Evergreen Environment in Smart Cities

Kailainathan M

Pg Student, 2nd Year Construction Management, Department Of Civil Engineering,

Kumaraguru College Of Technology, Coimbatore, Tamilnadu, India

***Abstract*— One hundred cities are proposed to be turned as smart cities across our nation. This paper serves in providing general guidance for planning of smart cities from an environmental perspective with a view to guide the conceptualization of the proposed smart cities towards a cleaner, greener and safer place to live in. A set of environmental criteria such as urban forests, green alleys, constructed wetlands, green roofs, permeable paving, green streets, green parking, green walls and rain gardens were discussed. Implementing the environmental protection measures in the developing smart cities would also add up to the benefits like improving water and air quality, serves as temperature regulator, increases the biodiversity thereby saving energy and creating job opportunities. Thus in this paper, methods of improving the environmental conditions as evergreen in smart cities and their benefits to the society has been briefed.**

***Index Terms*— Smart cities, evergreen environment, air quality, cleaner, greener, safer place**

I. INTRODUCTION

A smart city is an urban development vision to integrate information and communication technology (ICT) and Internet of things (IoT) technology in a secure fashion to manage a city's assets. These assets include local departments' information systems, schools, libraries, transportation systems, hospitals, power plants, water supply networks, waste management, law enforcement, and other community services. A smart city is promoted to use urban informatics and technology to improve the efficiency of services. ICT allows city officials to interact directly with the community and the city infrastructure and to monitor what is happening in the city, how the city is evolving, and how to enable a better quality of life. Through the use of sensors integrated with real-time monitoring systems, data are collected from citizens and devices – then processed and analyzed. The information and knowledge gathered are keys to tackling inefficiency.

Information and communication technology (ICT) is used to enhance quality, performance and interactivity of urban services, to reduce costs and resource consumption and to improve contact between citizens and government. Smart city applications are developed to manage urban flows and allow for real-time responses. A smart city may therefore be more prepared to respond to challenges than one with a simple "transactional" relationship with its citizens. Yet, the term itself remains unclear to its specifics and therefore, opens to many interpretations.

In contrast to the natural environment is the built environment. In such areas where man has fundamentally transformed landscapes such as urban settings and agricultural land conversion, the natural environment is greatly modified into a simplified human environment. Even acts which seem less extreme, such as building a mud hut or a photovoltaic system in the desert, modify the natural environment into an artificial one. Though many animals build things to provide a better environment for themselves, they are not human, hence beaver dams and the works of Mound-building termites are thought of as natural.

People seldom find absolutely natural environments on Earth, and naturalness usually varies in a continuum, from 100% natural in one extreme to 0% natural in the other. More precisely, we can consider the different aspects or components of an environment, and see that their degree of naturalness is not uniform. If, for instance, in an agricultural field, the mineralogical composition and the structure of its soil are similar to those of an undisturbed forest soil, but the structure is quite different.

II. METHODS

2.1 URBAN FOREST

An urban forest is a forest or a collection of trees that grow within a city, town or a suburb. In a wider sense it may include any kind of woody plant vegetation growing in and around human settlements. In a narrower sense (also called forest park) it describes areas whose ecosystems are inherited from wilderness leftovers or remnants. Care and management of urban forests is called urban forestry. Urban forests may be publicly-owned municipal forests, but the latter may also be located outside of the town or city to which they belong.

Urban forests play an important role in ecology of human habitats in many ways: they filter air, water, and sunlight, provide shelter to animals and recreational area for people.

They moderate local climate, slowing wind and storm water, and shading homes and businesses to conserve energy. They are critical in cooling the urban heat island effect, thus potentially reducing the number of unhealthful ozone days that plague major cities in peak summer months.

In many countries there is a growing understanding of the importance of the natural ecology in urban forests. There are numerous projects underway aimed at restoration and preservation of ecosystems, ranging from simple elimination of leaf-raking and elimination of invasive plants to full-blown reintroduction of original species and riparian ecosystems.

As cities struggle to comply with air quality standards, the ways that trees can help to clean the air should not be overlooked. The most serious pollutants in the urban atmosphere are ozone, nitrogen oxides (NOx), sulfuric oxides (SOx) and particulate pollution. Ground-level ozone, or smog, is created by chemical reactions between NOx and volatile organic compounds (VOCs) in the presence of sunlight. High temperatures increase the rate of this reaction. Vehicle emissions (especially diesel), and emissions from industrial facilities are the major sources of NOx. Vehicle emissions, industrial emissions, gasoline vapors, chemical solvents, trees and other plants are the major sources of VOCs. Particulate pollution, or particulate matter (PM10 and PM25), is made up of microscopic solids or liquid droplets that can be inhaled and retained in lung tissue causing serious health problems. Most particulate pollution begins as smoke or diesel soot and can cause serious health risk to people with heart and lung diseases and irritation to healthy citizens. Trees are an important, cost-effective solution to reducing pollution and improving air quality.

2.2 GREEN ROOF

A green roof or living roof is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems. Container gardens on roofs, where plants are maintained in pots, are not generally considered to be true green roofs, although this is debated. Rooftop ponds are another form of green roofs which are used to treat greywater.

Green roofs serve several purposes for a building, such as absorbing rainwater, providing insulation, creating a habitat for wildlife, increasing benevolence[citation needed] and decreasing stress of the people around the roof by providing a more aesthetically pleasing landscape, and helping to lower urban air temperatures and mitigate the heat island effect. They effectively utilize the natural functions of plants to filter water and treat air in urban and suburban landscapes. There are two types of green roof: intensive roofs, which are thicker, with a minimum depth of 12.8 cm (5.0 in), and can support a wider variety of plants but are heavier and require more maintenance, and extensive roofs, which are shallow, ranging in depth from 2 cm (0.79 in) to 12.7 cm (5.0 in), lighter than intensive green roofs, and require minimal maintenance.

2.2.1 BENEFITS

- Reduce heating (by adding mass and thermal resistance value)

A 2005 study by Brad Bass of the University of Toronto showed that green roofs can also reduce heat loss and energy consumption in winter conditions.

- Reduce cooling (by evaporative cooling) loads on a building by fifty to ninety percent, especially if it is glassed in so as to act as a terrarium and passive solar heat reservoir – a concentration of green roofs in an urban area can even reduce the city's average temperatures during the summer
- Reduce storm water runoff — see water-wise gardening study presented at the Green Roofs for Healthy Cities Conference in June 2004, cited by the EPA, found water runoff was reduced by over 75% during rainstorms. See the PDF at for more information.

- Natural Habitat Creation — see urban wilderness
- Filter pollutants and carbon dioxide out of the air which helps lower disease rates such as asthma— see green wall
- Filter pollutants and heavy metals out of rainwater
- Help to insulate a building for sound; the soil helps to block lower frequencies and the plants block higher frequencies
- If installed correctly many living roofs can contribute to LEED points
- Increase agricultural space
- With green roofs, water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere through transpiration and evaporation.
- Green roofs not only retain rainwater, but also moderate the temperature of the water and act as natural filters for any of the water that happens to run off.

2.3 PERMEABLE PAVING

Permeable paving is a range of sustainable materials and techniques for permeable pavements with a base and sub base that allow the movement of storm water through the surface. In addition to reducing runoff, this effectively traps suspended solids and filters pollutants from the water. Examples include roads, paths, lawns and lots that are subject to light vehicular traffic, such as car/parking lots, cycle-paths, service or emergency access lanes, road and airport shoulders, and residential sidewalks and driveways.

Although some porous paving materials appear nearly indistinguishable from nonporous materials, their environmental effects are qualitatively different. Whether it is pervious concrete, porous asphalt, paving stones or concrete or plastic-based pavers, all these pervious materials allow storm water to percolate and infiltrate the surface areas, traditionally impervious to the soil below. The goal is to control storm water at the source, reduce runoff and improve water quality by filtering pollutants in the substrata layers.

Permeable solutions can be based on: porous asphalt and concrete surfaces, concrete pavers (permeable interlocking concrete paving systems – PICP), or polymer-based grass pavers, grids and geocells. Porous pavements and concrete pavers (actually the voids in-between them) enable storm water to drain through a stone base layer for on-site infiltration and filtering. Polymer based grass grid or cellular paver systems provide load bearing reinforcement for unpaved surfaces of gravel or turf.

Grass pavers, plastic turf reinforcing grids (PTRG), and geocells (cellular confinement systems) are honeycombed 3D grid-cellular systems, made of thin-walled HDPE plastic or other polymer alloys. These provide grass reinforcement, ground stabilization and gravel retention. The 3D structure reinforces infill and transfers vertical loads from the surface, distributing them over a wider area. Selection of the type of cellular grid depends to an extent on the surface material, traffic and loads. The cellular grids are installed on a prepared base layer of open-graded stone (higher void spacing) or engineered stone (stronger). The surface layer may be compacted gravel or topsoil seeded with grass and fertilizer. In addition to load support, the cellular grid reduces compaction of the soil to maintain permeability, while the roots improve permeability due to their root channels.

In new suburban growth, porous pavements protect watersheds. In existing built-up areas and towns, redevelopment and reconstruction are opportunities to implement storm water water management practices. Permeable paving is an important component in Low Impact Development (LID), a process for land development in the United States that attempts to minimize impacts on water quality and the similar concept of sustainable drainage systems (SuDS) in the United Kingdom.

A. Advantages

1) Managing runoff

Permeable paving surfaces have been demonstrated as effective in managing runoff from paved surfaces. Large volumes of urban runoff causes serious erosion and siltation in surface water bodies. Permeable pavers provide a solid ground surface, strong enough to take heavy loads, like large vehicles, while at the same time they allow water to filter through the surface and reach the underlying soils, mimicking natural ground absorption. They can reduce downstream flooding and stream bank erosion, and maintain base flows in rivers to keep ecosystems self-sustaining. Permeable pavers also combat erosion that occurs when grass is dry or dead, by replacing grassed areas in suburban and residential environments.

2) Controlling pollutants

Permeable paving surfaces keep the pollutants in place in the soil or other material underlying the roadway, and allow water seepage to groundwater recharge while preventing the stream erosion problems. They capture the heavy metals that fall on them, preventing them from washing downstream and accumulating inadvertently in the environment. In the void spaces, naturally occurring micro-organisms digest car oils, leaving little but carbon dioxide and water. Rainwater infiltration is usually less than that of an impervious pavement with a separate storm water management facility somewhere downstream.[citation needed].in areas where infiltration is not possible due to unsuitable soil conditions permeable pavements are used in the attenuation mode where water is retained in the pavement and slowly released to surface water systems between storm events.

3) Trees

Permeable pavements may give urban trees the rooting space they need to grow to full size. A "structural-soil" pavement base combines structural aggregate with soil; a porous surface admits vital air and water to the rooting zone. This integrates healthy ecology and thriving cities, with the living tree canopy above, the city's traffic on the ground, and living tree roots below. The benefits of permeable on urban tree growth have not been conclusively demonstrated and many researchers have observed tree growth is not increased if construction practices compact materials before permeable pavements are installed.

B. Disadvantages

1) Runoff Volumes

Permeable pavements are designed to replace Effective Impervious Areas (EIAs), not to manage storm water from other impervious surfaces on site. Use of this technique must be part of an overall on site management system for storm water, and is not a replacement for other techniques.

Also, in a large storm event, the water table below the porous pavement can rise to a higher level preventing the precipitation from being absorbed into the ground. The additional water is stored in the open graded crushed drain rock base and remains until the sub grade can absorb the water. For clay-based soils, or other low to 'non'-draining soils, it is important to increase the depth of the crushed drain rock base to allow additional capacity for the water as it waits to be infiltrated.

The best way to prevent this problem is to understand the soil infiltration rate, and design the pavement and base depths to meet the volume of water. Or, allow for adequate rain water run off at the pavement design stage.

2) Pollutant load

Highly contaminated runoff can be generated by some land uses where pollutant concentrations exceed those typically found in storm water. These "hot spots" include commercial plant nurseries, recycling facilities, fueling stations, industrial storage, marinas, some outdoor loading facilities, public works yards, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing and steam cleaning facilities. Since porous pavement is an infiltration practice, it should not be applied at storm water hot spots due to the potential for groundwater contamination. All contaminated runoff should be prevented from entering municipal storm drain systems by using best management practices (BMPs) for the specific industry or activity.

3) Weight and traffic volumes

Reference sources differ on whether low or medium traffic volumes and weights are appropriate for porous pavements. For example, around truck loading docks and areas of high commercial traffic, porous pavement is sometimes cited as being inappropriate. However, given the variability of products available, the growing number of existing installations in North America and targeted research by both manufacturers and user agencies, the range of accepted applications seems to be expanding. Some concrete paver companies have developed products specifically for industrial applications. Working examples exist at fire halls, busy retail complex parking lots, and on public and private roads, including intersections in parts of North America with quite severe winter conditions.

4) Siting

Permeable pavements may not be appropriate when land surrounding or draining into the pavement exceeds a 20 percent slope, where pavement is down slope from buildings or where foundations have piped drainage at their footers. The key is to ensure that drainage from other parts of a site is intercepted and dealt with separately rather than being directed onto permeable surfaces.

5) Efflorescence

Efflorescence is a hardened crystalline deposit of salts, which migrate from the center of concrete or masonry pavers to the surface to form insoluble calcium carbonates that harden on the surface. Given time, these deposits form much like how a stalactite takes shape in a cave, except in this case on a flat surface. Efflorescence usually appears white, gray or black depending on the region.

Over time efflorescence begins to negatively affect the overall appearance of masonry/concrete and may cause the surfaces to become slippery when exposed to moisture. If left unchecked, this efflorescence will harden whereby the calcium/lime deposits begin to affect the integrity of the cementatious surface by slowly eroding away the cement paste and aggregate. In some cases it will also discolor stained or coated surfaces.

Efflorescence forms more quickly in areas that are exposed to excessive amounts of moisture such as near pool decks, spas, and fountains or where irrigation runoff is present. As a result, these affected regions become very slick when wet thereby causing a significant loss of "friction coefficient". This can be of serious concern especially as a public safety issue to individuals, principals and property owners by exposing them to possible injury and increased general liability claims.

Efflorescence remover chemicals can be used to remove calcium/lime build-up without damaging the integrity of the paving surface.

2.4 GREEN STREETS

A green street is a storm water management approach that incorporates vegetation (perennials, shrubs, trees), soil, and engineered systems (e.g., permeable pavements) to slow, filter, and cleanse storm water runoff from impervious surfaces (e.g., streets, sidewalks). Green streets are designed to capture rainwater at its source, where rain falls. Whereas, a traditional street is designed to direct storm water runoff from impervious surfaces into storm sewer systems (gutters, drains, pipes) that discharge directly into surface waters, rivers, and streams.

EPA's Green Streets: The Road to Clean Water Exit video highlights green streets as a technique for managing storm water and providing other economic and community benefits. Shown are examples of green streets in localities that have worked with EPA and other partners to incorporate green streets as part of their storm water management plans. Green features shown include permeable pavement, rain gardens, vegetative curb areas, and sidewalk trees.

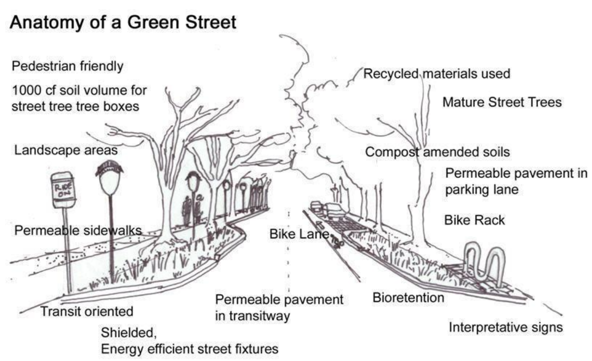
2.4.2 Anatomy of a Green Street

Streets comprise a significant percentage of publicly owned land in most communities, thereby offering a unique opportunity to incorporate green street elements that will not only protect the environment, but can improve community health and prosperity.

Green streets incorporate a wide variety of design elements including street trees, permeable pavements, bioretention, and swales. Successful application of green techniques will encourage soil and vegetation contact and infiltration and retention of storm water. Although the design and appearance of green streets will vary, the functional goals are the same:

- provide source control of storm water to limit the transport of pollutants to storm water conveyance and collection systems,
- restore predevelopment hydrology to the extent possible, and
- create roadways that help protect the environment and local water quality.

The "Anatomy of a Green Street" design graphic below provides details of green street elements. The Low Impact Design Center Exit provides a list of green street practices Exit that also support green street Design-Build concepts.



2.4.3 BENEFITS

- Minimize storm water impacts on the surrounding area through a natural system approach that incorporates a variety of water quality, energy-efficiency, and other environmental best practices;
- Integrate green storm water management features to increase infiltration and/or filtration of runoff, reduce flows, and enhance watershed health;
- Reduce the amount of water that is piped and discharged directly to streams and rivers;
- Make the best use of the street tree canopy for storm water interception, as well as temperature mitigation and air quality improvement;
- Mitigate or prevent localized flooding;
- Encourage pedestrian and/or bicycle access;
- Improve the aesthetics of a community; and,
- Increases a community's livability.

2.5 GREEN PARKING

A parking lot also known as a car lot, is a cleared area that is intended for parking vehicles. Usually, the term refers to a dedicated area that has been provided with a durable or semi-durable surface. In most countries where cars are the dominant mode of transportation, parking lots are a feature of every city and suburban area. Shopping malls, sports stadiums, megachurches and similar venues often feature parking lots of immense area.

Parking lots tend to be sources of water pollution because of their extensive impervious surfaces. Most existing lots have limited or no facilities to control runoff. Many areas today also require minimum landscaping in parking lots to provide shade and help mitigate the extent of which their paved surfaces contribute to heat islands. Many municipalities require a minimum number of parking spaces, depending on the floor area in a store or the number of bedrooms in an apartment complex. In the United States, each state's Department of Transportation sets the proper ratio for disabled spaces for private business and public parking lots. Various forms of technology are used to charge motorists for the use of a parking lot. Modern parking lots use a variety of technologies to help motorists find unoccupied parking spaces, retrieve their vehicles, and improve their experience.

2.5.2 ENVIRONMENTAL CONSIDERATION

Parking lots tend to be sources of water pollution because of their extensive impervious surfaces. Virtually all of the rain (minus evaporation) that falls becomes urban runoff. To avoid flooding and unsafe driving conditions, the lots are built to effectively channel and collect runoff. Parking lots, along with roads, are often the principal source of water pollution in urban areas.

Motor vehicles are a constant source of pollutants, the most significant being gasoline, motor oil, polycyclic aromatic hydrocarbons (PAHs), and heavy metals. (PAHs are found in combustion byproducts of gasoline, as well as in asphalt and coal tar-based sealants used to maintain parking lots.) Many parking lots are also significant sources of trash which ends up in waterways.

Treatment of pollution : Traditionally, the runoff has been shunted directly into storm sewers, streams, dry wells or even sanitary sewers. However, most larger municipalities now require construction of storm water management facilities for new lots. Typical facilities include retention basins, infiltration basins and percolation trenches. Some newer designs include bioretention systems, which use plants more extensively to absorb and filter pollutants. However, most existing lots have limited or no facilities to control runoff.

Alternative paving materials : An alternative solution today is to use permeable paving surfaces, such as brick, pervious concrete, stone, special paving blocks, or tire-tread woven mats. These materials allow rain to soak into the ground through the spaces inherent in the parking lot surface. The ground then may become contaminated in the surface of the parking lot park, but this tends to stay in a small area of ground, which effectively filters water before it seeps away. This can however create problems if contaminants seep into groundwater, especially where there is groundwater abstraction 'downstream' for potable water supply.

2.5.3 Technology

Modern parking lots use a variety of technologies to help motorists find unoccupied parking spaces using parking guidance and information system, retrieve their vehicles, and improve their experience. This includes adaptive lighting, sensors, indoor positioning system (IPS) and mobile payment options. The Santa Monica Place shopping mall in California has cameras on each stall that can help count the lot occupancy and find lost cars.

In outdoor parking lots, GPS can be used to remember the location of a vehicle (some apps saves location automatically when turning off the car when a smartphone breaks communication with a vehicle's Bluetooth connection).[citation needed] In indoor parking lots, one option is to record one's Wi-Fi signature (signal strengths observed for several detectable access points) to remember the location of a vehicle.

Online booking technology service providers have been created to help drivers find long-term parking in an automated manner, while also providing significant savings for those who book parking spaces ahead of time. They use real-time inventory management checking technology to display parking lots with availability, sorted by price and distance from the airport.

There are mobile apps providing services for the reservation of longterm parking lot spaces similar to online or aggregate parking facility booking services. Some long-term parking mobile apps also have turn-by-turn maps to locate the parking lot, notably US and UK based Park Jockey.

2.6 GREEN WALLS

A green wall is a wall partially or completely covered with greenery that includes a growing medium, such as soil or a substrate. Most green walls also feature an integrated water delivery system. A green wall is also known as a living wall or vertical garden. It provides insulation to keep the building's inside temperature consistent.

It is useful to distinguish green walls from green facades. Green walls have growing media supported on the face of the wall (as described below), while green facades have soil only at the base of the wall (in a container or in ground) and support climbing plants on the face of the wall to create the green, or vegetated, facade.

Green walls may be indoors or outside, freestanding or attached to an existing wall, and come in a great variety of sizes.

Stanley Hart White, a Professor of Landscape Architecture at the University of Illinois patented a "vegetation-Bearing Architectonic Structure and System" in 1938, though his invention did not progress beyond prototypes in his backyard in Urbana, Illinois.

Patrick Blanc, a botanist specialized in tropical forest undergrowth, worked with architect Adrien Fainsilber and engineer Peter Rice implementing the first successful large indoors green wall in 1986 at the Cité des Sciences et de l'Industrie in Paris. In 2005, he created the landmark vegetal exterior wall of the administrative building of the Musée du quai Branly with architect Jean Nouvel.

Green walls subsequently saw a rapid surge in popularity. Of the 61 large-scale outdoor green walls listed in an online database provided by greenroof.com, 80% were constructed in or after 2009 and 93% in or after 2007. Many iconic green walls have been constructed by institutions and in public places such as airports and are now becoming common.

As of 2015, the largest green wall covers 2,700 square meters (29,063 square feet or more than half an acre) and is located at the Los Cabos International Convention Center, a building designed by Mexican architect Fernando Romero for the 2012 G-20 Los Cabos summit.

2.6.1 Function

Green walls are found most often in urban environments where the plants reduce overall temperatures of the building. "The primary cause of heat build-up in cities is insolation, the absorption of solar radiation by roads and buildings in the city and the storage of this heat in the building material and its subsequent re-radiation. Plant surfaces however, as a result of transpiration, do not rise more than 4–5 °C above the ambient and are sometimes cooler."[11]

Living walls may also be a means for water reuse. The plants may purify slightly polluted water (such as greywater) by absorbing the dissolved nutrients. Bacteria mineralize the organic components to make them available to the plants. A study is underway at the Bertschi School in Seattle, Washington using a GSky Pro Wall system, however, no publicly available data on this is available at this time.

Living walls are particularly suitable for cities, as they allow good use of available vertical surface areas. They are also suitable in arid areas, as the circulating water on a vertical wall is less likely to evaporate than in horizontal gardens.

The living wall could also function for urban agriculture, urban gardening, or for its beauty as art. It is sometimes built indoors to help alleviate sick building syndrome.

Living walls are also acknowledged for remediation of poor air quality, both to internal and external areas.

2.7 RAIN GARDEN

A rain garden is a planted depression or a hole that allows rainwater runoff from impervious urban areas, like roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed. This reduces rain runoff by allowing storm water to soak into the ground (as opposed to flowing into storm drains and surface waters which causes erosion, water pollution, flooding, and diminished groundwater). They should be designed for specific soils and climates. The purpose of a rain garden is to improve water quality in nearby bodies of water and to ensure that rainwater becomes available for plants as groundwater rather than being sent through storm water drains straight out to sea. Rain gardens can cut down on the amount of pollution reaching creeks and streams by up to 30%.

Native and adapted plants are recommended for rain gardens because they are more tolerant of the local climate, soil, and water conditions; have deep and variable root systems for enhanced water infiltration and drought tolerance; habitat value and diversity for local ecological communities; and overall sustainability once established. There can be trade-offs associated with using native plants, including lack of availability for some species, late spring emergence, short blooming season, and relatively slow establishment. The plants — a selection of wetland edge vegetation, such as wildflowers, sedges, rushes, ferns, shrubs and small trees — take up excess water flowing into the rain garden. Water filters through soil layers before entering the groundwater system. Root systems enhance infiltration, maintain or even augment soil permeability, provide moisture redistribution, and sustain diverse microbial populations involved in biofiltration. Also, through the process of transpiration, rain garden plants return water vapor to the atmosphere. A more wide-ranging definition covers all the possible elements that can be used to capture, channel, divert, and make the most of the natural rain and snow that falls on a property. The whole garden can become a rain garden, and each component of the whole can become a small-scale rain garden in itself.

2.7.2 Characteristics

A rain garden requires an area where water can collect and infiltrate, and plants to maintain infiltration rates, diverse microbe communities, and water holding capacity. Transpiration by growing plants accelerates soil drying between storms. This includes any plant extending roots to the garden area.

Simply adjusting the landscape so that downspouts and paved surfaces drain into existing gardens may be all that is needed because the soil has been well loosened and plants are well established. However, many plants do not tolerate saturated roots for long and often more water runs off one's roof than people realize. Often the required location and storage capacity of the garden area must be determined first. Rain garden plants are then selected to match the situation, not the other way around.

2.7.2.1 Soil and drainage

When an area's soils are not permeable enough to allow water to drain and filter properly, the soil should be replaced and an underdrain installed. This bioretention mixture should typically contain 60% sand, 20% compost, and 20% topsoil, and there is a current trend to replace compost with biochar. Existing soil must be removed and replaced. Do not combine the sandy soil (bioretention) mixture with a surrounding soil that does not have high sand content. Otherwise, the clay particles will settle in between the sand particles and form a concrete-like substance, as demonstrated in a 1983 study.[15] Deep plant roots also create additional channels for storm water to filter into the ground. Microbial populations feed off plant root secretions and break down carbon (such as in mulch or desiccated plant roots) to aggregate soil particles which increases infiltration rates. A five-year study by the U.S. Geological Survey indicates that rain gardens in urban clay soils can be effective without the use of underdrains or replacement of native soils with the bioretention mix. Pre-installation infiltration rates should be at least .25 in/hour, however. Type D soils will require an underdrain paired with the sandy soil mix in order to drain properly.[16]

Sometimes a drywell with a series of gravel layers near the lowest spot in the rain garden will help facilitate percolation. However, a drywell placed at the lowest spot can become clogged with silt prematurely turning the garden into an infiltration basin defeating its purpose. Depression-focused recharge of polluted water into wells poses a serious threat and should be avoided. Similarly plans to install a rain garden near a septic system should be reviewed by a qualified engineer. The more polluted the water, the longer it must be retained in the soil for purification. This is often achieved by installing several smaller rain garden basins with soil deeper than the seasonal high water table. In some cases lined bioretention cells with subsurface drainage are used to retain smaller amounts of water and filter larger amounts without letting water percolate as quickly.

Rain gardens are at times confused with bioswales. Swales slope to a destination, while rain gardens do not; however, a bioswale may end with a rain garden. Drainage ditches may be handled like bioswales and even include rain gardens in series, saving time and money on maintenance. Part of a garden that nearly always has standing water is a water garden, wetland, or pond, and not a rain garden. Using the proper terminology ensures that the proper methods are used to achieve the desired results.

2.7.2.2 Plant selection

Plants selected for use in a rain garden should tolerate both saturated and dry soil. Using native plants is generally encouraged. This way the rain garden may contribute to urban habitats for native butterflies, birds, and beneficial insects.

Well planned plantings require minimal maintenance to survive, and are compatible with adjacent land use. Trees under power lines, or that up-heave sidewalks when soils become moist, or whose roots seek out and clog drainage tiles can cause expensive damage.

Trees generally contribute most when located close enough to tap moisture in the rain garden depression, yet do not excessively shade the garden. That said, shading open surface waters can reduce excessive heating of habitat. Plants tolerate inundation by warm water for less time because heat drives out dissolved oxygen, thus a plant tolerant of early spring flooding may not survive summer inundation.

Another plant that works particularly well is bamboo. It has been tested, and it can clean water 27.6% better than domestic plants like grass or clovers. Rice, although it is hard to grow and maintain, works even better.

III CONCLUSION

Using these methods in smart cities the environment will be evergreen, the standard of the smart cities will be upgrade on next level. Pollution can be prevented. Improve air quality and reduce air temperature. Etc.,

REFERENCES

[1] *Lev, Jiri (2017). "The power of streetscape and how to protect it". Newcastle Herald. Newcastle NSW Australia. Retrieved 2017-09-03.*

[2] *Craig W. Johnson; Fred A. Baker; Wayne S. Johnson (1990). "Urban & Community Forestry, a Guide for the Interior Western United States" (PDF). USDA Forest Service, Intermountain Region, Ogden, Utah.*

[3] *Maller, Cecily; Townsend, Mardie; St Leger, Lawrence (March 2008). Healthy parks, healthy people: The health benefits of contact with nature in a park context (PDF). Deakin University and Parks Victoria..*

[4] *Vandermeulen, Valerie; Verspecht, A.; Vermeire, B.; Van Huylenbroeck, G.; Gellynck, X. (November 30, 2011). "The use of economic valuation to create public support for green infrastructure investments in urban areas". Landscape and Urban Planning. **103** (2): 198–206. doi:10.1016/j.landurbplan.2011.07.010. Retrieved 28 February 2014.*

[5] *Volder, Astrid; Dvorak (February 2014). "Event size, substrate water content and vegetation affect storm water retention efficiency of an un-irrigated extensive green roof system in Central Texas". Sustainable Cities and Society. **10**: 59–64. doi:10.1016/j.scs.2013.05.005. Retrieved 27 February 2014.*

[6] *Bianchini, Fabricio; Hewage (December 2012). "Probabilistic social cost-benefit analysis for green roofs: A lifecycle approach". Building and Environment. **58**: 152–162. doi:10.1016/j.buildenv.2012.07.005. Retrieved 27 February 2014.*

[7] *Emilsson, T.; Czemiel Berndtsson, J.; Mattsson, J-E; Rolf, K. (2007). "Effect of using conventional and controlled release fertilizer on nutrient runoff from various vegetated roof systems". Ecological Engineering. **29** (3): 260–271. doi:10.1016/j.ecoleng.2006.01.001.*

[8] *Czemiel Berndtsson, J.; Emilsson, T.; Bengtsson, L. (2006). "The influence of extensive vegetated roofs on runoff water quality". Science of The Total Environment. **355** (1–3): 48–63. doi:10.1016/j.scitotenv.2005.02.035.*

[9] *Nelson, Bryn (15 April 2008). "Green roofs popping up in big cities - Business - Going Green". MSNBC. Retrieved 25 April 2012.*

[10] *Saadatian, Omidreza; Sopian, K.; Salleh, E.; Lim, C. H.; Riffat, Safa; Saadatian, Elham; Toudeshki, Arash; Sulaiman, M. Y. (2013-07-01). "A review of energy aspects of green roofs". Renewable and Sustainable Energy Reviews. **23**: 155–168. doi:10.1016/j.rser.2013.02.022.*

[11] *Ferguson, Bruce K. (2005). Porous Pavements. Boca Raton: CRC Press. ISBN 978-0-8493-2670-7.*

[12] *National Menu of Stormwater Best Management Practices.* 2009-09-10. *"Permeable Interlocking Concrete Pavement". Permeable Interlocking* https://www.epa.gov/sites/production/files/styles/large/public/2016-05/anatomy_of_a_green_street.jpg*Concrete Pavement. EPA. Retrieved 18 September 2012.*

[13] Bean, Eban Z.; Hunt, William F.; Bidelspach, David A.; Smith, Jonathan T. (2004)."Study on the Surface Infiltration Rate of Permeable Pavements." North Carolina State University, Biological and Agricultural Engineering Dept. Raleigh, NC.

[14] *Volder, A; Watson, Viswanathan (2009). "Potential use of pervious concrete for maintaining existing mature trees during and after urban development". Urban For. Urban Gree. **8** (4): 249–256. doi:10.1016/j.ufug.2009.08.006.*

[15] Brattebo, B. O., and D. B. Booth. 2003. "Long-Term Stormwater Quantity and Quality Performance of Permeable Pavement Systems." *Water Research*. 37: 4369–4376. doi:10.1016/S0043-1354(03)00410-X

[16] *National Menu of Stormwater Best Management Practices.* 2009-09-10. *"Porous Asphalt Pavement". Porous Asphalt Pavement. EPA. Retrieved 18 September 2012.*

[17] *Rocheleau, Matt (26 November 2012). "Raising the railroad in Forest Hills". Boston Globe. Retrieved 12 February 2016.*

[18] • *Kayser, Heidi (3 July 2012). "Good-bye Axiom!". Axiom Center for New and Experimental Media. Archived from the original on 19 August 2013.*

[19] • *"Boston Cyberarts Gallery Exhibitions". Boston Cyberarts Gallery. Retrieved 7 November 2014*

[20] *Joshua Correa, Ed Katz, Patricia Collins, Martin Griss (November 2008). "Room-Level Wi-Fi Location Tracking" (pdf). Carnegie Mellon Silicon Valley MRC-TR-2008-02.*

[21] *Motavalli, Jim (October 11, 2012). "New York Times contributor blogs about interesting ways of getting around. Streetline app aims to end the hunt for a parking space". Mother Nature Network.*

[22] *Mandell, Nina (April 9, 2013). "PayByPhone App Finally Available To Make Parking Easier In New York City (Big Apple drivers are getting a little help from the Department of Transportation)". FastCompany*

[23] Ong, B. (2003). Green plot ratio: an ecological measure for architecture and urban planning. *Landscape and Urban Planning*, 63 (4). Retrieved June 19, 2009, from ScienceDirect database.

[24] Indoor Air |Darlington, A.; Chan, M.; Malloch, D.; Dixon, M. A. Indoor Air 2000, 10, 39-46

[25] *"Upwards trend". www.airport-world.com. Airport World. Retrieved 29 March 2013. An increasing number of airports are investing in vertical gardens and living walls to create a unique setting.*

[26] *"The International Greenroof & Greenwall Projects Database!". greenroofs.com. Greenroofs.com, LLC. Retrieved 17 October 2013. select 'green wall' as type and 'living wall' under 'greenroof type'*

[27] • • University of Rhode Island. Healthy Landscapes Program. "Rain Gardens: Enhancing your home landscape and protecting water quality."

[28] Kuichling, E. 1889. "The relation between the rainfall and the discharge of sewers in populous districts." *Trans. Am. Soc. Civ. Eng.* 20, 1–60.

[29] *"Urban Runoff" (PDF). Nonpoint Source News-Notes. No. 42. Washington, D.C.: U.S. Environmental Protection Agency (EPA). August 1995. Archived from the original (PDF) on 2012-07-07.*

[30] University of Delaware Cooperative Extension. "Rain Gardens in Delaware."