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Storm Water Sustainable Solutions in New Cairo Using Landscape Elements

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Abstract

Sustainability is one of the most important requirements and standards that is taken into consideration when establishing or developing a project. It is necessary to pay sufficient attention to urban planning and study. This involves a structured form of the city and the establishment of its own cities, connecting them with different communities, providing all social and economic services for the population as well as improving the performance of the city in accordance with international standards of urban planning.

Storm water is the water that remains after rain, melted snow or floods. The effects of storm water is devastating on the environment, the economy and the social environment, especially in cities. In New Cairo, this problem is still ongoing with no implemented solution and receiving insufficient attention. New Cairo has faced the risk of flooding and major traffic disruptions in most of its main roads in 2018.

In this research, an attempt is made to arrive at a merger between the elements of the Landscape and the infrastructure to find sustainable solutions. This solution can limit or prevent the existence of storm water problems and discusses the possibility of developing existing cities that have problems.

This will be done through analysis, study of the problem, analysis of the case study and the soil, study the elements of the Landscape. Take in consideration that the data is up to date and the solution is possible to implement to solve the problem.

Keywords

Storm water, landscape elements, planning new cities, effect of the landscape.

1. Introduction

Since ancient times, humanity has faced problems caused by stormwater, such as precipitation, thawing or flood. The combination of this water affects the lives of people negatively when not dealt with well. Humans have long since begun to develop ways to get rid of this water efficiently and have now come to reuse it for useful purposes and not merely reduce its damage.

1.1. Stormwater background

Stormwater management has a long history and a number of ancient drains still exist today, such as the Cloaca maxima in Rome, dated at around 600 BCE. (Mohan, 2019).

For the greater part of the historical backdrop of urban drainage, stormwater and waste water have been managed together and have been jointly considered a hazard to be removed from urban centers as quickly as possible to reduce flood risk. Underground stormwater pipe networks were common to most cities in Europe and North America and were constructed in the mid-19th century, following rapid urbanization due to the industrial revolution. (NIWA, 2018).

Fig.1: Historical stormwater management. (Atlas Obscura, 2018)

1.2. City's background

When old cities get crowded with people, it is inevitable for the situation to escalate. The country moves to plan and identify new cities that meet the current needs of the people and predict problems that cities can face in the future, in order to implement solutions in the proper planning from the beginning.

Fig. 2: Madinty streets. (Madinty.com,2018)

New Cairo City is located in the eastern part of Cairo governorate and was established by Presidential Decree No. (191) in the year 2000 on an area of 70 thousand acres. It contains the areas (The Fifth assembly - The First assembly – The Third assembly - Al Rehab – Madinaty – El-Sherouk city) and these cities are considered the newest cities established on Egyptian land. (Cambanis, 2010)

Fig. 3: Madinty entrance fountains. (Madinty.com,2018)

New Cairo City is surrounded by a network of main roads; Suez Road, Ring Road, Katameya Road, Ein El Sokhna, the regional ring, and Al Mashir axis, that provide easy access from the city to the rest of Cairo. (New Cities Government of Egypt, 2016)

The state was seeking good futuristic planning for these cities; meeting the current needs of people, taking in-consideration the increase of the population density and the varying social classes. Part of this plan was for these new cities to be sustainable, which means minimizing the negative environmental impacts and best use of the materials, energy and the ecosystem at large. This would provide a high quality of life along with the lowest environmental footprint, whilst ensuring that the needs of future generations are not compromised. (Baharash, 2018)

The nature and geography of these new cities are characterized by large areas, planning was characterized by large green spaces and wide ways are supposed to meet the purpose.

Fig.4: Madinty Streets. (Madinty.com,2018)

2. Problem Statement

Due to ongoing climate change, the rain map had shifted to different countries and, specifically in Egypt, new cities suffer from poor planning for that regard. Despite the amount of money that was spent on them, no precautions were implemented to prepare these cities to face the problems of rain, floods or other natural disasters that have increased with the climate crisis.

On October 7th and 8th of 1994, the governorates of Assiut, Sohag and Qena were hit by torrential floods that swept through a large number of houses and archaeological sites As a result, more than 15,000 houses were destroyed and 250,000 agricultural acres were drowned along with over 500 people dead in Upper Egypt alone. The reasoning for this was down to poor planning in the placement of homes and facilities in flood surges.

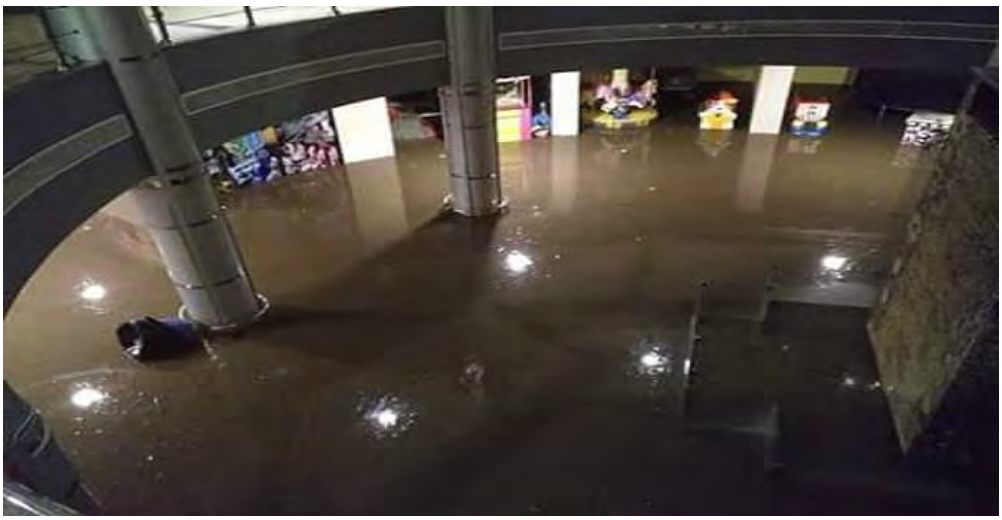

Fig. 5: Sinking of mall. (Masrawy.com, 2018)

Most recently, New Cairo has faced the risk of flooding and major traffic disruptions in most of its main roads in 2018, that proved defects in planning as well as defects in the maintenance work and non - observance of the standards.

Fig. 6: Sinking of main street. (Masrawy.com, 2018)

Fig.7: A high level of water. (Masrawy.com, 2018)

Fig.8: Sinking cars and homes. (Masrawy.com, 2018)

This problem has had a negative impact on the economy, the environment, and the society of New Cairo. Economically, the sinking of the streets was a reason to disrupt the traffic, a large number of sidewalks were

destroyed, which led to the closure of many shops and commercial malls, causing large financial losses as well as damaging many facilities and cars. The high level of water caused the sinking of many basements and damaged many electricity wires. Losses are highly valued. Environmental wise, a large part of the landscape components were damaged and water could be polluted. The increase in the water level led to the destruction of some of the infrastructure pipes, electric lines and others. And finally socially, people were diasabled from their work, many suffered financial damage. The crisis prevented people from leaving their homes which had psychological consequences.

3. Conclusion

In conclusion, stormwater is an issue that has existed for a long time and climate change has made the problem even bigger overtime. The total paralysis that hit New Cairo in 2018 after the rain and the gathering of water was a dangerous warning, as the city has not exceeded the age of 18 years. There is a fundamental importance and great use for landscape elements to raise the performance of cities in order to tackle stormwater. By gathering data, information and analysis for case studies, this paper aims to find a sustainable solution to this problem.

4. Storm water

Climate is the overall weather in an area for a long period of time. Scientists describe the state of the climate on the basis of monthly and annual averages of temperature and fall. It includes rainfall, snow and other forms of moisture falling on the ground. They also describe changes in it from year to year and cause wet periods and dry periods. The weather may change from day to day, and the day may be stormy and cold while the next is bright and warm. To determine the climate in a particular area, scientists rely on the study of daily weather conditions for a long time to take several years. Each area on the Earth's surface, however shrinking, has its own climate. Differing countries may share a similar climate, and the climate may also vary between a high mountainous area and a low adjacent area.

Climate change is one of the major challenges of our time, adding great stress to our societies and environment. The global impacts of climate change are vast and unprecedented in magnitude, from changing weather patterns that threaten food production, to rising sea levels that increase the risk of catastrophic floods. Adapting to these impacts will be more difficult and costly in the future if radical action is not taken immediately. (Un.org, 2018)

Recently, scientists have related climate change to the rise in anthropogenic activity of greenhouse gases in the atmosphere. It is the prevailing state of the atmosphere in an area for a certain period of time and there are many reasons for the phenomenon of climate change like; pollution of land, air and sea; human activities such as cutting forests and burning trees; volcanic eruptions and large industrial development as a result of the increasing number of factories. So the resultant is that the map of the world changes in parallel to it and therefore countries change their priorities and plans, as well as their vision and preparations. Stormwater is considered one of the most dangerous environmental reactions to this phenomenon. It is water that arises during natural events, in which humans do not intervene directly such as precipitation, snow, ice melt or flood. In addition to the strong storms that may cause the destruction of cities at a time. It will be clarified as a result of rainfall, stages of its formation and factors affecting it. (Un.org, 2018)

4.1. Stages of rain formation

- *The high temperature:* of the sun together with the movement of air near the water's surface, which evaporates and rises up in the form of gas atoms. Spaces between the air carry a number of atoms of water near its surface and lifted due to its lightweight.
- *The formation of the clouds***:** as soon as water vapour and water atoms rise up to the sky, they gather around the dust particles and steamed salts forming clouds.
- *Rain phase:* clouds condense around each other increasing its weight clearly, so that the density of combined water atoms is greater than the density of the air allowing it to fall to the ground as rain.

4.2. Types of Rain

- *Convectional rainfall:* Occurs with warm moist air being heated from the ground surface. As a result of heating of the surface air, the air expands and forced to rise to great heights. As the air rises, it cools and becomes saturated and dew point temperature (the temperature at which water vapor in the air condenses (gas-liquid) is attained and then clouds will form. By further cooling, precipitation takes place. It needs intense heating of the surface which causes the air to expand and rise and an abundant supply of moisture in the air to produce a very high relative humidity. Turbulence in the atmosphere and obstructions like mountains, provide the inciting upward push for the air. This type of rainfall can happen throughout the year in areas near the equator daily, typically during the afternoon. In middle latitudes, convectional rainfall occurs in early summer, in continental interiors.

- *Cyclonic/Frontal rainfall:* A type of precipitation linked to cyclonic activity and occurs along the frontal zone (front is a narrow zone of transition, dividing two air masses of differing temperature and humidity characteristics, intersecting the earth's surface. Fronts are most clearly developed in areas where are masses converge) of convergence particularly at the ITCZ (inter tropical convergence zone) and at the polar fronts. In a zone of horizontal wind divergence, the warm air forced up over the colder air. In this slow ascend pressure decreases, air expands and cools, condensation and cooling produce a precipitation.

- *Orographic/Relief rainfall:* when large mass of air is forced to rise across landform barriers, such as high mountain ranges, plateaus, escarpment. The leeward side of such mountain barrier where the air is ascending and warming are characteristically drier are called rain shadow region**.** It's most common on the windward slopes of the mountain where the on-shore moisture laden-winds come from sea. The ideal condition for heavy orographic rainfall is a high relatively continuous mountain frontier (boundary) close to the coast and the winds from off a warm ocean meet the barrier at right angles.

4.3. Factors Affecting the Rain Process

- *Wind direction,* the wind direction plays an important role in determining the amount of rain carried by clouds. If the wind moves from the sea and ocean areas to the land areas, it is loaded with large amounts of steam and water atoms, which helps in forming clouds and rain and vice versa.

- *Temperature,* high temperatures on water bodies help raise water evaporation rate and load air with water droplets, which fall in the form of rain in their destination areas, and vice versa.

- *Geographic location,* the areas near the water bodies are more likely to have rainfalls, and areas far from the water bodies are experiencing less rainfall.

- *The mountains and highlands,* have a greater chance of precipitation on the plains and valleys, where the mountains act as a barrier to prevent the passage of rain-laden winds into those areas.

5. Storm water in Egypt

The climate in Egypt is generally a desert climate; hot dry summers with moderate rainy winters. The prevailing winds towards the Mediterranean are constantly blowing over the Northern Coast without any obstruction of a mountain range. These winds make temperatures moderate throughout the year. Due to climate change over time, every 10 years the temperature increases by 3 to 5 degrees in summer and decreases by 3 to 5 degrees in winter. Although temperatures are moderate along the coasts, the situation in the interior of the country is far from moderate northern winds and is currently changing. In the more southern parts of Egypt, daytime temperatures are generally hotter, especially in the summer where temperatures can rise above 40 Celsius (104 Fahrenheit) in cities such as Aswan, Luxor, Assiut and Sohag. Some mountainous sites in Sinai, such as St. Catherine, have cold night temperatures due to high altitudes.

Every year, sometime in March to May, very hot, dry and dusty winds blow from the south or south-west. These winds are called the "*Pentagons*". When dry winds blow continuously across the vast desert region, they pick up soft

sand and dust particles that ultimately lead to the dusty winds that generally appear in the desert suburbs. As soon as these winds blow over Egypt, the temperature rises temporarily to dangerous levels, usually more than 45 Celsius (113 Fahrenheit) with relative humidity levels that fall below 5%. The precipitates cause sudden early heat waves and the absolute highest temperature records in Egypt.

5.1. In Cairo

The capital of Egypt, Cairo is 110 miles (180 kilometer) away from the sea and it is located at the boundaries of the huge Nile delta. Cairo's climate is considered a transitional one, between the desert and the Mediterranean climate. Therefore, the summer temperature is higher than the coast line, but lower than that of the desert area. The highs are around 95F (35 C) in August and July with a high degree of moisture, which can be stifling. In summer the maximum temperature rises above 82 F (30 C) in the time interval from May till the middle of October. The "Urban heat island effect" increases the obnoxious sensation of heat in the city. The "Urban heat island effect" can be created in big cities and by pollution.

Table 1. Cairo - Average temperatures

Cairo - Average temperatures												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min (°C)	9	10	12	15	18	20	22	22	21	17	14	10
Max (°C)	19	20	24	28	32	34	35	34	33	29	25	20
Min (°F)	48	50	54	59	64	68	72	72	70	63	57	50
Max (°F)	66	68	75	82	90	93	95	93	91	84	77	68

In Cairo the rainfall is very low, it piles to only 1 in. (25 mm) each year and in the summer rainfall vanishes. In fact, it is essentially a desert from the point of view of rainfall. Meanwhile, in winter the climate of Cairo is reciprocal to that of the north coast. The highs are around 64/68 F (18/20 C) in the interval between December and February. Despite some clouds and cold days that may arise when the northern currents overrule, the sun shines regularly throughout the seasons of the year and it practically shines consistently in the period from spring to autumn.

Table 2. Cairo - Sunshine

Cairo - Sunshine												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hours	7	8	9	10	10	12	12	11	10	9	8	6

6. Sustainability

Sustainability is one of the latest topics that bridges social science with civil engineering and environmental science with future technology. It is a broad area in most aspects of the human world from business to technology to the environment and social sciences. The modern world is looking to dramatically reduce carbon emissions, discovering and developing future technologies.

Sustainability depends on politics, economics, philosophy and other social sciences, as well as hard sciences. Sustainability and environmental awareness skills are now priorities in many corporate functions. The most common area is in urban planning and environmental consulting (built and natural environment), agriculture, corporate strategies and health assessment. It focuses on renewable sources of fuel, reducing carbon emissions, protecting the environment in order to maintain the sensitive ecosystems of our planet in balance. It protects our natural environment, our human, ecological health and at the same time stimulates innovation without compromising our way of life. It

calls for a diverse biological environment, organisms and natural factors that sustain their existence for the longest possible time. It maintains our quality of life by adapting to the environment via exploiting natural resources for the longest possible time to sustain life. (Mason, 2019)

6.1. Principles of Sustainability

The application of sustainability in any dynamic environment depends on four principles;

- *Scope of sustainability:* is the domain or community in which sustainability is applied at home, and its existence is usually associated with a combination of social, economic and environmental factors that together constitute full support for sustainability across all its components.
- *Consumption:* the rate of utilization of natural ingredients that are an important catalyst for the sustainability of living organisms, and the higher the consumption rate, the more sustainable the life, and vice versa.
- *Resources:* all natural and industrial resources that contribute to sustaining sustainability. When resources are adequate and appropriate to the number of living organisms, this will help sustain their life as long as possible.

6.2. Sustainability objectives

The sustainability scale is a tool that uses a set of numerical scales contributing to the management of sustainability components by relying on an understanding of human knowledge. The Sustainability Measure measures the nature of sustainability in different forms of life, by providing a set of vital indicators that provide accurate measurements. It helps to implement many biomedical studies related to the concept of sustainability. The most important types of sustainability measures are: population scale, urban scale, urban planning, and other measures. Provide a range of solutions to maintain global food ratios. Reducing poverty rates and trying to find alternative ways to deal with economic crises that provide equal financial stakes to individuals. Ensure that comprehensive, adequate and sustainable education is provided through the emergence of new studies providing ideas for adequate support for sustainability. Take advantage of natural, industrial sources of energy to provide reliable materials at affordable prices and within the financial capabilities of people. Ensure the provision of a health sector capable of reducing the prevalence of diseases, and provide appropriate remedies to reduce the global health crises.

6.3. Green Infrastructure

Green infrastructure is an approach to water management that aims to protect, restore, or recreate the naturally occurring water cycle. It incorporates both the natural environment and engineered systems to provide clean water and conserve ecosystem values. (American Rivers, 2019). It is a general culmination of technologies used to reduce surface runoff from causing flooding and dispersing pollutants. It consists of the retention, or provision of a discharge point for rainwater that can be reused or infiltrated into groundwater. It should maintain or replicate the natural hydrological cycle and fit the capacity of the existing infrastructure. (Wanielista, 2019) It is also an effort to reduce runoff from rain and snow melts in streets, meadows and other sites and raise water quality.

Rainwater is absorbed into the soil, the aquifers are eventually filtered and fed into streams or rivers. However, when rainwater strikes heavily, the waterlogged soil creates excess moisture that extends across the surface into storm surges and trenches. These waters often carry debris, chemicals, bacteria, decaying soil and other contaminants, and carry them to streams, rivers, lakes or wetlands. (Wanielista, 2019)

Stormwater management helps in urban, non-resilient surfaces such as paving and ceilings prevent rainfall naturally on the ground. Instead, water flows quickly to storm banks, sewage systems and drainage trenches, and can cause flooding, erosion, turbidity, hurricane and sewage flows, and infrastructure damage. Stormwater design and "green infrastructure" capture and reuse stormwater to maintain or restore natural water resources. Retaining rainwater and removing contaminants is the main objective of rainwater management. The porous back surfaces allow for precipitation, snow in the soil, gray infrastructure such as canals, gutters, storm surges, traditional pipe drainage, and

blue / green infrastructure that protect or restore or mimic the natural water cycle, all play a role in rainwater management. (EEC ; wanielista, 2019).

7. Sustainable landscape solutions to manage stormwater

7.1. Bioswale

In bioswale systems, the water running off from roofs and roads does not flow into the sewers, but is instead led into the bioswale via above-ground gutters and/or ditches. Bio-swales can be incorporated into the green infrastructure and can help enhance biodiversity and quality of life. A bioswale is a ditch with vegetation and a porous bottom.

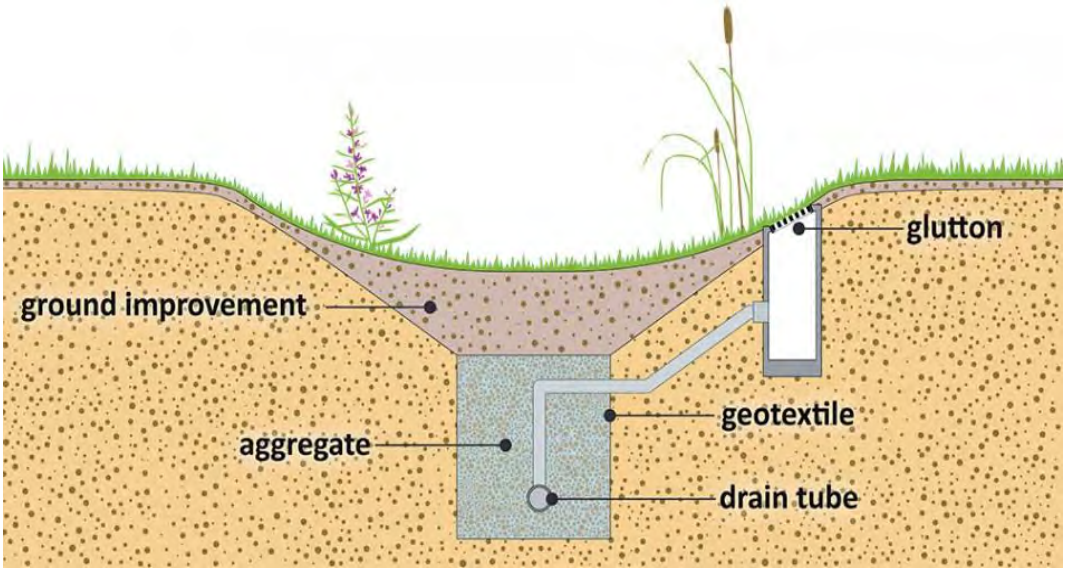

Fig.9: Section scheme of a bioswale when it is dry. (Boogaard et al, 2006)

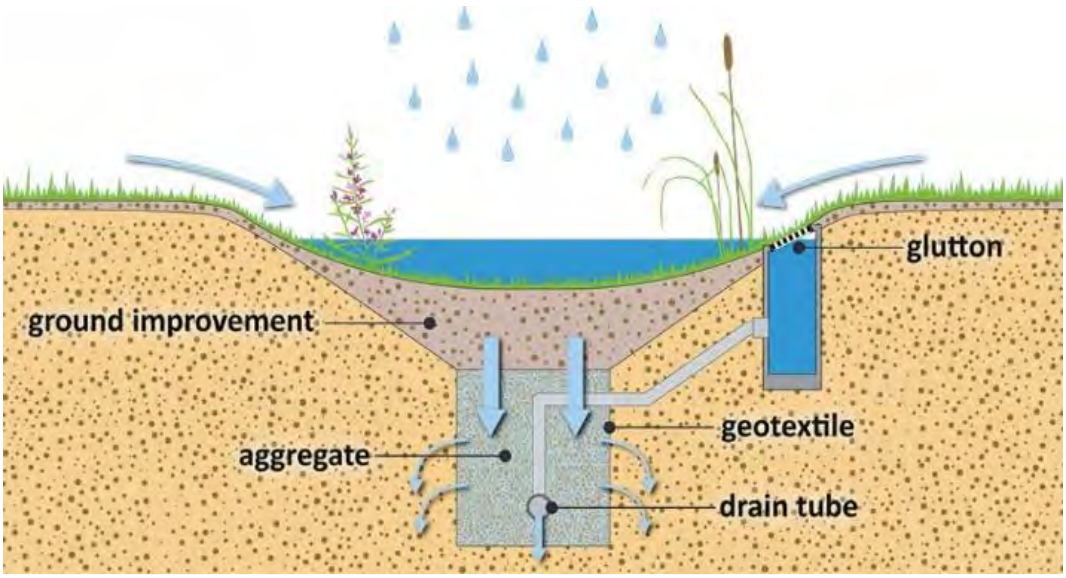

Fig.10: Section scheme of bioswale when it is wet. (Boogaard et al, 2006)

The top layer contains enhanced soil with plants and the layer underneath is made of gravel, scoria or baked clay pellets that is packed in geotextile. These are materials that have large empty spaces that allow rainwater to drain. The geotextile wrapping the layer prevents it clogging by sludge or roots that may seep through. An infiltration drainpipe is placed below the second layer, in order to stop the bioswale from overflowing during heavy rainfall. Overflows are added that are connected directly to the infiltration pipe/drainpipe. Rainfall infiltrates into the ground by way of the ditch and the packed layer and should the water rises above the level of the overflow, the water runs through it to the drainpipe. The bioswale's dimensions should be made to ensure that this occurs no more than once

every two years. If the drain and the overflow both fill up, the bioswale acts as an above-ground drainage system and leads the water directly to surface water.

7.2. Rain garden

Rain garden are called bioretention facilities, are one of a variety of practices designed to treat polluted stormwater runoff. Rain gardens are a designed depressed area in the landscape that store runoff from impervious urban areas like walkways, driveways, roofs,compacted lawn areas and parking lots.

Fig. 11: Rain gardens in University of Minnesota. (Minnesota, 2019)

7.3. Rain barrels

These can contain large amounts of rainwater, thus reducing the damage that can be caused by rain, such as mud accumulation, infrastructure damage and contamination of clean water supplies. And can be covered with drums, leaving a hole in the barrel to allow the rainwater to enter, and can be connected to long hoses of these barrels, these hoses contribute to the transfer of water equally for the irrigation of the garden and plants and trees, Especially in the dry classes. (Bogaard, 2019)

The purpose of the design of rain barrel garden is to help capture rainwater and stop its use for reuse in agricultural land. These gardens are built on low elevation land. The best places to build these gardens are near the houses, about 3 meters from the pipes Drainage coming from water gutters connected to the roofs of houses. These farms can be built away from houses. Regardless of the surrounding areas, the garden must be built in a lower area than the surrounding areas. These gardens are usually long and narrow. Gardens with water quantity Which can absorb them after 24 hours of rain, and the types of plants that can be planted in these gardens, plants, shrubs and long-rooted plants that absorb a large amount of water, which gives a wonderful vegetable appearance, and contribute to this method of preserving the plants. (Bogaard, 2019)

7.4. Wells

Rainwater can be exploited by constructing dry wells for collecting rainwater. These wells are built in the soil and are around 3 meters below ground. It is poured with a special texture that reduces water permeability in the soil. The idea of these wells is to accumulate a large amount of precipitation, then to penetrate it slowly in the soil, which helps in minimizing the erosion process and helps keep the soil moist. (Woods, 2019)

7.5. Vertical Garden

Vertical gardens is the name for a technique used to grow plants on a vertically suspended panel using hydroponics. These unique structures can be either stand-alone or wall-related. Vertical gardens have been used in ancient civilizations such as in the Hanging Gardens of Babylon. Modern vertical gardens can last for decades and give a pop of nature in urban environments.

Many buildings throughout the country and the world have vertical gardens installed on the outside. Many outdoor gardens contain moss, vineyards and other plants often used on vertical gardens installed outdoors. Outdoor vertical gardens feature direct natural sunlight that makes them thrive. (Ambius, 2018)

Fig. 12: Outdoor vertical garden (Gsky, 2019)

The external vertical gardens on buildings provide great protection and insulation from temperature, ultraviolet and heavy rain fluctuations. In the summer, outdoor vertical gardens use the process of evaporation to help to cool the surrounding air. The plants that are installed in external walls are chosen by the region's climate. The vertical plants absorb any extra rainwater and reduce its intensity. (Ambius, 2018)

7.6. Roof Garden

Roof gardens are diverse in their functions, they may be designed to grow production, provide play space, give shade and shelter, or simply be there as a lively, green area. A great advantage of roof gardens is their ability to manage rainfall, making them cleaner while minimizing their amounts and thus relieving the burden on local sewer systems. When the Canadians compared surface runoff from an exposed roof to a rooftop garden; the roof garden reduced the runoff by 75 percent in the run time of 45 minutes. Although researchers have not measured water quality in runoff, defenders of green roofs and roof gardens claim that rainfall on a bare surface contains many contaminants such as volatile organic compounds (VOCs). (Lallanilla, 2019).

Fig. 13: Hotel Metropolitan 5th floor roof garden, Bologna. (Gianclaudio, 2016)

7.7. Porous Pavement

A porous pavement is designed to allow percolation or infiltration of storm #water through the surface into the soil below, where the water is naturally filtered and pollutants are removed. In contrast normal pavement is an impervious surface that sheds rainfall and associated surface pollutants forcing the water to run off paved surfaces directly into nearby storm drains and then into streams and lakes (Selbig, 2019).

Fig. 14: Aggregates porous pavement. (Presto, 2016)

Fig. 15: Permeable paving.

8. Egyptian Road rules

Based on what is mentioned in the Egyptian Code of Road Leaders established by the Permanent Committee to prepare the basis for the design and requirements of roads by Ministerial Resolution No. 159 of 1998. Roads are

classified according to the size and type of traffic expected on the roads and the average length of the journey served by the road and the location of the road in relation to the roads adjacent to the network.

8.1. Types of roads

The main roads and free roads: They serve mainly the volumes of traffic dense and connect areas of transportation main and distant.

Sub-roads: It is a network that connects the main or free roads and local roads, which is the average in its design elements commensurate with the size of traffic.

Local roads: It is between residential neighborhoods and within it to serve local traffic.

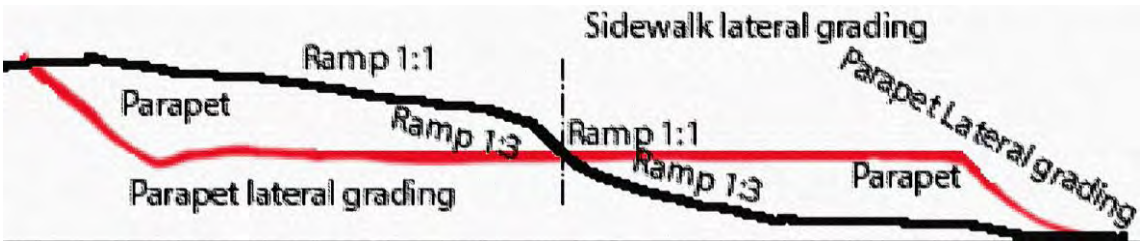

Fig. 16: Cross section in divided roads. Egyptian rule No. 159 of 1998. (The author)

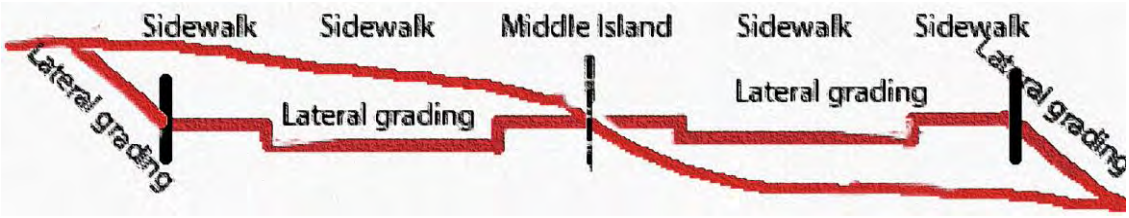

Fig. 17: Cross section in non divided roads. Egyptian rule No. 159 of 1998. (The author)

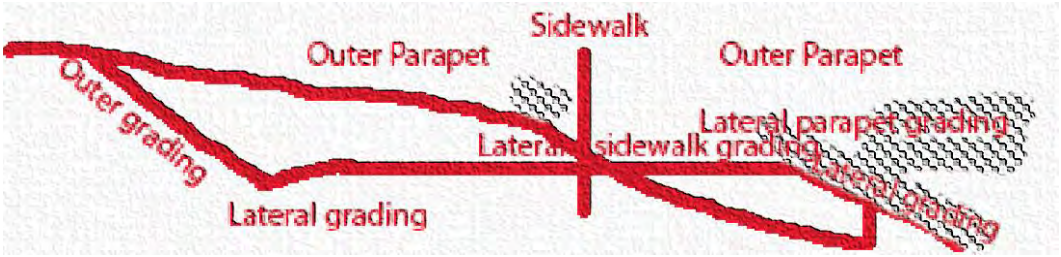

Fig. 18: Cross section in non divided roads. Egyptian rule No. 159 of 1998. (the author)

Fig. 19: Cross section in main roads, Egyptian rule No. 159 of 1998. (the author)

8.2. Inclinations of pavement:

The lateral inclination provides an effective method for discharging the surface water to keep it away from the road lanes because of its danger to the safety of the Cayenne, and should not increase the accidental inclination of 2% so as not to drive the vehicle in the direction of inclination, the driver must make a remarkable effort on the steering wheel to maintain the presence of the vehicle. The roads are hot and it varies if the roads are paved or unpaved; paved roads ranges from 1.5% to 2%, coarse paved surface ranges from 2% to 3% and unpaved roads can be increased slope

of about 3%. In roads with more than two widths and a one-way cross-section, the lateral slope of the outer lane is increased by 0.5% to 1% for each lane; Lower width of the Sidewalk. Taking into account that appropriate tendency for the pavement to drain the surface water.

Table 3.Width of the sidewalks in different roads

Type of road	Free road	Main road	Sub-road	Local road
Sidewalk width (m)	2.5	2.5	1.5	1.5

8.3. The central part of the road

The central part of the road, which separates the directional movement in the divided roads, provides a view that enables the commander of the vehicle to regain control in emergency situations and allows the display to provide an area with which to change the speed of the lanes, or the lanes of the left and the future expansions of the roads and reduce the island center of influence. The headlights of the car are shown on the driver's side.

Table 4. Central part width of the different roads

Types of road	Highway road	Main road	Sub-road	Local road
Lowest width of the island (m)	4	2	2	-

8.4. Drainage channels and lateral tendencies

The drainage channels are placed on the sides of roads and on the central island for the drainage of rainwater. They are suspended on the rainfall rates and quantity and on the type of soil adjacent to the road. The lowest tendencies of the sides of the channel are 3: 1. There are two types of drainage pipes. The width of the channel should not be less than 1.20 m and the length of the channel no less than 0.5 m. The channel sector should be designed according to the amount of rain, the slope of the channel and the speed of water in the channel. In the case of discharge of rainwater in the central island is used side tendencies estimated at 6: 1 or less.

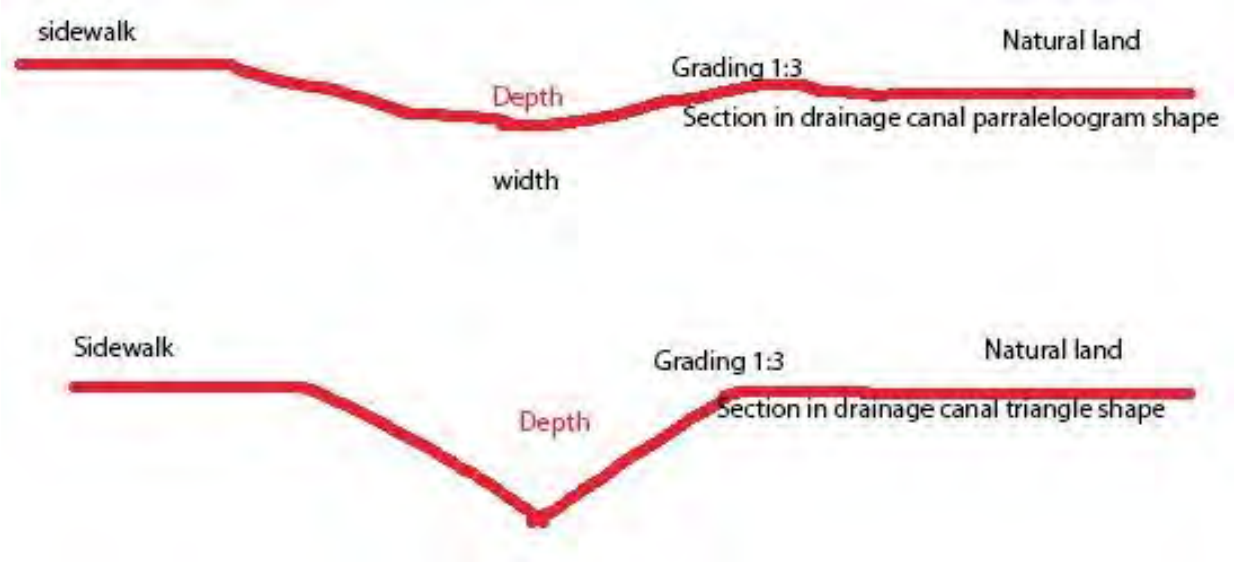

Fig 20: Drainage channels, Egyptian rule No. 159 of 1998. (the author)

9. International case studies

The exploration strategies directed add to accomplishing the examination point and destinations. Table 5 shows the connection between techniques for research and the four targets of exploration mentioned previously. (KOTHARI, 2019).

Table 5.Concluded table. (The authors)

		Case study 1	Case study 2	Proposal
Types of stormwater	Rain			
	Floods			
Types of rain	Convectional rainfall			
	Cyclonic/Frontal rainfall			
	Orographic/Relief rainfall			
Factors Affecting the rain	Wind direction			
	Temperature			
	Geographic location			
	The mountains and highlands			
Sustainable landscape solutions to manage stormwater	Bio-swales			
	Rain garden			
	Rain barrels			
	Wells			.
	Vertical garden			
	Roof Garden			
	Porous Pavement			

Table 6.The relationship between methods of research and objectives. (The authors)

Research methods		Research Objectives			
		1	2	3	4
Data collection	Literature review	√			√
	Case studies		√		
	Survey questionnaire			√	
Data analysis	Quantitative	√		√	
	Qualitative	√	√	√	√
Action required	Proposes framework				√

A case study is an exploration strategy dependent on information accumulation and examination. It enables complex issues to be very much investigated and comprehended. It is typically required when a top to bottom examination is required and gives proof and clarification by using quantitative and qualitative techniques. Yin (1984) characterized case studies as the device to research a specific marvel, all things considered, where confirmations are not clear enough in this way a case studies is utilized to give enough proof to demonstrate this wonder. A case studies gives an

orderly method to watch a specific occasion by gathering information, analyzing, and revealing outcomes over prolonged stretch of time (Yin, 1984). It is an exceptional technique for watching wonders; as it looks at information in itemized territory of intrigue not at all like full scale information examination, a contextual analysis watches information in smaller scale level (Zainal, 2019). It is recommended the application of the specific conclusion to any new city or case study, for achieving sustainability and stormwater management. It was applied into two international case studies and a local Egyptian one in the 90th street, the fifth settlement, New Cairo, Egypt.

9.1. Augustenborg, Malmö , Sweden:

A governmental project and with the objective of transforming the district of Augustenborg and Malmö into sustainable neighborhoods through several factors, including the establishment of an open stormwater network connected to the sewage network. Water is collected in an environmental drainage system and rainwater is directed to the surfaces towards the collection sites, thereby reducing the flow of rainwater. The aim was to address the problems of floods and heavy rains, and to eliminate those problems completely. The main purpose of the new stormwater system in the region was as an open system in which water was visible, contributing to the aesthetic and positive environment of the community. The goal was to have 70% or more of the new rainwater system routed. One of the targets was to test several different techniques in the same area; The Augustenborg Botanical Roof Garden. With an area of 10,000 square meters of plant surfaces, it has an effective role in reducing and retaining rainwater and has an insulating effect on buildings. Stormwater is transported from the storage area below the road to the canal and open drainage system through the pond. The neighborhood is conveyed in a concrete canal bioswales. The water is allowed to spread out in this wetland. These ”onion gutters” are found in a lot of places around Augustenborg. They were designed to create movement in the water, which brings about a degree of self-purification.

The water’s path continues in this ”cube canal”, designed as a stylized brook. There are ponds with a varied view in many of the neighborhood squares for rain water to be collected. (Klamméus, 2019).

Fig.21: Roof Gardens. (Klamméus, 2019)

Fig. 22: Bioswales. (Klamméus, 2019)

Fig, 23: Onion gutter. (Klamméus, 2019)

Fig. 24: Cube canal. (Klamméus, 2019)

9.2. Malaysia

A governmental project in Malaysia, its objective provide a practical model for the application of water management concepts and the role of landscape elements in solving the problems of stormwater, floods, and properly directing water. The approach of urban stormwater management was monitored between 1971 and 2001. It was discovered that the problem is increasing as well as the frequency and intensity of the floods, therefore greatly increasing the budget of flood relief. The area was introduced the Sustainable [USW] Management Manual in Malaysia to limit the problems of flood, rainwater drainage and management. Based on the adoption of the rapid approach to the elimination of runoff, the focus was on the evolution of river improvement works in urban rivers as the city grows; the urbanization and its effects on the amount of runoff and increasing the intensity of floods and the Sustainable USW Management Manual. (Jin, 2019).

Fig. 25: New Branch steps. (edited by the author, source: Jin, 2019).

9.3. Case study conclusion

It was found that factors affecting the amount of rainfall are very similar, but the elements of landscape used to reducing rainfall differs from one place to another. In Malizia, preference was in using Bioswales, Rain barrels, wells, Roof Garden and Porous Pavement. In Sweden they used bioswales, rain gardens, rain barrels, wells and roof garden. The elements used were based on the amount of rainfall in the area.

The following table compares the two case studies in terms of the factors that affect rainfall amount and the landscape elements used to control them. The table also uses the model to examine the case the paper is currently tackling, 90th street in Egypt, in order to determine the applicable solutions for the area.

Table 7. Comparison in sustainable applications between the 2 cases and the proposed solutions. (source: the authors)

		Case study 1	Case study 2	Proposal
Types of stormwater	Rain	✓	✓	✓
	Floods	✓		
Types of rain	Convectional rainfall	✓		✓
	Cyclonic/Frontal rainfall		✓	
	Orographic/Relief rainfall	✓		
Factors Affecting the rain	Wind direction	✓	✓	
	Temperature	✓	✓	✓
	Geographic location	✓	✓	✓
	The mountains and highlands	✓		
Sustainable landscape solutions to manage storm water	Bio-swales	✓	✓	✓
	Rain garden		✓	✓
	Rain barrels	✓	✓	
	Wells	✓	✓	.
	Vertical garden			✓
	Roof Garden	✓	✓	✓
	Porous Pavement	✓		✓

10. The 5th settlement

This is a design solution proposal for 90th Street in 5th settlement, New Cairo in Egypt in response to the 2018 flood of the area. Although not the largest stormwater based disaster to occur in the region, it is taken as a case study due to the large interval between the previous disaster (one in 1994 and this one 2018) and the fact that the state has not learned from the mistakes of the past and repeats its errors in newer cities being built. Should this pattern continue, the escalation of climate changes and rain map shifting over time will insure the repetition of disasters in current and future cities with greater risk and greater losses over time. It is imperative to realize that this scenario is a strong possibility and to prepare for it.

This paper seeks to solve this problem and to insure 90th Street is able to absorb the ratios of rain water later and not face the same problems again.

10.1. Landscape Solution Process

The paving of 90th Street to fit as a main road had not taken into consideration that it is a Cone of the Torrent. The street was poorly installed in order to save money and pavement. (Abdeltawab, 2019). Lack of studies related to soil, as well as the poor quality of implementation, led to pumps in pavements' asphalt and the inability of the infrastructure (drainage system) to absorb large quantities of water (Ahmed, 2019). The absence of special rain drainage was due to the assumption that Egypt's desert climate would scarcely rain. Poor landscape element installation, from paving or plantation, led to sandy soil areas that could lead to crisis.

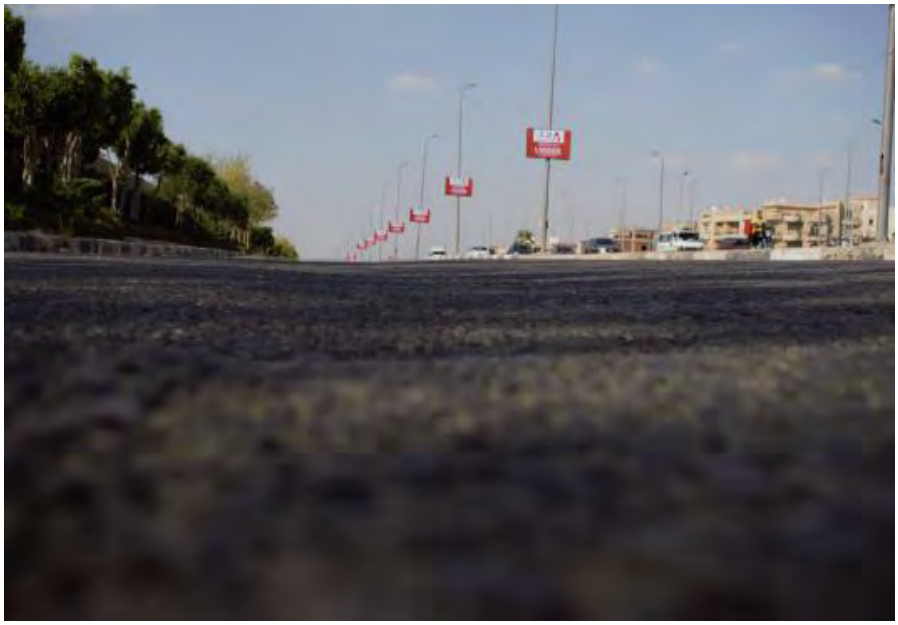

Fig. 26: Pavement damage. (Source: the authors)

Fig. 27: Absence of special rain drainage. (Source: the authors)

Fig. 28 Poor landscape. (Source: the authors)

10.2. Proposed landscape elements solutions

- Reconstruction or repair of the infrastructure and the placement of outlets for water drain on the side of the road as shown in fig. 29.
- Re-paving the roads and adjusting their angles towards the outlets of the water drains.
- Exchange the existing flooring of the sidewalks to Porous Pavement that can absorb water and direct it to the drainage network.
- Construction of bioswales in the street islands in order to retain water when the rain fall see fig. 30.
- The exploitation of normal roofs of buildings to create roof gardens to absorb rain, heat and contribute in reducing Co2.
- The implementation of vertical gardens into some buildings facades to reduce heat and pollution and help in stormwater management see fig. 34.

Fig. 29: 90th street before drain installment. (Source: the authors)

Fig. 30: After side drainage. (Source: the authors)

Fig. 31: Street island before proposed landscape elements.

Fig. 32: Street island after landscape

Fig 33: Building facades before vertical garden.

Fig. 34: Building facades with vertical gardens.

11. Conclusion

Climate changes occur everywhere in the world, be the causes natural or man-made. This paper has depicted the environmental conditions and its changes in Egypt. The concept of Storm Water has been clarified in general, as well as its types and reasons that lead to its formation and methods. Briefly the concept of sustainability was the main purpose of this paper; adding concepts of Constitution management, storm water management and the means of conserving water. The factors affecting and solutions that were used in the three cases were studied and compared and the percentage of sustainability and proportion of the use of different solutions is shown in the following table (table 8).

Table 8.The percentage of sustainability and factor usage. (Source: the authors)

		Malaysia	Augustenborg, Sweden	90th Street, Egypt	Ratio of factors usage
Sustainable landscape solutions to manage storm water	Bio-swales	✓	✓	✓	100%
	Rain garden		✓	✓	66.66%
	Rain barrels	✓	✓		66.66%
	Wells	✓	✓	.	66.66%
	Vertical garden			✓	33.33
	Roof Garden	✓	✓	✓	100%
	Porous Pavement	✓		✓	66.66%
Ratio of sustainability		71.42%	71.42%	71.42%	

Based on the comparison between the three previous cases namely; Malaysia, Sweden and Egypt. The following chart shows the importance of landscape items used in the studies cases.

This research contributes to the current knowledge of stormwater problems, and helps develop sustainable solutions by using landscape elements to solve them. The results are keen to open a debate for awareness and widen the scope of using landscape elements in solving environmental problems.

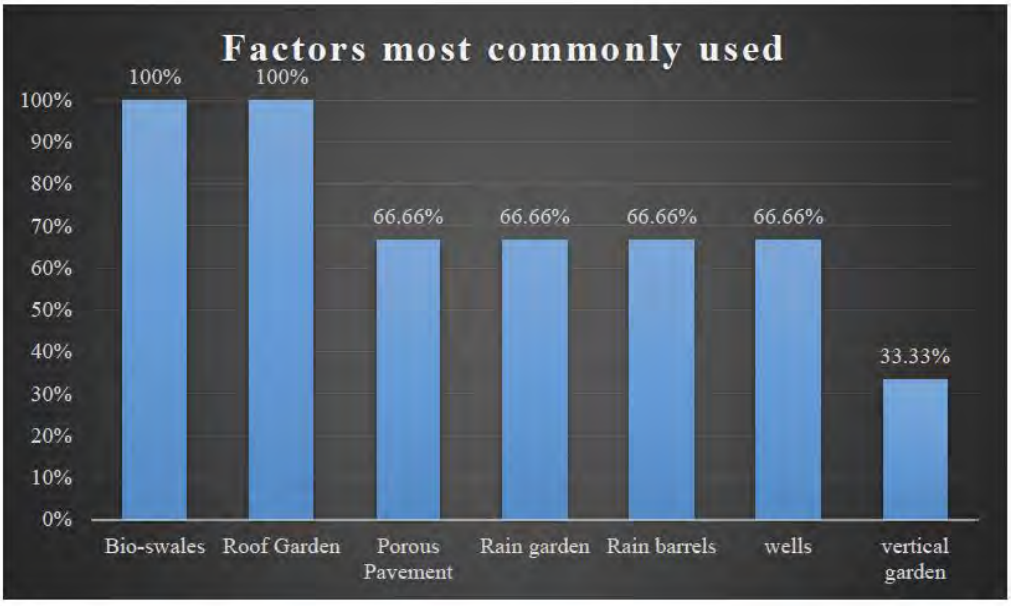

Fig.35: Factors of landscape commonly used in sustainable landscape projects. (The authors)

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