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Water as an Ecological Factor for a Sustainable Campus Landscape

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Abstract

University Campuses are large entities with huge impacts on the environment and therefore on the overall urban sustainability. Water is a scarce resource worldwide and has an obvious critical situation in the Egyptian case. Water sustainability for landscape depends mainly on reduction of consumption, collection of water and recycling of water. The paper tackles the lack of care towards sustainability issues on contemporary Egyptian campuses' design and management. The occurring initiatives are insufficient. This research aims to define a checklist for sustainable landscape measures regarding water on university campuses based on international best practice cases and literature. The study examines the state of campus landscapes in some of the contemporary campuses in Egypt and the application of sustainability criteria and measures.

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Keywords: Water; ecological sustainability; university campus; guidelines

1. Introduction

The main aim of sustainability is to reduce the consumption of resources and at a better extent reach the limit of production of resources. For water, this could be applied through processes such as: water reuse, water harvesting,

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and minimal water consumption. Nature provides the accurate balance through processes of ecosystem while the unwise human consumption creates the unbalance. Since landscape is a part of the natural ecosystem, it is exposed to the balance between growth and decay, thus eco-landscaping would lead to the decrease of the costs for the property owner and the decrease of the use of intense water and other structures needed to imitate the nature since the basic concept of sustainable ecological landscape is to blend with nature and return back to the natural systems. Businesses ignore these services provided by the ecosystems and exclude them from accounting budgets for projects, although their loss creates a very large gap that needs a huge amount of money to be replaced and sometimes it is irreplaceable. (The Sustainable SITES Initiative, 2014, p. 5).

Water is covering 70% of the globe and is considered almost 99% of the human body. As Ambrose Bierce stated "Water occupies 2/3 of a world for man – Who has no gills". Paul Simon, the U.S senator predicts that coming wars will be over water rather than oil (Thompson & Sorvig, 2007, p. 152). Recently the scarcity of water is becoming a global issue, "Water is now recognized as one of the most contentious, uncertain resources of the future" (United Nations 2006), water is becoming limited and needs a better and more careful consumption in the future. This matter leads to the sustainable methods regarding dealing with water. Since university campuses are from the most water consuming projects in the case of landscape and especially potable water, then it is essential to study the means of better sustainable usage of water on campus landscape, as well as the awareness and educational aspects that the university provides supporting sustainability. (Johnson & Castleden, 2011)

The research methodology firstly deduces from literature review and formulates a checklist used in the empirical study. This part includes checking different landscape sustainability measures on international campuses. The "SITES" rating system has an input in the formulation of the basic checklist. The second part feeds the checklist inductively from the case studies and leads to a set of guidelines for the contemporary Egyptian case, showing the current situation and supported by results generated through comparative analysis.

The three cases, namely the American University in Cairo (AUC), the German University in Cairo (GUC) and the British University in Egypt (BUE) refer to recently opened campuses that were expected to be more manageable and innovative in applying the measures of sustainability. The three campuses have different sizes and share the desert environment as a common environment. The cases are analysed according to the checklist through visits, observations, questionnaires from users and discussing points with units responsible for landscape management on campus.

According to the studied cases, the ecological sustainability of landscape related to water is only partly achieved. AUC was the only campus that considered sustainable measures before construction and during operation, yet many aspects are still missing. In most cases, the main driver remains the economic benefit and traded design concepts, while the ecological benefit is mostly not considered.

2. Water sustainability

Water sustainability is not about saving available sources of water on site only. It is the saving of resources, restoring natural systems and producing new resources. It is about integrating different systems together supporting each other: water, soil, vegetation and materials. Also the balance between the different water uses is a very important aspect. The misuse of water resources will lead to pollution, ecosystem degradation. Some actions that support water sustainability (Calkins, 2012 kindle version, pp. 1929-1938):

Preserve and restore the interaction of rainfall, vegetation, and soil - Promote onsite infiltration of rainfall and runoff - Protect or improve surface water quality - Promote groundwater recharge - Maintain predevelopment stream bank base flow - Cleanse wastewater onsite - Reuse or infiltrate wastewater onsite - Minimize use of potable water - Capture and reuse rainwater, grey-water, and treated black water onsite

Water cycle is globally balanced as water evaporates from water surfaces then it returns back to the ground going through infiltration, evapotranspiration and surface run off and this cycle goes on. The site comes as an intermediate factor that could affects the cycle on a small scale which will be the water cycle on site only, but through efficient and proper water consumption and preservation the balance is kept on site too which serves the sustainability of the site.

These are some of the approaches or examples of application of water sustainability in the University of Oregon, which includes the water systems (Development, Oct. 5, 2000. Updated Sept. 2005, p. 9):

- Maximize on-site storm-water management. Focus on filtering runoff resulting from rainfall events that are equal to or less than 1" (about 80% of all rainfall events in Eugene). Limit off-site drainage whenever possible.
- Use plant materials and terrain to slow and absorb runoff, filter sediments, and facilitate infiltration.

- Maximize pervious surfaces to permit water infiltration where possible.
- Minimize the need for landscape irrigation. Use weather-based irrigation controls to minimize runoff and excess water use.
- Use natural drainage ways wherever possible.
- When appropriate, make use of grey-water and water-saving devices.
- Use plantings that can tolerate low summer watering.

The interaction and integration of different disciplines is the source of success for sustainable performance of different systems on site. This requires the participation of different specializations: landscape architects, architects, civil engineers, mechanical engineers, hydrologists, ecologists and others. Each one of them complements and adds to the other which is the basic concept of sustainability.

The integration of the water balance planning on site with the site design is a major solution for the efficient utilization of the water on site. This is achieved through the holistic strategies including water supply, storage, use and disposal integrated with the natural hydraulic processes in order to reach that the land and the water systems act as a single entity. (Calkins, 2012 kindle version, pp. 2235-2244)

3. Storm water management

From the main water saving systems is the storm water management systems which is only obvious in countries with rainy climate. This is not available in most of the regions in Egypt but is considered from the important systems for water saving in other countries. This systems decreases the wasted runoff, protecting and restoring water bodies. The main outcome is the balance of ecological health and the economical and durable manner. Storm water management is applied through different facilities as: roof gardens, bio-retentions, rain harvesting systems and different systems that provide infiltration and evaporation of water. There are many benefits for the storm water management system (Calkins, 2012 kindle version, pp. 2057-2093):

- It prevents the hazard of floods resulting from storms on site, as the water is dispersed to different parts of the system as different ponds and basins linked to the system.
- Storm water infiltration systems would help in recharging the groundwater.
- Collected water could be used directly to irrigate planted areas or it could be harvested, stored in cisterns.
- It can also prevent and minimize the erosion and the change in the characteristics of the soil that might be affected due to the large masses of water from storms.
- These systems could provide a rich field to support biodiversity.
- Providing appropriate soil moisture.

The provision of different water systems on site that are very near to nature supported by vegetation that mimics the structural and botanical diversity of the native plant community leads to a comprehensive storm water management strategy that is very similar to the natural systems . The dispersion of different components of the storm water system decreases the over usage of soil for infiltration due to the concentration on different spots as well as better distribution, connectivity, integration and aesthetical value on the site see Fig. 1.

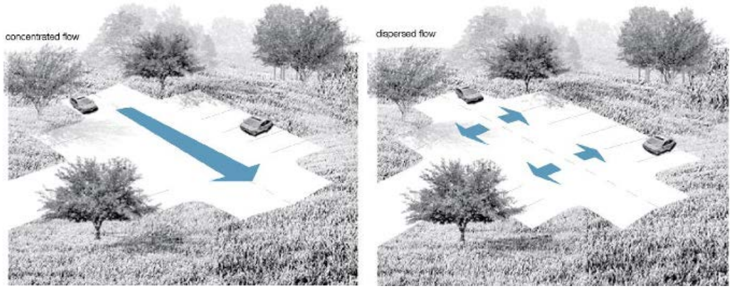

Fig. 1 Difference between dispersed and not dispersed water systems (Calkins, 2012 kindle version)

3.1. Bioretentions and non-point source pollution solution

Bioretention is a depression in the land to allow the accumulation and infiltration of water. It is supported by vegetation to support the purifying process of water. Point source pollution is defined to a certain defined source while non-point source pollution is wider including e.g. excess of toxic chemicals, pesticides, salts, oil, hydro modification…etc. Bioretentions act as a solution for non-point source pollution because the pollutants are filtrated from the first flush of water and the vegetation absorb phosphorous and nitrogen and the metallic constituents mixed with the collected water, and also prevents the thermal pollution of the infiltrated water.

University of Missouri decided to build a bioretention that catches up water runoff from a near asphalt parking lot. The intention was not only to reduce runoff velocity, temperature and pollutants but also to promote the campus involvement in storm water improvement. The position was selected to have a dual benefit for the community and the campus. (University of Missouri Campus Facilities, 2013)

3.2. Educational awareness, aesthetics, recreation and safety

Serving the educational goals supporting sustainability, used systems should be obvious and highlighted in order to enhance and widen the knowledge about water sustainability. Different systems as bioretentions, rain gardens, porous pavement…etc. could have tags indicating its process and the ecological benefit behind this process. One of the functions of landscape is serving aesthetics. Providing water saving or collecting systems serving aesthetical matters should be highly integrated rather than neglected since the end user need to accept the landscape aesthetically in order to support the ecological function. Aesthetical factors could be applied when considering visual design theories during design e.g. unity, variety, balance, rhythm, colours, texture…etc. As a link between ecology and aesthetics, Paul Selman stated" There is a possibility that we can develop or perhaps reacquire, an ecological aesthetic that looks beyond the prettiness and tidiness of a landscape to detect cues about its underlying sustainability and resilience." (Selman, Sustainable Landscape Planning- The Reconnection Agenda, 2012, p. 13). Providing interactivity between the user and the landscape creates a good field for good publication and serving the needed recreational factor of landscape. Safety should be a priority in consideration. Water quality, contact, depth and isolation are all factors that need to be considered for the safety of users when interacting with provided systems.

3.3. Runoff reduction

For an efficient stormwater or any water saving system, the runoff has to be reduced from different components of landscape. From the means of loss of the runoff are the impervious different surfaces of landscape such as: roads, sidewalks, rooftops, and parking lots. All these surfaces have to be permeable to allow the infiltration of the water and this preferable to be next to the source of water. For the soil, it is better to keep in mind the infiltration process when grading or compacting. (Calkins, 2012 kindle version, p. 2736 till 2745)

There are two concepts for infiltration: the first is to slow down the flow of water and the second is to provide permeable ground. There is a method called the French drain for infiltrating the water, which is simply a trench or a pit that contains graded gravel and sometimes it has filter fabrics for further filtration of water. (Thompson & Sorvig, 2007, p. 176). One of the channels toward sustainability achievement is returning the site to its original natural state and mimicking the nature in order to decrease the harmful effects on the environment. Directing efforts to previously developed sites is another approach serving sustainable measures.

Some of the methods to reduce runoff is to keep the initial site attributes which could support infiltration and reduce the use of other new materials and accordingly reducing costs. The main concept is to decrease the areas of impervious surfaces generally on site. From the main means to decrease the amount of runoff are:

Decreasing the footprint of built area on site to increase the surface areas of pervious surfaces - The implementation of green roofs in the case of rainy environments - Decrease the areas of impervious surfaces in parking lots - Decease the use of curbs, and gutters to allow the direct flow of runoff to the nearest vegetated areas - The use of infiltrating plants that could increase groundwater recharge.

3.4. Compost blankets

Are 1-3 inches of compost that is spread over disturbed soil in order to provide more permeable soil and reduces the erosion of the soil and it could also provide healthy soil for permanent vegetation and it also acts on reducing the runoff. It could be applied to different types of soils with different slopes. There are some restrictions to using compost blankets which are (Calkins, 2012 kindle version):

- The presence of high velocities of water runoff.
- The irrelevance of the PH value of the compost with the permanent vegetation.

3.5. Rain harvesting systems

The harvesting of water is divided into two ways. The first is directly collected without much of further treatment as it is collected directly from roof tops or means with less amount of pollutants while the other way is deeply filtered and treated as well as it is limited to certain uses such as washing or toilets due to the presence of different chemical pollutants and salts that could be resulted from automobiles for example.

In Mcgill University, as a part of concern of the university regarding water resources and water management, the university introduced the installation of a water collection system Fig. 2 as a part of a class project in order to integrate between the education and the practical application. This project will provide water for the Horticulture Research Center and will provide a training site for current and future students studying water resources and sustainable practices on the campus. (Adamowski, 2014)

Fig. 2 A side view of the Horticulture Services Building (Macdonald Campus, Sainte-Anne-de-Bellevue, QC, Canada) (Adamowski, 2014)

3.6. Porous pavement

Porous pavement is a load bearing surface that could be used for different pathways or roads with high porosity that allows the permeability of water through a layer of aggregates that ranges from inches till a feet deep which allows the infiltration of water and its storage in a reservoir and overall decrease in the amount of wasted runoff (Calkins, 2012 kindle version, p. 2980 till 2993). “Where land is affected by increased runoff and erosion, or by extremes of flooding and drought, successful restoration may depend on removing excess hard surfaces. For parking still in use, porous pavement may replace all or part of the impervious surface and bio- filtration can infiltrate runoff on-site”

(Thompson & Sorvig, 2007, p. 86)

In 2002 and 2003, the University of Rhode Island added porous parking lots in order to collect water runoff from parking lots. One of the two was a previous turf land used for the overflow of parking and the other is a retrofitted parking lot. In order to prevent contamination of water, industrial and commercial vehicles are not allowed to use these parking lots with porous pavements. (McNally, Joubert, & Philo, 2003)

3.7. Rain gardens and rain pockets

Rain gardens or pockets are depressed areas of 6-8 inches depth to hold water from storms or rains for infiltration or storage. This system mimics the naturally created pools of water. The types of plants used in these gardens should be selected to adapt to the submergence in water as well as the drought times. This system is relevant for soils with infiltration rates not less than 0.5 inch per hour and it should be spread over the site in order to receive runoff from different sources on site as well as abandon spots with runoff of high velocities. Unlike the bioretentions rain gardens don’t have under drain system.

After a 100 year flood in 2006 that flooded different parts on campus. Seattle University built a rain garden Fig. 3 to collect water from two streets. Rain gardens hold the water then releases it to the ground water slowly. (Seattle University Campus, 2014)

Fig. 3 Rain garden on the University of Seattle Campus (Seattle University Campus, 2014)

3.8. Green roof for water saving

There are two types of green roof: intensive and extensive. The intensive could include larger variety of plants since the depth of the soil is deeper. The extensive ranges from 1 to 6 inches is limited by certain numbers of plants and is more relevant to slopes with performing some modifications. From the main benefits of green roofs are: Limiting heat island effect, reducing the amount of lost runoff and due to the porous character of the soil, it keeps water for the planted vegetation. According to (Scholz-Barth 2001; VanWoert et al. 2005) green roofs decreases the loss of water runoff by 50-90%. Green roofs could be a way to support biodiversity, a source of aesthetical enjoyment for buildings lacking surrounding vegetation and source of food if the concept of edible landscaping. (Calkins, 2012 kindle version, p. 2906 till 2939).

Many of the roofs of Carnegie Mellon University are planted. In Fig. 4 Doherty Hall and Gates Center green roofs are shown. A 10000 gallons tanks collects rain water from green roofs and it is used for toilet flushing of both buildings. For the Gates/Hillman Building construction project, green space was increased from 52,209 sf to 120,100 sf. (Carnegie Mellon University, 2014)

Fig. 4 Photo of Doherty Hall and Gates Center green roofs courtesy of Brad Temkin, 2011 (Carnegie Mellon University, 2014)

3.9. Vegetation swales and bioswales

Vegetation swales are channels that are lined with vegetation and act as pre-treatment systems for filtering sediments before other deeper systems of filtration and infiltration. Vegetation swales are cheaper than concrete gutters that need more maintenance and more surface area. Different check dams could be added to slow down the flow of water. Bioswales are channeled linear bioretentions having the same underdrains and vegetation. As different systems since it is exposed then it is a very good opportunity for awareness about sustainability on site and its methods.

The University of Regina incorporated the use of bioswales Fig. 5 in the perimeter surface parking lots to clean surface water runoff and to green the parking environment. In Bioswales are used in a rural form on the left photo and in an urban form on the right photo. (DIALOG, 2011, p. 68)

Fig. 5 Two methods of using bioswales in parking lots on the University of Regina Campus (DIALOG, 2011, p. 69)

4. Water conservation

The main target for any sustainable site is to provide a healthy, beautiful and living landscape with the least usage of provided potable water and without over consuming the natural water sources if available on site. The usage of water from operational processes within the buildings is an efficient method for the conservation of water available on site. In the beginning of any project a water budget has to be calculated. This budget includes: The rain water, the site runoff, the grey water available, the available supply of water. Even losses like evaporation, infiltration are included. The output of these calculations lead to decisions regarding the used vegetative species, the possible water features, and storage sizes needed. In order to minimize the amount of water consumed for irrigation some sustainable strategies should be applied:

- Growing native plants.
- Holistic sustainable maintenance systems including: pest management, natural and non- toxic landscape care creates a stable state for the plant.
- Turf grass areas could be managed with natural lawn care practices decreasing water consumption.
- Managing to balance between the site water demand and the renewable resources of water
- Water delivery efficiency, distribution efficiency and irrigation methods as well as water features on site play major roles for water conservation.

5. Water storage, reuse and recycling

When the water supply is higher than the demand then the excess of water is stored in order to be available in the time of need. In case that the demand is higher than the water supply then the amount of water needed on site has to be decreased until a balance is reached. The amount of water to be stored is a percentage of the highest monthly water demand according to the available supply. It is always less than 100%, mostly it is in the range of 75% - 90% (Calkins, 2012 kindle version, p. 3636 till 3641). There are different types of storage:

- Surface storage includes any depression on site that stores water.
- Cisterns which includes tanks or storage vessels.
- Modified cisterns which is integrated with an infiltration system consuming no land area.

Since one of the methods of sustainability is returning back to natural systems or at least mimicking the mechanism of the nature. In natural landscape water supply is through rainwater, groundwater and condensation of dew. Applying the same concept on the site, the main supply of water would be the renewable resources of water as the treated wastewater, water processed from building use and other sources related to stormwater and rain in rainy sites: Green roofs, bioretention, porous pavement systems.

The Water Reuse Association defines “reused, recycled, or reclaimed water as water that is used more than one time before it passes back into the natural water cycle.”

6. Irrigation

In US irrigation consumes 30-50% of water supply and in dry regions or hot months it could reach 75%. (Thompson & Sorvig, 2007, p. 179)

Efficient irrigation system is the one providing optimum amount of water suitable for the available vegetation and minimizing the loss of water as much as possible with the consumption of the renewable water resources in the first place rather than consuming potable supplied water.

The excess of water usage could affect the plant and could cause erosion or soil subsidence and accordingly the plants require more maintenance and consume higher amount of fertilizers due to excessive water usage. (Thompson & Sorvig, 2007, p. 181)

The efficiency of irrigation systems depends mainly on the maintenance of these systems as many leaks or over-gravitational flows that could lead to wasting water and even keeping some of the land requiring water totally dry, thus the maintenance process plays an essential role to provide an efficient irrigation system with limited loss of water.

One of the methods of providing efficient irrigation is dividing the vegetation types into hydrozones which gathers different types having common water requirements to decrease the loss of water. Different types of irrigation systems according to different species affects the efficiency of water usage e.g. drip irrigation for some cases may be preferred over spraying with sprinklers. The same is applied for control systems e.g. smart control systems are preferred since irrigation depend on climatic conditions and water requirements.

7. Case studies

Three recent contemporary university campuses were analysed as case studies. The aim of analysing these cases is to highlight the sustainable methods or initiatives that are applied, to filter and fine-tune the aggregated international checklist of sustainable landscape on university campuses and reach conclusions and recommendations regarding future steps for a more sustainable campus landscape in the common Egyptian context.

All the selected cases are in the new urban communities of Cairo, are in the same desert environment and are all opened after the year 2000. According to the hypothesis these universities’ campuses may have applied sustainable measures in the composition of their landscapes according to their recent operation. All the three campuses have different schools on the same campus. The three campuses are of different sizes. Some campuses e.g. AUC have initiatives for achieving sustainability in different fields (American University in Cairo, 2013). All the cases chosen were in the new developing spots in Cairo creating new communities and providing the expansion in the desert and this part of East Cairo had several examples of campuses that could be included in the study.

The three campuses were studied through observations, transect walk, filling a checklist, and online questionnaires for different users to fill. The following analysis are based on all the previous methods used.

7.1. British University in Egypt (BUE)

The amount of green areas present on campus are very minimal. There are no water features present on campus. This is a good indication for the minimal amount of water consumption on site. At the same time very minimal number sustainable methods of water usage is applied on site. Still to be constructed, the university will have a water tank to save raw water that will be used in the future for the irrigation of the landscape. This indicates that the used water for irrigation is potable water.

The methods of xeriscaping are not applied to the campus landscape, but normally the action of grass mowing is less frequent due to the small number of workers working on the landscape. No systems of any kind are used for the collection of water runoff.

Irrigation systems are taken into consideration, dripping systems are used to irrigate palms and trees while sprinklers are used for the irrigation of grass.

7.2. German University in Cairo (GUC)

Not all disciplines were included as ecologists, geologists…etc. which should have provided a comprehensive view and analysis of the site. The campus is provided by treated water from the government through El Ain El Sokhna road, covering only 10% of the water consumption since it is not continuously available. The treated water is being worried of to have any health effect on users, then it is used only drippers of trees and palms only.

Methods of minimizing the use of potable water includes: Irrigation at night to decrease evaporation, efficient irrigation systems as drippers and sprinklers, 1/3 of the used species on campus are cacti Fig. 6.

Fig. 6 Cacti species planted on campus

Against considering the stability of the site, trees and palm trees were introduced to the site while construction took place but the rest were planted later. All roofs on campus are not accessible and are not planted. Less frequently mowing of turf grass is taken control of through fertilization. Regarding growing native plants, it is partially applied as couple of trees that naturally grew on site were kept.

No computerized control systems for irrigation and to limit leakage and is performed manually. Storage of water is present but due to the shortage of water in summer but sometimes available water is not enough. Plants having similar water requirements are connected through one irrigation line and each line has its own valve that is manually operated.

Only treated water is provided neither graywater nor wastewater are used. Very minimal water from air conditioners is directly linked to the landscape. Neither minimal rainwater nor HVAC blowdown are used.Users don’t notice any sustainable measures regarding ecological factors except the efficient irrigation systems

7.3. American University in Cairo (AUC)

Treated water provided by the government is filtered and used for irrigation of landscape. Chemical assessment is applied to the used water and results indicate its safety. Researches and trials are currently conducted to use blue-down water from cooling towers for irrigation and this needs salt tolerant vegetation to adapt. No wastewater is treated or reused onsite till now, since it is very expensive. The campus was designed to have maximum areas of exposed sand to allow the infiltration of water and enhance groundwater recharge. Also outer drains are connected to five retention basins Fig. 7 surrounding the parking lots which also receives water from the parking lots' interlocking blocks. The received water is not utilized, only gutter at parking lots are limited to allow the flow of runoff to reach the planted areas.

Fig. 7 One of the retention basins surrounding the parking areas

Very efficient irrigation systems are applied which includes drip irrigation for most of vegetation on campus and sprinklers for limited lawn on campus. Automated systems are used for irrigation and automated systems are used to control and give alert and prompt cut of water in case of any leakage. Most spaces are divided into hydrozones to limit the loss of water. Most plants are selected to have very limited consumption of water. Turf grass is limited to the minimum with application of less frequent watering and mowing.
Total water consumption is decreased by around 30% than the baseline case beyond the establishment period.

8. Conclusions and recommendations

8.1. Conclusions

Table 1 Final Checklist and its application and aggregation according to studied cases

Water	BUE	GUC	AUC	**Total**
The integration of different disciplines in the water system initiation (ecologists- landscape architects- geologists -civil engineers….etc.)				
Reuse of wastewater onsite.				
Methods of minimizing the use of potable water.				
Promote groundwater recharge and maximize the pervious surfaces to permit the water infiltration.(taking into consideration through compaction of soil)				
Reuse of rainwater and runoff. (if available)				
Application of storm water management. (if available)				
Maximize the pervious surfaces to permit the water infiltration and ground water recharge with soil that allows infiltration with rate 0.5 inch per hour without slopes and away from contamination sources.				
Reaching the point where the water supply is higher than the demand.				
Dispersing stormwater system to decrease the over usage of soil. (If available)				
Solving non- point source pollution problem. (if available)				

Installing signs showing the different sustainable systems used for water or vegetation to support educational factor.				
Provision of safety measures for interaction with the displayed water systems**.**				
The presence of bio-retentions to infiltrate water and prevent the loss of runoff. (if large amount of water is available)				
Applying French drain system to allow the infiltration of water and prevent the loss of runoff. (In case of available run off)				
Making use of site natural attributes that supports infiltration to reduce costs.				
Decrease the use of curbs and gutters to allow the direct flow of run off to the vegetation**.**				
Use of compost blankets to provide permeability of soil and reduce erosion, keeping in mind the water velocity and the PH value**.**				
Treatment of harvested water before using for vegetation. (If water case is available)				
Isolating water storing systems of water harvesting to provide hygiene and safety.(If water case is available)				
Introduction of rain gardens to infiltrate water to the ground, infiltration rate has to be not less than 0.5 inch per hour and not of slope and away from high velocity and pollution points. Used plants have to adapt to submergence in water and drought.				
Provision of good insulation for green roofs, check if the structure would bear the addition of green roof, and prevent adding vegetation at the edges to protect against wind shear forces.				
Addition of vegetated swales or bio-swales to perform infiltration of water before deeper water systems.				
Less frequent mowing and watering of turf grass and overseeding to decrease the consumption of water.				
Growing native plants to decrease the water consumption.				
Availability of pest management and natural and non-toxic landscape care creates a stable state of vegetation which accordingly decreases water consumption.				
Maintenance of water delivery, distribution and irrigation to decrease any leak of water**.**				
The percentage of stored water is relevant to the use of the campus. ((75%-90%) of highest monthly demand)				
Distribution of vegetation according to common hydrozones to provide the best water consumption**.**				
Using the proper way of irrigation in order to achieve the least loss of water.				
Using the proper control system of irrigation in order to achieve the least loss of water**.**				
SITES rating system added point: Reduce water usage by at least 50 percent from the baseline case beyond the establishment period.				
SITES rating system added point: If graywater or wastewater is to be recycled for landscape irrigation, consider conducting chemical tests to determine suitability for reuse on intended vegetation.				
SITES rating system added point: Reuse graywater, captured rainwater, HVAC blowdown, or condensate water for irrigation to decrease potable water use for irrigation and to create a net benefit to the local watershed by making the landscape part of the natural water-treatment process**.**				

- Efficient irrigation systems are applied in all of the studied campuses but the computerized control systems are only applied on AUC campus.
- Storm water systems are mostly not applicable to the Egyptian case due to the absence of sufficient rain, but resembling systems could be used to make use of the wasted runoff and limited rain could limit the water resources used on site. The addition of green roofs, bioretentions, and rain gardens…etc. would help catching water even if in a small scale. Not only rain, but also normal run off could be included rather than losing it.

- Treatment of wastewater onsite is still unavailable in all the studied campuses so this field needs to be enhanced in order to increase recycling of water and minimize the use of potable water.
- Treated water is used by all studied cases in a small range, as treated water is provided by the state and is unsteady, but most of them don't take gray-water into consideration.

8.2. Recommendations

- The influence of governmental regulations is a major milestone for the proper application of sustainable landscape locally and internationally.
- Highly connecting the measures for saving and protecting nature to economical values to be an incentive for wider application.
- The application of graywater use and wastewater reuse need to be activated since the water problem will increase in the coming years and each drop will be valuable.
- Showing and interacting with physical media supporting sustainability is totally unavailable in order to support educational and public awareness.
- Treated water systems are used with different percentages on the three studied campuses, but continuous provision needs to be applied in order to minimize potable water as much as possible.
- Including stormwater management systems to save water need to be encouraged and provided as a method to solve water scarcity.
- BUE, GUC and AUC are incomplete campuses. Better systems fulfilling sustainable measures could be applied and taken into consideration in the next phases.
- Stressing on including sustainability of landscape and its benefits in different syllabus in order to raise awareness and increase knowledge.
- The checklist is a start point highlighting the status quo and the application of different measures of sustainable landscape. Deeper analysis and calculations are required for weighing this list.

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