the planners and policy makers can begin the

development process at ease. On the other hand, for the making of future sustainable cities the transportation planning should have emphasis on pedestrian mobility. We can also see in the early days of Urban Planning cities were developed on focusing the concept of neighbourhood which was much about pedestrian mobility. No matter how much the technology develops in transportation system pedestrian would always be prime in sustainability of future cities.

Berlin is going to act as an economic and transportation centre in Europe. The transportation has a considerable amount of impact in their lives. Berlin transportation has witnessed the transformation from old slow cars to modern fashioned high-speed commuter trains. Comparing with the increasing population it is well coping in its transportation services. The development of technology and sensible implementation is critical for sustainable transportation. The aspects of renewable energy and tech- savvy transportation systems such as hyper loop should be considered carefully for our future sustainable cities.

Transportation development largely depends on policy and budgeting. There should be proper structure of transportation budget which is essential for structural development of sustainable cities. In country like India, where policy making depends and changes on electoral polling, construction and implementation of transportation policy suffer greatly from the shift of power among political parties.

The airport of Berlin has planned to be finished in 2011 but for delays, bad planning, and bad construction, the opening of the airport will be happening almost in 2021. On the other hand, the opening of the airport will increase the occupation and the price of the land close to the airport. Also, the industry, housing, and jobs will increase. To reduce the pollution and the CO2 in these cities, the government is planning to invest in green technology for the public transportation. For example, Helsinki is planning to change the diesel of the buses for new biodiesel, gas and electric. A more radical solution is Berlin that is planning to get free the public transportation for the population. According to the United Nations, 66% of the global population will live in cities by 2050 (UN, 2014). For the governments, it is important to create a Political and generated urban plans to created “green cities”. The new ideas, new technologies must be implemented and grow “shoulder to shoulder” with the cities.

Berlin is a centre for advanced projects and development research. It is a city that contains factories, companies, schools, barracks, hospitals and all the services needed by any large and developed city. As mentioned above, transportation is the main pillar of these services within the city. It represents the artery and beating heart. Trains in Berlin are all powered by electricity, which helps keep the environment safe because it does not emit carbon dioxide, such as cars and buses. Those who travel on Berlin's trains do not represent the upper classes of society. Compared to another city in Germany such as Munich. You will find that the trains and metro are modern in style and spacious with electronic screens. Allowing for luxury and pleasure for travellers to all classes of society.

Also, in the same context. The waiting stations in Berlin are old and dirty. Comparable to the Munich stations that radiate lights and colours. As well as sophisticated electronic screens. If we go back to the buses, for example. Many cities have buses that run on electricity. Compared to Berlin, which operates fossil fuel buses. All Berlin buses can be converted into eco-friendly buses. Another feature of electric buses is the speed of mobility and they do not produce noise like regular motors. All these things make it an exclusive and sustainable city in terms of transportation.

Helsinki is a well-planned city and it has strong transportation infrastructure represented by the streets, highways, foot baths, bike lanes, metro, and commuter trains. All these means form together a solid integrated mobility network that gives the residents wide range of travel options and this lead to more reliability on public transport system.
Helsinki has developed short-term and long-term strategic planning for the present and future aims mainly to increase the sustainable journeys – journeys via walk, cycling and public transport means.

The future sustainable cities should consider the following aspects.

1. Minimize walk distance from the origin to the nearest public transport point.
2. Maximize the cycling distance since it is eco-friendly.
3. Offer parking area close to metro and train stations that allow car drivers to park their car and use public transport.
4. Utilized IT solution to facilitate journeys via trip-planner tool, e-tickets and mobile apps.
5. All above cause to increase the percentage of residents who prefer to use public transport means rather than private cars and would lead to reduce CO2 emissions.
6. Suggestions to encourage traveller to use sustainable means.
7. Extend metro network by adding new lines to the existing transporting system.
8. Improve the status of metro stations and bus/tram stops by making them closed to minimize the impact of weather especially during winter time.
9. Provide commuter trains, tram and buses with internet connection.
10. Merge bike ticketing with the general ticketing system (single ticket, day ticket and travel card).
11. Raise the awareness of the sustainable mobility as well as the negative impact of CO2 emissions.
12. Provide main tram and bus stops with real-time info via electronic displays to increase the reliability on public transport.

Chapter 3 - Image Sources

Figure 3.1 : Travel Zone Berlin
Source: https://www.berlin-welcomecard.de/en
Figure 3.2 : Transportation map in Berlin
Source: http://mapa-metro.com/mapas/Berlin/mapa-berlin-web.jpg
Figure 3.3 : Delhi City
Source: http://anuragarch.blogspot.com/2013/12/delhi-history-timeline.html
Figure 3.4 : Skyline of Delhi City
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Figure 3.5 : Delhi Ring Railway
Source: https://www.quora.com/What-are-some-lesser-known-interesting-facts-about-Delhi-Met
Figure 3.6 : Delhi Ring Railway
Source: https://www.quora.com/What-are-some-lesser-known-interesting-facts-about-Delhi-Metro
Figure 3.7 : Delhi Major Highways
Source: https://www.google.com/maps/place/Delhi,+India/@28.6466772,76.8130664,10z/data=!3m1!4b1!4m5!3m4!1s0x390cfd5b347eb62d:0x37205b715389640!8m2!3d28.7040592!4d77.1024902
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Figure 3.9: Helsinki metropolitan Area
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Figure 3.10: Helsinki Metro stations
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Source: https://yle.fi/uutiset/osasto/news/countdown_one_year_until_the_western_metro_line_is_operational/8268319
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Source: https://commons.wikimedia.org/wiki/File:1920_Helsinki_tram_map.png
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Source: https://www.hsl.fi/en/new-tram-routes-2017/new-routes-and-maps
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Figure 3.15: Commuter train service
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Figure 3.17: Map of Maharashtra Regions
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Source: https://www.hindustantimes.com/pune-news/pmc-gives-green-signal-for-pune-cycle-plan-470-km-of-segregated-tracks/story-BxB9eaYdrg0ZGndtaiOURP.html
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Source: http://mrane.com/portfolio/pune-bus-map/
Figure 3.25: Pune Metro route map
Source: https://twitter.com/metrorailpune/status/849900192153223168
Figure 3.26: Pune Metro route map Line 1
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4. Sustainable InfraStructure
Case Study: Delhi and singapore

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Abstract

This study of Delhi city and its infrastructure is to make it more sustainable. The study primarily focused on the construction techniques of city infrastructure like roads, railways and all related infrastructure to roads and railways. The aim of this chapter is to study all the possible solutions of roads, railways, and metro lines to make them more sustainable. In the case study of Singapore city is compared with Delhi City transportation infrastructure to identify the required areas and fields in Delhi City Transportation Infrastructure that needs proper attention to make the infrastructure of Delhi City at par with Singapore City. The study discussed the main pillars of sustainability related to an urban city and how all these pillars affect the wellbeing of the population in the city. Also, the environment effects of construction techniques of the infrastructure are also assessed with scale of carbonfoot print reduction and the conservation of the natural resources. Additionally, the characteristics of sustainable Infrastructure are disscussed in detail and the steps taken by the Delhi governments to achieve the principles of a sustainable city. Although, the literature about making the railway and metro lines in the city sustainable was not available in detail, we made an andeavor to achieve the concept of sustainability in metro lines of Delhi City.

Keywords: Sustainability, Sustainable Construction, Roads and Railway

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Introduction

The transport system plays a vital role in the development of a country. It has huge effects on the economic and social sector of the human well-being in the current scenarios. For the last few decades, the cities are getting more concentrated, owing to more urbanization. Keeping in mind the increase in urbanization the city should be planned and designed in such a way to keep them more sustainable.

According to UN report on world urbanization prospects 2014, currently 54% of the world population is living in urban areas, and it is expected to increase to 66% by 2050. The projection identified that urbanization combined with the overall growth of the world's population will add another 2.5 billion people to urban area or cities by 2050 and majority of the population concentration areas will be Asia and Africa. According to the report the world largest urban growth will take place in India, China, and Nigeria (prospects, 2014).

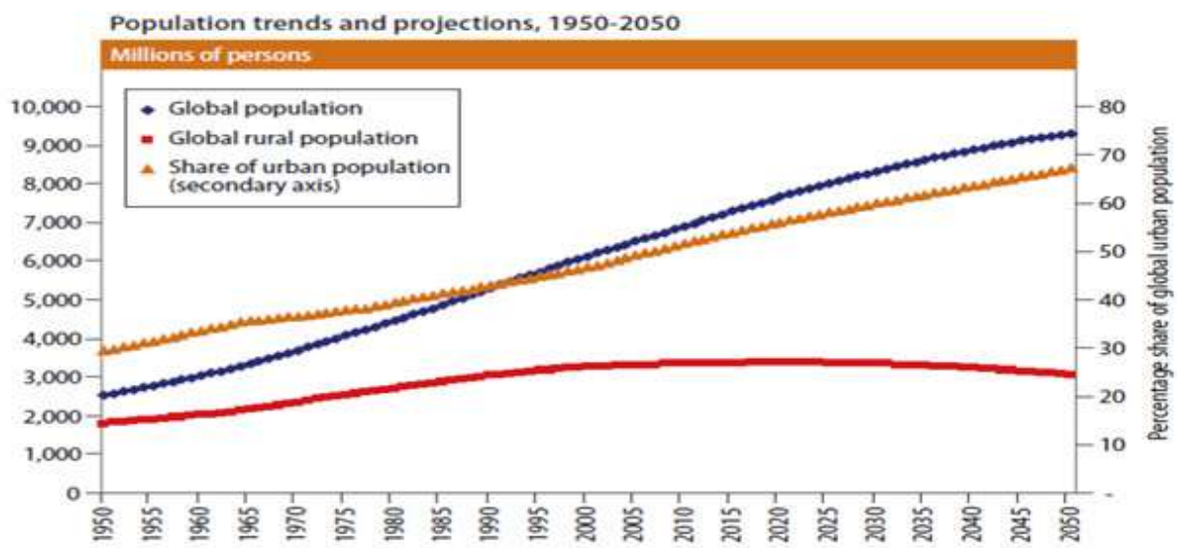

Figure 01: Population trends and projections, 1950-2050
Source: United Nation, Department of Economic and Social Affairs, Population Division 2011,2012

According to UN reports on world urban population, it is expected that world urban population will surpass the figure of 6 billion by 2045, and home to much of the world urban population will be the developing regions and particularly Africa. As a result of much urban growth, the countries will come across a variety of challenges to handle the need of the population including housing, infrastructure, transportation system, energy, employment, basic services such as education and health services. Managing all these will be a big challenge of the 21st century for the developing regions.

In 1990 there were only ten megacities with 10 million inhabitants, but; now, according to the UN report 2014 on urban population, there are 28 mega-cities worldwide with 10 million or more inhabitants, and it is projected that by 2030, there will be 41 mega-cities with 10 million or more peoples (prospects, 2014).

Delhi is the largest city in India with an urban population of 25 million (prospects, 2014).The process of urbanization in Delhi is dating back to the 20th century. As the population of the city increased with time same has happened with urban area growth continuously since 1901 from 43.3 to 168.1 sq.km in 1921. This was happened just because of the transfer of Imperial capital

from Calcutta to Delhi. After independence, the rate of urban area growth become more steady with urban area 326.3 sq.km in 1961 to 918.7 sq.km in 2001 and to 1113.6 sq.km in 2011. The population density which was 4,850 person per sq.km in 1901 increased to 7227 persons per sq.km in 1961 and 14,667 people per sq.km in 2011 (Directorate of Census Operations 1991, 2011; Economic Survey of Delhi 2008–2009, 2005–2006). Currently, roads networks in Delhi city has significantly changed.

This kind of growth in city population in addition to the growth in the urban area had created many challenges like environmental, social and economical. The basic challenges currently the city is confronting are water, waste disposal, health-care, environmental cleanup, pollution, infrastructure, transportation system and housing. Moreover, urbanization put an environmental pressure by consuming more and more natural resources and also emitting more carbon dioxide to the environment.

Additionally, growth in population in the cities brings challenges, but the most obvious challenge is the infrastructure for mobility and the transportation system which are the main factors to affect the social, environmental, and economic development of the city. The transport infrastructure like roads and railways needs to be assessed according to the requirements of the city in order to provide the easy mobility to people of all ages. Due to the increase in the economic activities in the urban area, the mobility of the people have increased significantly and it is very obvious in the mega-cities like Delhi. The economic development brought so much motorized transport in order to fulfill the needs of transportation but, all these systems developed are not very much sustainable and are the main contributors to the greenhouse gases.

Keeping in mind the needs of future generations, cities should be developed and adapted to the various aspects of sustainability. The 1987 report of the World Commission on Environment and Development, also known as the Brundtland Commission, defined sustainable development as development that meets the needs of the present, without compromising the ability of future generations to meet their own needs.

Presently, the urban infrastructure of many mega-cities like Delhi is developed without giving careful consideration to the aspects of sustainability. According to World Bank´s sustainable cities Framework: the sustainable cities are those which are resilient cities that adjust and mitigate the changes in economic, social and environmental sectors or areas.

The development of the urban sustainability concept is dependent upon the four pillars: economic development, social development, environmental management and the most important one the effective urban governance. Keeping the four pillars of the sustainable cities the chapter is produced to manage and develop the infrastructure of Delhi city in order to make it sustainable for the future population and area growth of the city. The paper will just focus on the roads, railways, parking and related utilities. The main objective of the paper is to compare the city of Delhi, India with a sustainable city like Singapore and assess the cities to adopt the steps and guidelines in order to make the infrastructure of Delhi city more sustainable and environmentally friendly.

Literature Review

The concept of sustainability is not a new concept, although it is not entirely functional or applicable to the civil engineering and construction industry. The most commonly used term for sustainability in infrastructure design and construction is "green design." Generally, when a decision about the "green" concepts are made some compromises are made because often the concepts of sustainability cause conflicts with one another and also the concept are presumed to be more costly than the baseline or routine practices, perhaps the case is the other way around. Likewise, the sustainability is measured with different units which are not very easily convertible to commonly used units and also the profit and benefits are not very much physical because these are considered among the sustainable choices.

Sustainability emergence in transportation field is in the infant stages, but, there is some sustainability rating system that defines the sustainability practices in transportation and infrastructure in design and construction of transportation infrastructures. This research paper is dedicated to identifying the aspects that help to develop and establish sustainable roads and railways in urban cities like Delhi, India.

The review will begin with the definition of sustainable infrastructure – "it is the designing, construction, and operating of these structural elements in such a manners that do not diminish or absorb the social, economic and environmental processes required to maintain human equity, diversity, and the functionality of natural systems for the future generations."As aforementioned, the paper is only limited to discuss the city transportation infrastructure like roads and related infrastructure and the railways and related infrastructures.

Roads

Roads network play a vital role in the economic development of a country, but more important is the road network in the city or urban areas. The urbanization process made the cities more prone to various challenges and the transport system and related infrastructure are one of the prominent challenges in order to handle the population of a city.

According to reports, India has the world´s second largest network of roads with 4.24 million km (MoRTH, 2005) and it is considered as one of the most cost-effective and ideal modes of transport for passengers and freight. Considering the roads in the capital city Delhi, India, according to statistics the total length of roads in Delhi is more than 28,508 km that includes about 400 km of highways. The road network in Delhi city is well laid out that include Ring Road and Outer Ring Road which are in the pattern of concentric circles traverse the entire periphery and middle of a gigantic spread of the city.

According to estimates, the infrastructure projects all around the world face a shortfall of 1 trillion USD funding each year. To cover this gap, there is a need for sustainable development, in order to economize the project without compromising the natural resources and also the environment. Sustainable development is meant to maintain the balance between social, economic and environmental needs and benefits (World Bank,2001). The Millennium Development Goals (MDG) acted to inspire the international community to develop an environment for development.

To achieve the objectives of Millennium Development Goals many countries developed and made progress by doing research to develop material and techniques to achieve the objective

of sustainability in infrastructures. In this connection, South Africa developed the concept and technique of warm mix asphalt (WMA) and made the application of this asphalt in road construction in November 2008. According to the literature, the benefits of the warm mixed asphalt are the less emission of greenhouse gases (GHG) during the mixing at the mixing plant and also at the paving process at the site. Also, lowering the temperature of asphalt can reduce the consumption of the renewable fuels while mixing and heating the material for mixing (IRF, 2013).

Similarly, the addition of rubberized asphalt (RA) with warm mixed asphalt (WMA) is an additional advantage toward sustainability. Various trials were conducted with different percentage of RA mixed with warm mixed asphalt and got the same result as the conventional asphalt at a higher temperature. But, the advantageous things to achieve the same properties at 20 C lower temperature than the conventional asphalt that are generally produced at temperature 160 C to 180 C. Producing the warm mixed asphalt is more preferred owing to the least emission of greenhouse gases during its production and also least usage of fossil fuels for the processing and mixing (IRF, 2013).

Currently, owing to the increased emission of greenhouse gases and the uncontrolled urbanization the length of road infrastructure is increased and still increasing. The asphalt work of increased road length is also not very much economical, and its paving process produces much greenhouse gases. To make the roads more sustainable of Delhi city, as the summer average temperature of Delhi city is between 25C to 45C, the new technology of road energy system is more suitable to make the roads more sustainable. The road energy system was first developed and used on trial basis in the Netherlands. Such technology is used to utilize the heat of asphalt pavements and use it in summer, as in summer the asphalt gets very hot. The heat of the asphalt is stored in underground aquifers and later in winter, the heat is used to warm the buildings. Until now, about thirteen projects have been completed with the system. As aforementioned, the average summer temperature of Delhi city is more feasible to install this technology and to use that heat for different purposes other than heating the buildings. It is also estimated that adopting this technology, there will be a reduction of 1600 ton CO2 emission annually (IRF, 2013).

Figure 02: Road energy system. *Source: Road Energy system, 2018*

Growing concept of climate change and sustainability encouraged the transportation professionals to integrate this concept into the transportation planning, designing, construction and maintenance and operation of the transportation infrastructures. In that regard, various techniques are developed and implemented. One of such technique is the process of micro-surfacing, which not only reduce the cost but also an environmentally friendly process by reducing the emission of greenhouse gases and fossil fuel consumption.

According to AppaRoa G et al various countries are adopting the energy conservation techniques in road construction and maintenance by using cold mix construction and recycling pavement. As it is known that for production of hot mix a lot of fossil fuel is used as raw materials and as main energy source, the hot mix plants depend upon their age and efficiency, on average uses 10 cubic meter of natural gas which in turns emits near 0.525kg of carbon and one ton of hot mix asphalt produce about 5.25 kg of carbon. If the techniques of cold mix asphalt and cold mix recycling is adopted the quantity of carbon emission to the atmosphere can control up to some extent (AppaRoa G, 2013). The production of aggregates also produces approximately 2.5 to 10 kg of CO2/ton and for asphalt, it is 221 kg CO2/ton (Dorchies (2008).

To control the emission of greenhouse gases the technology of cold mix (micro-surfacing) is developed and is very commonly used in Germany, Spain, and France since 1976 and it is introduced in India in 1999-2000. This technology is used mainly to maintain the road's surface by paving the cold mix on already road structure. The process includes recycling and reusing the existing pavement layer, after milling and pulverizing it into the specific aggregate size and then mixing it with asphalt emulsion and some ratio of water to make a slurry type mix and then apply in the required amount of thickness. The overall process is very cost effective and according to the principles of green roads or sustainability, because no heating is required at all for asphalt. The cold in-place recycling reduces the emission of fumes and other pollution associated with asphalt that is hazardous to the health of worker and environment (AppaRoa G, 2013).

Similarly, the concept of three R`s (reuse,recycle,repair) in sustainability is an important and most distinguishable concept. This concept can also be applied in road construction by recycling the existing asphalt and concrete pavements. The recycling of pavements is most common in Germany, Austria, and many other European countries. In India, more than 90 percent of the road pavements are bituminous and during their rehabilitation and maintenance, either the pavement material is entirely removed and dumped somewhere, or new layer is paved on the existing pavement structure that causes the burial of the non-renewable resources. To save the resources the recycling of pavements is the most justified and logical way to conserve the natural construction materials and to reduce the cost (Sharma, 2018).

The conservation of natural resources is becoming a challenge owing to the increase in urbanization in last few decades. India, one of the worlds most populated countries, will add like 404 million people to the cities in 2050 (United Nation, 2012). Considering the population, the production of waste material and their disposal will become a serious problem in India. The estimated Delhi 2016 population is 18.6 million (world population review 2018) and the quantity of plastic waste generated every day is almost 689 ton and it is the reason Delhi has earned the name of worst plastic polluting city in India (The pioneer, 2013). To handle the disposal of plastic waste they are generally burnt which causes environmental pollution. .

Figure 03: Road made of waste Plastic. *Source: Highways Industry, 2018*

Figure 04: Plastic road. *Source: Volkerwessels/PlasticRoad, 2018*

Sustainability of the road infrastructure is not a new concept but after the innovation of plastic roads open the doors for other inventions in road construction. The idea of solar roads is developed in the Netherlands to utilize the sunrays in a maximum way. The solar road is officially open for traffic in November 2014. This is the technique of combining road construction and photovoltaic to consume the clean, renewable energy in the form of electricity. Adopting this technique is most suitable one owing to the amount of sunlight in India all around the year. This is the most economical solution for the street lights and all related infrastructure to roads (Wattway, 2018).

Figure 05: Solar Road. *Source: Wattway, 2018*

Railways

Railways are also one of the important communication infrastructures that play a vital role in the economic development, along with economic importance the value of railways cannot be underestimated for the movement of passengers. Along with this other public transportation system has their significance in urban cities. The transportation system of the urban cities has a direct impact on the living standards both in terms of economic as well as social well-being. The uncontrolled urbanization of cities makes it difficult to cope with the challenge of transportation-related services that derive demand for other economic and social activities such as health, education, employment and many more. The transport infrastructure needs in a city are generally assessed from activities that have an impact on the city economic and social well-being of the population. Delhi, the capital of India, has the population of 25 million (world population review, 2018) and according to some estimates, the population will increase to 36 million in 2030 (prospects, 2014).

The growth in the population of the city is caused by the economic activities that lead to the rise in the per capita income. According to statistics, in 1980, per capita income in Delhi was US$ 92.6 which rose to US$ 2562.2 in 2011, which is almost 28 times increase in the per capita income. Rise in the per capita income ultimately lead to the increase in the size of house holdings: like personalized vehicles and ownership of cars in Delhi city increased from 400,000 in 1990 to 870,000 in 2000, and this further increased to 2173,000 in 2011 (Alam, 2015). Along with the number of personal vehicles, there are buses which are considered the backbone of Delhi city transport. These vehicles consume non-renewable fuels and they are considering to be the main supplier of greenhouse gases and pollution in Delhi city.

For successful urban planning and management, it is vital to provide public transportation along

with other required basic facilities for daily life with less damaging effect on the environment. To cope with the mobility issues in Delhi, planning and development department, along with road infrastructure, developed and still developing the Delhi Metro Rail (DMR). According to Delhi Metro Rail Corporation (DMRC), after the commissioning of the metro in 2002, Metro became one of the most crucial modes of public transport in Delhi. The total length of the metro network is about 213 km with 160 stations and according to report an average of 2.6 million people travel through metro on daily basis. But, after the Odd-Even scheme for lowering private car traffic was launched in Delhi the number of commuters further increased and crossed the 3 million figures on those days (IGLUS, 2016).

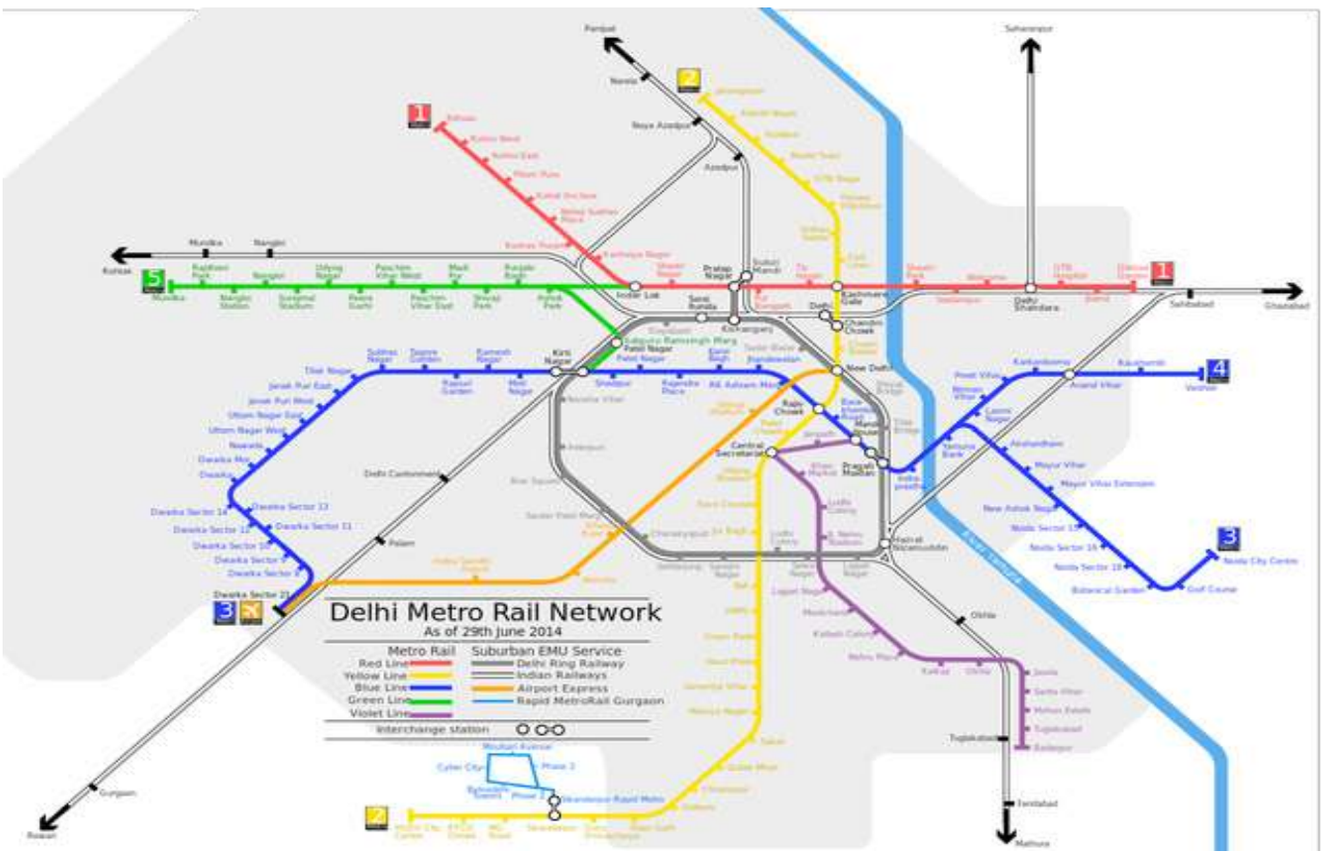

Figure 06: Delhi Metro Line. *Source: DMRC, Delhi Metro Rail, accessed 2018*

For sustainable railway operations, the most important factor is a clean energy supply to the trains and all related infrastructure of the railways. The metro lines and other public transport in the city are required to follow the pillars of sustainability in the urban areas and these pillars are social development, economic development, and environmental management. Social, economic and environmental indicators of sustainable development are focusing on the sustainable infrastructure projects. From social aspects of the Delhi metro rail have some issues of inaccessibility to the various metro station and passengers who have their own vehicles and they want to travel with public transport are facing problems in parking (Prathamesh Saygaonkar et al, 2016).

Various research and publication provide detail classification on various social and environmental impacts. Environmental impacts consist of high energy consumption, solid waste generation, greenhouse gas emission, air pollution, natural resource depletion and so on (Xiaolong Xue et al. 2015)

Environmental management of the sustainable city can be assessed from the amount of greenhouse gas emissions from all kinds of infrastructure but in this chapter discuss the transportation infrastructure. Limiting the discussion more into a narrow path by life cycle assessment of the public transport like the metro in the city (Cambero et al., 2015). Various studies researched the GHG emission of transportation system using LCA and calculated that GHG emissions produced during the life cycle of the infrastructure include the material production, construction, use/operations, maintenance, and end of life. Some only study or researched the one phase without considering the whole life cycle of the system, for instance, Chang and Kendall (2011) estimated the greenhouse gases (GHG) emission during the construction of the high-speed rail infrastructure from San Francisco to Anaheim.

Similarly, Hong and Kim (2004) studied the amount of energy consumption of subway station in four cities in South Korea and examine the various aspects, such as floor level, number of passengers at all stations. Doll and Balaban (2013) study and discussed the energy consumption and GHG emission during the operation phase of Delhi metro in India. Anderson et al. (2009) developed techniques and approaches for managers and developers of the metro to reduce the energy consumption. Che (2012) described that Urban Rail Transit (URT) is one of the significant elements of the urban ecological environment and it is our basic responsibilities to study and design the greenest transportation system in our cities. Topalovic et al. (2012) and Poudenx (2008) both studied the environmental impact of rail transit system and GHG emission and pointed out that such kind of public transport like URT will reduce private cars movements and that will, in turn, reduce the consumption of fossil fuels and reduce emission of GHG to the environment.

To reduce the emission of GHG, Delhi metro is shifting from fossil fuel produced power to more renewably produced power, and DMRC are initiated the process and already got a platinum rating from the Indian Green Building Council for installation of solar power projects. DMRC's consumption of electricity is expected to be 300 megawatts over the next five years. It has currently 17 megawatts of rooftop solar power capacity installed on the top of some stations and it will further increase to 50 megawatts in next five years (Saurabh Mahapatra, 2017).

Owing to the limited research on the sustainable construction of railways, metro lines, and the Light Rail Transit (LRT) in the cities like Delhi, they are not reviewed in detail. Also, the unavailability of literature in the specified area of urban transportation infrastructure the subjects are not explained in detail.

Problems to sustainable Infrastructure

Delhi is one of the leading metropolitan city in terms of economy, but it is the 11th most polluted city in the World. In the past two years, level of pollutants is also increasing day by day and affecting the health of people in the city. Major problems of increasing the pollution in the city are increased in numbers of vehicles near about 97 percent (Sattiraju, 2016) over the last decade, increase in pollution, following the old construction methods, lack of water conservation and waste management plants, uses of old traditional vehicles and so on. Some of the drawbacks have a great effect on the development of sustainable infrastructure. Major downsides are:

-Population Increase and Urban Growth: The Population of New Delhi is increasing due to the immigrants. From 1951 to 2017, the total population of Delhi has steep arise from 1.74 mil-

lion (Grover, 2015) to 18.75 million. The density of population has also increased from 4194 to 11320 per sq. km. The Urban Population has also increased from 82.4 % in 1951 to 97.5% in 2017 and the population of Rural Area has decreased. Also, the Rural Area of the Delhi has already shrunk compare to Urban area of Delhi. Major migration of people has occurred due to neighboring areas such as Uttar Pradesh, Haryana, Punjab and Bihar. These problems are affecting the infrastructure and urban space.

-Deficiency of Land: Total land area of Delhi is 1485 sqkm, out of which 783 sqkm covers in rural area and 700km2 covers in urban. But, as the time passed, the development of urban area has been increasing. In that most of the urban land has been occupied by the immigrants, housing construction, metros, complex, factories and many more. Right now, the situation of Delhi is worst, because they do not have efficient area for implication of sustainability development.

-Environmental Changes: The environment changes due to the overpopulation, overuse of resources, by road dust, industries, unclean engines in transportation especially diesel-powered buses and trucks, and so forth. As per study of IIT Kanpur, major environmental changes have been occurred by road dust (Sattiraju, 2016) from poorly maintained roads. The Delhi Government has also banned the construction sites, who are using the old traditional techniques, for improving the environmental conditions. Also, the Badarpur Thermal Power Plant and bituminous plants was temporarily closed for improving the air quality.

-Use of Old Construction Methods and Resources: While construction in the past years, the infrastructure companies have only focused on the final product, not taking care about the lifecycle and environmental conditions (J M Reid, June, 2008). They follow the traditional or conventional methods of construction. These methods brutally and severely affected health of people and the environment. The exploitation of the environment that leads to exploit the nature, land degradation and the climatic changes.

-Use of Older Transport System: The old vehicles are effecting on the quality of air. Majorly, diesel engine is one of the major contributor of emission of gases in the air. As the engine become old, Emission of diesel is more, and it effects on the health of people. The older vehicle also effects the life of roads and their sustainability.

-Political Issues: This issue is one of the major problem for the sustainable infrastructure. In this, the Delhi has a new party government named as Aam Adami Party and, the party is run by the Mr. Arvind Kejriwal, who worked as a joint commissioner in the Income Tax Department. Due the lack of political knowledge he faces difficulties to manage the finance of Delhi government. For example, The Central Government have given the 787 crores to the Delhi government for taking steps towards cleaning the environment and sustainable infrastructure. But, Delhi government didn’t use a dime for improving the infrastructure and air quality. And the opposition party has also claimed that the “"Instead of using the money which is lying idle, he is busy aiming at other state governments and the Centre instead of doing his bit" (Indian Today, 2015).

Apart from that, Delhi has also had lack of awareness about systems and tools to quantify the greenhouse emissions gases. The major issues faced today in business of infrastructure development over the next couple of years are thought to be depravation, political and regulatory risk, and access to financing and macroeconomic instability. In the case of Delhi, denial mode of payments from the government that go against contractual agreements are perceived as highly likely to influence future investment decisions. One of the other constraints, access to financing, touches upon the core feature of infrastructure: its long-term payback period. It affects financi-

ers and investors who are looking for long-term and steady returns. After the global financial crisis though, long-term lending is not easy to get, India not being an exception.

Taking infrastructure as one illustration, Infrastructure is the foundation of monetary development in entrepreneur social orders making the exchange of products and enterprises conceivable. Building railways, ports, extensions, and interstate roadways encouraged monetary change and success. This development was made possible through far-located arrangement and speculation by the legislature and by the way that conveying open assets made pioneers more powerful. The current circumstance is the same; we require open speculation to goal the advancement of green framework. We must create green transportation for individuals and merchandise and additionally for the generation, transmission and capacity of clean vitality. The advancement of brilliant framework foundation is fundamental for the improvement of disseminated, decentralized age of energy.

-Lack of awareness toward sustainability.
-Governance problem
-Uncontrolled urbanization

For sustainable infrastructure in Delhi city it is important and crucial to compare the the city with a city who already developed a sustainable infrastructure, to make the city at par with goals of sustainable city.

Case Study of Singapore City

Introduction

A crucial aspect in the drive towards sustainability of any city is the aspect of transport management. Transportation systems have three specific divisions which are: land, water and air transport systems (Meyer, 2009). These broad divisions have definite ways by which they operate and with the increasing global discuss on sustainability, modern environmental-friendly methods have been devised to make them more sustainable.

In the following sub-headings, a robust discussion will be had on how Singapore developed a sustainable land transport system with direct emphasis on its railway and road transportation. This will begin with an overview of Singapore, then we will look at the infrastructure policies of their land transport system done with a view to drawing out some applicable lessons for Delhi City's push towards sustainability.

Overview of Singapore City

Singapore is an independent republic in Southeast Asia, made up of one (1) main island and about 50 small adjacent islets of the southern tip of the Malay Peninsula. The main island, Singapore Island, is separated from Malaysia on the north by the narrow Johor Strait and is linked by road and rail to the Malaysian city of Johor Baharu. On the south, Singapore Island is separated from Indonesia's Riau Archipelago by the Singapore Strait, an important shipping channel linking the Indian Ocean to the west with the South China Sea on the east (Ulack, 2009). See figure 7 below.

Figure 07: Map of Singapore. *Source: Microsoft Encarta, 2009*

Singapore is one of the most densely populated independent countries in the world (Lee, Kwon, Cho, Kim, & Lee, 2016). Its total land area is 597 sqkm with a population of 5.5 million (as per 2014) means that it has a very high population density of 9,213 persons per square kilometer. This is higher than the 6,500 people per km2 given by Hale and Charles (2008).

Since Singapore is a small island with a high population density, the number of vehicles on road is restricted to limit pollution and congestion (Boey & Su, 2014). This is done using several deliberate bottlenecks. Vehicle owners are required to pay for high duties (one-and-a-half) times the vehicle's market value and bid for a Singaporean Certificate of Entitlement (COE), which allows the vehicle to run on the road. Therefore, despite the population of 5.5 million, only 0.65 million vehicles are registered and other transport modes such as foot, bicycles, bus, taxis and train (Mass Rapid Transit or Light Rail Transit) are used more generally (Lee, Kwon, Cho, Kim, & Lee, 2016).

Challeneges

The lack of physical space coupled the fast-growing population of Singapore have combined to make traffic management progressively problematic over the years. It is even projected that by 2020, travel demand is expected to rise from 8.9 million journeys per day to about 14.3 million, signifying the marked increase in the city-state's population (C4O Cities Climate Leadership Group, n.d.).

Concurrently, Singapore faces major constraints in space, with 12% of land already occupied by the 3,300 km-road networks and another 15% devoted to housing. Expanding the road network to address transport demand has not been a sustainable option (C4O Cities Climate Leadership Group, n.d.). Instead, the Singapore government has utilized policy and technology

to manage transport demand and supply, maximizing the current sustainable systems while minimizing more environmentally impactful modes of transit.
This approach by the Singaporean authorities is smart because in more recent years an understanding has emerged that increasing capacity of roads can lead to greater demand because of "induced travel" (also referred to as "latent demand" or "generated traffic") (Pojani & Stead, 2015). Induced travel has the negative consequence of restoring road congestion levels to its pre-expansion levels with only marginal savings made in time of travels. According to Pojani & Stead (2015), induced travel is due to diversion of travel from: (1) other lower volume hours of the day to more peak hour use of improved facilities; (2) parallel commuting routes; and (3) public transportation.

In further studies, researchers have found that road investments also have adverse long-term effects on traffic congestion (Pojani & Stead, 2015). This is partly because road construction itself is disruptive for densely-built urban areas. In many cases, the demolition of buildings and/or open space is necessary, and these actions harm the environment, thus unsustainable (Boey & Su, 2014). In developing countries, new road construction is very often seen as a measure of modernization. Consequently, governments have often allocated public expenditures in favor of new road construction at the expense of other urban transport investments and the maintenance of existing infrastructure. But the reality on ground is that in terms of road investment, evidence to date suggests that developing cities need to focus their resources on existing road maintenance rather than new road construction (Pojani & Stead, 2015).

Land Transport System

In the light of the challenges highlighted in the previous sub-heading, Singapore developed what can best be described as the carrot and stick approach to managing land transportation systems. Simply put, this method involves enticing the public with efficient public transport and restraining private car ownership and usage using a variety of policies ranging from fiscal measures (high custom duties, vehicle quotas) to car usage restraint policies (area licensing, electronic road pricing, variable pricing) (Teriman, Yigitcanlar, & Mayere, 2010).

Singapore's current land transport system came to be because of a 25-year development strategy incorporating a comprehensive land use and infrastructure plan which was drawn up in 1971 and has been regularly revised to ensure workability and efficiency. This is shown in figure 2 below. At the helm of this plan was the construction of high density housing estates, or New Towns, connected by a Mass Rapid Transit (MRT) system linking them to the central business district and the industrial estates (Teriman, Yigitcanlar, & Mayere, 2010).

Figure 08: Development plans for land Transport System. *Source: Sun, 2013*

In summary, the land transport system of Singapore emphasizes a “balanced” city. This is one in which the cities are not adjusted to cars, rather it is a city that prioritizes the people that will make use of the transport system. Based on this guiding transport policy, the following are key features of the Land Transport System of Singapore:

- Improve public transport services parallel with highway/ street growth
- Developed coordinated modes
- Encourage pedestrians
- Enhance cities’ livability → sustainability (Sun, 2013)

Road Transport System

Singapore’s treatment of its road transport system follows its already established Mass Rapid Transit (MRT) master plan. In this case, it is called the Intelligent Transport System. Singapore has implemented a sophisticated Intelligent Transport System (ITS), which uses data collection and ITS solutions to keep road traffic running safely and smoothly (C4O Cities Climate Leadership Group, n.d.). The ITS acts in concert with many other transport initiatives: free public transportation in pre-morning peak hours, a vehicle quota system, a congestion charge, and an extensive public transport system (Hale & Charles, 2008). The overall idea behind the decision to use these measures is to reduce traffic congestion and actively discourage people from doing so.

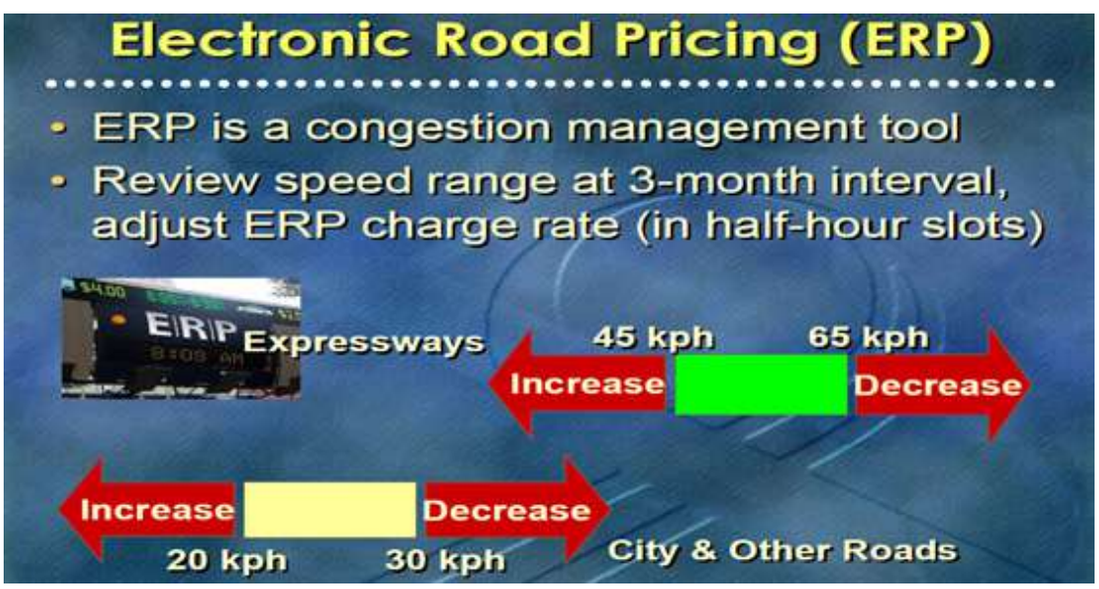

Figure 09: Cycling plan for Sustainable Singapore. *Source: Sun, 2013*

Other ITS elements include an expressway monitoring and advisory system, alerting motorists to traffic accidents on major roads; a GPS system installed on city taxis, which monitors and reports on traffic conditions around the city; and a parking policy in which the government determines the minimum parking provision and empowers car park operators to determine charges based on demand (C4O Cities Climate Leadership Group, n.d.). Information from the systems feeds into the ITS Operations Control Centre, which consolidates the data and provides real-time traffic information to the public. All vehicle owners and drivers in Singapore can access this traffic information via a web portal called ONE MOTORING. This portal also provides information on current ERP rates, sections where road works are in progress, traffic images of major

expressways, traffic news, travel time calculator, road maps and street directions, and parking information (Lee, Kwon, Cho, Kim, & Lee, 2016). In addition, this portal can be accessed with mobile devices and offers advice and tips on how to buy, sell and maintain their vehicles. Aside motorized road transport considerations; appreciable attention is given to cycling and walking. Both are mainly presented as means of arriving at rail stations or bus stops. Pedestrian infrastructure is restricted to climate compatibility and amenity issues such as covered and/or raised walkways (Hale & Charles, 2008). As Sun (2013) highlights, the overall walking experience has the following features which aims to ensure sustainability and truly livable environments:

- Sheltered link-ways
- Lifts at pedestrian overhead bridges
- 20km of noise barriers along elevated tracks.

It is important to state at this juncture that the road transport management system in Singapore ensures that car owners purchase only those vehicles that have a low carbon emission rating. This is achieved in part by providing advice on the carbon emission rating of different vehicle brands. In addition, low carbon emission car models enjoy rebates between $5,000 and $20,000; plus, a surcharge levied for high carbon emission car models (Sun, 2013). Lastly vehicle owners are required to pay for high duties (one-and-a-half) times the vehicle's market value and bid for a Singaporean Certificate of Entitlement (COE), which allows the vehicle to run on the road. The COE is the quota license for all the bid applier in the auction which gives him/her the right to own and register a car or other vehicle for at least the period of ten years. This become quite expensive and costly when the demand is very high. Thus, it put a more stringent thrust on owning a personnel vehicle and encouraging public transport, which ultimately adds value to environmental friendly tactics and hence toward the sustainability. These deliberate measures help to maintain Singapore's drive towards having a truly environment-friendly road transport system.

Figure 10: Cycling plan for Sustainable Singapore. *Source: Sun, 2013*

Rail Transport System

The second aspect of the Land Transport System is the Mass Rapid Transit (MRT) which appears to be the focal point of the entire transport system in Singapore (Hale & Charles, 2008). The level of integration between bus and rail is good, and reasonably well-integrated into shopping, residential and commercial areas of the city. Such high level of coordination makes it possible for Singapore to have eight (8) in ten (10) households within a 10-minute walk of a rail station (Sun, 2013).

In designing the rail way system, consideration was given to the specific needs of the residents of the area, type of institutions along the train's track, and potentials for future development (PwC, 2016). At present, there is a projection to have five (5) fully functional rail lines. Singapore also uses sophisticated elevated and completely segregated systems of Light Rapid Transit (LRT). These three LRT systems act as feeders to serve the MRT lines. The MRT lines link the high-density housing estates, or New Towns, to the central business district and industrial estates. Currently, three (3) radial routes, representing a total of 109 km of tracks, have been built and extension programs are planned (Teriman, Yigitcanlar, & Mayere, 2010).

Conclusion

In this case study discussion, we have looked at the road and rail transport system of Singapore focusing on how it has used them to effectively fight traffic congestion and air pollution despite its huge population (which is still growing fast) and scarce land. Already road transport networks occupy about 12% of Singapore's total usable land area, second only to housing which takes up 15% of land (C4O Cities Climate Leadership Group, n.d;Teriman, Yigitcanlar, & Mayere, 2010). We also highlighted that the effectiveness of the Singaporean plan rests on years of coordinated planning that was hinged on efficient land use policy.

It is up for debate whether road-based or rail-based public transport should be emphasized in medium-sized developing cities. Movement patterns in cities are influenced by both population size and population density, especially the latter (Pojani & Stead, 2015). In urban areas with a small but dispersed population, the provision of either rail- or road-based public transport might not be economically viable. Rail should have a definite advantage over road-based systems to justify implementation in smaller and/or dispersed cities, since new rail systems are very expensive to construct and operate. A full cost-benefit analysis of both options should guide decision-making.

Comparison Between Delhi and Singapore

Singapore implemented several systems to reduce the traffic congestion such as; Intelligent Transport System (ITS), which uses data collection and ITS solutions to keep road traffic running safely and smoothly (C4O Cities Climate Leadership Group, n.d.). The ITS proceeds through several kinds of transport initiatives such as; free public transportation in pre-morning peak hours, a vehicle quota system, a congestion charge and an extensive public transport system (Hale & Charles, 2008).

One of the great tools used for solving the problem of traffic congestion is the developed Electronic Road Pricing (ERP). This technique ERP uses a short-range radio communication system to deduct charges from smart cards inserted in all vehicles, and charges varies according

to traffic flows and the time of day (C4O Cities Climate Leadership Group, n.d.).

There are also other developed sophisticated techniques related to ITS elements, in which Singapore implemented it such as; an expressway monitoring and advisory system, alerting motorists to traffic accidents on major roads; a GPS system installed on city taxis, which monitors and reports on traffic conditions around the city; and a parking policy in which the government determines the minimum parking provision and empowers car park operators to determine charges based on demand (C4O Cities Climate Leadership Group, n.d.).

Vehicle owners are required to pay for high duties (one-and-a-half) times the vehicle's market value and bid for a Singaporean Certificate of Entitlement (COE), which allows the vehicle to run on the road. The COE is the quota license for all the bid applier in the auction which gives him/her the right to own and register a car or other vehicle for at least the period of ten years.

Singapore also improved and enhanced the pedestrian infrastructure to adapt the climate conditions and provided all the comfortable ways for their people such as; covered and/or raised walkways; they took care for cycling and walking. Both are mainly presented as means of arriving at rail stations or bus stops (Hale & Charles, 2008). Some road sustainable characteristics found in Singapore as; Sheltered link ways, Lifts at pedestrian overhead bridges and 20Km of noise barriers along elevated tracks.

For the environmental preservations, Singapore also achieved a noticeable progress in ensuring the reduction of carbon emission rating by making sure that car owners purchase only the cars with low carbon emission rating. Singapore government encouraged car owners with low carbon emission by providing them rebates and high surcharges for those who has high carbon emission cars (Sun, 2013).

New Delhi faces a substantial amount of challenges to reduce the traffic congestion and to improve the road networks towards sustainability. Existing problems in the road infrastructure do not allow the Indian authorities and government to develop the road networks. Besides, Singapore uses developed technological systems to tackle and mitigate the traffic congestion, but Delhi must solve the existing issues of the road infrastructure first in order to apply and implement the technological techniques on road transport systems and also Delhi has to investigate and to solve the environmental problems caused by the current motorized transportation systems.

Some features of the existing problems, it is well known that Delhi has more vehicular density than any other developing country standards and regulations, in which the limit for road space area should be 20 % for the urban area but in Delhi it is already 21 % of the land area space, so any increase in the road capacity will meet automatically a demand in travel. During 1989, the motorized transports caused 70 % of the total air pollution. Al large proportion of the travel demand was achieved by old buses which are not suitable for usage. Regarding the arterials roads of Delhi, bicycles are responsible for 30% of the traffic. Bicycles and Rickshaws are usually using the most left line of the road, which do not allow for the buses the availability to stop at the designed bus stops normally, buses stop in the middle of the road and causes traffic for all the lines of the road. Non-motorized transports should have a specific study for infra-structure planning (Satish Kumar Beella).

New Delhi government and authorities have started to get rid of some problems by legislation some rules and recommendations to push Delhi towards sustainability and to improve its infrastructure relatively such as;

-The BIS (Bureau of Indian standards) recommended fuel with specific quality for Gasoline and Diesel in period of 200-2005 and after 2005 also, accordingly, the minister of petroleum supplied Diesel with 0.05 m/m Sulphur to the capital region area starting from 2001 (Satish Kumar Beella).

-Prevention and prohibition of 15 years old commercial vehicles and ban on registration of new Rickshaw and replacement it with taxis of new vehicles using clean fuels as compressed natural gas (Satish Kumar Beella).

-All buses should be changed to compressed natural gas fuels instead of diesel. The government of Delhi will not concentrate on the sales tax on compressed natural gas to encourage the use of the clean environmental fuel and mitigate the emissions (Satish Kumar Beella).

-Several flyovers and underpasses are under construction in Delhi to avoid traffic congestions and facilitate the traffic movement (Satish Kumar Beella).

-Many of Expressways are also under construction in Delhi, in order not to mix with the local roads to produce smooth flow of the traffic (Satish Kumar Beella).

-Mass rapid transit system is involved also to decrease the congestion issue and fulfill the expected demand travel trips on the future (Satish Kumar Beella).

Railway Networks

Singapore has a well-developed Mass Rapid Transit (MRT) which appears to be the focal point of the entire transport system in Singapore (Hale & Charles, 2008). The level of integration between bus and rail is good, and reasonably well-integrated into shopping, residential and commercial areas of the city. Such high level of coordination makes it possible for Singapore to have eight in ten households within a 10-minute walk of a rail station (Sun, 2013).

In designing the rail way system, consideration was given to the specific needs of the residents of the area, type of institutions along the train’s track, and potentials for future development [4]. At present, there is a projection to have five fully functional rail lines. Singapore also uses sophisticated elevated and completely segregated systems of Light Rapid Transit (LRT). These three LRT systems act as feeders to serve the MRT lines. The MRT lines link the high-density housing estates, or New Towns, to the central business district and industrial estates. Currently, three radial routes, representing a total of 109 km of tracks, have been built and extension programs are planned (Teriman, Yigitcanlar, & Mayere, 2010).

New Delhi has one of the top promising metro networks in the world currently, however like any other facility in Delhi, it suffers from some problems and challenges. There are considerable amount constraints that affect the efficiency of the metro such as; a lot of locations are not easily accessible from the adjoining road networks due to the existence of buses. There is a lack of pedestrian's facilities in the areas and places near the stations. There are no tracks and routes for bicycle, there is a traffic management around the metro stations and the information systems for the commuters is not available. On the other hand, there are promising results and consequences resulting from the metro project such as; it was observed that most of the passengers of the Metro are from youth, passengers who have the lower income are the big sample of the utilizers of the metro services, significant

amount of car ownerships prefers metro services also (Prathamesh Saygaonkar, 2016).

It was estimated that Delhi metro had kept about 230000 vehicles off the road, which was a great attempt to fight the traffic road congestion. It also helped in reducing the amount of road accidents; it was observed that by the construction of metro, for somehow the amount of road accidents decreased from 2015 accidents in 2008 to 1548 in 2016, moreover, it reduced the consumption of fuels, preserve the environment and mitigates the air pollution. It is the first metro to deal with the carbon issue in the world, in addition to applying renewable technologies and techniques to preserve the environment such as; braking technology to generate energy, installing solar panels to generate electricity and compliance to the standard policies of carbon emissions (Metro, 2018)

Success factors for sustainable city

Since the dawn of the 21st century, global discourse on building new cities has mainly centered on adapting new cities to the existing environmental or natural limitations they have. This restraint placed on cities is not targeted at discouraging technological advancement in any way, but rather seeks to make it more efficient to the society while reducing the damage posed to the biosphere. Thus, when cities pursue this goal and implement policies aimed at attaining lower pollution levels and enhancing the natural environment, they are said to be sustainable cities.

However, the path to this objective is fraught with many challenges. In recognition of this fact, this paper focuses on the underlying factors that are responsible for determining whether a city's attempt towards sustainability will be successful. The following success factors for sustainable cities have been identified, drawing lessons from cities that have made appreciable attempt at making their cities more sustainable.

-Communication
In any integrated sustainable city (re)development plan, communication is very essential as it is the foremost factor that creates the link between the various actors in the program. But this type of communication is all about being able to make the right connection by exchanging the right message and information on the right moment and at the right level to the right stakeholders. So, without good communication the integrated approach to attaining sustainable cities will not work. Or, to turn it around, with good communication city developers can make urban (re) development even more successful.

-Managing Knowledge and Technological Innovations
The managing of knowledge and technical innovations is one of the success factors to achieve a sustainable city development. City development projects have to cope with volumes of data coming from different fields in different (technical) languages and with different uncertainties. And to successfully integrate all aspects into a (re)development process, enough knowledge about (the values of) the specific innovations as well as the costs of implementation should be available.

-Stakeholder Benefits
As mentioned earlier, an integrated approach towards achieving a sustainable city is best because it brings together the different segments of the city together through coordinated discussions. This invariably means that there are several stakeholders who will play one major role or the other in this drive. So, a strategy with clear benefits attributed to individual stakeholders is a success factor that will be notable in the continuous feedback received from the stakehold-

ers, indicating the level of satisfaction or dissatisfaction of the Smart City elements. Strategies that are developed based on real needs are more likely to have a measurable outcome. Hence, these benefits should be very clear to both the citizens, stakeholders and governments.

-Clarity
Whereas the previous factor emphasizes general communication of plans, ideas and policies to all the players in the sustainable city effort, clarity here is concerned with ensuring that the plan is easily understood by residents and businesses. Although information and communication technology are fast becoming a basic city infrastructure, it is still advisable for a sustainable city plan to include examples and outcomes that can be as clear as a “ribbon cutting” for a new bridge, building or road. Public messaging and branding of a sustainable city strategy is key to support the focusing of initiatives, and to remind staff and the public of the key reasons for undertaking projects. Benefits and outcomes drive understanding and key-in.

-Regional Alignment with A Community Focus
A good sustainable city strategy should strengthen connections and collaboration within the region. This implies that businesses and residents, including travelers, do not see (or try to draw) city borders and expect continuity and expansion of services. Thus, a successful sustainable city plan must encourage regional economic development that apply across the region. For this to be effective, a city developing their strategy should be specific, focusing on enhancing the competitive advantage of the peoples of that community as a means of attracting growth.

-Urban Integration
Integration of technology within the public realm is an emerging trend in most cities globally. Including an urban planning component within the sustainable city plan is critical to improving the quality of life for citizens. As a matter of fact, that is the general objective of sustainability: to provide citizens with healthy, truly habitable cities.

At present, there is evidence of technology being quickly deployed in our communities with little thought to the impact on customer service, or the resident experience. Often, these technologies were not planned for or were not coordinated with other departments. Consideration should be given to developing the sustainable city as an integrated effort within the urban master plan process. This approach ensures that the conversation around technology and the built environment is happening at the highest level. The best technology deployments are those that provide benefits to the community, are not visually intrusive in the public realm, and are implemented with a long-term vision.

-Efficient Supply Chain
Another important success factor of sustainable city is the creation of a reliable supply chain. This depends primarily on the interconnection and coordination of all participants in the process of delivery. For this to be achieved, there must be well-developed transportation system and city logistics. Without a quality-developed transportation system, logistics would not be able to realize its advantages in the overall process. The development of a transport system cannot be realized by itself but requires the efforts of the public and private sectors.

Fast broadband internet, information technologies and assorted services that will be developed in the future on these platforms (smart phones, smart city, sustainable urban mobility plans), should affect future ways of doing business which will certainly open many possibilities and will emphasize the need for interactivity among all participants of the supply chain. This mainly refers to the coordination of transport, with a focus on better organization and management of

urban transport. Reducing transportation time, I the supply chain provides savings in cost of delivery, carbon emission and traffic congestion which all marks of an “unsustainable city”.

-Performance Indicators
There are several different Key Performance Indicators (KPIs) that have and are being developed by different organizations including ISO (organization setting international standards) and ITU (International Telecommunication Union) through the UN. Determining the KPIs that are relevant to an individual city is a critical discussion topic as these become the reporting yardstick over time for both internal operations as well as the outward message to the residential and business community. The key consideration is to develop KPIs that are meaningful to citizens and to those who are considering living or do business in the community. Tracking and reporting these in an easily understood format, often through dashboards, is an important element of a sustainable city.

-Creating a Lasting Smart City Culture
One of the reasons that many cities invest time in developing a sustainable city strategy is to enhance and integrate the implementation of information and communications technology within the organization. This is often the starting point for removal of barriers and bottlenecks that might exist. Ensuring that there is “open data” policy is a good way to initiate this discussion. The involvement of all relevant stakeholders within the organization is key to creating a culture of buy-in that goes beyond the creation of the sustainable city plan. Ongoing coordination and sharing of challenges and successes (starting with the early wins) as part of the Smart City governance is key to long-term success.

Characteristics of Sustainable Infrastructure

Roads

In the recent years, Delhi has turned out to be most polluted city in the world. There are so many drawbacks of enhancing the pollution, but one of the biggest culprit is large and small scale construction in Delhi-NCR, and their methods of constructions are worst. Also, the companies have only focused on the final product, not being take care of lifecycle of the project and environmental conditions. So, for that correction, the Delhi government follows the green highways policy 2015 (Barar, 2016). The aim of the policy is “to develop eco-friendly National Highways with the participation of the community, farmers, NGOs, private sector, institutions, government agencies and the Forest Department for economic growth and development in a sustainable manner”, according to the policy document (The Hindu Newspaper, 2015).

Design Consideration to make Roads Green

To formulate the green highway policy, basic design consideration of the sustainable roads accumulate (Barar, 2016). These are:

-To make an initial action plan for preserving the natural beauty of environment while designing.
-Minimum utilization of non-renewable resources, materials and products.
-Use of Cold Mix Asphalt or Warm Mix Asphalt in lieu of Hot Mix Asphalt is to be considered in design stage after considering quality of road, economic considerations and life of designed.
-Do the survey and inspection of fly ash and other industrial waste products, which can easily use in the flexible or rigid pavement construction.

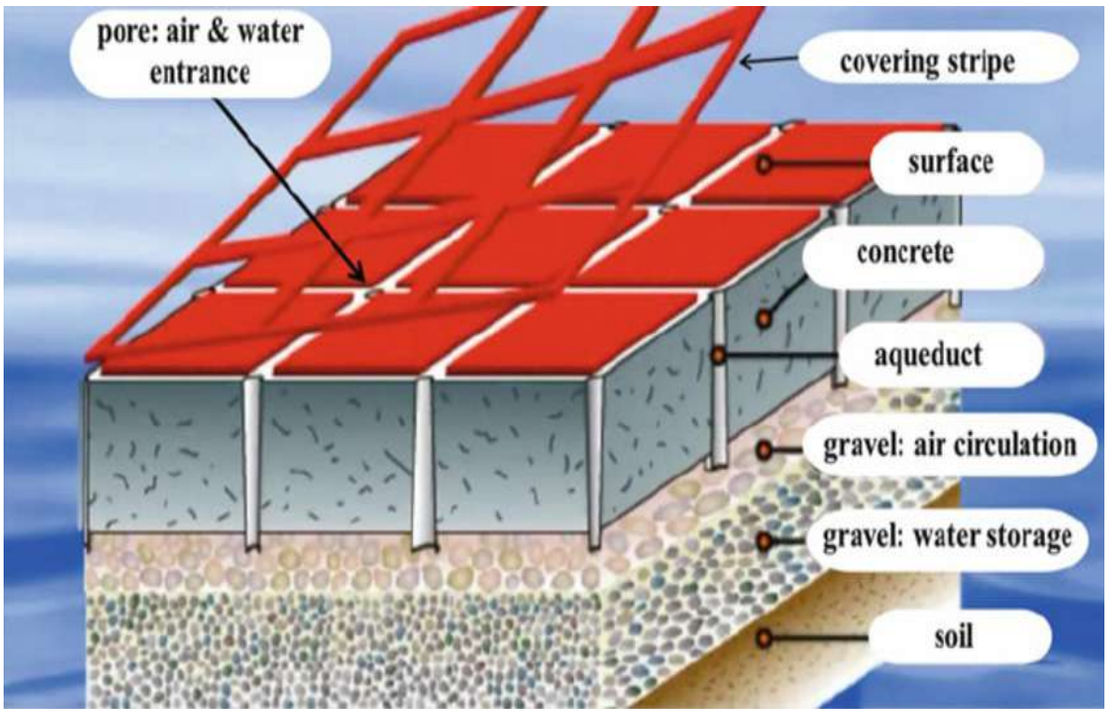

Figure 11: Low carbon Non-Cement Soil Pavement. *Source: Chung-Ming li,2016*

Materials

In general terms, the choices of sustainability practices for roads should be one or more of the following (Ahlstorm, 2014):

- Try to avoid the use of virgin material instead of recycled, co product and waste materials (RCWMs)
- Try to avoid the use of virgin material for improving the mix design and enhanced longevity.
- Try to avoid the impacts of material production by improving efficiency and reducing emissions.

For the sustainability practices of roads have been divided into different applications:

a. Aggregates:

In the pavement design mix, aggregates has a highest proportion whether used with or without binders (Ahlstorm, 2014). Although, aggregates are cheaper compare to other ingredients of the mix and have a less environmental impact.

Typical volumes of aggregates in dense-graded asphalt concrete and in dense-graded hydraulic cement concrete.

But they have huge impact on pavement sustainability, because they are consuming too much quantities. It will affect our future because it is non-renewable natural resource. It is nothing to impossible to manufacture the aggregates. Aggregates sustainability practices includes:

b. Asphalt Materials

Asphalt materials include binders or asphalt concrete mixtures (Ahlstorm, 2014). For sustainable road, we have to use the Recycled Asphalt Concrete instead of primary aggregate and binder. And, Delhi govt. wants to increase the resistance to fatigue, plastic deformation and durability of pavement. Asphalt sustainability practices includes:
-Try to avoid the use of primary aggregates and binder, increase the use of Recycled Asphalt Concrete.
-Always use the waste oil (Cooking oil and used oil) instead of non-renewable fuel.
-Always use the Warm Mix Asphalt or Cold Mix Asphalt for reducing the gases and energy emission in the mixture production.
-Always use the modified polymer and CMRB for increasing the pavement surface life.
-Accept the Open Graded Frictional Course (OFGC) technology for making roads in Delhi for avoiding the environmental problems.

c. Concrete Materials

Concrete is a versatile material and, we had already enhance our property towards sustainability. In the Hydraulic Cement Concrete, greenhouse gases emission and energy are severe, become a major drawback for the rigid pavement. So for reduction, it's better to use the Fly ash and Slag Cement. For concrete sustainability practices includes:
-Use the Fly Ash or Slag cement up to 20 percent (Congress, 2013) of total cementitious material in the concrete mixture.
-Try to use the recycled wastewater for the production of concrete mixture.
-Try to get the material by local availability, and avoid as much as we can transportation (Barge, Rail or Trucks) used for placing the aggregates.
-Try to use the alternative oil for improving the ready mix plant efficiency.

Railways

New Delhi Railway Station

Indian Railways is the world's largest transportation system, spread over all over the India. In Indian Railway, there are 12 busy railway stations in terms of frequency of train and passenger movement and New Delhi Railway Station is one of them. The infrastructure and resources of the railway station are so old, they want changes. The Indian railway has already taken steps towards the green station. For the requirement of green environment in station, Indian Railway are doing work on low carbon mass transportation system, reducing the carbon footprints, uses of renewable energy, alternate fuel, water conservation, green buildings, bio toilets and solid waste management. Also, they want to renovate the New Delhi Railway Station (Swach Rail as a part of Swach Bharat). For the redevelopment of New Delhi Railway station, the Indian Railway consider the five sustainable pillars of environmental sustainability (Railway M. o., 2009), these are:

1. Energy efficiency
2. Material and Resource Conservation
3. Indoor Environmental Quality
4. Operation and maintenance
5. Water conservation.

Sustainable Strategy for Railway Station

For the redevelopment of New Delhi railway station, Sustainable strategies for station configuration (Railway M. o., 2009) are:

- Space Planning: Plan space to minimize overall excavation required. Optimize plant room arrangement to suit planning and design manual and efficient utility or duct routing. Consider amalgamating MEP plant and equipment rooms of similar function where there is no statutory separation required. Station configurations that efficiently utilize the geometry of the structure to provide strength and reduce material use are encouraged.

- Improving the Vertical Circulation Elements (VCE): For redevelopment, consider the percentage of VCEs as per the present and future conditions. Also, it has the capacity to deal with both without weight or overabundance. Utilize control frameworks that consider adaptability to acclimate to varieties in the quantity of users and in the peak direction of activity.
- Choice of Elevator and Escalator: Consider the Elevator and Escalator that require the minimum space for the installation, use less energy or use renewable energy, and have longer span life and less maintenance.
- Use of Renewable Energy Light and Ventilation: Try to avoid the use of artificial light majorly in station roof area, railway pole and signals. Try to use the natural ventilation wherever possible.

Characteristics of Green Railways

On the behalf of sustainable strategy for making sustainable New Delhi railway station, we must focus on major area, such as low carbon mass transportation system, reducing the carbon footprints, uses of renewable energy, alternate fuel, water conservation plant, green building, and other green initiatives (Railway I. , 2016). Their characteristics are as per sustainability:

Figure 12: Solar Roof Top, Jammu, India. *Source: Railway I. , 2016*

- Use of Alternate Fuel: From the past few years, Indian Railway has right now using the BIO DIESEL instead of Diesel Locomotive. And, they are also promoting the use of CNG (Compressed Natural Gas) and Solar Energy in mechanical asset. dia. One of them is in Delhi. Major purpose of utilizing the waste water is to reduce the water bills and consumption of fresh water.

- Use of Green Building policy: Indian Railways is already accepted the policy for first green buildings, is located at Secunderabad, India. Similarly, Indian railway wants to accept the green building concept for New Delhi Railway Station. By the green building concept, it helps to avoid the use of non-renewable resources, reduce carbon footprint, waste management strategy, water conservation, and many more.

Figure 13: Bio Diesel Engine. *Source: Railway I. , 2016*

Figure 14: Bio Toilet, *Source: Railway I. , 2016*

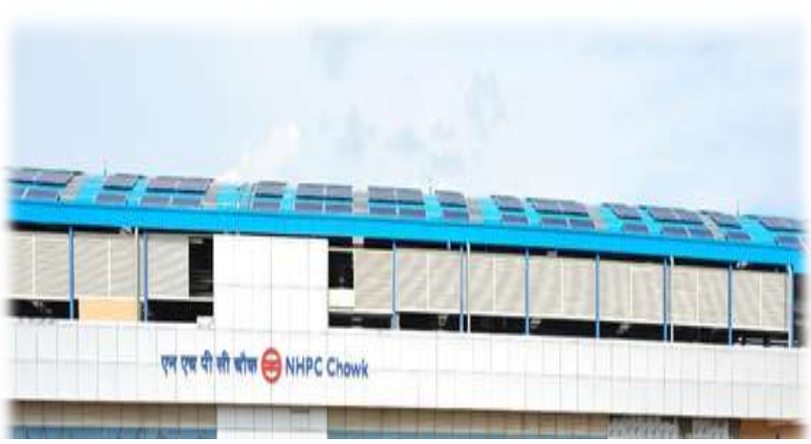

Figure 15: Solar on roof top. *Source: Delhi Metro, n.d.*

- Low Carbon Mass Transportation system: Indian Railway have already switched the normal diesel engine into Low carbon or energy efficiency (CNG or LPG) engine. The emission of gases has already reduced by approx. 10 percent in three years. It is taking the sustainable energy efficiency engines and use the clean fuel for less emission. Indian Railway is aiming that try to reduce the emission of gases up to 33 percent in 2030 by prompting the energy efficiency engine.
- Reducing Carbon Footprints: For reducing the carbon emission, do the more plantation with the local species, establish a waste management and water recycle plant as per Indian Railway Code at every railway station.
- Increase of Renewable Energy: Indian Railway have already setup 16MW solar panel at different railway station. For New Delhi Station, they are thinking to setup a 5MW solar panel at roof top, signal pool etc. for conserving the electricity and purify the environment.
- Use of Alternate Fuel: From the past few years, Indian Railway has right now using the BIO DIESEL instead of Diesel Locomotive. And, they are also promoting the use of CNG (Compressed Natural Gas) and Solar Energy in mechanical asset.

- Water Conservation: For utilizing of waste water, Indian Railway are already setup the water recycling plant. Near about 43 recycling plant (Railway I. , 2016) are already setup in all over the In
- Improving the lavatory: In this, Indian Railway has decided to provide virtuous environment to passengers and to keep the station clean and hygienic. For this, they are providing a BIO Toilets in the railway coaches and station premises.

- Uses of Fly ash and Slag Cement: In the concrete, use of flash and slag cement are up to 20 percent (Congress, 2013). By this, the emission of gases and energy will be less.

- Other Green Initiatives: Providing the Affordable Drinking Water Kiosk, Bio Diesel Shed, Major Coaching Depot, Railway hospitals, Training Centers and Schools.

Delhi Metro

Since metro transport frameworks are very capital-escalated ventures, the environment supportability of such systems is a vital issue that requirements to be investigated. This study analyzes the feasible methodologies (conserving assets, vitality security, and energy proficiency) and green activities needs to be taken by Delhi metro to assemble a low carbon and an ecological amicable rail transport in India.

Key features of Delhi Metro:

- It conveys 2.7 Million travelers every day
- 56 % of vitality is devoured by footing and the rest of the 44 % by other administrations

- The worry for supportability is showed in its Mission and Culture proclamation itself i.e. to make Delhi Metro self-feasible and amid construction it should neither reason bother nor imperil open life nor should their work prompt natural or ecological debasement.

- According to an investigation, Delhi Metro has helped in evacuating around 3.9 lakh indian rupees vehicles from the avenues of Delhi.

Sustainable Policies to be Implemented

Water Conservation Initiative:

Delhi Metro should take all conceivable measures to support its proper utilization of water also, reuse and recycle water however much as could reasonably be expected. With a specific end goal to streamline the water preservation measures of the association, an itemized water approach has been set up since 2013. In option to this, in 2014-15, Delhi Metro additionally included 99 Rain Water Harvesting pits at 37 areas with limit of 990 CuM. Rain water reaping structures have been introduced at raised stations, viaducts and stops.

Solar Initiative:

National Solar Mission and has been proactively working towards economical utilization of sunlight-based vitality to tackle power for its tasks. It has set up rooftop top sunlight-based power plants at numerous of its stations. It has introduced nine new sun-oriented power age offices in the stations and the terminal of the Badarpur – Faridabad Metro passageway for halfway satisfaction of the vitality prerequisites. The power produced is utilized for the lighting and other helper prerequisites of the station and terminal structures. Altogether, DMRC has so far authorized sunlight-based power offices with age limit of approx.2, 800 kWp with plants at Dwarka Sector 21, Anand Vihar, Pragati Maidan, Metro Enclave, Yamuna bank station, and Yamuna bank terminal, Faridabad RSS, ITO, Ajronda warehouse and the Faridabad metro stations. Likewise, the examination for introducing sun powered boards on the Foot Over Bridges (FOBs) giving network to the workers over the National Highways has additionally been embraced. It has officially commissioned 3 MW Solar Power Plants and means to accomplish 20 MW by 2017 and 50 MW by 2021.

- Rain Water Harvesting Initiative

Right now, DMRC has 84 rain water gathering structures with 464 pits which have an aggregate limit of 8607.08 cum. In the fiscal year 2016-17, DMRC wanted to introduce 24 new RWH frameworks with 107 pits with an aggregate limit of 1350 cum. DMRC is additionally investigating greater possibility of limiting new water utilization by treating and reusing the waste water. Squander water treatment is an essential activity to be taken for the improvement of the public. Treating waste water and reusing the treated water is a critical part of water preservation. Squander water treatment is a procedure, wherein the contaminants are expelled from squander water to create refluent appropriate for reuse or release in squander water reservoir. It has introduced Sewage Treatment Plants (STP) and Effluent Treatment Plants (ETP) in stops and settlements bringing about reuse of water for cultivation and flushing of toilets. An Effluent Treatment Plant treats the waste water to expel any harmful and non-dangerous materials or chemicals from the waste water. A Sewage Treatment Plant (residential waste water treatment) expels contaminants from squander water and family unit sewage. Five warehouses of DMRC (in particular SaritaVihar, Shastri Park, Yamuna Bank, Sultanpur and Khyber Pass alongside the private states at Shastri Park, Sarita Vihar and Yamuna Bank) have been furnished with these plants.

DMRC has likewise made another stride towards reusing of waste water by introducing bio-digester tanks. In bio-digester tanks, a consortium of anaerobic microbes goes about as inoculum (seed material) to the bio-digester and processes the natural waste into methane and carbon

dioxide.

- Conservation of Ecology:

There has been an arrangement to plant 10 saplings for each tree that it evacuates. With a specific end goal to guarantee that the right sort of saplings is planted and kept up, DMRC has drawn in the administrations of Forest Department, Govt. of Delhi. All of the costs for this are borne by DMRC. With a specific end goal to additionally extend the green cover in the National Capital, DMRC gave over a land territory estimating 15 hectares (close Shastri Park) to the Forest division for estate exercises. What's more, DMRC has likewise tied up with a non-administrative association 'Manageable Green Initiative' for doing ranch drives in various parts of the city. DMRC intends to plant more than 25,000 saplings deliberately in the years to come. Tree ranch by DMRC has potential ability to sequester around 5,500 t of CO2 and create 12,400 t of O2 every year.

- Green Building Initiative:

All the forthcoming Metro stations under the Delhi Metro as a major aspect of its third stage are planned and being developed as 'Green Buildings' with arrangements for the protection of vitality and in addition better CO2 reduction, saving water and squander administration courses of action. These stations buildings have following highlights:

- Reduced Heat Island Effect: The tops of the stations are either completed with high intelligent materials or/and finished with vegetation.
- Landscape Plant Species: The plant species utilized for the finishing (wherever conceivable) of the stations are either local or versatile which devour less water and help in expanded water effectiveness of the building.
- Insulated Building Envelope: To diminish heat accumulation in the stations and enhance vitality effectiveness, the dividers, rooftop and windows are protected from the sun.
- Adequate Fresh Air: The Metro stations are being intended to give satisfactory natural air according to ASHRAE 62.1-2004 through ventilation framework.
- Water Efficient Fixtures: Low water expending installations like double flush WC, low stream taps and so forth are introduced at the stations.
- Energy Efficient Equipment: All the lift and elevators are outfitted with Variable Voltage Variable Frequency drives which devour less energy in comparison with customary lift and elevators.

Delhi Metro is focused on vitality preservation, condition assurance and economic improvement which is noticeable from its positive methodologies and endeavors. It can be inferred that each traveler who utilizes Metro rather than auto/transport contributes in diminishment of discharges (approx. 100 gm of carbon-Co2 for each outing of 10 km and in this way, moves toward becom

Figure 16: Green Building Concept. *Source: Green Building Concept in India, n.d.*

Delhi Metro is focused on vitality preservation, condition assurance and economic improvement which is noticeable from its positive methodologies and endeavors. It can be inferred that each traveler who utilizes Metro rather than auto/transport contributes in diminishment of discharges (approx. 100 gm of carbon-Co2 for each outing of 10 km and in this way, moves toward becoming gathering to the lessening in an Earth-wide temperature boost). It has set a seat check execution against world's best Metros. Moreover, DMRC has taken activities for bury modular last mile availability like Feeder Bus Service, Grameen Seva from Metro Stations, Bicycle Service and Battery-Operated Taxis from stations.

Parking areas

Sun oriented energy is thought to be a perfect sustainable asset of vitality with zero discharge and has the capability of vitality which can be saddled utilizing solar panels. With late advancements sun based vitality frameworks which are effectively accessible for modern and local use with additionally included the favorable position of low upkeep. Sunlight based energy could be made monetarily temperate and solid with government tax breaks and reimbursement. In the most recent decade, Delhi's power demand ascended by a normal 6% consistently. From 20 billion units in 2002, the request no doubt will reach more than 33 billion units by 2017, a 65% development. This offers a major conversation starter of how to guarantee a predictable power supply.

The city's numerous shopping centers, Delhi Metro and top class offices as of now get three-fourths of their power supply from outside the state, depending for the most part on naturally unsustainable energy like coal. A move from petroleum based power sources to decentralized, inexhaustible sources like Solaris is the ideal approach to beat these obstacles, while accomplishing other generous advantages like the production of employment in the green area and freedom from different states for vitality supply. The National Action Plan on Climate Change likewise calls attention to: "India is a tropical nation, where daylight is accessible for long hours every day and an awesome force. Sun oriented vitality, consequently, has extraordinary potential as future vitality source. It likewise has the benefit of allowing the decentralized appropriation of vitality, in this manner engaging individuals at the grassroots level" (Srivastava, 2013).

Sunlight based panels have begun to find a new place in the sun — on parking areas encompassing business and modern structures, mounted on shelters giving shade to the parked autos. Parking garages in black-top rich urban communities have extraordinary sun based potential in light of the fact that the panels can be arranged to boost power creation amid summer evenings when power is generally important. Sun-powered fuelled parking areas can alleviate the considerable increment in top hour vitality request that real advancements make, yet a couple of designers now introduce sunlight based shelters over their parking areas. Despite the fact that the interest for power crests on days when the sun sparkles brightest, sun-powered power represents under 1 percent of our aggregate power supply (Shoup, 2012).

Since the aeration and cooling systems for new structures increment the danger of neighborhood control disappointment on sweltering summer days, it appears to be sensible to expect engineers to counterbalance this hazard. Urban communities can revise their zoning codes to require sun-powered power in the parking garages of new structures. Requiring a particular electric creating limit, for example, 1 kilowatt for each parking spot, will give engineers the opportunity to meet the necessity in the most financially savvy way. Because the sun-powered capability of a parking area relies upon numerous components, for example, atmosphere and

geography, sunlight based power necessities would contrast among areas and land utilizes, similarly as off-road stopping prerequisites do. Urban communities ought not to receive sun based necessities in all areas and for all land utilizes, yet radiant regions with substantial parking areas are a decent place to begin. Urban areas can likewise offer engineers who incline toward not to introduce sun powered panels on their parking areas the alternative to pay for comparable sustainable power source or protection measures somewhere else, maybe at a school or other public building (Shoup, 2012).

Sunlight based clusters won't deface the presence of parking garages on the grounds that most parking areas are now appalling. Sun based shelters, which look like tech trellises, can enhance the presence of most parking garages and turn into a vital compositional component of a building. They can likewise decrease the visual scourge and NIMBY issues related to building power plants and transmission lines (Shoup, 2012).

In the event that each sunlight based shelter has an electric-vehicle charging station at its base, the sun-powered stopping necessity will disperse charging stations all through the city. Delhi requires that, by 2025, 15 percent of all autos sold in the state must have zero tailpipe outflows, and different states are embracing comparative prerequisites. Sun based shelters over parking areas can give a portion of the power required for these autos without stressing the network's age and dispersion frameworks. The discontinuous idea of sunlight based power yield makes it appropriate to charging electric autos. On the off chance that the sunlight based vitality is being

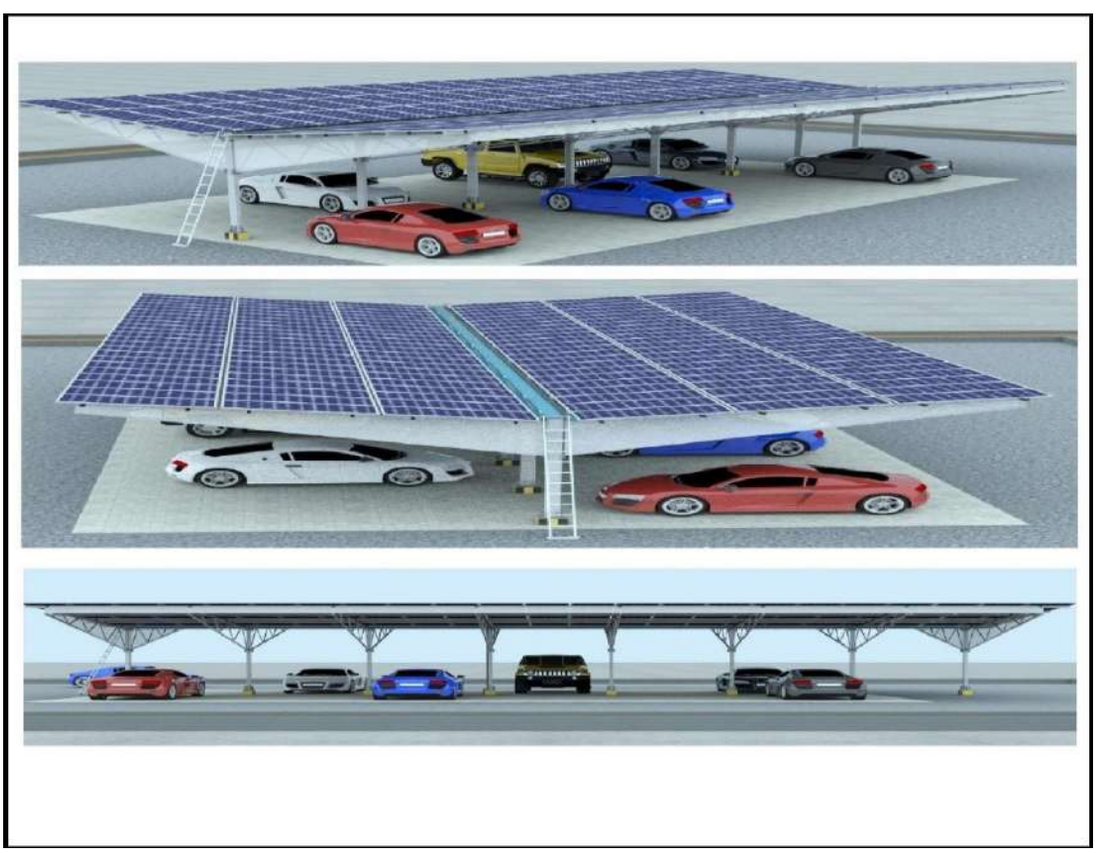

Figure 17: Solar Roof Top on Parking shades. *Source: Mahindra Susten, 2017*

put away in batteries as opposed to encourage into the electric grid, the power changes caused by mists won't cause steadiness issues for the network (Shoup, 2012).

Sunlight based parking garages are very obvious confirmation of an organization's sense of duty regarding the earth. In the event that the parking areas at new structures accompany sun-powered coverings, tremendous Parking parcels without sunlight based boards could start to look introverted. The proprietors of some more seasoned structures may refresh their parking areas with sun-powered clusters to stay aware of the green look of the new rivalry. Indeed, even drivers who don't possess electric autos can feel green when they stop in the shade of sun-powered boards(Shoup, 2012).

The government and numerous state governments give liberal endowments to the sun-powered panels, so designers won't need to pay the full cost of agreeing to a city's sunlight based stopping prerequisites. Since parking garages are generally greater than the structures they serve and normally have unhindered sun oriented access, the sun-powered panels can exploit economies of scale in development and can catch a greater amount of the accessible daylight. Conversely, few houses have appropriately arranged rooftops, unhampered sun based access, and the auxiliary ability to help sunlight based panels. In this manner, parking areas will produce more power per dollar of government endowment than houses would (Shoup, 2012).

Sun oriented overhangs create control as well as diminish the interest for it. Shading stopped autos will lessen the utilization of cooling by drivers when they leave the sun-powered parking garages on radiant days, bringing about better fuel proficiency and decreased tailpipe discharges. The shelters can likewise decrease the warmth island impacts of parking garages around structures, and in this manner lessen aerating and cooling request in the structures (Shoup, 2012).

Sunlight based parking areas conveyed all through the city will likewise create power right where it is utilized, diminishing transmission misfortunes and anticipating power blackouts caused by over-burden transmission lines. With just a slight change to the stopping necessities in their zoning statutes, urban communities can lead the path toward a future fuelled by the sustainable power source(Shoup, 2012).

Design Considerations

Design Wind Speed	47	mps
Module	Trina / Canadian	
Tilt Angle	6	degrees
Orientation of Module	Portrait	
Orientation of Structure	EW-NS	
Power	325	wp

Table 1: Design Values for Rooftop for solar panels. *Source: Own collaboration*

Type	Car Parking
Type of Structure	Single Pole
Span (metre)	3 m
Ground Clearance	2.2 m
Array	23 * 6
Total nos. of foundations	8
Total nos. of modules in structure	138
Power (kwp)	44.85

Table 2: Design Values for structure for solar panels. *Source: Own collaboration*

It's exactly what it sounds like — concealing a parking area with sun oriented panels, which are hoisted over the ground so autos stop in the shade underneath a shelter of photovoltaics. Depending obviously on the extent of the exhibit, you can create a lot of energy. For example, one sun oriented parking space establishment at Rutgers University is 28 sections of land in size and delivers 8 megawatts of energy, or sufficiently about vitality to control 1,000 homes. Sun-powered garages have numerous advantages, going from feel (yes, the things look exceptionally cool) to subtler variables.

Truth be told, as indicated by the Environmental Protection Agency and Department of Energy, having the capacity to stop in the shade in the late spring is really a generous supporter of expanded vehicle fuel effectiveness since it spares cooling your auto move down by turning the ventilation system (Mooney, 2015).

Physical Infrastructure in India

For India to keep up the development force, it is fundamental to fortify framework offices, for example, transportation, vitality, correspondence, et cetera. Be that as it may, execution of physical foundation in the Indian economy in the last one and a half decades has been blended and uneven. And additionally being hard to find, India's framework much of the time is likewise of low quality by world measures. Indeed, India's high rate of monetary development will be hard to maintain if foundation improvement does not increment and keep pace with request. Thusly, various measures are expected to address the different framework requirements that the nation faces and enhance the efficiency of foundation segment (Agarwal, 2015).

Environmental Assessment

Road based transport is one of the preferable ways of transportation for passengers and shipments. India has the 2nd largest road network in the world currently by 4.2 million Km. However, the Highways and expressways constitute only 2 % from the whole road network in India. A lot of encouragements and trials have been achieved to adopt the green highways in India. Many attempts have been done to protect and preserve the non-renewable energy and resources, decreasing the pollution. Because of that, many authorities from different countries set rules, policies and legislations to mitigate energy consumption. Accordingly, they use new technologies in the construction of roads to be more eco-friendly, sustainable and protect the environment. They use cold mix construction and recycling of pavement especially in the hot mixes asphalt production, this will help the road networks to be more sustainable in the future (AppaRoa G, Rajiv Kumar, Amar D.D, Ryntathiang T.L, 2013).

As we know for the hot mix production, many things should be involved in the mix such as; fossil fuel as a raw material, moreover, the hot mix plants need a lot of energy and resources to process, a single plant can consume in normal 10 cubic meter of natural gas with weight of 0.525 kg of carbon. But in case of the usage of cold mix it can decrease the emission of carbon. In this section, we will talk briefly about the cold mix technology and recycling which can be generated in field at temperature more than 10 degrees (micro-surfacing) and what are the results and conclusion if it will be implemented in New Delhi. Micro-surfacing has been used in Europe since 1976 and in United States in 1980. It has been imported to India in 2000 (AppaRoa G, Rajiv Kumar, Amar D.D, Ryntathiang T.L, 2013).

A previous study has been done on Delhi roads by using bitumen emulsion as an attempt to maintain the roads of Delhi instead of using hot mix plants. And from that time, it was approved by Delhi government and ministry of road and road transport to implement this technology on the road networks of New Delhi (AppaRoa G, Rajiv Kumar, Amar D.D, Ryntathiang T.L, 2013).

Cold in place paving process is a good way to push the road networks towards sustainability, recycling and reusing the aggregate and materials used in the existing pavement layers will help in reducing the cost of purchasing and transporting the fresh aggregates from quarries and thus it will help in the mitigation of raw materials depletion. In addition to that, during the cold in-place recycling process 2 to 5 inches of the existing road surfaces are crushed and recycled to be recycled aggregate and mixed with asphalt emulsion to be used again.One of the main advantages for cold in place is that it does not need heat at all to be applied on asphalt, which can reduce the noxious fumes and pollution and save environment and labors (AppaRoa G, Rajiv Kumar, Amar D.D, Ryntathiang T.L, 2013).

Environmental Impact

It is observed that pavement preservation as a green approach is a great help in saving energy, prevents the depletion of raw material and decreasing the emission of greenhouse gases. Micros-surfacing environmental footprint is lower than the typical methods of pavements maintenance and conservations (AppaRoa G, Rajiv Kumar, Amar D.D, Ryntathiang T.L, 2013).

Recycling of pavements is an important process for reaching sustainability in road networks, this methodology is widely used and applied in Unites States. Asphalt pavement is the common material which is widely recycled. It was estimated that 80% of Asphalt pavement are recycled in USA, the recycled material is used in many road projects. Adopting of recycled asphalt pavements will help in cost saving and improving the amount of profits. Generally recycling of pavements can provide many options and advantages more than the traditional methods such as; Decrease in cost of construction, protection of virgin aggregates and mitigate the emission of co2 gas due to the extraction of virgin aggregate from natural quarries, preservation of the pavement shapes and geometry as the traditional way of rehabilitation is to overlay the pavement thickness and this can affect the geometry of the pavement and make problems in drainage (AppaRoa G, Rajiv Kumar, Amar D.D, Ryntathiang T.L, 2013).

Economic Factors

Road Transport Infrastructure investments

By 2021, approximately 28 million passengers will use the transport services of Delhi per day. They will use public transport such as; metro and bus services. Delhi should develop the infrastructure of public transport to meet this expected high demand in the future; Delhi has already succeeded in this aspect by constructing the Metro as a mass transit and the bus rapid transit. However, the expected progress was not good enough to fulfill the economic needs and absence of promising results concerning transport expenditure section in the annual infrastructure budget year of Delhi Government (M A. A.).

From year 2002 to 2007, a huge investment went to the mass rapid transit only; the total budget was 939.1 million dollars, 54% was expended on transport department, and 506.7 million dollars for mass rapid transit; which achieved 49 % from the transport budget od Delhi government. On the other hands the local authorities who are responsible for NMT(non-motorised transport) obtained only 11 % from the total transport annual budget. From year 2002 to 2007, huge objectives were priority as rapid bus transit, metro rail transit system and expansion of roads, these targets were provided by a great proportion of the total budget, while expenditure for NMT infrastructure was 17.241 million dollars and this proportion accounts for 0.02 for the total outlay for transport infrastructure annual budget (M A. A.).

From 2007 to 2012, transport department budget was 1,341.3 billion Indian rupees, similarly major part of the expenditure accounted to DTC (Delhi transport Corporation), rapid transit corridors and improving of Delhi Metro rail network. Also, the NMT investment and encouragement of pedestrian did not take a big proportion from the annual transport department budget, it took only 0.06 from the total budget. Delhi government supported the idea of developing urban transit system as buses and metro, which is very important for the facility passenger mobility, but it should take care of the NMT system and improve it, as it plays an essential role in connection between the several systems of the urban transit transport (M A. A.) metro profits for

passengers and initial costs.
Delhi metro was constructed by different entities, the financing of phase I and II was a result of a combination between international, national, state and local authorities. It is a huge project and the backbone of urban transport infra-structure of Delhi. It was estimated that the cost of the first 118 kms in 1994, was 8.4 billion dollars by the prices of 2009. However, 60 % of funds from the Metro project were in the form of long term loan from the state sponsored Japanese bank of international cooperation. Recently, the Metro profits from the fares of the passengers, property development, advertising and other activities, but the main profit comes from the tickets of the passengers. Also, Metro gains from the sale of carbon credits, which come from the adoption of braking technologies and the carbon clean development mechanism. These profits can help in developing the stations, maintenance and enhancing of the operation performance (Rizvi, 2013).

The DMRC accomplished many advantages such as; reducing the consumption of fuel and limited slightly the costs resulted from using fuel, decreasing in Road accidents and air pollution and increasing in the productivity in manufacturing and economical industries due to saving time for the commuters (Rizvi, 2013).

Observations and recommendations on cost

- Bus transport system is the most common mean of road transport, it is about 60% of Delhi total demand, DTC is the largest driven CNG (compressed natural gas) in the world now, it accounts for 75% of total cost congestion (Neema Davis, 2017).
- Congestion due to the huge amount of vehicles taxis and rickshaw causes fuel wastage which participates in the congestion cost (Neema Davis, 2017).
- The road congestions will result in slow speed for any kind of transportation including buses, vehicles, 2 and 3 wheels motorized utilities and even NMT, that will lead in loss of productivity, pollution and wastage of fuel (Neema Davis, 2017).

Social Factors

Making urban communities, towns and groups that are financially and socially manageable, and which address the difficulties of populace development, movement and environmental change will be one of the greatest undertakings of this century. The improvement of new settlements is in progress on a phenomenal scale.

In Europe, 32 new towns are being made over 11 nations. In China, new urban areas are jumping up from Kunming to Shanghai in light of mass movement to urban zones. A few appraisals recommend 100 new urban communities, each with a populace of one million, will be created in China in the following three years.1 Pujiang New Town in Shanghai expects to house 500,000 new inhabitants in its 100 square kilometers One City, Nine Towns venture, as a component of the World Expo 2010 resettlement program. It has desires to be the 'perfect city'. Incheon Development Area outside Seoul will house 200,000 individuals by 2020; while in Delhi four new satellite urban areas, including Patparganj and Gurgaon, are being made to manage and to cook for India's developing working classes.

The quantity of family units in England is anticipated to increase by about 5.8 million in the vicinity of 2008 and 2033. There is as of now a build-up of the greater part a million families requiring leased social lodging who are at present destitute or living in packed or generally unsatisfactory lodging. Four new eco-towns have been proposed and various vital development regions distin-

guished to build lodging supply to 240,000 homes every year by 2016. In spite of the fact that the monetary downturn and a difference in government have brought up issues about the future for these new groups, there will be a proceeding with the need to fabricate more homes in the UK for the individuals who can't find sufficient lodging without some type of endowment (Caistor, 2011).

Asia alone has 16 megacities with a populace in excess of 10 million, including Mumbai, Karachi, Dhaka, and Jakarta. Such substantial scale populace development makes specific difficulties for urban areas endeavoring to make feasible groups and adapt to congestion, weight on lodging and transport frameworks, environmental change and maturing social orders. UN studies demonstrate that one billion individuals, one-sixth of the total populace, now live in shanty towns and, by 2030 more than two billion individuals on the planet will live in ghettos, with the related issues of poor sanitation, and access to social insurance and instruction(caistor, 2011).

India has a tremendous populace of youngsters. Indeed, even following 66 years of autonomy, a shockingly huge extent of our youths are not getting adequate instruction or professional training. From one viewpoint, this keeps an expansive number of them in destitution and wretchedness for absence of beneficial aptitudes; then again, it diminishes the rate of financial development on account of the absence of enough adequately gifted laborers in numerous regions, which lessens our universal aggressiveness.

Subsequently, India requires a solid instructive framework to keep pace with the developing economy and give it quality labor. Training can quicken monetary development and speculation and is a key marker to personal satisfaction and the Human Development Index (HDI). In advanced education as well, there is a need to execute significant changes as rising wealth and desires goad solid interest for training at all levels and the conventional strength of people in general segment as a supplier of instruction retreats.

There is far-reaching comprehension of the physical and ecological difficulties associated with making new settlements. Much is thought about how engineering shapes social conduct and individuals' feeling of place; how top notch, all around kept up open spaces impact impression of individual security; the part neighborhood green spaces play in prosperity; and how to configuration out wrongdoing. Be that as it may, encounter demonstrates that high desires for new settlements regularly end in dissatisfaction and disappointment.

Social infrastructure like schools, shops, neighborhood parks, community groups and local transport, must be provided at an early stage in the life of new communities. Much is known from both new and existing communities about how local identity and social networks influence people’s feelings of attachment and belonging to places. There is growing evidence of the effect of local social networks on community wellbeing and resilience; and there is widespread understanding of how to foster volunteering, neighborliness, activism and local democratic engagement (Agrawal, 2015, pp. 10-20).

Wellbeing administrations in India are described by (a) deficient and second-rate foundation; (b) poor open administration conveyance; (c) absence of value decisions for buyers; and (d) absence of access particularly for the poor because of a high reliance on moderately costly secretly gave administrations. In this sub-segment, we examine a few difficulties that the wellbeing area countenances, and how they undermine the normal effect. In this unique circumstance, accomplishing the manageability of urban communities can be considered as involving the joining of four columns: social improvement, financial advancement, natural administration, and urban administration. However, the manners by which a city can assemble supportability

will mirror its ability to adjust, inside the setting of its specific history, to the strategy needs and objectives characterized by every column (Anon., 2013, pp. 60-65).

Pillars for achieving Social Sustainability

- Education and health.
- Food and nutrition.
- Green housing and buildings.
- Water and sanitation.
- Green public transportation.
- Green energy access.
- Recreation areas and community support.

Pillars for achieving Economic Development

- Green productive growth.
- Creation of decent employment.
- Production and distribution of renewable energy.
- Technology and innovation (R&D).

	Developing Countries		Developed Countries	
Main Urban Trends	***Challenges***	***Opportunities***	***Challenges***	***Opportunities***
By 2025, urban population will live mainly in small cities (42 per cent) and medium-sized cities (24 per cent)	Improve access to housing, water, sanitation; improve public infrastructure; foster institutional capacity	Investment in public infrastructure (including transportation); construc-tion of compact buildings in middle-income countries; strengthen links between cities and rural areas	Social cohesion	Investment in copmpact urban development and decentralization
Number of urban people living in slums continue to Grow	Reduce number of urban poor and disease risk; improve social cohesion; reduce youth unemployment	Investment in universal access to affordable water and sanitation; establishing public transportation, and creation of jobs to reduce growth of slums; employment of the “youth” dividend in low-income countries	Reduce urban unemployment due to economic crises (of youth in particular); provide adequate housing in poor neighborhood’s	Strengthening and widening social safety nets; upgrading investment in social protection for an effective response to crises and their aftermath
Inefficient use of public services (water, electricity)	Improve waste and recycling management; support consumption of local produce; change overconsumption patterns of high-income households	Subsidies to households and small firms to reduce non-saving water systems and waste; incentives to local communities to improve recycling systems	Change overproduction and overconsumption styles; improve waste and recy-cling management	Investment in retrofitting of buildings; in water- and energy-saving devices; upgrading of public infrastructure
Ageing	Create productive employment for older persons	Investment in universal pensions; extension of working age; support for family networks	Fiscal pressure to reduce health costs; improve productivity	Investment in retraining older persons, and extending the working age

Table 3: Urban trends. *Source: World Development Indicators, 2012*

Utilities

Delhi – the dark capital?

Delhi has been swarmed with increasing incidents of crime and accidents because of inadequate lighting on its roads and streets. Adequate and appropriate lighting on streets and roads facilitates mobility and affords a sense of security to the citizens.
A detailed survey by a leading women's organization suggests that the poor lighting and dark corners both in residential spaces and public spaces are safety concerns for women inhabiting the city. Not only rape but reported cases of theft, eve-teasing and stalking, a menace to pedestrians, has also increased in the city with increasing inconsistency of lighting on its roads and streets. The crime-ridden neighborhoods in the city have been demanding better street lighting. Streetlights are integral to a city's surveillance infrastructure, improving community pride and making communities safe and liveable. A review of various studies on street lighting interventions in the UK and US, covering four decades, finds that areas with improved street lighting experienced 21% reduction in crime as compared to similar areas without improvement. Therefore, to empower citizens and help they reclaim urban spaces, adequate and reliable streetlighting must be made possible (Dhruv Singhal, 2014, pp. 9-10).

Sustainable street lighting solutions can be considered as a solution but it does not allow a physical barrier to crime. By the way, it can act as a mediator to reduce crime through changes in the perceptions, attitudes, and behavior of residents and criminals. The need to find a source of energy which would be immediately available and ensure reliable and consistent illumination throughout the year to eliminate the dark spots in the city. The opportunity for this lies in solar technology for street lighting (aka Solar Street lighting). While it relies on a reliable source of energy, which is the sun, the technology is able to function well with minimum solar insulation and long storage efficiency. It combines well with the LED luminescence technology as its panels are photosensitive, and they can also switch off the lights during the day when illumination is not required. A few advantages of installing stand-alone solar street lights are:

- Institutional and social benefits
- Solar street lights have highly improved efficiency and luminescence
- Have improved visibility and range thereby restore confidence in people
- Solar Street lights have a payback that can ensure that investment in these street lights can be recovered effectively.

Most of all, it provides the opportunity to establish infrastructural facilities like street lights where there are no street lights or poles, which have been estimated in the subsequent matter, to be quite substantial. This is further significant because it can be done without requiring the state or city to purchase additional power for its operation through the grid, additional wiring, and installation of transformers. Furthermore, a state's Renewable Purchase Obligations (RPOs) can also be fulfilled by using solar energy for meeting some of its demands. For Delhi, a laggard state in the matter of fulfilling its RPOs, Solar Street Lighting (SSL) is an opportunity to meet one of its important needs like street lighting while also fulfilling its RPOs. Most of all, it will eliminate dark spots, which is turning out to be a major safety and equity issue in the National Capital(Dhruv Singhal, 2014, pp. 13-14).

Components of Solar Street Lighting System

- Solar Panel: Solar panels are made up of small units called solar cells. The most common solar cells are made up of from silicon, which is the second most abundant element on earth. In a solar cell, the crystalline solar cell is sandwiched between silicon layers. Solar cells absorb energy during the day. Cells convert solar energy into electrical energy which is stored in the battery.

- Lighting Fixture: Light Emitting Diode (LED) is usually used as lighting source of modern solar street lights, as the LED requires very little current hence solar panels of smaller sizes are required for solar street lights with LED.

- Rechargeable Battery: A battery stores the electricity from the solar panel during the day and provides energy to the fixture at night. Two types of batteries are generally used which are Gel Cell Deep Cycle Battery and Lead Acid Battery. During daytime, the battery gets recharged through solar power and the process keeps on repeating daily.

- Controller: If there is motion near solar street lights has detected by the controller, all LEDs will glow with 100% bright illumination.

- Pole: Poles for solar street lighting are of utmost importance and should be hot deep galvanized iron poles, so has to carry the load of mounting panels and a lead-acid battery. Also, wind effect should also be taken into consideration when designing and choosing the pole.
In Delhi, the height of a standard installed pole ranges from 4 to 6 meters for curbside street lights and 10m for the high mast, various heights are observed. Thus, we recommend similar heights of poles to be used while keeping in mind various hindrances in the illuminating area. (Dhruv Singhal, 2014)

- LED Lighting

LED or light emitting diode is an environment-friendly semiconductor lighting system. It signifies and implements a number of advantages over the conventional ones. Compact Fluorescent lamps (CFL) and LED save on energy consumption costs as compared to standard HPSV lights.

- Advantages of LED Lighting

1) Reduces power consumption.
2) No cost of replacement of LEDs.
3) LEDs being a no-filament lamp, shock and vibration don’t have any effect on its life.
4) Lifespan of around a 100,000 hours.
5) Reduced maintenance costs.
6) Highly energy efficient.
7) Contain no toxic chemicals like mercury unlike traditional mercury-vapor lamps or high-pressure sodium lamps.
8) Produce directional light - light emitted in one direction, rather than a diffused glow - they can be used to direct light on specific areas.
9) Can be dimmed, allowing for more flexibility in controlling light levels.
10) Don’t produce ultraviolet light, which is what that attracts bugs.

Figure 18: LED Solar Light system. Source: Solar Streer Light, 2018

Electricity

One of the major and important sources of energy in human's daily life is electricity which is required for machine operations, household and comfort living and for running of various other appliances. In case of India particularly in Delhi, we have data on three indicators: percentage of the population which has access to electricity network; electricity consumption per capita (kilowatt hours per year); and electricity loss i.e. power and transmission losses. The first two display gauge access to electricity and average consumption, the third gauge the efficiency of distribution in power transmission and the viability of electricity networks. (Agrawal, 2015, pp. 22-23).

Indicators	Year	India	China	East Asia	BRCS (Basic Reference Coordinate System)	Developed Countries
Access to electricity network percent of population	2010 2000	75,0	99,7	85,9	93,6	99,9
Electric power consumption (kWh per year per capita)	2010 2000	641.0 391.0	2943.0 993.3	3505.8 2456.0	4101.9 3195.0	8493.6 8326.4
Electric power T&D loss (% of output)	2010 2000	20.3 27.63	6.1 6.9	7.5 8.44	10.6 11.08	5.53 6.02

Table 4: Quality of electricity Networks, China, East Asia and Developed countries. *Source: World Development Indicators, 2012*

Thus, from above chart, we can conclude that India's electricity infrastructure is weakest, and one should switch to Solar and other forms of renewable source of energy.

Drainage Systems

It is amazingly impossible to miss that Delhi, which is India's national Capital, one of the speediest creating metropolitan urban groups of the country, does not have a proper sewage exchange and waste system. Delhi is confronting the extreme issue of untreated sewage with the end goal that exclusive around 55% homes in Delhi are connected to an appropriate sewerage and whatever is left of the 45% of squanders goes into the Yamuna River straightforwardly. Truth be told, it is extremely tragic to state that the excrement of the advanced restrooms in urban Delhi is adding to the contamination of Yamuna. Despite the way that different plans and ventures have been executed by the Government for sewage and wastewater treatment, these are not having the ability to keep pace with the amount of wastewater. While there are certain regions out of Delhi which are given wastewater treatment organizations to a degree, the ghettos or the clamorous zones are not given any sewage treatment, the reason being these are that they are not inside the domain of the Delhi Jal Board (DJB). (Phukan, 2014).

Statistical data points of sewage treatment in Delhi

As shown by report appropriated in 2012, just around 30% of all the sewage that comes in Delhi is managed. It has been surveyed that on a typical for consistently 3296 million liters of sewage is dumped in the Yamuna. Consistently, Delhi makes around 600 million gallons of sewage, yet the sewage treatment plants (STPs) set up in Delhi have a capacity to treat only 512.4 million gallons of waste. Uncalled for and lacking sewage treatment have influenced nature and the locals of Delhi from different perspectives:

- Malfunctioning septic frameworks have brought about the defilement of good water,

groundwa ter, stream water and making danger for general wellbeing.
- Untreated and open wastes have delivered helpful rearing for mosquitoes, flies, rodents, creepy crawlies and different sicknesses.
- Untreated sewage is an initiator for stinking and foul smell
- Easily penetration for individual washing garments and utensils. (Phukan, 2014)

Other problems:
- Lack of infrastructure
- Weak financial base
- Corruption
- No coordinating bodies
- No Political support

Solutions

Figure 19: Sustainable Drainage system of Road. *Source: Society of cheif officers of Transportation in Scotland*

Permeable pavements

The requirement for surface water depletes and off-site sewers can be decreased or disposed of where run-off is urged to move through permeable asphalts produced using materials like solid pieces, squashed stone or permeable black-top. Contingent upon the ground conditions, the water may penetrate specifically into the subsoil or be put away in an underground repository (for instance, a pounded stone layer) before gradually dousing into the ground. In the event, that invasion isn't conceivable or fitting (for instance, due to ground tainting), an impermeable film can be utilized with a flood to keep the asphalt free from water in all conditions. Toxin evacuation happens either inside the surfacing or sub-base material itself or by the sifting activity of the supply or subsoil. (Anon, 2013).

Infiltration trenches and filter drains

Penetration trenches are stone-filled repositories to which storm water run-off is coordinated, and from which the water steadily invades into the ground. Their lifespan is upgraded by consolidating a channel strip, chasm or sump pit to evacuate intemperate solids at the inflow. Channel channels (here and there known as French Drains) are broadly utilized by thruway specialists. They are like invasion trenches with a punctured pipe which conveys stream along the trench.

This empowers the capacity, sifting and some invasion of water going from the source to the release point. Toxins are expelled by retention, separating and microbial disintegration in the encompassing soil. Frameworks can be intended to effectively consolidate both penetration and channel frameworks (Anon., p. 6).
Supportable Drainage Systems (SUDS) are outlined because three targets:

- To control the amount and rate of run-off from an improvement;
- To enhance the nature of the run-off;
- To upgrade the nature protection, scene and enhancement estimation of the site

SUDS can be taken a toll successfully intended to work withheld normal highlights, for example, trench or lakes, and to frame a basic piece of hard and delicate finished zones. Along these lines, they can contribute towards an alluring plan that upgrades the nature protection and convenience estimation of the advancement, while likewise making the best utilization of the significant water asset (Anon, 2013).

SWOT Analysis

SWOT stands for Strengths, Weaknesses, Opportunities and Threats. Strengths (S) and Weaknesses (W) are thought to be interior factors of the project which we control by their own. Also, by definition, Opportunities (O) and Threats (T) are external factors of the project which you have essentially no control (Management Study Guide, n.d.). To describe the strengths, weaknesses, opportunities and threats (SWOT analysis) of infrastructure of the Delhi, that are: The strength and the opportunities are identified in this analysis are principally related to enginery, such as sustainable design of rigid and flexible pavement, and accepting renewable system for the roads. In the case of the weakness and threats, these are linked to poor environmental conditions, traditional construction methods, and traffic congestion, which are crucial for the improvement of Delhi Environment and infrastructure and represent an important challenge for the future improvement.

STRENGTH

- Delhi is the second largest city with an urban population of 25 million.
- The total length of roads in Delhi is more than 28508 km that includes about 400 km of highways.

- The road network in Delhi city is well laid out that include Ring Road and Outer Ring Road which are in the pattern of concentric circles traverse the entire periphery and middle of a gigantic spread of the city.
- The Delhi government follows the green highways policy 2015.

- In 1999-2000, Delhi has already accepted the cold mix technology for laying of roads. This technology is majorly used for recycling and reusing the existing pavement layer. The overall process is very cost effective and according to the principles of green roads.

- In 2013, Delhi has already accumulated the use of plastic waste for the road construction. In this, waste plastic is shredded and mixed with aggregates and heated to coat the aggregates and the mix is then used in road construction. It enhances the properties of mix and a good solution for disposal problems.
- Indian Railways is the fourth largest railway network in the world.

- For the redevelopment of New Delhi Railway station, the Indian Railway has already considered the five sustainable pillars of environmental sustainability.

- Indian Railway are doing work on low carbon mass transportation system, reducing the carbon footprints, uses of renewable energy, alternate fuel, water conservation, green buildings, bio toilets and solid waste management.
- Delhi Metro is focused on vitality preservation, condition assurance and economic improvement which is noticeable from its positive methodologies and endeavors.
- DMRC has likewise made another stride towards reusing of waste water by introducing bio-digester tanks.
- DMRC is shifting from fossil fuel produced power to more renewably produced power. Right now, it has already installed 17 megawatts of rooftop solar power capacity installed on the top of some stations.

WEAKNESS

- Delhi is the 6th most polluted city in the World.
- Right now, Delhi is facing the problem of water shortages, waste disposal, health-care, environmental cleanup, pollution, infrastructure, transportation system and housing.

- To handle the disposal of plastic waste they are generally burnt which causes environmental pollution.
- The environment changes due to the overpopulation, overuse of resources, by road dust, industries, unclean engines in transportation especially diesel-powered buses and trucks, and so many.
- They are follows the traditional or conventional methods of construction. These methods were brutal and severely affected health of people and environment.

- The exploitation of the environment that leads to exploit the nature, land degradation and the climatic changes.
- Lack of solid waste management facilities, (for treatment and disposal) in the city leading to indiscriminate dumping of garbage and land pollution.

- Lack of parking space, Lack of drainage and sewerage, Lack of infrastructure facilities and Lack of proper public transport system in the city.

- Insufficient uses of renewable resources.
- Disposal of untreated industrial waste in Yamuna River.

- From social aspects of the Delhi metro rail have some issues of inaccessibility to the various metro station and passengers who have their own vehicles and they want to travel with public transport are facing problems in parking's.

OPPORTUNITY

Delhi has good connectivity of transport, having a high literacy rates, urban development as well as rural development increase.
- Due to good connectivity, the National Capital city has the potential to attract private developers and FDI in the housing and infrastructure sectors.
- For improving the environmental condition, In 2016, Delhi has accepted the South Africa

road paving concept and technique of warm mixed asphalt for the less emission of greenhouse gases (GHG) during the mixing at the mixing plant and also at the paving process at the site.

- Sustainability of the road infrastructure is not a new concept but after the innovation of plastic roads open the doors for other inventions in road construction.
- They are accumulating the new green technique such as recycling of waste material, utilizing the solid waste management, recycling of used oil and so many, for improvising the environmental condition.
- For using the natural energy resources, Indian Railway have already setup 16MW solar panel at different railway station. For New Delhi Station, they are thinking to setup a 5MW solar panel at roof top, signal pool etc. for conserving the electricity and purify the environment.
- Indian Railway have already had BIO Diesel engine or CNG engine, water recycling plant, and BIO toilets.
- Delhi Metro had additionally included 99 Rain Water Harvesting pits at 37 areas with limit of 990 CuM. Rain water reaping structures have been introduced at raised stations, viaducts and stops.
- DMRC has so far authorized sunlight-based power offices with age limit of approx.2, 800 kWp with plants at Dwarka Sector 21, Anand Vihar, Pragati Maidan, Metro Enclave, Yamuna bank station, and Yamuna bank terminal, Faridabad RSS, ITO, Ajronda warehouse and the Faridabad metro stations.

THREAT

- The Population of New Delhi is increasing due to the immigrants. From 1951 to 2017, the total population of Delhi has risen from 1.74 million to 18.75 million. Also the survey predicts that, the population should reach to 25 million until 2025.

- Total land area of Delhi is 1485km2, out of which 783km2 covers in rural area and 700km2 covers in Urban. But, as the time passed, the development of urban area has been increasing. In that most of the urban land has occupied by the immigrants, construction of houses, metros, complex, factories and many more. Right now, the situation of Delhi is worst, because they do not have efficient area for implication of the sustainability development.

- The growth in the population of the city is caused by the economic activities that lead to the rise in the per capita income.

- The most obvious challenge is the infrastructure for mobility and the transportation system which are the main factors to affect the social and economic development of the city.

- High population growth can lead to further pressure on the infrastructure sector in the future.
- Poor infrastructure in new colonies especially in the urban extensions and urban villages are a threat to quality of life.

- The major issues faced today in business of infrastructure development over the next couple of three years are thought to be corruption, political and regulatory risk, and access to financing and macroeconomic instability.

Conclusion and Recommendation

This chapter discussed and researched the various option of making the roads, railways and related infrastructure more sustainable in the city of Delhi. A short comparision is made between the Delhi City and Singapore City and the possible options to make the infrastructure more sustainable. Also, about the construction of Roads and Railways possible methods of sustainable construction, operation and maintenance are specified, which are feasible to be adopted in Delhi City.

The increasing trend of urbanization all around the world and specifically in Aisan and African countries are very alarming. According to UN report on world urbanization the world urban population will rise to about 66% of the world population by 2050 and majority of the population concentration areas will be Asia and Africa. But, the focus here is entirely on India and its capital city Delhi.

According to UN reports Delhi is the second largest city with urban population in the world with population density of about 14,667 people per sq.km in 2011 which will increase much more in the near future. The urban population growth in Delhi city created many social, environmental and economical challenges, but, the paper had discussed only the challeneges related to infrastructure like roads and railways, in order to find the feasible solution to solve the challenges to make the infrastructure of Delhi city more sustainable.

Moreover, the study identified some problems or issue which created impediments to achieve the principals of sustainable city. The main problems are the lack of interest of government agencies in the concept of sustainablity, no proper legislation for uncontrolled urbanizations, no proper planning and designing of the city, the most important one is the depravation in the projects and lack of population awarness toward sustainability are some of the hurdles in achiveing sustainable infrastructure in Delhi city.

Singapore is a sustainable city, developed various techniques that helped in achiveing the principals of sustainability, with urban population density less than Delhi City, but, looking into Delhi city with prism of Singapore it is possible to achieve the principals of sustainability in Delhi City infrastructure. Considering the population of Delhi City it is vital and important to have sustainable metro line. Currently the number of population using Delhi metro or other public transport is significantly less than the threshold value, owing to less capacity or the metro line was not carefully and properly designed, keeping in mind the principlas of sustainability.

Although, cuurently DMRC is trying to change the whole infrastructure of Delhi Metro Rail but, still there are things which need full attention to make the line more sustainable like by adopting the technique of off grid technology instead of diesel engine, CNG, and electricity/power produced with usage or buring of nonrenewable resources.Some of the methods and techniques are studied in the paper, are considered some of the significant options to make the infrastructures of Delhi City more sustainable and reduce the usage of the nonrenwable resources for the future generations and reduce the emission of green house gases and carbon footprints.

Also, from the study it is assessed that construction of new roads in the city is not the need of the day, but, to maintain the existing roads and infrastructure in way that is sustainable. Because , the construction of new roads in the city might create the problems traffic congestion and that another problem to social, environmental, and economic pillar of sustainability.

Recommendations

After a detailed study of the infrastructure of Delhi and Singapore cities, it is easy to recommend for a layman that, what are the main options Delhi city has to adopt to make the roads and railways sustainable. However, the focus is on the construction of sustainable roads and railways of Delhi city, but after the study it will be unfair to recommend only the construction factors of making the infrastructure of city sustainable. But, along with construction factors we will also discuss some of the factors for already developed infrastructure and how to make already developed infrastructure sustainable.

From the study it is assumed that while constructing the new infrastructure we can use a variety of options to make the roads and railways sustainable. Some of the option for the construction and maintenance of new and old roads and railways in Delhi city to make the infrastructure of city sustainable are:

- Use of Warm Mixed Asphalt (WMA) for construction new roads, because of less Green house gases emission.
- Use of Rubberized Asphalt in construction of roads is also good option in conservation of natural resources.
- Owing to the overall yearly temperature of Delhi city the use of Road energy system is highly appropriate to install which is good and sustainable option.

- For maintenance of existing road pavements, the option of micro-surfacing is already adopted in Delhi but, it need to be adopted in full essence.

- Recycling of the existing pavements and also the cold mix construction of the roads.

- Use of plastic waste in construction of roads is already employed in India but, it further needs to improve in the construction process for the sustainability of delhi city infrastructure.

- Construction of Solar Roads and walkways are another sustainable option that need to be adopted in Delhi city roads to make them sustainable.

- Government should take action against the uncontrolled urbanization of Delhi city to make the roads sustainable.

- For sustainable railways and metro lines in Delhi it is important to shift from the consumption of nonrenewable or fossil fuels to the off grid system for the energy or power consumption the lines.

- Government should do proper legislation for sustainable infrastructure construction.

- Proper campaign should be carried out for the awarness of the populace toward sustainability and how it can be adopted.

- Although, the population density of Singapore is less than Delhi city but, by adopting the several bottleneck solutions employed by Singapore City, can help to control the number of vehicles on the roads to avoid congestion and pollution.

- It is also important that governemnt of Delhi city should focuse on the existing infrastructure to make it sustainable rather than construction new infrastructure.

- The initative of green cab and cycling in city area need to start to avoid the use of motorized transport to reduce the consumption of fossil fuels and emssion of carbon dioxide.

- A well integrated public transport system needs to be developed in Delhi city to make the infrastructure and delhi city a sustainable one.
- Proper urban planning and design is required to make Delhi city and its infrastructure sustainable.
- The most effective toll for sustainable city is implementing the approach of Avoid-Shift-Improve (ASI) to make the infrastructure of the Delhi city sustainable.

As a matter of fact the construction of new roads and railways need to adopt the sustainable procedures and techniques. But, owing to the current situation of Delhi city it is very imperative to focuse on the existing infrastructure and find out the option making the existing infrastructure sustainable.

Chapter 4: Image Sources

Figure 4.1 : Population trends and projections, 1950-2050
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Table 1: Design Values for Rooftop for Solar Panels
Source: Own collaboration
Table 2: Design Values for Structures
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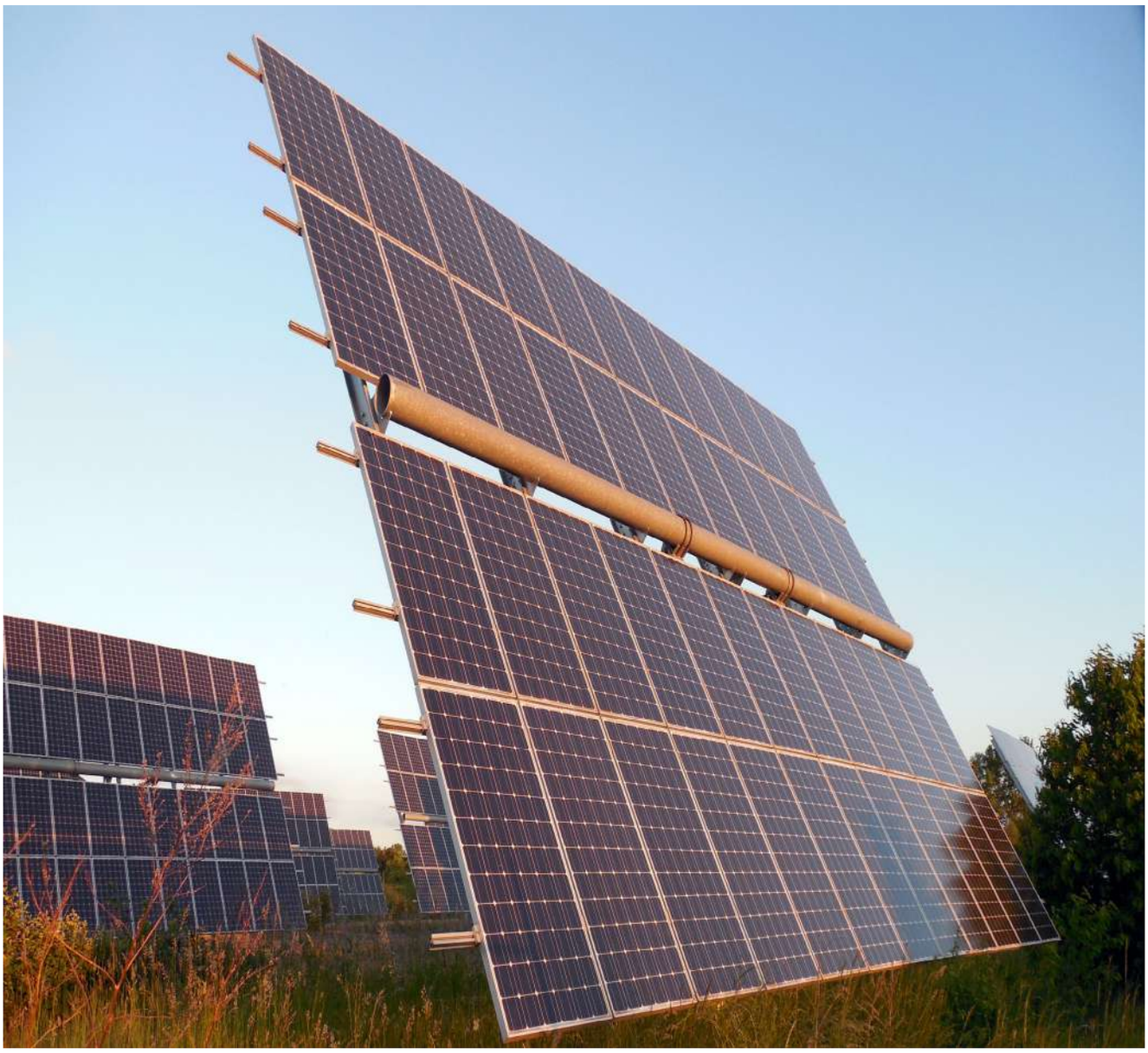

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Source: www.pixabay.com, https://pixabay.com/en/solar-cells-solar-solar-energy-796700/

5. OFF GRID RENEWABLE ENERGY

Hargeet kaur
Rajesh Shinde
Sinan Batineh
AbhirupDandapath

ABSTRACT

The term sustainability is frequently associated with our future cities. However, in the most remote and unprivileged corners of the world off-grid system has already established a new dimension of the meaning. With no infrastructure and disconnected from the main system it offers a impeccable instance for the cities how to self-sustain and thrive with the least resources. If dealt with proper planning and caution off-grid systems can be beneficial in large scale and it can also contribute to the integrated networks of our future cities. This chapter delves into the depth of off-grid systems in its various forms such as electricity generation, bioenergy, off-grid housing, earthship housing etc. It provides the reader a systematic journey from the introduction of the topic to analytical discussion of numerous off-grid systems. As sustainability is of global interest the issue of off-grid is also reviewed globally in remote locations of India, Jordan and Mexico. The latest advancement in technology are considered. The three main pillars of sustainability namely as social, economical, and environmental would be central theme of consideration. The chapter would display how off-grid systems are advantageous in terms of the basic needs of life e.g. shelter, energy and food. The study includes a wide array of crucial case studies in different continents. Each of them are critically analysed in all the essential parameters of sustainability. Some of the main case studies include biogas plants, and solar electricity in India, Zaatari Refugee camp in Jordan, Earthship housing in Mexico.

Keywords: Sustainability, off-grid, bio-energy, water supply, electricity, waste management, refugee camps, earthship housing, solar, hydro-panel.

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Introduction

The term sustainability can be misunderstood as how far we are prepared to sacrifice our present need and lifestyle in order to meet the demands of the future. However, sustainability can be achieved by meeting our needs today and keeping the promises of future alive simultaneously. One of the most significant testimonies to this fact is off-grid systems. The idea has been implemented and verified. It has also been widely accepted by government organizations, local communities and as well as NGOs ((Louie, Dauenhauer, Wilson, Zomers, & Mutale, 2014).

The popularity of off-grid systems has emerged from the imbalance between demand and supply. It is a noble approach towards development being independent of any initiative from higher or external authorities. In places where there is negligence from the government or development has not reached yet with all its fruits, off-grid is critical for self-help development. Off-grid provides scope for sustainability in the allthree aspects e.g.-social, economic, and environmental. Furthermore, it also helps to maintain a balance between them.

One of the world's biggest concern at present is sustainable energy production. The off-grid system offers possibilities in and not limited to electricity from solar power, Hydro or wind systems, self-supply of water and sanitation, energy generation from biogas, food production, Earthship housing etc. Apart from these, there is a considerable amount of innovative systems which often go unnoticed due to the small scale or remoteness of the location.

In the last thirty years remarkable acceleration has been noticed in the pace of off-grid improvement in the Global South. The globalization has helped technology and innovation to spread across borders. The remote areas of India comprise of the lower economical section of the country. Therefore, the need to promote off grid projects is essential to meet the demands of the people. The analysis made after revising the case studies mentioned in the report clearly states that the small scale off projects are creating a difference in the lives of the people and if the projects get support from the government sector on a large scale then definitely progress can be made on a vast scale.

The efficiency of off-grid systems such as 'PV-BESS' for charging 'Electric Vehicles' (EVs) has been proved to be viable and reliable as well in Madrid, Spain ((Energetic, economic an economic viability of off-grid PV-BESS for charging electric vehicles: Case study of Spain, 2018) by the 'HOMER' analysis.

The chapter would be related to various case studies on a global scale concerning various aspects off-grid systems. Broadly the major areas of discussion would revolve around off-grids systems in India, refugee camp in Jordan, Earth ship housing in Mexico, water-based startup in the United States. The study is highly benefited from the wide variety of knowledge and experts of the co-authors of this section.

In remote areas of India off-grids systems are used majorly in electricity generation, and cooking. The previous uses of wood caused air pollution and health hazards from the cooking smoke. In many present off-grid systems utilizations of charcoal improves the situation environmentally and health-wise. The bio-gas is used widely in domestic and community scale in rural areas. The small-scale implementation off-grid systems in the villages in India is a recent but widely accepted phenomenon. It generates the opportunity of cheap production and social employability. Being a religious country India also witnesses waste to energy and solar systems in some

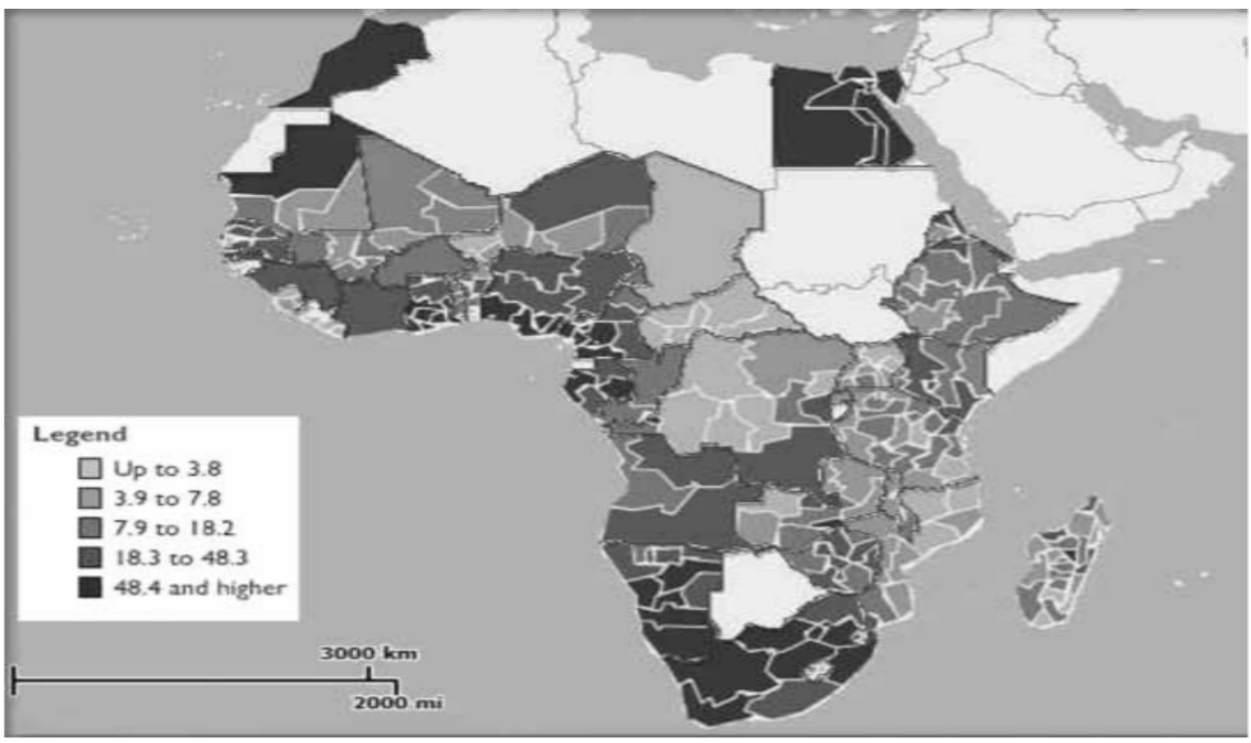

Figure 01: Electricity percentage in households in African regions. *Source: Acey & Culhane, 2013*

major temples of the south.

One of the most remarkable mention is the earth ship housing. The American Architect Mike Reynolds has contributed a lifelong innovation in the making. It has helped the waste management issue in housing to reach an innovative solution. Earth ship housing has successfully created green oasis in the middle of the Mexican desert. It has provided the solution to the waste issue, utilized water to the maximum feasibility in a 3-way filter process.

Most importantly earth ship has thoroughly exploited the abundance of waste and earth as the major and valuable resource. It has also created hope for housing needs, provided community spirit in the making and developed the idea of independence. The physical environment of these houses is strikingly stress-reducing. The heap of garbage has turned into furnished castle of earth ships. With innovative ideas, noble design and specific competency it has created many hopes in the dead desert. Moreover, it has efficiently served the three pillars of time, cost and quality.

Another important aspect of this chapter is the discussion on refugee camps in Jordan. It deals with whole life-cycle of the project of 10 years and more. The construction was started in 2011 and finished within 7 months. It has been able to provide all the facilities such as energy, water etc. to the refugees. With no infrastructure and network in the desert it has offered home to 80,000 people with the help of limited budget from the UN. The project developed through many steps like supplying of waters through reservoirs, installing solar panels etc.

Literature review

The need for energy in our society is ever increasing. We are having more awareness and usage of renewable energy resources. However, 85% of our energy consumption (Cambridge,

2012) comes from burning fossil fuel (oil, coal, and gas). Off-grid is one of the newest and most innovative approaches in this area. The term off-the-grid (OTG) is referred to the system which is independent of the grid infrastructure such as electricity, water et al. The concept is becoming popular mainly for two reasons. Sustainability and independent energy generation. Research and application have included single houses to large communities, ranged from energy generation to distribution. Off-grid can be considered as an effective solution to meet the demand of our climate change goals.

The practical infeasibility and financial availability of grid extension into remote areas assign a remarkable importance to off-the-grid energy generation (Sen & Bhattacharya, 2014). Roughly, the cost of electricity generation depends upon the efficiency of the off-grid model. A third of increased demand in energy comes from India (International Energy Agency, 2017). In India, HOMER or Hybrid Optimization Model for Electric Renewables is a limited and popular field of research. In many parts of the country, Integrated Energy Renewal System (IERS) is suggested (Kanase-Patil et al., 2010) to meet the demand of electricity and cooking. India is large as a continent consisting remote areas where till date energy from the traditional grid has not been made available.

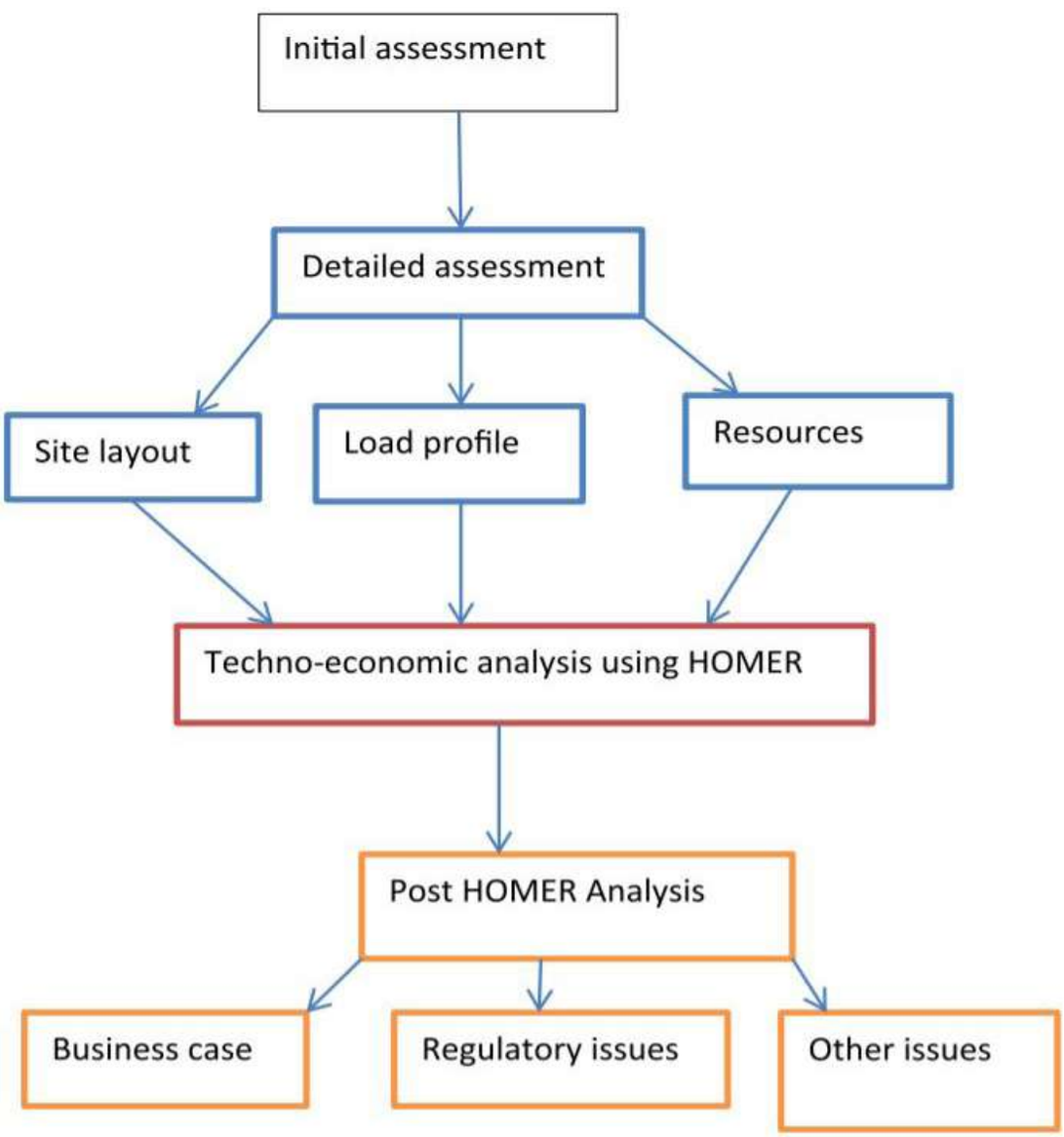

Figure 02: Analysis Framework, HOMER. *Source: Sen & Bhattacharya, 2014*

In other developing countries the usage of the off-grid model is popular especially in electricity generation and cooking. Electricity is one-third part of the energy consumption. Others are transportation and cooking etc. In southern Asia observations on off-grid has shown mixed trend (Palit&Chaurey, 2011) in various countries. The bridging of financial gap between affordability and electricity cost (Brijesh&Semida, 2011) can be addressed by off-grid.

Solar Energy is the most popular in all off-grid systems. It includes various applications such as solar lighting system, heating system, lanterns, cooking etc. The easy availability, cheaper price than other alternatives, and poor quality of conventional energy resources take solar off-grid systems on the top of the list. Besides in climate like India where there is an abundance of solar power, it is difficult to understand the wide implementation of PV based off-grid systems. Besides in the numerous remote location in India SE – Solar off-grid lighting systems (SOLS) i.e. Solar Lanterns (SLs) and Solar home lighting systems (SHS) ((Choragudi, 2013). These systems provides the opportunity to have lighting systems without the cost of electricty production in remote areas of Indian subcontinent.

Globally, off-grid systems have been adopted widely from concerns of economic and environmental sustainability. In Western Australia significant contribution has been noted in the rural areas from unwise usages of fossil fuel, particularly diesel and gas ((Ali & Shahnia, 2017). The demand quantity from the area and prices of electrical components in the market promptly suggests for alternatives like off-grid. Nigeria for instance has many resources but limited with power (Udoakah & Umoh, 2014). The potential of these abundantly available resources has been explored in the remote areas of Nigeria which are far away from the energy grids.

In Africa, a socio-techno-ecological study (Brent & Rogers, 2009) noted economical beneficiation by the intervention of technology. It further observed significant energy loses in the storage and conversion (DC to AC).

However, scope of off-grid in developing region is often limited (Bhattacharya, 2012). Major issues being lack of resources, infrastructure, and poor technology. From the electricity generation to storage the off-grid model demands efficiency. There is a considerable amount of scope in improvement in off-grid systems.

OFF GRID HOUSING - Electricity generation a major factor

Introduction

Around 1.6 billion people in the world will be forced to live without electricity not because of the non- availability but due to dispersed population living in off grid area. Therefore the concern of producing electricity in these areas become a relevant area of discussion.The population that faces the major concern are described in the table

Regions	Population without Electricity(millions)
South Asia	706
Sub-Saharan Africa	547
East Asia	224
Others	101

Table 1 : Estimated Population without electricity. Source: www.worldstatistics.com

The major source of energy production in the remote areas is from fossil fuels. The energy produced by this is not efficient enough to cater to the needs of the population and also this produces a lot of carbon dioxide (CO2) and Carbon Monoxide (CO) resulting in increase in the greenhouse effect.This definitely provides a motivation to look for alternatives that do not emit green-houses gases.The challenge is to find a solution for the off grid areas without disturbing the ecosystem.
Renewable resources have a great potential to provide a solution that could help in resolving the problems of electricity generation. One of the abundant renewable source of energy is the Solar energy. Although its availability depends on the geographic location of the area still it can resolve the problem of electricity production in many asian and african countries.

Remote Areas of India

There are approximately 649481 villages in India (List of villages in India, 2018).Although there is a universal electrification policy adopted by Indian government still the one third of the populated areas is without or merely electrified. The census state that 93 % of urban household and 55% of rural households currently receive electricity.(“India Village Directory”) Therefore India needs an alternative solution to cater to this problem.Looking towards the possible options to provide electrification to such a vast country with almost 1.4 billion people, off grid housing definitely stands out to be the best possible solution.

The ministry of new and Renewable energy (MNRE) is supporting the off grid technology and is trying to electrify India completely.The new scheme launched by MNRE is “Off-Grid and Decentralized Concentrated Solar Thermal (CST) Technologies for Community Cooking, Process Heat and Space Heating & Cooling Applications in Industrial, Institutional and Commercial Establishment” (Gupta, 2018).The main objective of this scheme is to promote the off grid technology and to meet/supplement heating /cooling systems and to generate electricity through solar and thermal energy. (energy, 2018)

OFF GRID PROJECTS-INDIA

1. Bioenergy-Gasifier
2. Bioenergy-Biogas
3. Bioenergy-Biofuel
4. Solar Power-Solar PV

Bioenergy-Gasifier

“Biomass is an industry term for getting energy by burning wood, and other organic matter. Burning biomass releases carbon emissions, but has been classed as a renewable energy in the European Union and United Nations legal frameworks, because plant stocks can be replaced with new growth.” (Page, 2016)
Biomass has a high potential energy source in India, it enjoys great support from the state and the centre.Currently India is a leading country in Bioenergy. ‘Gosaba island’ gasifier is an epitome of how the biomass energy can be utilized to change the lives of people in remote areas in India.

Case Study- Gosaba Island Gasifier

Gosaba Island is an island in west Bengal’s Sundarban region and was deprived of electricity as it was not economically feasible to extend power from the grid to these widespread islands. West Bengal Renewable energy Development Agency (WBREDA) took the initiative to provide electricity to the island.The Vadodara based Ankur Scientific energy technology in collaboration with WBREDA opened a biomass plant in the village.The island that was once lit with kerosene lamps gave a way to the electric bulbs and soon the island became a small town.

Case Study - Turning Destructive Pine to Productive gas; Kumaon Valley

AVANI- a voluntary organisation helped the people of Kumaon valley in Uttarakhand to produce electricity by the use of pine needles. The organisation aims to produce about 14.65MW of electricity from the biomass (Off grid Technology, 2011).The state has the opportunity to electrify the state through the gasifier which is more accessible and cheap.

Pine Based Gasifier

The gasifier volatize the pine needles into a producer gas which is a combination of the combustion gas. The gas is passed through the filters consisting of the saw dust and fine cloth to remove the impurities from it, the resultantant gas is used to run the diesel engine which generates electricity.

Benefits from the Gasifier

The pine based gasifier guarantees to benefit the common household kitchen by allowing them to use charcoal effectively as it is one of the byproduct (10% of the residue) of the gasifier, this allows the smoke free household eliminating the pollution and the lung diseases.Charcoal produced by the 120 KW gasifier is sufficient to meet the household demands of at least 100

homes in the area.The villagers can pay for the charcoal or can collect the pine needles and get it in exchange. This project aims at increasing the employment growth in the area and as well as providing them with electricity and also smoke free alternative to cook food. The efficient charcoal is also considered as a substitute for the LPG gas which is very expensive and limited in India. therefore the project actually aims towards the off grid solution leading towards the sustainability.According to the estimates, the pine gasifier has the potential to generate electricity in whole of the himalayan region thus meeting the need of 1.4 crore families (Off grid Technology, 2011).

Figure 03: Pine needle gasifier, Kumaon Valley. *Source: Avani, 2014*

Bioenergy- Biogas

Biogas consists of methane, carbon dioxide, Hydrogen sulphide, moisture and siloxane.The resultant gas can be used for heating purposes and cooking and can also be used as a major ingredient for generation of electricity.

Case Study- Hybrid Vermicompost Biodigesters

Karnataka is a developed state of India. Bengaluru, the capital of Karnataka is known as the silicon valley of India. However the rural areas of this state are still deprived of the modern technology and survive on open fire cooking, which is a threat to the environment. The women generally collect wood from the forests to support their cooking with the traditional means.

SKG Sangha(SKGS), a non profit organisation of Kolar district of Karnataka has pledged to provide a safe and clean cooking gas to the people of this district and also generate a source of income by selling the fertilizers made from the biogas as a byproduct. “The biogas is prepared

by cow dung, it consists of an underground brick built digester , an inklet at the ground level to feed the digester with new feedstock and two separate outlets to collect biogas and to remove the residue" (Off grid Technology, 2011).The galvanised steel and HDPE pipes are used to transport the gas from the plant to the kitchen stoves.

The biogas has the capacity of producing upto 4m^3gas/day from an input of 50-100 cow dung. The liquid residue produced from the plants accounts for 36 to 72 tons and can be used directly in the fields but to transform the liquid fertilizer to the organic matter SKGS use the Vermiculture technique.This technique involves the storing of the liquid residue into a compost and then addition of fibrous materials to decompose it for at least 3 weeks. After the decomposition is completed, the earthworms are added to the mixture. The top layer of the worm casts are scraped off and is used as vermicompost (Off grid Technology, 2011).

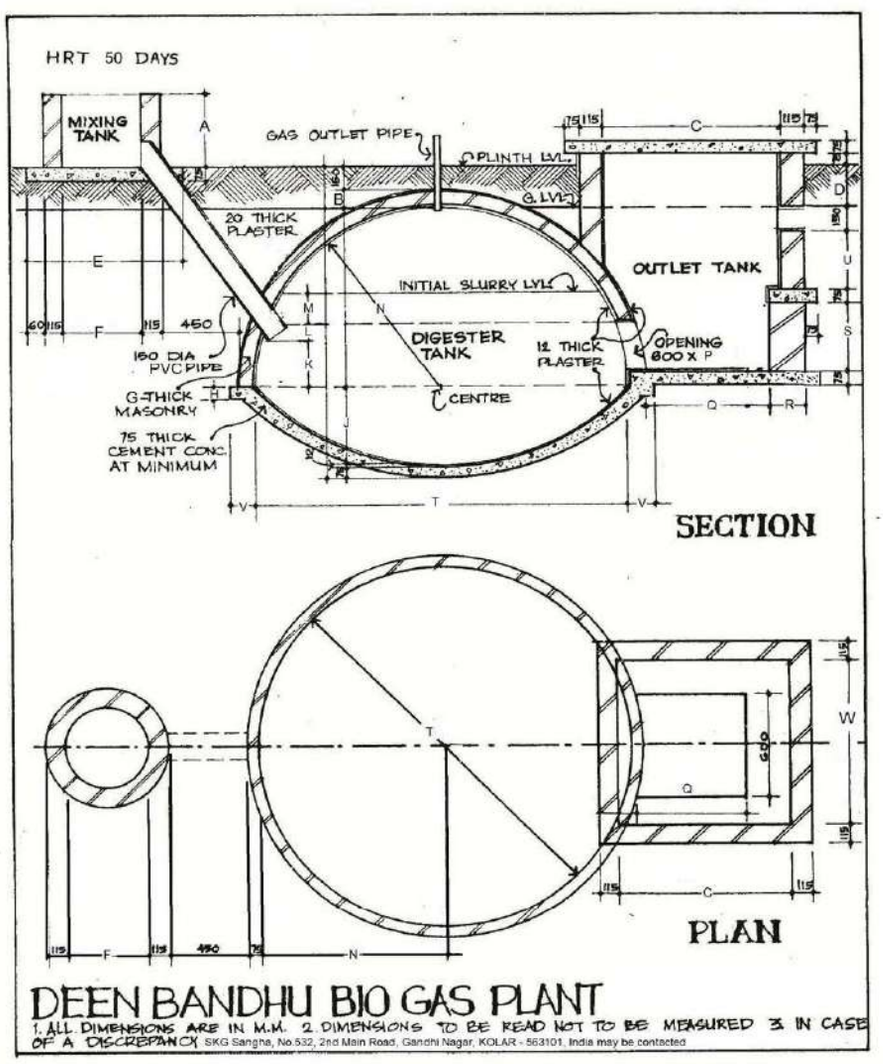

Figure 04: Pine needle gasifier, Kumaon Valley. *Source: Avani, 2014*

Benefits of the Project

- Smoke free household generated decreasing the respiratory problems for women.
- Saves a lot of time for women as the search for wood is a tiresome activity.
- Generates employment for the people of the rural areas.

- The vermicompost replaces the chemical fertilizers
- Increases the soil fertility and the water retention of the soil.

Bioenergy- Biofuel

Biofuel is produced through anaerobic digestion of the wastes produced through agriculture, industrial or the domestic waste.The waste generally consists of plants or plant driven materials.Some of the biofuels are Bioethanol, Biodiesel, Biogas, Syngas, Jatropha biofuel.
Case Study- Jatropha, an emerging option for rural electrification

'Ranidhera' village in Chhattisgarh is one of the electricity deprived village.The electricity was generated after the 'Winrock International India' started an innovative project of producing electricity by the extraction of biofuel from the seeds of the Jatropha plant.The project was collaboratively supported by the British high commision, Swiss Agency for Development and Cooperation and the ministry of New and Renewable Energy. The aim of the project was to electrify around 6000 remote areas of the country.

The power plant initially(april,2007) had the capacity of producing 11 KW of electricity thus providing 3 hours of electricity for households and around 3.5 hours for the street lighting.The off grid projects helped in producing the cheap electricity for the remote areas (Off grid Technology, 2011).

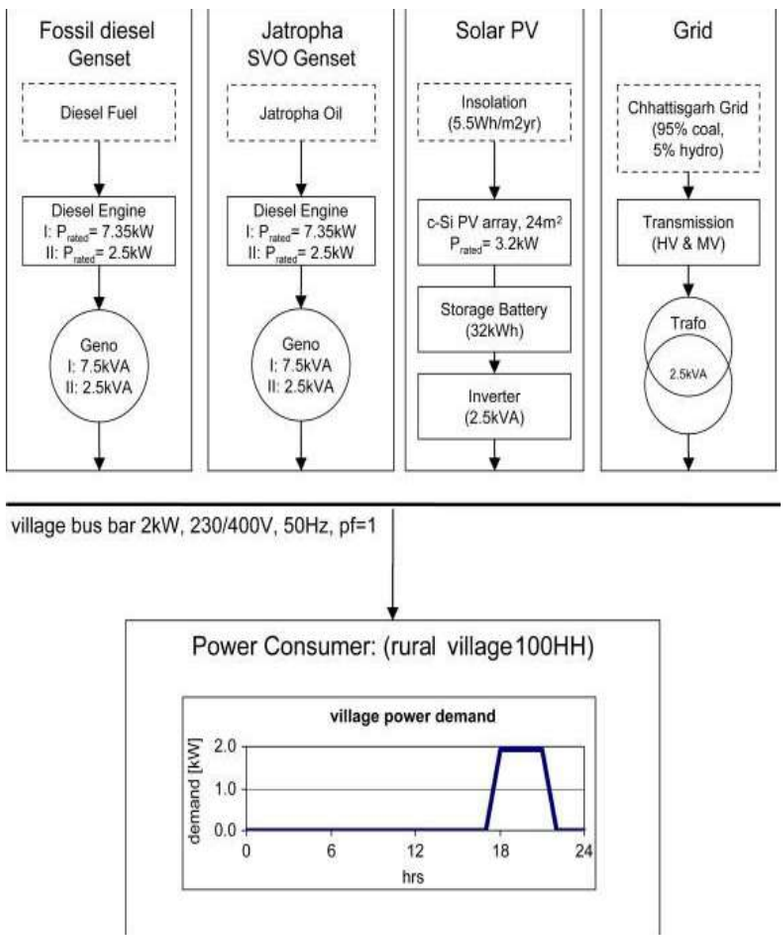

Figure 05:Comparison of four electricity supply. *Source: Salomonsson D, 2008*

Figure 06: Solar panel installed in Karnataka. *Source: Solartoday.co.in, 2016*

Solar Power- Solar PV

The most abundant form of energy available in India. “India is located in the equatorial sun belt of the earth, thereby receiving abundant radiant energy from the sun”(ShirishGarud,IshanPurohit). According to the recent report India has a capacity of 20 GW of electricity generation.(Priya Sanjay,2018).India aims to achieve 100 GW target by 2022 (Das, 2015). The India’s largest solar power plant known as ‘Shakti Sthala’ is installed in India.It generated 2000 MW of electricity and is laid upon on 13000 acres covering almost 5 villages (NDTV, 2018).

Case Study -Tirupathi, The Green Temple

‘Tirumala TirupatiDevasthanam’ is the richest temple in the world. It has the largest number of devotees visiting on a single day.The temple is located in southern part of India in Andhra Pradesh and has been trying to adopt renewable sources of energy for meeting its everyday requirements.The temple has a wastewater treatment plant that recycles and purifies the water

Figure 07: Solar panels installed at the Tirupathi Temple. *Source: Terienvis, 2015*

requirements.The temple has a wastewater treatment plant that recycles and purifies the water for another cycle of usage.The canteen of the temple provides the free mineral water to discourage plastic bottles and they also use the solar energy for cooking meals for the devotees. The solar cooker was installed in 2002 and has the capacity to prepare 50,000 kg of rice along with curry for 15000 persons in one cycle.The solar technology is installed by the Gujrat based company 'Gadhia Solar' and the HTT Gmbh of Germany (Off grid Technology, 2011).

The installation cost of the system is around 11 million rupees.The expenses were covered by the temple as well as the Union ministry of Non-Conventional Energy sources.The solar cooker needs no modification and has a lifespan of 25 years (Off grid Technology, 2011).

Future Plans- The temple authorities have decided to utilize the steam produced in the solar plant to meet the requirements of the Kalyanakatta, where the pilgrims do the rituals of head tonsuring.The Gadhia is also planning to install 500 KW solar thermal system in the temple (Off grid Technology, 2011).

Zaatari Refugee Camp

Introduction

Politics play a major role in today's communities, and lately the world has been facing critical situations and wars, unfortunately all of that creates instability in the existing communities where conflicts occur, resulting to force large populations to immigrate to safest areas and build their new communities, one of the latest sadly conflicts is the one happening in Syria started

Figure 08: Syrian Conflict 2011. *Source: East, 2016*

in 2011, which so far has forced millions to evacuate their homes and turn to be homeless or refugees. Refugees from Syria immigrated to many countries whether it has borders along with Syria or not, many refugee's camps have been established in remoted areas to host those people and try to secure basic life needs for them, but with lack of resources, infrastructure and communications it was a huge challenge to secure their needs; water supply, food production, energy, waste treatment, medication, education and others in the built up camps (East, 2016).

Overview

ZAATARI Camp in Jordan is one of the largest camps for Syrian refugees around the world which was established in 2012 hosting more than 80,000 refugee covering an area of 5.3 sq.km in northern Jordan, near to AL MAFRAQ which is a deserted area with lack of water resources, food supply and energy, the challenge was to secure these needs for more than 80,000 refugees -the population is growing at least for the next 15 years –average refugees camp lifetime-, no temporary solutions would be practical or even acceptable. Off-grid housing is a convincing approach in such situations, a need to develop a self-standing sustainable community to host

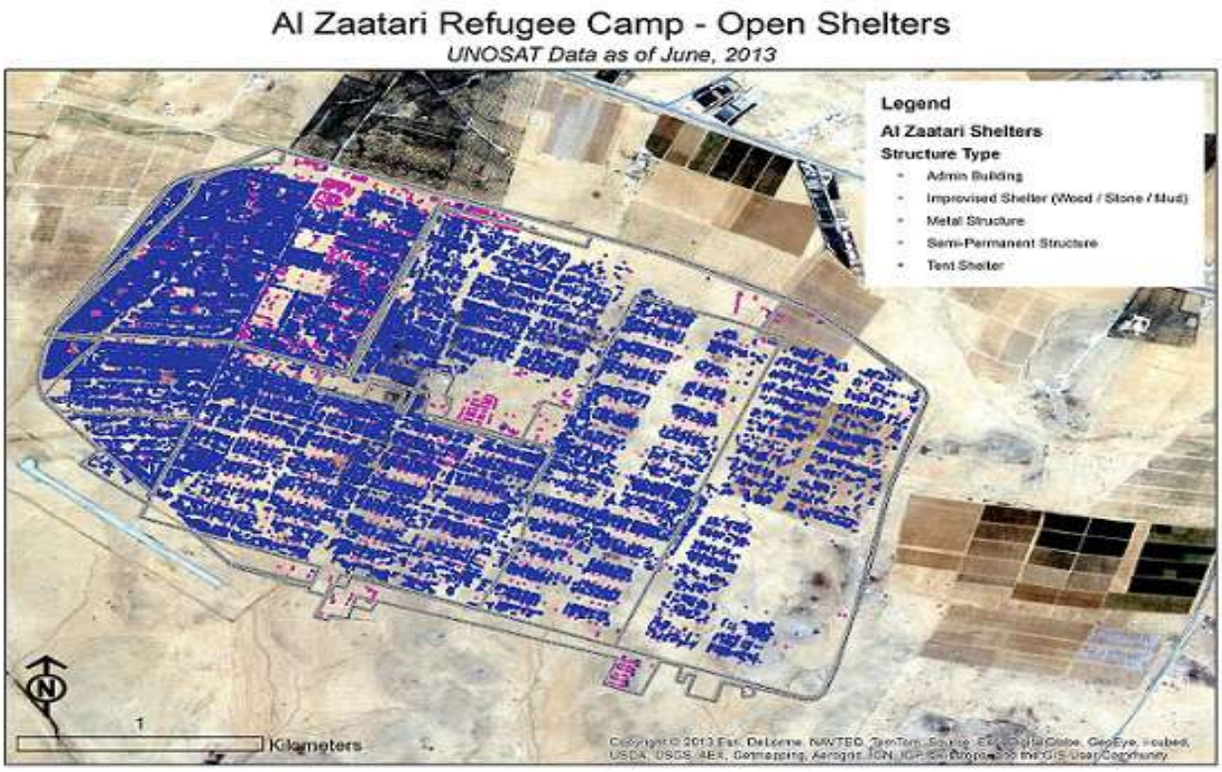

Figure 09: Satellite Image for ZAATARI Refugee Camp in June 2013. *Source: Data, 2013*

all these people for years (EAST, 2014).

ZAATARI refugee camp was opened in July 2012 for Syrian refugees where almost 461,701 refugees have passed through the camp, on 26 March 2015, the camp population was estimated at 83,000 refugees by United Nations High Commissioner for Refugees (UNHCR), average of 80 births per week, and 14,000 weekly consultations, while statistics shows that 19.9 % of the population are children below 5 years' old who need intensive care (EAST, 2014).

ZAATARI Refugee Camp; Off-Grid Housing

Housing

Once the camp was opened for refugees in 2012, tents were pitched on as a place for them to live in temporary which will be replaced by better housing options later on, shelter programs started supplying donated 'caravans'. While other programs helped providing other shelters such as; cabins & built up units (AFP, 2012).

Water Supply

Water is essential for any living creature and its one of the main needs for humans, without water or even lack of it no life can be assured, so organizations along with the Jordanian government had to implement a plan to secure water supply for the camp in an amount can cover the whole population essential needs, as an initial temporary plan water was supplied by trucks to the camp, although It was expensive and time-consuming and can be delayed or interrupted but it was the only solution at that time till the drilling of the two new internal boreholes near the camp are completed provides 3.2 million liters of drinking water per day (UNHCR, reliefweb,

Figure 10: Housing in ZAATARI Refugee Camp. *Source: AFP, 2012*

2017). Also work is ongoing to improve the water supply in villages surrounding ZAATARI, which will benefit both Syrian refugees and host communities. In addition to some expansions in MAFRAQ pipeline which feeds the nearest city to the camp will benefit 25,000 Syrian refugees and local residents (Degan, 2012).

The results and goals of these projects are that “People living here will get double the amount of water, better pressure and more reliable. The work we’re doing here will not only help the Syrian refugees in the camp, but also serve the people in the surrounding communities,” says Mr. Hameed. Water distribution presently takes place via a fleet of approximate 82 trucks delivering water to communal public and private water tanks (Degan, 2012).

Figure 11: Water Supply in ZAATARI Refugee Camp. *Source: Acted, 2016*

Energy

Electricity as a power supply is one more requirement to establish a new residential area, provides an essential lifeline for camp residents, from lighting shelters to preserving food and maintaining hygiene, “Light is absolutely essential,” said Anne-Marie Grey, the executive director and CEO of USA for UNHCR, in an interview. “When you go into a camp, you realize how it’s a safety issue as much as a right to light or a right to energy issue” (UNHCR, Jordan’s Za’atari camp goes green with new solar plant, 2017). As stated before, in the case of ZAATARI camp the challenge was to provide enough power to supply all population in that remoted area, using generators and some connections from the local network was defiantly a temporary solution; as it was costly and insufficient; especially with a monthly bill of 800,000 $ (Pyper, 2015), so UN started considering the idea of constructing a renewable power supply project to serve the area’s needs.

Figure 12: World's biggest solar power plant for a refugee camp opens in Zaatari. *Source: Luck, 2017*

The UNHCR's three-year Energy Strategy 2015-2018 plan was to build a solar plant which will be the largest ever built in a refugee camp, providing clean and much-needed power to the Syrian refugees in camp. According to UNHCR "The plant will reduce annual carbon dioxide emissions from the camp by 13,000 metric tons per year, equivalent to 30,000 barrels of oil. It will also deliver annual savings of around US$5.5 million, which UNHCR – the UN Refugee Agency – will be able to reinvest in vital humanitarian assistance" (UNHCR, Jordan's Za'atari camp goes green with new solar plant, 2017)

Briefly, The 40,000 photovoltaic panels solar plant was constructed on the outskirts of the camp with an approximate area of 0.8 square km, arranged in rows hundreds of meters. According to UNHCR "the 12.9 megawatt peak solar photovoltaic plant was funded by the Government of Germany with a cost of 15 million euros (US$ 17.5 million)" and will be operational by the end of 2017 (Luck, 2017).

Figure 13: Waste Management in Zaatari Refugee Camp. *Source: www.youtube.com, accessed: 2018*

Waste Management

Waste management considers two main categories; waste water and solid waste, in order to maintain a healthy hygienic life in the camp it is necessary to develop a plan to control, dispose and even recycle general waste. According to UNHR approximately 2,100m3 of sludge is collected by desludging trucks every day; 750 m3 of solid waste is collected every day. A wastewater treatment plant was established to approximately treat 80% of the wastewater generated in the camp; methodology was by collecting and transporting the generated wastewater by a fleet of sewerage trucks to the treatment plant. For solid waste, some efforts has been done so far, it is collected by trucks and transferred to external solid waste facilities, in order to consider recycling an approach to start separating the solid waste; plastic, paper, cardboard, glass & metal has been taking place (Motasem N. Saidan A, 2016).

Community and Social Services

- 11 schools; 20,771 school-aged children enrolled (UNHCR, reliefweb, 2017).
- 27 community centers provide psychosocial support & recreational activities (UNHCR, re liefweb, 2017).
- 2 hospitals with 55 beds and 9 health care centers, 1 delivery unit and 120 community health volunteers (UNHCR, reliefweb, 2017).

Recommendations and Improvements

Well so far a lot of efforts has taken place to organize the lifestyle in the camp but still there is much room for improvements in terms of housing, energy and waste management.

Earth-Ships

Earth-ships can be a housing solution, also it involves water harvesting, energy production and even recycling.

Let's describe briefly the structural elements of an earth-ship, the building is often forced to be horseshoe-shaped due to the use of rammed tires. The opening of the horseshoe faces depends on the location in order to maximize natural light and solar-gain. Rammed earth tires will be filled in place usually with soil that prevents tires from burning when exposed to fire or heat and provide more stability, extra insulation is added on the outside of the tire walls. After building the walls a can – concrete or a wooden bond beam will be laid on top and attached using concrete anchors. The roof is either a truss, or wooden support beams, that rest on wooden shoes on top of the bond beams. External insulation will be applied for the walls and roofs in order to reduce heat loss (Reynolds, 2016).

Earth-ships has proven to be a practical way to recycle not only tires but other material such as cans, bottles and many other. It has been sustainable in every function as mentioned above, with extra efforts and awareness among people we might see cities of earth-ships in the near future (Reynolds, 2016).

Unfortunately it is a fact that, in the world today, a staggering 1.3 billion people have limited access to water, sanitation and electricity. Many of these people live in rural and semi-rural communities. Until such communities have access to efficient water, energy and sanitation services, little progress can be made to develop their economies and improve their lives (Reynolds, 2016).

Turn Waste into Energy

An approach to turn food and animal wastes into clean and safe fuel and fertilizer, although eliminating pathogens from the bio waste is a challenge due to it's potential to cause illness and attract disease-carrying animals, it has been possible by involving educated biogas technicians and closed-loop farmers. This will provide energy and even a chance to residents for learning, sharing and implementing clean and renewable energy solutions within ZAATARI Refugee Camp.

Studies proved that this approach will reduce fossil fuel usage and indoor air pollution by properly managing food waste (Initiative, 2016).

Figure 14: Use of cans & tires as material. *Source: Vyas, 2018*

Figure 15: Rammed earth water tank using tires. *Source: Vyas, 2018*

CASE STUDY: EARTHSHIP PROJECTS - NEW MEXICO, USA.

Overview

The three step solution ‘reduce – reuse – recycle’ has been rhetorically exploited by anyone and everyone, who’s genuinely concerned or even vaguely aware about the global issue of environmental degradation. Down the line, waste management becomes critical. While the popular belief suggests that once the waste is out of sight, combusted or eliminated somewhere ‘away’ from the habitation, majority of the problem is solved. However, Annie Leonard, the executive Director of Greenpeace, US says “There is no such thing as “away.” When we throw something away it must go somewhere.” (Vyas, 2018)

Similarly some architects believe in the thought of reduce, reuse & recycle. One such architect is Michael Reynolds in the history of architecture fraternity in the US for creating earthship projects. The architect is a living legend for producing these self sustaining houses around the world which are a classic example of offgrid projects. The work began by him can be seen from projects dating back from 1970’s and still happening around the globe under his initiative and architectural practice “EarthshipBiotecture”. However the journey he started was not smooth

Figure 16: A typical completed earthship project. *Source: Vyas, 2018*

in the beginning but was much appreciated in the later phase of his life. His fascination for this work led him up in getting 2 acre land in the city and outskirts of New-Mexico.
He could build some projects but the houses later in the life cycle of structure had issues regarding leaked ceilings & cracking of plasters. Customers who once highly regarded the projets started reporting issues which resulted in confistication of his licence for almost 17 years & his practice came to a standstill. However due to international exposure to the projects different projects kept happening around the globe. Over the course of years and development in the technology now the projects built are much more refined version of what it was earlier. However what started out of shear passion now has been considered as one of the sustainable solutions for housing across the globe. Some people consider it as post apocalyptic houses in the US.

5.1 Introduction

Design and Structure

The houses are basically a solar passive structure made using recycled material. Reinforcements used are bottles, aluminium cans, plastic bottles, recycled tyres which are fused with concrete. The materials take away the space from concrete and a substantial amount of concrete is required. The structure is self-sustaining as it develops some organic food, sewage water system with triple use for grey water for toilets, bath and tree plantation. It is also equipped with the solar energy utilization and water harvesting equipment. Combination of all of these factors results in a smooth functioning for a family of four people.

Construction

“The buildings are often horseshoe-shaped due to the difficulty of creating sharp 90 degree angles with rammed tires. In Reynolds’s prototype at Taos, the opening of the horseshoe faces 10–15 degrees east of south to maximize natural light and solar-gain during the winter months, with windows on sun-facing walls admitting light and heat”. (Fire, Earthship Hondo 2018) The floor plan explains the typical prototype design.

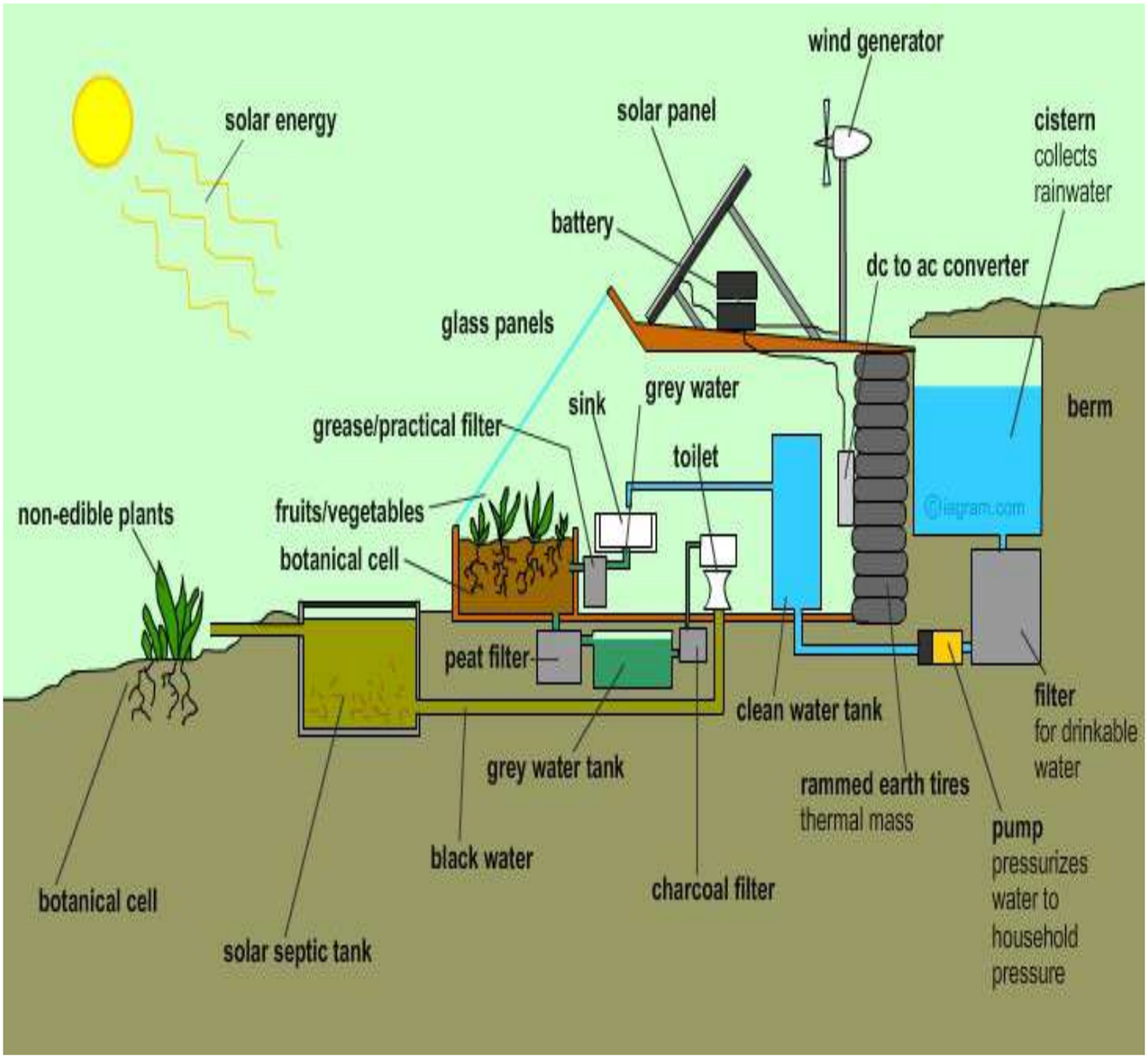

Figure 17: Typical Section of the Prototype. *Source: Vyas, 2018*

“The book,Earthship I, describes how to find the best angle depending on the building’s geo-spatial location. The thick and dense walls provide thermal mass that naturally regulates the interior temperature during both cold and hot outside temperatures. The outer walls in the majority of Earthships are made of earth-rammed tires, but any dense material with a potential to store heat, such asconcrete,adobe,earth bags, or stone, could in principle be used to create a building similar to an Earthship” (Fire,Earthship Hondo, 2018).
The typical floor plan encompasses the hill ascend shown in brown and the space division of the house.

“The tire walls are staggered like traditional brickwork, and often have “concrete half blocks” every other course, to equal the length of the staggered tire below. In an effort to cut down the use of concrete even further, they also use “squishies” - tires rammed in between a tight space to even out the course or to compensate for varying tire size” (Fire,Earthship Hondo, 2018). (Fire, Earthship Hondo 2018)

“Teams of two people assemble the earth-rammed tires of an Earthship. One person shovels dirt and places it into the tire one scoop at a time. The other person, who stands on the tire, uses a sledgehammer to pack the dirt in while moving in a circle around the tire to keep the dirt even and to avoid warping the tire” (Fire,Earthship Hondo, 2018).

“Rammed earth tires can weigh up to 300 pounds, so they are typically filled in place. Because the tire is full of soil, it does not burn when exposed to fire. In colder climates, extra insulation is added on the outside of the tire walls.On top of the tire walls are either “can or concrete bond beams” made of recycled cans join by concrete, or wooden bond beams with wooden shoes. These are attached to the tire walls using concrete anchors, poured blocks of concrete inside the top tires” (Fire,Earthship Hondo, 2018).

“Wooden shimming blocks placed on top of the wooden bond beam make up the wooden shoes. The wooden bond beam consists of two layers of lumber bolted on to the concrete anchors. Rebar is used to “nail” the wooden shoes to the wooden bond beam.Internal, non-load-bearing walls are often made of a honeycomb of recycled cans joined by concrete; these are nicknamed tin can walls. These walls are usually thickly plastered with adobe, and resemble traditional adobe walls when finished. The roof is made using trusses, or wooden support beams called vigas, that rest on the wooden shoes or the tin can walls placed on the bond beams. The roof as well as the north, east and west facing walls is heavily insulated to reduce heat loss” (Fire,Earthship Hondo, 2018).

“Earthship structures have a natural ventilation system based on convection. A 30 ft pipe extends from the interior of the house under the berm, cooling the air by the time it gets to the comfort zone. As the hot air rises, the system creates a steady airflow - of cooler air coming in, and warmer air blowing out though a smaller vented window in the greenhouse” (Fire,Earthship Hondo, 2018)

Finishes

Initially the houses were not accepted as the surface finishes were exposed and customers hesitated to invest. Later the techniques developed helped in acquiring smooth finishes. Due to the developed technique & who had been trained under him started developing their own earthship projects, leading to a mass movement in the earthship projects history. The internal finishes in terms of bootle usage, staircases and floor finishes can be observed directly from the figures below.

Conclusions

Based on observations & study of the design & construction technique the project can be divided in subsections of merits, demerits & recommendations.

Merits

The projects follow all the architectural & design fundamentals for an efficient prototype. The overall house is self-sustaining and caters to needs of 4 people.” The majority of electrical energy is harvested from the sun and wind. Photovoltaic panels and wind turbines on or near the Earthship generate DC electricity that is stored in deep-cycle batteries. However they can be connected to the city grid.

Figure 18: Tires rammed with earth and stacked. *Source: Vyas, 2018*

"The energy run through the Power Organizing Module can be used to run any household appliance including washing machines, computers, kitchen appliances, print machines, and vacuums. Ideally, none of the electrical energy in an Earthship is used for heating or cooling" (Fire,Earthship Hondo, 2018).

Demerits

The projects are classic example of sustainable housing solutions. However the viability of the projects in an urban metropolis or in a gated community needs to be addressed. Also the structure is ground floor and has a wide across span. Therefore the space occupied in terms of footprint is also more. The work is a labor-intensive work & high skilled workforce needs to be trained for taking up such projects.

Recommendations

The prototype needs to be developed further into ground and first floor structures minimum since it would add more occupancy to the house. A gated community of such housing projects can be marked as a new urban development policy for new district centers coming up in the

Figure 19: Interior's post completion. *Source: Vyas, 2018*

outskirts of cities.

Special structural & architectural certification category needs to be developed and tested for such prototypes.

A central funding source or resource allocation from the Governments are necessary since these type of houses would cater more to the requirement of people than creating a conventional structure. The use of renewable sources such as "Zero Mass Water Technology" in such projects would make these kinds of projects' more efficient & could be a solution of more advanced earthships.

Figure 20: Hydro panel networks for mass collection placed on a terrace. *Source: Zero Mass Water, 2018*

CASE STUDY: WATER BASED STARTUP ZERO MASS WATER – ARIZONA, USA.

Introduction

“You can’t connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future” (Steve Jobs, 2011).

This is what exactly some people do in the world and achieves results. Have you ever wondered if you can extract water from air on your rooftop using solar panels, nanoparticles, and data along with no use of electricity? Sounds next level of innovation right? Yes now it has been made possible by combining these dots into products. Renewable water drinking system, which is drinkable and completely made by air, is designed my Mr. Cody Friesen. He is the CEO of company named “SOURCE” who have made it possible together as a team. The product is named as “ZERO MASS WATER” (Zero mass water).

Working System

The devices are known as hydro panels. The panels look like a typical solar panel. But there is more to it. The panel is a mixture of solar panel & nanoparticles with surface boards. Beneath the panel is a rotor which makes the water percolate in the system of substrate thus making it more suitable for mixing it with the nanoparticles.It is extraction of water from air using nanoparticles as a substrate. Which further goes into a rotor, which is beneath the solar panel where the pH level is maintained for making it potable by using the nanoparticles substrate. The company’s network operation is known as “KNOCK” which monitors the panels installed all over the world. It uses algorithm to monitor & maximize the water extraction output. It’s a similar process of natural dewdrops formation on the grass. The company claims that one panel produces 5 liters of water every 24 hours & the installation time is 1 hour for the panel. It can be set up immediately in event of disaster. The two panel system costs 4500 $ which is expensive. The company relies on NGO’s & donations for making these panels available in quantities wherever required.

However the difficult part is taking the connection of the pipe connected to the panel to the

Figure 21: Hydro panel water being extracted onsite in South Africa. *Source: Zero Mass Water, 2018*

refrigerator or tap. The company claims that commercial output can lead to making the panel cheap & eco friendly.

The material used for controlling the pH value of water are organic and completely biodegradable. The company claims that the water can be produced even in desert. The aim is to replace PET (Polyethylene Terephthalate) certified bottled water with this instant resource which are recyclable.

In the end the question that needs to be addressed is the methods sustainability and is it the the only source and renewable source to extract water from the nature ? Since reuse and recycling of water is still considered as sustainable source of using water. Further it can be connected with the earthship projects. And further recommendations addressed are as follows.

Recommendations

The project is a sustainable solution for housing especially in countries like India. We already have huge terrace spaces that can be filled with hydro panels. Also if made economical it can be included in planning policies for housing projects. This can solve enormous pressure on water systems of a city & also an alternative for ground water.
The panels can also be part of earthship projects since the system used in earthship projects are completely based on reusing water and are established on such project. So the system can be connected to the project. If for example say 10 panels are installed and they produce on an average 4 liters of water. They can produce 48 liters every day. This would enhance the recycling system of the housing regarding water. The only thing required is making the system more economical.

Critical Analysis

SWOT

Off-grid systems in India

Strength - The three major strengths are cheap production, employment generation, and smokeless cooking.

Weakness – The majority of the systems are home-made or on a community level. The output is minimum. There is a significant amount of loss in energy as they are unconnected to the city-grids. The issue of power cuts is critical.

Opportunity – If these systems are made possible to be integrated with the urban grids, the future sustainable cities can be highly benefited.

Threat – There is no proper standards and norms available and due to this there are often safety issues and undesired outcomes.

Earthship Housing in Mexico

Strength – The prototype of earthships can be very useful in building earthship communities and villages. It utilizes waste water, garbage, earth as the major resources.

Weakness – The scale of earthship is not suitable for large scale development specifically for sustainable cities. There is no clear analysis for the whole life cycle of the building in terms of sustainability. It does not offer any solution for urban areas suffering from scarcity of land.

Opportunity –It can create affordable and sustainable housing solutions even in extreme desert situation. It provides an opportunity to develop housing without any help from higher authority or financial aids.

Threat – It can face challenges from the local authority in terms of land-use and sanction of construction. The viability and safety of the structures is also crucial. The pioneer architect of this idea has already lost his architectural license due to safety issues.

Refugee camps in Jordan

Strength – The major support came from the German government, local specialists, and UN funding. It has created waste to energy supplies.

Weakness – The lack of local specialist in sustainable off-grid systems in Jordan.

Opportunity – The camps has offered food, water, and energy supply It has created the opportunity of implementing the earthship principles.

Threats – It has fire hazards, lack of standardization. There is possibility of diseases from toxic gases produced from the bio energy plants.

PEST

Off-grid systems in India

Political – Often there are dependencies on funding from the Government which ultimately oscillates based on the political equations. The shifting of political power in the democratic election can create challenges for a project. The political influence on the local labor can be conflicting with sustainable goals of the off-grid systems. There is scope of large scale cooperation between government and private enterprises.

Economical – Energy can be produced on a very cheap rate. It is a significant step forward to balance the demand and supply of renewable energy. It is economically efficient and effective in small scale.

Social – Major initiatives from the government and NGOs are based on social benefits. The off-grid solutions often benefitthe unprivileged sections of the society.

Technological – Integration of solar and geo-thermal energy can be achieved in order to produce a much more efficient system with the technological advancements.

Earthship Housing

Political – it creates the golden opportunities of public private partnership (PPP) to achieve a mass-scale production on a larger scale.

Economical – The time and labor involved in these projects are intensive. However, the end-product can be produced at almost half-price courtesy to the utilization of waste materials.

Social – Ranging from design, construction and operational phase it has the potential to create community spirit. It can offer very healthy social housing for small scale neighborhoods.

Technological – There is a demand of specific technological knowledge and competency for designing and construction earthship housing. Specific aspects such as water refinement and reuse, solar passive design, labor supervision, material selection demands sound technological knowledge which is not always readily available.

Refugee camps in Jordan

Political – The political scenario is very sensitive. Providing housing to people from other country in a ‘war-like’ scenario in Jordan cries for high political sensitivity.

Economical – It is economically sustainable. It can produce ten times cheaper electricity.

Social – There has been 9 schools and 2 social centers already built in this project which clearly reflect careful communal planning. There is an ongoing effort for gaining more training centers to spread knowledge and awareness on self0sustainability.

Technological – The telecommunication in the area has been a major challenge. In the future access to the web in necessary by satellite or mobile towers which would connect the neighbor-

hood with the rest of the world. There is a scope of further technological innovation to reduce the carbon footprint of the camp.

Conclusion

Unfortunately, the off-grid systems are sluggish and unable to meet the demand of the rapidly growing energy need (Louie, Dauenhauer, Wilson, Zomers, & Mutale, 2014). The scale of these is also tiny compared to Cities. We need more ideas, innovation, attention, knowledge and attention to make these systems beneficial for our future 'Sustainable cities'.

The small-scale implementation of off-grid systems in rural areas of India bring much hope but is not sufficient to cater the massive demand of energy of growing India. The government needs to come up with innovative measures to accommodate the benefits of these systems into our future cities. The economies of scale of the systems has to grow critically to be comparable to cities. Technological advancement should be adopted to integrate the on-going systems to the main grid for achieving the optimum sustainable outcomes.

In earthship housing, there is a possibility of incorporating geo-thermal energy and technological advancement in water supply. The integration of newest technology to these housing can give a promising model for the sustainable cities. Multi-disciplinary approach with an wider flexibility would bring this model one major step forward to be ready for implementation in the future cities. The prototypes need to be more efficient and accommodate more people which is essential for the growing need of a city. A higher efficiency is necessary in time, labor, and design. This can be a considerable option for Urban agglomeration for our future cities.

The refugee camp is a unique example of off-grid systems. However, this model is crucial to study as a remedy for crisis (Natural or political) situation of the cities. It shows quick response in developing a sustainable community which can be an effective lesson which dealing with natural disasters in cities. However, one has to think about larger case solutions more apt for a sustainable city. The situation is highly undesired as a permanent or even a temporary state in any city.

Chapter 5: Image Sources

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Figure 5.9 : Satellite Image for Zaatari Refugee Camp in June 2013
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Figure 5.10: Housing in ZaatariRefugee Camp
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Figure 5.11: Water Supply in Zaatari Refugee Camp
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Figure 5.12: World's biggest solar power plant for a refugee camp.
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Figure 5.13: Waste Management in Zaatari Refugee Camp
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Figure 5.14: Rammed earth water tank using tires
Source: https://www.arch2o.com/earthships-michael-reynolds/
Figure 5.15: Use of cans & tires as material
Source: https://www.arch2o.com/earthships-michael-reynolds/
Figure 5.16: A typical completed earth ship project
Source: https://www.arch2o.com/earthships-michael-reynolds/
Figure 5.17: Typical Section of the Prototype
Source: http://rghomedesign.com/earthship-home-designs.html
Figure 5.18: Tires rammed with earth and stacked
Source: https://www.pinterest.com/pin/548242954612544544/?lp=true
Figure 5.19: Interior's post completion
Source: https://www.arch2o.com/earthships-michael-reynolds/
Figure 5.20: Hydro panel water being extracted onsite in South Africa
Source: https://ascensionenergies.com/2016/10/29/these-new-solar-panels-use-sunlight-to-create-clean-drinking-water-from-the-air/
Figure 5.21: Hydro panel networks for mass collection placed on a terrace.
Source: https://inhabitat.com/airstream-launches-its-first-ever-fiberglass-camper-for-under-50k/

Table1: Estimated Population without electricity
Source: www.worldstatistics.com

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Zero mass water [Motion Picture].

Photographer: Geralt, CC0
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Conclusion - Cities can be Sustainable

Eric Pollock

This sustainable cities research is the result of M. Sc. student teams working on subjects of their own choice from all over the world. Their points of reference are so different that the urban cases chosen show how development can be seen in many ways. Although the students are Bachelor level architects and engineers, governance comes to the forefront in almost every case, as well as the battle against corruption. For some, sustainable development has been taken seriously for the first time.

City Planning in Cairo

Cairo Area is Egypt's' largest urban area and the world's 16th largest metropolitan area. Regionally, Cairo is considered the third largest Muslim City in the world after Jakarta and Karachi.The Greater Cairo Area (GCA) consists of multiple districts, with a total area of 1,709 km2. The current population is ca. 19,8 million, and projected to be 24,5 Million by the year 2030, making it the top city in the world in terms of population growth, above other mega-cities like Shanghai,Manila, Jakarta, Beijing and Karachi.The weaknesses of Cairo include poor infrastructure and transportation, construction waste, unsafe buildings and large informal areas. The strengths are rich historical background, strategic location, renewable energy potential and investment opportunities.

The New and Renewable Energy Authority must continue to develop wind and solar power plants, like the biggest electric power plant in the world, producing 14.4 GW. The nuclear plants under construction must include quality engineering and safety measures.Informal areas are a critical challenge and Cairo's authorities have to supply a framework for development, as displacement for some informal area residents would inflame the situation more than improving it. Overall, the structural condition of informal buildings is good, but condition studies must continue. To improve housing and living conditions, government's determination and funding are the main factors, without which improvement cannot be reached.

The main issues of transportation in Cairo are high population density, high private automobile growth rate, low public transport utilization and poor pedestrian environment causing major traffic problems and air pollution.In health and education, the government should increase salaries in order to enhance the quality of public services and eliminate corruption. Also, scientific research and exchange programs with developed countries should be encouraged.

Santiago High-rise housing

Chile has implemented several regulations related to sustainable housing area during the last years through the Ministry of Housing and Urbanism. The goal of these regulations is to improve the performance of Chil¬ean cities regarding three pillars of the sustainability (social, economic and environmental). Santiago, as the capital of Chile and focus of this research, has defined different methods to apply these regulations. However, this city still has challenges to implement them, such as the environmental pollution, the social segregation and the lack of economic and natural sources.
The first specific objective is to define the key concepts of density, high-rise buildings with green guidelines and low carbon solutions. The construction of high-rise and dense buildings can decrease their cost. New green solutions for buildings can reduce environmental impacts and also improve the health of the inhabitants and limit of economic expenses during the life circle of the buildings.Secondly, to compare successful and unsuccessful examples of dense, high-rise buildings with green, low carbon solutions for housing considering the features of the city of Santiago.

Vertical gardens, mixed uses, energy efficiency and bio climate design can all improve the quality of life.Disadvantages are many, such as difficulties in expensive maintenance and investment, errors in the design and execution and ignorance of the inhabitants on how to use the new technologies.These weaknesses are important to overcome if the goal is to reply the guidelines of these buildings to other housings complex.

Thirdly, the distribution of wealth is unequal, a situation that is reflected in housing projects. The fourth question is to explore new possibilities to design better housing complexes and also the necessity for policies that support these guidelines, since the current law does not consider new technologies and architectural strategies. The education of the inhabitants can contribute to create environmentally friendly housing projects.
In summary, despite the benefits that represent the incorporation of new guidelines related to the increase in density and high-rise and low carbon solutions in housing projects of Santiago, it is important to consider that not all of these are applicable to this city. Each territory has its distinct features (weather, culture, resources and norms), which determine the requirements for each project's need.

The future research topics are the methods to implement and evaluate the new guidelines proposed to Santiago because it is relevant to study the feasibility and resources for development.The new Sustainable Construction Strategy and Code can produce real possibilities to implement change.

Sustainable Transport in four cities: Berlin, Helsinki, Delhi and Pune

If one comprehends a city as a human body, then transportation would be its arteries and veins. It makes mobilization possible. In the age of rapid globalization transportation not only within a single city but transportation deals on a global scale. Comparative analysis of four cities in terms of the different transportation methods and how new sustainable transportation concepts can be applied to make our future better.
Cities flourish, develop and revolve around transportation. Our future sustainable cities would be no different. We need to approach transportation from all the three aspects of sustainability e.g. – social, ecological, and environmental. We have chosen our cities for case studies on a broad range in various scale ranging from low density in Helsinki to very high population in

Delhi

The rapid growth in transportation has remarkably increased the carbon footprints of the cities. A modern city runs on its mobility. In today's world, subways and railways are essential in the daily life of citizens. Rail traffic is one of those basic infrastructures on which common people heavily depend. The Delhi Metro is the lifeline of the citizens. It connects the big city from one part to another. The basic purpose of public infrastructure like Metro is to serve the public a safe and convenient transport. The policy makers must not forget that Delhi metro is also keeping the pollution and the traffic of the city in control.
The Pedestrian safety should be given prior importance in sustainable development of transportation.In older cities pedestrian lanes is where the planners and policy makers can begin the development process at ease. On the other hand, for the making of future sustainable cities the transportation planning should have emphasis on pedestrian mobility. We can also see in the early days of Urban Planning cities were developed on focusing the concept of neighborhood which was much about pedestrian mobility. No matter how much the technology develops in transportation system pedestrian would always be prime in sustainability of future cities.

Berlin

Its the economic and transportation center in Europe. Berlin transportation has witnessed change from old slow cars to modern, high-speed commuter trains. Compared to the increasing population, transportation services are coping well. The development of technology and sensible implementation is critical for sustainable transportation. The aspects of renewable energy and tech- savvy transportation systems such as hyper loop should be considered carefully for our future sustainable cities. Although policy measures that involve restraining the use of private cars and two-wheelers are likely to be unpopular, a gradualist approach of progressively introducing restraints on road use, while at the same time improving public transport, is more likely to lead to greater acceptance. It is believed that improved public transport and more efficient management of demand would help to combat the trend away from public transport vehicles towards greater use of personalized modes. Furthermore, an urban transport policy should encourage the need for developing 'green' modes like bicycling, walking, through a provision of pedestrian paths and cycle tracks especially in new development areas of larger cities and small and medium towns which should be integrated with the transport network. The application of Transport System Management (TSM) strategy such as one-way systems, improvement of signals, traffic engineering improvement measures for road network, intersections, bus priority lanes and suitable policies and development of intermediate passenger transport as a short-term measure should be introduced in all cities especially in metropolitan cities so that the existing road capacity and road user safety is increased. Transportation development largely depends on policy and budgeting. There should be proper structure of transportation budget which is essential for structural development of sustainable cities. In country like India, where policy making depends and changes on electoral polling, construction and implementation of transportation policy suffer greatly from the shift of power among political parties.

For example, Helsinki is planning to change the diesel of the buses for new biodiesel, gas and electric. A more radical solution is Berlin that is planning to get free the public transportation for the population. According to the United Nations, 66% of the global population will live in cities by 2050 (UN, 2014). The infrastructure of the cities must change to improve the Public Transportation and break the walls and believes that the public transportation is for "Poor" people. The private car will never disappear, but with political laws, the used of them can be reduced if the government invest all the energy in develop of public transportation. Germany is the leadership in invest in Public Transportation to reduce the CO2 footprint in the cities.

They are trying to introduce the free transportation to get the people not used the private cars. Break the wall rich-poor and united that used free, environmental and new technologies in a way to reduce the CO2.The investment of the government will be tremendous and in a way to this new law works they must work by the hand of the private sector. Berlin is a Centre for advanced projects and development research. It is a city that contains factories, companies, schools, barracks, hospitals and all the services needed by any large and developed city. As mentioned above, transportation is the main pillar of these services within the city. It represents the artery and beating heart. Trains in Berlin are all powered by electricity, which helps keep the environment safe because it does not emit carbon dioxide, such as cars and buses. Those who travel on Berlin's trains do not represent the upper classes of society, compared to another city in Germany such as Munich. Munich trains and metro are modern in style and spacious with electronic screens. Allowing for luxury and pleasure for all travelers. Berlin stations are old and dirty, where Munich stations radiate light and color, As well as sophisticated electronic screens.

Many cities have buses that run on electricity. Berlin buses do not, but could be converted into eco-friendly buses. Another feature of electric buses is the speed of mobility. They do not produce noise like regular motors. All these things make an exclusive and sustainable city in terms of transportation.Helsinki is a well-planned city and it has strong transportation infrastructure represented by the streets, highways, foot baths, bike lanes, metro, and commuter trains. All these means together form a solid integrated mobility network that gives the residents wide range of travel options and this lead to more reliability on public transport system. Helsinki has developed short-term and long-term strategic planning to increase the sustainable journeys – journeys via walking, cycling and public transport. For example, minimize the distance to the nearest public transport point, maximize cycling use for both private and city bike users, offer parking areas close to metro and train stations, utilize IT solutions like the tripplanner tool, e-tickets and mobile apps. Also, raise the awareness of the sustainable mobility as well as the negative impact of CO2 emissions and provide main tram and bus stops with real-time info via electronic displays to increase the reliability on public transport.

Sustainable Infrastructure, Delhi and Singapore

Delhi is the 6th most polluted city in the World. Right now, Delhi is facing the problem of water shortages, waste disposal, health care, pollution, poor infrastructure and transportation and a housing shortage. The environmental changes are due to overpopulation, overuse of resources, road dust, polluting industries, unclean engines in transportation especially diesel powered buses and trucks. The Population of New Delhi is increasing due to immigrantion, to 18.75 million in 2017, and projected to reach 25 million by 2025.

The major issues facing business today in infrastructure development is corruption, political and regulatory risks, and access to financing and macroeconomic instability.
New solutions for roads, railways, and metro lines must be implemented to make our cities more sustainable. The transportation infrastructure of Singapore and Delhi are compared to identify the required areas for improvement, such as the environment effects of construction techniques, carbonfoot print reduction and the conservation of the natural resources.
The Delhi road network is well laid out. The total length of roads is more than 28000 km that includes about 400 km of highway.

The Delhi government follows the green highways policy 2015, and has already accepted the cold mix road technology in 1999. Delhi has already accumulated the use of plastic waste for road construction and has accepted the warm mixed asphalt system for lowering emission of greenhouse gases. Use of Rubberized Asphalt in construction of roads is also good option in conservation of natural resources. For maintenance of existing road pavements, the option of micro-surfacing is already adopted in Delhi but, it needs to be adopted in full essence. Indian Railways is the fourth largest railway network in the world. Indian Railways are working on a low carbon mass transportation system, reducing the carbon footprints, using renewable energy and alternate fuels, conserving water, and using bio toilets and improving solid waste management.

The Delhi Metro is focused on vitality preservation, condition assurance and economic improvement. Improvements are reusing of waste water by introducing bio-digester tanks, and shifting from fossil fuel produced power to more renewably produced power. 17 megawatts of rooftop solar power capacity have been installed on the top of some stations. Delhi Metro has included 99 Rain Water Harvesting pits at 37 areas. Delhis' opportunities are good connectivity of transport, high literacy rate, and increasing urban development as well as rural development. Due to good connectivity, the National Capital city has the potential to attract private

developers and FDI in the housing and infrastructure sectors.The increasing trend of urbanization all around the world and specifically in Aisan and African countries are very alarming. The world urban population will rise to about 66% of the world population by 2050 and majority of the population concentration areas will be Asia and Africa.
Delhi has a higher population density than Singapore, but, the positive attitude toward sustainable infrastructure in Delhi city is required to achieve the objective of the Millennium Development Goals (MDG). The main problems are the lack of interest of government agencies in the concept of sustainablity, no proper legislation for uncontrolled urbanizations, no proper planning or sustainable design.The construction of new roads in the city is not the needed, but, to maintain the existing roads and infrastructure in way that is sustainable. Because the construction of new roads in the city might create traffic congestion. It is also important that governemnt of Delhi city should focus on the existing infrastructure to make it sustainable rather than construction new infrastructure.

Off-grid renewable energy

The small scale implementation of off-grid systems in rural areas bring much hope but is not sufficient to cater the massive energy demand, for example in India. The government needs to come up with innovative measures to accommodate the benefits of these systems into our future cities. Technological advancement should be adopted to integrate the on-going systems to the main grid for achieving the optimum sustainable outcomes.
In earth ship housing, there is a possibility of incorporating geo-thermal energy and wise use of scarce water supplies. The integration of newest technology can give a promising model for the sustainable cities. A multi-disciplinary approach with a wider flexibility would bring this model one major step forward for implementation in the future cities. The prototypes need to be more efficient and accommodate more people which is essential for the growing need of a city. A higher efficiency is necessary in time, labor, and design.

The refugee camp is a unique example of off-grid systems. However, this model is crucial to study as a remedy for crisis (Natural or political) situation of the cities. It shows quick response in developing a sustainable community which can be an effective lesson when dealing with natural disasters in cities. The situation is highly undesired as a permanent or even a temporary state in any city. The varied backgrounds of the authors gives both language and culture insights into the urban sustainability cases studied. The learning process has taken place in the group discussions. The young engineers and architects have used their strong technical backgrounds to go deeply into the questions of technical, economical and environmental development in cities. The analysis of data and the recommendations offered are only the beginning – the real progress will be made when these young professionals begin their careers, as responsible stewards of sustainable technology for the future our planet.

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Author’s Comments

Hargeet Kaur,
"It was a pleasure to be a part of the editorial group. I personally learned a lot in the whole journey, all thanks to Metropolia UAS and HTW Berlin."

Rajesh Shinde,
"A Challenging and rewarding journey. Much credit to Mr. Pollock for his unfalling trust and constant motivation.”

Abhirup Dandapath,
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Eric Pollock, Editor and Senior Lecturer - (Metropolia UAS)
"An Incredible group of architects, engineers, and designers contributed their best efforts for making this book possible.”

When undergraduates of architecture and civil engineering begin their Master of Science studies in Europe, their lives and their future careers undergo a quantum change. They have come from around the world to study in Europe, to start their professional lives either in design or construction of the built environment'. The basic goal of the whole publication is to look at the 17 sustainable goals (SDGs) of the UN 2030 agenda for sustainable development.
(http://www.un.org/sustainabledevelopment/cities/)

In particular, goal 11 states "Make cities inclusive, safe, resilient and sustainable. Cities are hubs of ideas, commerce, culture, science, productivity, social development and much more." The authors have not hesitated to jump centuries of development to explore urban development of cities, with thought provoking ideas and contemporary debates.

I am confident we will hear from them as sustainable developers.

Mr. Eric Pollock (ed.)
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