Department of Architecture
Faculty of Engineering
Ain Shams University

# SUSTAINABLE LANDSCAPE IN UNIVERSITY CAMPUS URBAN DESIGN

By

**Ahmed Ibrahim Amr**
B.Sc. Architecture, Ain Shams University, 2010

A thesis Submitted to the Faculty of Engineering in Partial Fulfillment of requirements for the degree of

**Master of Science in Architecture**

Supervised by

Prof.
**Shaimaa Kamel**
Professor of Architecture
Department of Architecture
Faculty of Engineering
Ain Shams University

Prof.
**Germin El Gohary**
Professor of Landscape
Department of
Urban Design and Planning
Faculty of Engineering
Ain Shams University

Prof.
**Johannes Hamhaber**
Professor of Urban and Regional Management
ITT
Cologne University of Applied Sciences

Ain Shams University
CAIRO, EGYPT
2015

# STATEMENT

This thesis is submitted to Ain Shams University for the degree of Master in Architecture. The work included in this thesis was accomplished by the author at the Department of Architecture, Faculty of Engineering; Ain shams University.

No part of this thesis has been submitted for a degree or a qualification at any other university or institute.

**Date:** / /2015

**Signature:**

**Name:** Ahmed Ibrahim Amr

**Faculty:** Faculty of Engineering – Ain Shams University

# BOARD OF EXAMINERS

| Examiner | Signature |
| --- | --- |
| **Prof. Ayman Hassaan Mahmoud**<br>Professor of Landscape<br>Faculty of Engineering<br>Cairo University | |
| **A. Prof. Ahmed Atef Faggal**<br>Associate Professor of Architecture<br>Faculty of Engineering<br>Ain Shams University | |
| **Prof. Shaimaa Mohamed Kamel**<br>Professor of Architecture<br>Faculty of Engineering<br>Ain Shams University | |
| **Prof. Germin Farouk El Gohary**<br>Professor of Landscape<br>Faculty of Engineering<br>Ain Shams University | |

ACKNOWLEDGEMENTS

First of all, I would like to thank God for his generosity, blessings and giving me power, health and patience to finish this piece of work. May He always guide me to help my country and widen my knowledge to serve humanity and Islam.

Second, this thesis is a tiny thank you to my mother Iman El Soufy, father Ibrahim Amr and brother Tarek Amr who always support me and are my backbone in everything. Nothing could be enough to show my respect, gratitude and endless love.

My deepest appreciation and thanks to my dearest supervisors. Words aren't enough to thank you for your great support and limitless help.

Thank you to Prof. Shaimaa Kamel, Prof. Gemin El Gohary and Prof. Johannes Hamhaber

Special thanks to my dear and supportive friends who always helped and really cared: Arch. Reem Fahmy, Dr. Marwa Abd El Latif, Arch. Merham Kelg.

I sincerely appreciate the help of Prof. Ahmed Sherif, Prof. Laila El Marsy, Prof. Maher Stino, Dr. Ahmed Amin, Prof. Tamer El Khorazaty, Prof. Hanan Sabry, Dr. Ahmed Rashed, Dr. Gehan Nagy, Dr. Samah El Khateeb, Eng. Tawheid (AUC), Eng. Aly (BUE), Arch. Mohamed Abeedo, Arch. Manar Mohamed, Arch. Mariam Ahmed and Arch. Sameh Ibrahim.

Thank you to my dear doctors who have great input in my knowledge and intellectual exposure Dr. Marwa Khalifa and Prof. Mohamed Salheen.

UPD staff, you are my second family that I am honored to be part of.

All members of ITT, Fachochschule Köln, I am so grateful for your company and support during my stay in Köln, Germany.

My friends and family, you are one of the pillars of my life. Thank you to: Mohamed Mamdouh, Ahmed Hany, Abdallah Salah, Abdallah Raouf, Akram Sherif, Moatasem Ziad, Mohamed Reda, Hatem Ahmed, Amira Nabil, Samar El Moatasem, Alaa Ehab, Sara El Ansary, Omneya El Mogy, Sara Abd El Baki, Mohamed Zayed and Simon Witti. To my dear uncle, and my favorite writer Mohamed Amr, thank you for the final review of the thesis.

# ABSTRACT

This thesis aims to reach a set of comprehensive guidelines and checklist for sustainable landscape measures in university campuses. The study managed to examine the state of campus landscape in some of the contemporary universities in Egypt and check the application of sustainability regarding campus landscape.

The thesis is based on four qualities affecting sustainable landscape. The qualities are: Physical qualities, ecological qualities, individual use qualities and social qualities. The integration of these qualities covers two pillars of sustainability which are environmental and social sustainability. The two first qualities target how physical urban properties could function efficiently performing the required benefit and at the same time serving and protecting the ecosystem. The last two qualities focus on another factor which is the user.

The first four chapters included theoretical data from literature, reports and best practices clarifying the application of sustainable measures in landscape and its reflection on the university campus landscape. Physical qualities included: Connectivity, edges and gateways, different circulations on campus, spaces and facilities provided. This aspect focused on the efficient operation of campus and how to reach optimum cases related to urban design. Ecological qualities included: Water, vegetation, soil and materials. This aspect focused on less consumption of resources and energy, enhancing and protecting nature and returning back to nature resemblance. The individual use qualities included: Wayfinding, safety and identity. Individual use qualities discussed ease of movement, interaction and sense of belonging of users. The social qualities included: friendship formation, group membership, communications, spatial separation based on social characteristics, gender differences, participation and the impact of physical space on social space.

The methods used are deductive in the theoretical part reaching compilation of different elements to be added on the guidelines' checklist. Some relevant points from "SITES" rating system for sustainable sites were added to the list. The process of validating the list according to the guidance of expertise in the field of landscape architecture occurred. Questionnaires and interviews' questions were formulated to use for the selected case studies based on theoretical part. A cross- cutting relational table was generated to highlight the interactions between different qualities complying with the main target of sustainability creating a holistic and integrated approach.

The selection of the three cases –American University in Cairo (AUC), German University in Cairo (GUC) and British University in Egypt (BUE) - was based on recently opened campuses that could be more manageable and updated to apply the measures of sustainable landscape. The three campuses are of different sizes sharing the desert common environment. Cases were analyzed according the checklist by visiting the cases and discussing points with units responsible for landscape management on campus. Questionnaires were distributed online and interviews were conducted to understand further relations on campus from different users.

According to the studied cases, the sustainability of landscape is still only achieved in limited fields especially the ecological qualities. Physical elements are mostly fine due to the good design of campuses especially the AUC. Even though AUC was the only campus of the three cases having actual steps towards the implementation of sustainable measures before construction and during operation, many aspects are still not achieved. Many elements need to be taken into consideration before construction as water systems, vegetation and soil. The main motive is the economic benefit in most cases while the ecological benefit is not obvious. The study resulted in a comprehensive comparison highlighting the main applied measures and main defects, a cross-cutting relational table for each case showing the integration between qualities positively and negatively, and the classification of the compiled checklist showing the degree of application.

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# LIST OF ACRONYMS

| | |
|---|---|
| **AUC** | American University in Cairo |
| **BEC** | School of Business, Economics and Communication |
| **BUE** | British University in Egypt |
| **DFD** | Design for disassembly |
| **EC** | Embodied carbon |
| **EE** | Embodied energy |
| **GSAS** | Global Sustainability Assessment System |
| **GUC** | German University in Cairo |
| **HUSS** | School of Humanities and Social Sciences |
| **LOS** | Level of service |
| **LULC** | Land use/land cover |
| **PVA** | School of Performing and Visual Arts |
| **RISE** | Research Institute for a Sustainable Environment |
| **SSE** | School of Sciences and Engineering |
| **SSI** | Sustainable Sites Initiative |

# Introduction

Universities are considered as tiny miniature cities. They are institutions that provide interaction for large spectrum of the society. The universities play a great role in moving the society towards a sustainable future. Although achievement of comprehensive sustainability is a utopian goal, yet practices towards targeting same are essential to reach said goal as much as possible. (Waite, 2003, pp. 86-87)

Since campuses are considered as large urban projects, they have a huge impact on possession and consumption of different resources. Many campuses could include rivers, forests and sometimes agricultural lands. In addition to that universities are educational facilities with very high population consuming large amount of resources water, food, transportation facilities, energy… etc. University campuses are sources of knowledge, science and includes character building. Thus university campuses should spread knowledge and application of sustainability. Including courses about sustainability, directing researches towards that topic and finally providing visions and master plans for a better sustainable campus in general, since the better way of spreading an idea is by practicing it on ground. Sustainability is concerned by the outdoor and the indoor environments and the connection between them. Although sustainability is based on holism, but the scope of the thesis only includes the outer landscape parts

Many studies were performed on the field of landscape analysis of campus, but linking the campus planning activities to environmental goals is a bit missing. Due to the lack of theories and research related to campus planning, most are done through a pragmatic process neglecting the environmental sustainability which is less explored. Throughout the 1990s, many universities started to raise issues of environmental universities as the case of Tufts University “Tufts Clean” (White, 2003). Over that 250 Universities worldwide followed Talloires Declaration[1] which had an environmental commitment on the universities “set an example of environmental responsibility by establishing resource conservation, recycling and waste reduction at the universities” (Creighton, 1998, p. 292)

[1] Talloires Declaration is a declaration for sustainability, created for and by presidents of institutions of higher learning. Jean Mayer, Tufts University president, convened a conference of 22 universities in 1990 in Talloires, France. This document is a declaration that institutions of higher learning will be world leaders in developing, creating, supporting and maintaining sustainability.

"A campus without landscape is as likely as a circle without a circumference, an arch without a keystone, an ocean without water. Most campuses have significant acreage devoted to lawns, greens, and playfields. Areas between buildings have aesthetic, functional, and symbolic purposes which landscape defines and sustains. Landscape can serve as the skeleton for the overall campus plan, and the interior circulation systems such as walks and roads, as well as provide a background for subtle and finer grain landscape motifs. The greenery includes the campus edges, gateways, gardens, arboretums, memorials, bell towers, fountains, outdoor sitting areas, signs, site furniture, and natural features on the site, including ponds, woodlands, and rock formations. These landscapes and plant material can abate noise, control dust, divert traffic, secure boundaries, afford privacy and be arranged for pleasure." (Dober, Campus Design, 1992, pp. 167-169)

Landscape has never been limited to providing aesthetical qualities using natural elements such as water and greenery supplemented by some street furniture. It is exceeding that limit, including defining outdoor identity, complementing urban design tools, creating a message, supporting environment, and providing healthy physical spaces to support available social spaces.

"Campus outdoor areas ought not to be treated as leftover spaces. Careful consideration should be given to the overall placement of buildings, protection of special spaces, location of entrances and main plazas, and detailing of building entries and outdoor study spaces. In campus planning, as in any other form of site planning, it is important to include the expected users in the decision-making process pertaining to the environments under consideration. Also, professionals whose focus is the outdoors, that is, landscape designers, need to be involved from the start, pressing for front porches, aware of the need for common turf, sensitive to the protection of special spaces, and skilled in the use of vegetation and design and the placement of site furniture to enhance the full use of the outdoors for study, relaxation, contemplation, socialization, and recreation." (Abu-Ghazzeh, 1999)

The environmental quality of the campus outdoor spaces in a university consists of three major components that have implications and need to be considered in the design of urban outdoor places in general, and in the design of outdoor spaces in the campus environment, in particular. These include the following (Abu-Ghazzeh, 1999):

- Physical and ecological quality: The natural environment characteristics.
- Behavioral and functional quality: Interactions between human behavior and physical setting. This component comprises the density or comfortability of a sitting space, the availability of amenities such

as food and drinks, and the degree of interaction with adjacent buildings and/or spaces.

- Aesthetic and visual quality: Visual preference based on visual sensation. This is the most important aspect of aesthetic-visual quality of outdoor spaces.

According to the previous quotes sustainability is not only based on the ecological aspect. Sustainability of physical, social spaces and users' use of spaces and landscape are considered very important aspects to be achieved as they affect the ease of space usage, the campus open spaces and landscape providing a good social environment, and the continuous success of the campus in performing its role.

Another support for the same concept is defining the meaning of sustainability from the Western Australian Planning Commission: “Sustainability is about understanding the connections between and achieving a balance among-social, economic, and environmental aspects that contribute to quality of life. It is not just about the environment. It is concerned with improving the health and welfare of the planet, its people and living organisms into the future (WAPC, 2001:1).” (Abou El Ela, 2004)

Previous statements are rich with the large amount of venues, spaces, resources, activities and connections. Activities on campus could be including four actions: Using and performing physical activities (e.g. pedestrian circulation, vehicular circulation….etc.), consuming environmental resources (e.g. irrigation, planting….etc.), users dealing with surrounding facilities (e.g. wayfinding, individual safety…etc.), and finally users dealing with each other (e.g. friendship, group membership…etc.). Connections and finding relations between these various activities is an initiative to explore how the integration works to reach an environmental-social sustainable landscape.

# Overview

## Conceptual framework: Dimensions of sustainable campus

### a. Sustainable campus

"University campuses are one of the largest users of potable water in the urban landscape. They are also steeped in tradition, laden with political and cultural symbolism, and often meticulously designed 'islands of green' (Gumprecht 2007). Considerable meaning can be derived from determining how such symbols are valued by those involved in different campus activities (Dakin 2003). The 'ivory tower' has continually changed in shape and function to attract and retain faculty, staff and students (Gisolfi 2004). While traditionally a space of power for the elite, the aim of campus planning in the 1990s was to use 'good architecture and professional landscaping [to] approach the laudable goal of making a campus a work for art' (Gaines 1991, 119)." (Johnson & Castleden, 2011)

Based on the previous statements, in the older days, the campus was considered only an aesthetical piece of art without focusing on the degree of resources consumption or the social environment created by the campus landscape. Nowadays according to the continuous decrease in the amount of resources, the campus landscape has to be productive, less consuming with the same level of aesthetical qualities it provides.

According to "Meeting the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987) as basic definitions of sustainability, campuses should start reducing, conserving and recycling resources in order to save resources that will be used by the coming generations. After that the idea of balancing, producing and regenerating was introduced to the ecological side of the campus. Still other factors that could give a comprehensive perception of sustainability are missing. What is being presented in this thesis is that achieving the sustainability of the four aspects: physical properties of campus, ecological aspects, individual use and social quality of campus are the real factors for creating a sustainable campus landscape that not only guarantees the ecological sustainability but also the usage, the interaction and sustainable functioning of the outdoor spaces on the campus. The four layered system used will be briefly explained in the dimensions of the open space.

"Growing environmental consciousness and corporate social responsibility has seen the emergence of new legislation in Canada committed to sustainable growth, such as the case of requiring new public sector buildings and facilities, including universities and colleges, to be built to LEED standards (British Columbia 2010). Such legislation has resulted in landscape transformations in the built environment. However, some argue that this legislation threatens the tradition and history that is embedded in the university landscape. The emergence of a campus landscape that seeks to mimic natural systems inevitably detracts from a traditional campus landscape that is more human and is designed as an open space for social interaction and activity (Hough 2010)" (Johnson & Castleden, 2011). Based on the previous statements, the different cross- cutting relations between the different aspects creating the environmental and social sustainability on campus and one of the main objectives of the thesis is to understand and highlight these relationships.

"Indeed, it has been argued that sustainability is, at its core, local and not universal in nature (McDonough and Braungart 2002). Thus, a sustainable resource practice at one college or university might not be sustainable at another institution. The conditions for successful planning will vary from institution to institution." (Waite, 2003) It is true that different factors of sustainability could vary from campus to the other according to the different environmental factors, social differences, and different locations. That is why some factors cannot be generalized to all different campuses while others can.

## b. Open space as an element in a sustainable campus and its dimensions

An open space acts as the main unit for containing any process or action that sustains the campus landscape. An open space could be a pathway that is serving efficient mobility on campus and sustaining the good design of a circulation network on campus. Another open space contains the native plants that reduces the water consumption, fertilizers and sometimes could be a source of remediation for the soil. The same open space could be identified by unique design of landscape creating a unique identity for the campus or the same space could or couldn't have different landmarks and signs facilitating reaching different places and supporting the wayfinding. Finally the open space could be a favorable place or unfavorable place for social interactions to take place affecting the social sustainability on campus.

According to LULC (Land use/land cover) concept, the connection between the physical properties and composition of outdoor space and the ecological properties of the materials and different covers composing that outdoor space i.e. a pathway on campus could be very efficient according to function but the material of that pathway needs large amount of energy for production. This created the environmental umbrella that engulfs the physical and ecological qualities. Regarding the second social part, it involves the different interactions of human beings involved. The first sub-part includes the user interacting with the surrounding which is entitled as individual use of campus i.e. Does the person feel safe in different parts of the campus? Does he find his way easily on campus? What are the factors affecting the wayfinding process or safety on campus? These are questions showing the idea of individual use discussed in the thesis.

"Students are not interested in hierarchy. They're interested in information and learning. Our job as planners and designers and landscape architects is to help provide the structure for that to happen. A lot of learning is social and a lot of that social learning happens out in the plazas and other outdoor spaces on campus where people meet. We shouldn't underestimate the power of landscape architecture to help define these spaces." (Hannah, 2013) This is the first statement that they started the report with, it shows how important are the open spaces on the campuses. Providing well designed open spaces ecologically and physically will assure saving the resources which are used in these spaces and assure that the spaces will be highly efficient for the use that it is designed for while serving social factors.

The other sub-part is the pure social part including friendship, group membership, and different activities including gender effect. Such factors altogether may lead to overcrowding certain spaces, leaving others fully abandoned. Such action can be attributed to social or spatial reasons i.e. cultural and social factors could have a role like separating boys and girls in some countries or the unavailability of seats and the space being hidden could be another reason. The thesis tries to explore the social vs. special factors affecting social interactions on campus.

As a base for the sustainable landscape design the following table provided by John F. Benson and Maggie H. Roe is a basic outline for the factors affecting the sustainability of the design of landscape (Benson & Roe, 2000, pp. 286-288), furthermore in the case of a university campus different factors are added, edited or eliminated according to the nature of the project and the scope of the thesis. The tables are as follows:

**Table 1 Checklist for sustainable landscape design (Benson & Roe, 2000, p. 286 to 287)**

| *Category* | *Considerations* |
|---|---|
| *People (Design and Community)* | |
| 1 Concept development | Early and effective liaison with all stakeholders<br>Early and effective liaison with other professionals<br>De-materialize aspects of design (e.g. replacement of a feature with a service or leased object) |
| 2 Optimization of design | Maximize use of existing/available features<br>Vernacular styles adopted where appropriate<br>Maximize utility and scope of design<br>Versatile design<br>Conflicts of interest considered<br>Inclusive/universal design of all facilities |
| 3 Access | Located within reach of target users<br>Links to external routes/features/places/public and private transport<br>Effective information and publicity systems in place<br>Clearly signed, entrance and exit points, paths and routes, accessible by all ages, abilities, etc.<br>Segregation of traffic where appropriate<br>Inclusive/universal design of all facilities |
| 4 Optimize initial lifetime | Reliability and durability considered<br>Ease of maintenance and repair<br>Adaptable/modular design and structural elements (allowing refinement and development)<br>Aesthetically resolved/'classic' design |
| 5 User stage | Productive landscape (e.g. food growing, art and craft materials etc.)<br>Closed system where possible (e.g. composting scheme, harvesting of rainwater etc.)<br>Monitoring mechanisms planned<br>Responsive management systems established<br>Follow up visits by designers |
| 6 Community involvement | Consensus building/facilitated workshops with local people of all ages/cultures/sexes/interests<br>Participation by local stakeholders in design process<br>Support and supervision of workshops/activities<br>Locals involved with supervision of site/security<br>Safety features to at least minimum standard |

**Table 2 Checklist for sustainable landscape design (Benson & Roe, 2000, p. 287 to 288)**

| *Category* | *Considerations* |
|---|---|
| *Planet (Environment)* | |
| 1 Biodiversity | Indigenous species given priority |
| | Local provenance of plant stock |
| | Disturbance minimized |
| | Pollution minimized |
| | Existing plants protected from damage |
| | Sensitive habitats/ecosystems protected during use |
| 2 Natural processes | Thorough site survey and analysis |
| | Hydrology preserved or enhanced |
| | Existing soils restored or enhanced |
| | Best practice planting, handling and storage of plants |
| | Pollution mitigated |
| | Microclimates considered |
| 3 Resources | Specification of materials and objects guided by ecodesign and life cycle thinking (Brezet and Hemel, 1997) |
| | Waste minimized |
| | Efficient working practices adopted |
| | Production steps minimized |
| | Renewable, local energy sources used where possible |
| | Recycle, re-use and repair where possible |
| | Separate and store waste for recycling |
| | Ergonomic layout |
| | Organic and low impact design and specification |
| *Profit (Financial)* | |
| 1 Funding | Ethical financing |
| | Multiple sources |
| | Grants and sponsorships considered |
| | Self financing |
| | Viable in medium to long term |
| | Cash flow adequate for projected activities |
| | Adaptable to changing scenarios |
| | Worst case scenarios considered |
| | Exit strategy planned |
| 2 Stakeholders | Community fundraising |
| | Community ownership/controlling interest |
| | Sponsorship by local businesses |
| | Favourable deal for locals for access charges |
| | Employment opportunities/experience for locals |

The thesis has four dimensions which are: Physical properties of the campus, ecological aspect, individual use of campus and finally the social quality of the campus. The study started bottom up approach as each of the four aspects depend on each other respectively, but through the study it appeared that there are some top bottom connections as well, which leads to a square like relation that the four aspects are nearly having equal relational distance from the center which is sustainability of landscape.

## Research problem

Campuses are large entities that have a huge impact on the environment and on society. According to the problem of limited resources that is world-wide and having a great impact on Egypt in the current time, environmental sustainability is very essential and considered a hot spot for researches nationally and internationally. Since the main output of a university is helping students gaining knowledge and building up personalities, thus social sustainability is a must to create a healthy environment for the society and providing healthy human interactions.

Water and energy problems are faced locally in Egypt and internationally Water scarcity is one of the main problems that the research is based on. Worldwide, as an indication of scarcity, the threshold value is 1000 $m^3$/capita/year. Egypt exceeded these values since the nineties and this indicates the critical situation of water (Ministry of Water Resources and Irrigation, 2014). According to research, energy consumption in Egypt is exceeding the limits of other more developed countries which indicates the critical case of energy. The consumption of oil increased by 30% over the last decade (Mohamed, 2013).

The research problem revolves around the lack of care towards sustainability issues on Egyptian campuses. Some initiatives are taking place, but still the effect is very weak including very limited number of universities. For many campuses, landscape is still somehow considered as complementary element for buildings and not a main element affecting the entire urban design of campuses. The absence of clear guidelines for sustainability of landscape and especially on university campuses is clear weak point that the research is tackling through the guidance of international examples and their first steps towards sustainable landscape.

## Research Hypothesis

Environmental and social sustainability of landscape might be partially applied as a limited factor for the design of some campus landscape. Based on "SITES" in 2009, the ranking wasn't applied for university campuses which may indicate the minimal or starting initiatives of sustainable landscapes for university campuses. Very limited steps are applied but not intended targeting sustainability. Minor interventions and changes applied could lead to a better sustainable landscape of campus. Some steps may be applied initially but remains incomplete to serve the goal of sustainability.

## Research objectives

### Main Objective

Reaching a set of guidelines and recommendations compatible with a social/environmental sustainable campus landscape and assessing their application in contemporary Egyptian universities.

### Secondary Objectives

- Defining sustainable campus landscape from a holistic approach.

- Highlighting the different physical and urban components of sustainable campus landscape.

- Clarifying components of healthy ecological landscape describing solutions and operation for better resources' saving and production rather than reduction.

- Describing the inter-relationship between individual use of campus and landscape elements providing physical and emotional comfort and ease by interacting with campus.

- Understanding the social structure and interaction on campus.

- Clarifying the different elements of a successful sustainable campus landscape and highlighting best practices.

- Deducing preliminary guidelines and cross cutting relations between four studied aspects and feeding up from "SITES" rating system.

-Analyzing the sustainable landscape case on contemporary Egyptian campuses.

## Research scope and limitations

### Scope of Thesis

This thesis is divided into two parts: First is the theoretical based part, while the second is the analytical comparative part which will not be pure experimental as it is hard to apply all sustainability aspects on field.

The thesis is focusing on two pillars of the sustainability which are: the environmental aspect and the social aspect. The environmental aspect has two branches: one is discussing the physical qualities of the campus urban landscape design and the second part includes deeper ecological qualities of different natural resources present on site as: water, vegetation, soil, and different materials. The social aspect includes other two points: One is related to the users as social target groups and how to provide them with easy and safe interaction with different facilities on campus while the second point includes the pure social interaction between different users and complementing it by good physical space allowing these interactions

The theoretical part was based on books and references related to the university campus landscape design, urban design of university campus, guidelines for campuses' initiatives towards sustainability of landscape, urban design and landscape for relative sizes and adapting the main concepts according to the case of campus landscape, rating systems and measures for sustainable ecological aspects of sustainability. This theoretical part ended with a broad comprehensive large set of guidelines that was organized, filtered and validated through experts then interpreted through application and the comparative analyses between campuses.

As previously clarified the core of the thesis is divided into four divisions: Physical descriptive properties, ecological quality, individual use and social quality of campus landscape respectively Fig. 1. The economical aspect is a very important too but was excluded from the scope of the research Fig. 2. There is an average link between the physical part and the individual use part, and a stronger link between the individual use and the social quality. Mostly the ecological quality is solely separated but considered also as one of the main pillars for sustainability, and partially connected to physical aspect by the land use- land cover concept.

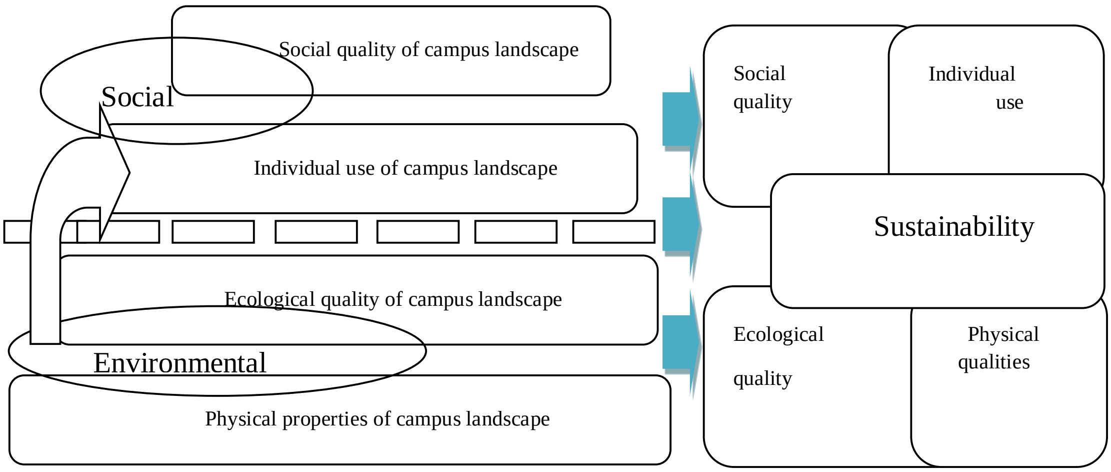



**Fig. 1 Different aspects of sustainability covered through the research**

**(The researcher)**

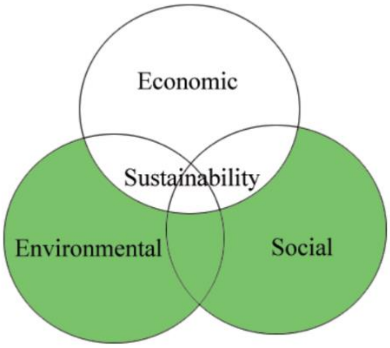



**Fig. 2 Exclusion of economical aspect**

The first two aspects can lead to a conclusion of measurable or physical guidelines to provide sustainability. Also according to these aspects, the results might be general suiting the majority of the campus cases, while for the other two aspects are variable according to each case studied as it depends on the social factor which differs from one case to the other.

The application part will act as a filter and organizer for the broad set of guidelines reached from the theoretical part. This will be conducted through interviews with campus landscape managers, then through questionnaires and interviews with the space users: students, academic staff, and workers. Each will be approached differently according to their role and use related to campus landscape. Finally these results of questionnaires and surveys will be the source highlighting the guidelines related to the social aspect which will differ from one campus to the other and reflecting on the ecological and physical parts according to the users' point of view.

The scope of the thesis is wide as the target is to explore how different systems and factors have cross relations rather than working on itself since sustainability is about holism and integrity. This lead to a more shallow interpretation of each element to include as many elements affecting the environmental and social campus landscape.

Since the scope of the thesis is wide some points were excluded. The physical part is including the urban landscape design and not including pure planning factors with surrounding sites excluding details of outside transportation, outer streets… etc. The ecological part is considering generic guidelines without getting very deep with calculations and detailed scientific work that includes other biological, chemical and physical disciplines for water, soil and different materials. Generally, the ecological healthy features are common for different site uses, that doesn't differ according to the project use, while the other three qualities: physical, individual and social are more specified for the case of campus landscape. The social limitations are that the large impact on society is not included in the thesis. It is only focusing on the social size relative to the social scale available on campus.

The choice of some aspects was according to different report, studies and master plans from a large variety of university campuses discussing the different landscape sustainability issues regarding the environmental and the social scope.

## Limitations of study

There is a difference between the delimitations which are defined by the researcher according to the scope and the points to be eliminated according to the research design while the limitations are the circumstances that could limit the research according to the status quo and the available resources. (Bloomberg & Volpe, 2007, p. 78)

There were some delimitations that were applied to the research: Although one the main pillars of sustainability is economic aspect, but it was not covered through the research due to its complexity and its field might have widened the scope more than needed. Another limitation is that the study is applied on definite type of campuses, which are gated and nearly separated from the surrounding urban context i.e. campuses that are totally opened and considered as a part of the city, were excluded since their buildings are integrated with the city streets and landscape. The social part is mainly targeting the non-physical definitions of the social sustainability including the provision of a healthy social interaction and atmosphere for the users of the campus. Since the main study zone is the landscape and open spaces of the university campus thus it is hard to study the full physical aspects of social sustainability as it is more relevantly applied to city inhabitants. It is briefly covered in parts related to transportation means provision, providing a clear legible pathways, and different aspects that are considered physical services that has to be fulfilled for different generations of users.

Some factors aren’t experimented due to the need for deep specialization regarding some aspects as i.e. water or soil, and the other reason is that some aspects are to be considered and modified through high administrative decisions supported by research teams such as i.e. different circulations, parking provision…etc.

The first rating systems for ranking different sites and parks according to their sustainability was “SITES” and "GSAS for parks", both established in 2009. Different references discussing sustainable landscape noted that sustainability of landscape is not fully applied on university campuses. Since the field of landscape sustainability is new and still currently partially applied in many universities of the world, finding solid data of deep application was a big issue. Most of the examples searched where still in the phasing of partial application or planning for the future of a more sustainable landscape on the university campus.

According to the wide scope of the thesis and the lack of application of sustainability methods in most of the campuses of Egypt, only three case studies were selected to be deeply analyzed rather than showing more examples with complete deficiencies after a general comparison between campuses. They were selected as being from the contemporary newly opened campuses. Some had small initiatives towards sustainability. International examples are shown as best practices through the theoretical part of the thesis.

# Research Methodology

## Data needs

The data needed for this research is analysis of reports sources about sustainable assessments of universities, plans and initiatives for sustainable university campuses and concluding generalized guidelines that could fit to a campus general case. Basics about urban design of spaces were needed. These data are analyzed and reinterpreted to explore and clarify the sustainability aspects of the campus from the physical properties point of view.

Regarding the ecological part of the thesis, basics and criteria for ecological sustainability aspect need to be gathered and analyzed, in order to seek the ones for the university campus. The use of different rating systems that are dealing with site sustainability e.g. "SITES". The items of these ranking systems should be classified to sort out the items that is relevant to the case of the campus landscape and especially the cases of Egypt.

For the individual use, theoretical books should explain the basics about how the user should be satisfied when using the campus or the factors that facilitate the use of the campus according to the different users that are available on campus. Basics and theories could be justified or manipulated according to the different cases of campuses that the research will present. Other complementary or contradicting to the basic theory should be understood through the empirical phase of the study by questioning people.

“Remember, one of the basic tenets of qualitative research is that each research setting is unique in its own mix of people and contextual factors. The researcher’s intent is to describe a particular context in depth, not to generalize to another context or population" (Bloomberg & Volpe, 2007, p. 69). Finally the social quality is mainly derived from the campus users as it is the field that differs according to each case as well as the nature of the users. The data needed for this part is mainly analysis from general questionnaires and interviews that will point out to the physical solutions that could be convenient to the detected problem. Some literature limited to the scale of the small society on campus will support understanding the social mechanism that is taking place on the campus, but the main source will be the analysis from the field work.

## Data acquisition

## Secondary data and info

"Theoretical information includes information searched and collected from the various literature sources to assess what is already known regarding your topic of inquiry. Theoretical information serves to" (Bloomberg & Volpe, 2007, p. 71):

• Support and give evidence for your methodological approach;

• Provide theories related to your research questions that form the development and ongoing refinement of your conceptual framework;

• Provide support for your interpretation, analysis, and synthesis; and

• Provide support for conclusions you draw and recommendations you suggest.

Secondary data is the data that the researcher acquired from resources, analyzed it and used it in his thesis as a theoretical support and base. The secondary data for the thesis is divided into two channels: The first is the reports and studies for application or assessments of sustainability in university campuses' landscape. These data should be analyzed and interpreted in the form that is relevant to the Egyptian case.

The other channel is the literature about general urban design and sustainable landscape design that should be used as a theoretical base for the discussion of the sustainability of the physical properties of the campus. In addition to this channel is the literature about the perception of the individual for the urban spaces as well as the social interactions between different users on the university campus.

## Primary data

The primary data is the data originally created by the researcher and is applied later for analysis which leads in the end to results and recommendations to the studied cases. The absence of data that could be used regarding the interaction between the campus users and the campus landscape, lead to this method of data acquisition. The primary data for this research is mainly based on gathering data through designed questionnaires and questions from the different users of the campus revealing the factors that require understanding the interaction between the users and the campus as: social interactions, individual perception and use of campus, physical properties related to the users use.

### Interviews

Interviews will be a second phase following the questionnaires in order to understand more the justification of different phenomena and getting deeper to know different personal ideas and opinions which makes the interviewees of less number than in the case of questionnaires and details could be more easily discussed.

According to Bloomberg and Volpe, “After discussing the site, if applicable, you proceed to tell the reader about the research sample—the participants of your study. You also need to explain in some detail how the sample was selected and the pool from which it was drawn.” (Bloomberg & Volpe, 2007, p. 68) Interviews will also be separated according to the type of users and the relation or the intervention of each group with the landscape. Students, workers, professors and high-board should be included. Complexity of terminologies will be chosen according to the scientific background of the interviewee and the nature of his relation to the campus landscape.

Different questions will be clustered according to the related topic from the interviewee perception, but internally the questions will be classified by the researcher according to the topic the question is feeding the main four aspects of the thesis: physical, ecological, individual and social.

### Questionnaires

Questionnaires is the phase before the phase of detailed interviews. The method of questionnaires is used to test or gather info from a large group of people that you can't include all in interviews. It is the method used to make a survey representing a large spectrum of the users which is represented statistically in the end giving indications which would help reaching and analyzing the objectives of the thesis. The questionnaires will be posted online and also printed, distributed then gathered once again after answering the questions as it will be very hard to ask a large list of questions to every person face to face. Questionnaires should deal with closed questions as it refers to a set of defined answers. Open ended questions will be more used in the case of interviews (Cloke, et al., 2004).

## Elements of participatory planning (e.g. transect walk)

Transect walk is gathering data and features a long the studied site. Transect walk allows the gathering of specified defects or problems facing the studied area. According to the questionnaires and interviews some special case based problems will appear and according to mapping these problems through exploring and observing the site. It is easier to find connections and relations between different aspects that might appear having no common linkage while the study would show other results that are supported by transect walk.

## Observation / Mapping

Mapping will be used for straight forward obvious physical properties of the campus that can be mapped, analyzed and translated into results indicating whether the campus is considered as a sustainable one or not, mostly it needs a single indicator and doesn't need a complex indicator of a mixture of indicators. A layout drawing of the layout will be used to apply the analysis derived from mapping or observing. At some complicated cases a mixture of indicators could be used to assess certain qualities. At some cases the support of analysis from the interviews and the questionnaires are needed in order to clarify some points that need intervention from the users.

## Role of researcher (reflexive)

The role of the researcher is a double role since being a student trying to understand the mechanism of the thesis topic and at the same time being an actor as a helping staff with the academic staff on campus.

# Research Structure

| Main Goal | Aspect | Objectives | Methodology | Contents |
|---|---|---|---|---|
| Reaching set of classified guidelines and recommendations compatible with a social/environmental sustainable university campus landscape internationally and highlighting on compatibility with the Egyptian case | | | | Overview |
| | Environmental aspect | -Defining sustainability and holistic approach | | |
| | Environmental aspect | - Highlighting different physical and urban components of campus sustainable landscape | Literature review<br>Reports' review<br>Deductive method | Chapter 1 |
| | Environmental aspect | - Clarifying components of healthy ecological landscape describing solutions and operation for better resources' saving and production rather than reduction | Literature review<br>Reports' review<br>Deductive method | Chapter 2 |
| | Social aspect | - Describing the interrelation between individual use of campus and landscape elements providing physical and emotional comfort and ease by interacting with campus. | Literature review<br>Reports' review<br>Deductive method | Chapter 3 |
| | Social aspect | - Understanding the social structure and interaction on campus | Literature review<br>Reports' review<br>Deductive method | Chapter 3 |
| | | - Deducing primary guidelines and cross cutting relations between four studied aspects and feeding up from "SITES" rating system | Analytical aggregation | Chapter 4 |
| | | -Analyzing the sustainable landscape case on new Egyptian campuses | Analytical and applied study | Chapter 5 |
| | | -Deducing the effect of physical space on social space | Comparative analysis +inductive method | Chapter 5 |

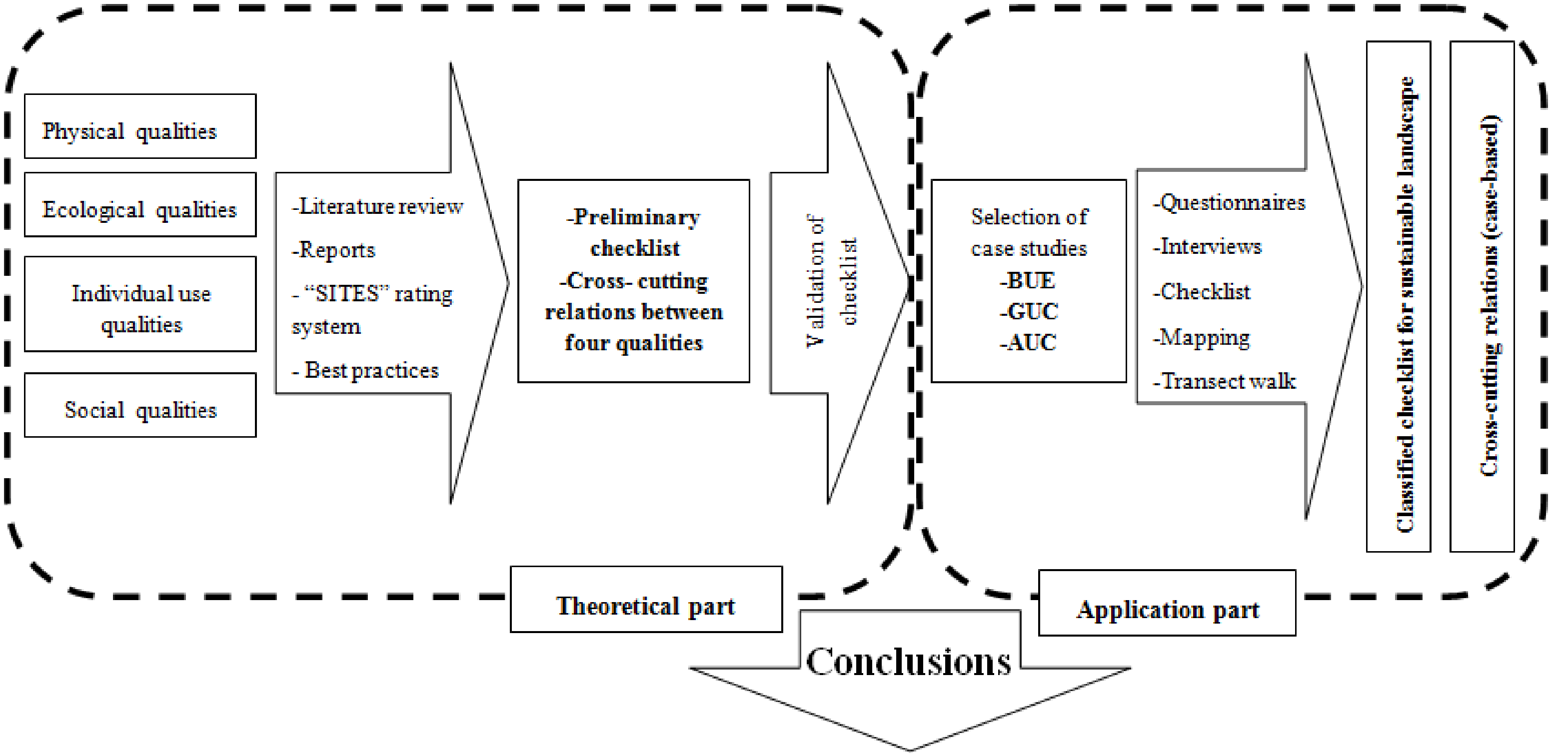



**Fig. 3 Structure showing the theoretical and the application parts**

## Previous Theses

Several researches discussed the issues of a university campus landscape or issues of sustainability of landscape separately, thus it is a strong motive to combine both approaches together for more integrated and comprehensive results. Some of these researches are:

- *Landscape for Learning: An approach towards the campus design uniqueness and memorable character with special reference to the visual influence on design decisions. MSc, Faculty of Engineering, Cairo University, Jan 2010, by Eman Ahmed Saleh Eldin Abdelhaleem.*

  The researcher discussed the evolution of university and their design, discussed different designing methods , different design factors on campus, campus urban image an supported it by case studies , integration of landscape in campus planning, and finally performed a practical application on campus urban image and landscape.
- *Analytical Study for Human Perception of Outdoor Spaces in Universities: Monitoring and analyzing Egyptian Universities and the relation between the place and the student behavior. MSc, Faculty of Engineering, Cairo University, June 2008, by Amr El Moatasem Bellah Mohamed Emam Alsherif.*

  The researcher discussed the different ways of university planning, design elements and methods of outdoor spaces on university campus, visual composition of outdoor spaces, student behavior in outdoor campus spaces, and practical case studies of different Egyptian campuses.
- *Success of Landscape Operations: An approach towards sustainable design outputs. PhD, Faculty of Engineering, Cairo University, May 2001, by Ahmed Mohamed Amin Mohamed Amin.*

  The researcher discussed the historical background of landscape, different phases of performance according to different pioneers, different landscape elements, different factors of sustainability, landscape and means of sustainable development, sustainable indicators, and different case studies supporting previous elements.

# PART 1 THEORETICAL PART

# 1. Physical Qualities of Sustainable Campus Landscape

## 1.1 Introduction

The physical aspect discusses the elements of urban design that supports the sustainability and the efficient performance of the campus. The sustainability for this chapter is mainly dealing with the longevity and the strength of the physical service the campus is providing.

The physical aspect is considered as the essential base for reaching higher levels as ecological, individual use and social. This aspect depends on initial decisions and designs that should be considered in the initial plans.

This chapter includes these topics: Connectivity, edges and gateways, different circulations, spaces and different facilities on campus

## 1.2 Connectivity and permeability of Campus Landscape:

The quality of connectivity between urban spaces has three levels of benefits: Firstly, regarding the environmental aspect, connectivity acts as connection for flora and fauna corridors (biodiversity). It also provides the movement of air masses. Secondly, with the same concept, connectivity helps to make the movement of users easy and safe. Thirdly, from the urban point of view, the presence of connectivity allows the effective linkage between spaces, formation of strong urban fabric and provides the sense of orientation when moving between different spaces. (Stiles, 2013)

"Connectivity (or permeability) refers to the directness of links and the density of connections in a transport network. A highly permeable network has many short links, numerous intersections, and minimal dead-ends. As connectivity increases, travel distances decrease and route options increase, allowing more direct travel between destinations, creating a more accessible and resilient transportation system (TDM Encyclopedia, 2009)." (Planning Institute of Australia, Canberra; Australian Local Government Association; National Heart Foundation of Australia, 2014, p. 1)

"The type and density of intersections in the network (not just those for cars) have a significant impact on how people move around, whether by foot, bike, public transport or car (Gebel et al. 2005). A less permeable network has few intersections making it difficult to reach a destination in a reasonably direct route, and using a number of different routes between point A and point B (Frumkin et al., 2004). Destinations in areas with a well-connected path network are easier to reach, than those in areas with a less connected path network." (Planning Institute of Australia, Canberra; Australian Local Government Association; National Heart Foundation of Australia, 2014, p. 2)

The degree of connectivity is shown through the functioning of the networks provided; streets, cycling roots and pathways, and how easy they provide connection for the users to their destinations. A good connected network provides a clear and easy route to the main destinations. An excellent connected network makes the users prefer to go to their destination on foot rather than using a car or another mean of transportation.

"Many people refer to 400 meters being a “reasonable” distance for people to walk. This stems from United States research in the 1960s. The purpose was to consider walking distances to public transport facilities. A “reasonable” walking distance is likely to be affected by location, topography, weather, pedestrian facilities, trip purpose and cultural factors. While a five minute walk (the time taken for the average person to walk 400 meters) may seem like a reasonable benchmark, it will not provide for a person’s daily exercise needs alone. More recent studies have shown that people are willing to walk much greater distances if the walking environment is favorable (an average of 1.2 kilometers in good conditions)." (Planning Institute of Australia, Canberra; Australian Local Government Association; National Heart Foundation of Australia, 2014, p. 3)

Different systems on the campus as roads, parking lots, walkways, service routes are very essential and interconnected for a comprehensive active campus. They are complement to the built structure of the campus. All these systems should have a balance between them, so none would dominate and affect the others. From the most important issues is the provision and the distribution of parking lots which will be discussed later and the balance between the pedestrian network and the vehicular network on the campus.

## Connectivity definitions

As seen in Fig. 4, clarification of some of the connectivity definitions: (Tresidder, 2005, p. 5)

**Link:** A roadway or pathway segment between two nodes. A street between two intersections or from a dead end to an intersection.

**Node:** The endpoint of a link, either a real node or a dangle node**.**

**Real node:** The endpoint of a link that connects to other links. An intersection.

**Dangle node:** The endpoint of a link that has no other connections. A dead-end or cul-de-sac.

**Circuit** A finite, closed path starting and ending at a single node.

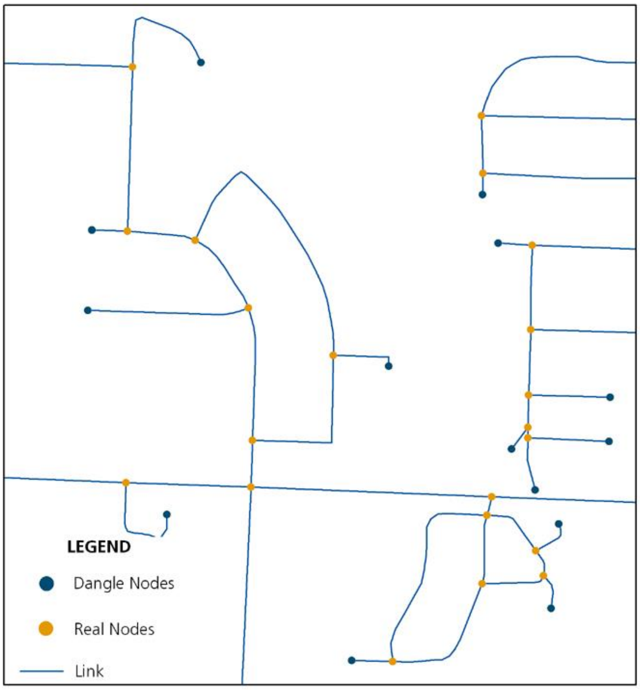



**Fig. 4 Clarification of different connectivity definitions (Tresidder, 2005)**

Table 3 **Measurements of connectivity** (Tresidder, 2005, p. 6)

| **Measure** | **Definition** | **Calculation** | **Comments** |
|---|---|---|---|
| Intersection Density | Number of intersections per unit of area | # Real nodes area /area | A higher number would indicate more intersections, and presumably, higher connectivity |
| Street Density | Number of linear meters of street per square meters of land | Total street length per unit of area / area | A higher number would indicate more streets, and presumably, higher connectivity. |
| Connected Node Ratio (CNR) | Number of street intersections divided by the number of intersections plus cul de- sacs | # Real Nodes / # Total Nodes (real + dangle) | The maximum value is 1.0. Higher numbers indicate that there are relatively few cul-de sacs and dead ends, and presumably a higher level of connectivity. |

| | | | |
|---|---|---|---|
| Link-Node Ratio | Number of links divided by the number of nodes within a study area | # Links per unit of area (streets) / # Nodes per unit of area | A perfect grid has a ratio of 2.5. This measurement does not reflect the length of the link in any way |
| Average Block Length | Block lengths can be measured from the curb or from the centerline of the street intersection. The GIS measures the street length from center of intersection to center of intersection. | Sum of link length per unit of area / # of nodes per unit of area | Shorter blocks mean more intersections and therefore a greater number of routes available. |
| Effective Walking Area (EWA) | A ratio of the number of parcels within a ~402 meters of walking distance from an origin point to the total number of parcels within ~402 meters radius of that origin point. | Taxlots within ~402 meters of walking distance of origin point / Taxlots within ~402 meters radius | Values range between 0 and 1, with a higher value indicating that more parcels are within walking distance of the pre-defined point. The higher value reflects a more connected network. |

These measurements could be adapted to the case of campuses especially the large ones.

## 1.3 Campus edges and gateways

There are two types of universities, one is self-contained which is surrounded by fences and gates or buildings and the other is totally integrated in the city having interfering streets and buildings sometimes. All the campuses present in Egypt belong to the first type.

The edges and gateways of the campus act as the introductory phase of perceiving the campus. The uniformity of design is required to reflect a good image of the campus and its design. The design of the gateways doesn't have to be monumental but it has to indicate the presence of the campus. In some campuses the problem is the blockage of the parking lots to the campus welcoming features. Simple pathways and plantation could be a good design to end the edge of the campus. Boundary markers raise the aesthetical value of the campus edge such as special lightings, banner, etc. In some cases gateways could act as placemarker for the campus especially if they have a historical background adding higher value. (Dober, 2000, pp. 84-101)

The consistency of the design of the gateway: materials, colors and forms would add higher value to the designed gate. The presence of the logo of the university and the use of this gate make it clear for users to interact with the campus.

## 1.4 Different circulations on the university campus

There are two main circulations on campus pedestrian and vehicular. Whether they are connected or separated, the pedestrian circulation should have the priority on campus as walking is the primary mode on campus. In case of mixing both, pedestrian routes should not be an extension for driveways. Provision of safe, efficient and comfortable pedestrian routes is very essential, as well as provision of a well-connected, accessible and easy vehicular network.

### a. Pedestrians' paths and walkways

Pedestrian circulation is essential factor in the campus landscape design. A campus with a good design is the one having most walks and buildings in a non-vehicular zone in the circle range of ten minutes' walk with a speed of 5-6.5 km/hr and gradient of less than 4 %, thus the boundary area ranges from 404686 to 505857.5 square meters. Greater areas could be dedicated to supplementary uses as residential facilities, research centers, athletic facilities…etc. As a rule of thumb slopes could range from 3-5%, 4.5 meters wide walkways could be enough for six people and less than 1.8 meters' wide path should be avoided. These rules are adaptable according to different climates and conditions. (Dober, 2000, pp. 112-119)

Paths work on connecting different buildings and different spaces on campus. These paths act as place making factors creating the image and the structure of the campus. Apart from its shape- wide, narrow-, its length, it gives a direction and circulation flow. Pathways have a functional and symbolic use. They organize and coordinate the visual experience of the campus. There are some criteria that organize the design of paths (Dober, 1992, p. 212):

- Paths should be proportional to the amount of users using it from the origin point to the destination without any obstacles.
- Minor paths or byways should be as important as the major paths regarding the visual design of the path as it is part of the campus whole picture
- All paths should be accessible for disabled people and should be accessible in all weathers and the materials should be suitable with the environment, easily maintained and visually coherent.
- Paths should be designed according to the hierarchy of the users, including safe separated lanes for bicycles and could be accessible for vehicles in case of emergency.
- Pedestrian and vehicular circulation is preferred to be separated or at least having problems of intersection solved.
- The intersection of the paths to the surrounding paths is very important to encourage participation in campus life. This is considered as a physical quality that targets another social quality.

Another ecological method could be added to paved surfaces which is "paving with grass". Grass could fill the opened concrete blocks for paving, allowing the infiltration of the water through the pavement and providing a vegetative space absorbing carbon dioxide and providing oxygen. It is considerably more expensive than asphalt but the maintenance expenses are lower. (Thompson & Sorvig, 2007, p. 213)

### b. Breezeways

Breezeways or arcades act as a method for dispersing the pedestrian pathways and giving a variety of options for moving. It also creates a good indoor outdoor relation that can suit different architectural typologies. It can add to the vitality of the campus life, and it reshapes the distribution of the green areas and open spaces according to the proposed breezeway and its effect on the exterior. It serves by adding an architectural detail, multi-function spaces, and an animated, safe environment for pedestrian movement. (UNB Fredericton Campus, p. 80)

### c. Cycling on campus

Since long time, bikes' use on campuses is increasing internationally as a means of transportation on campus. According to University of Minnesota Office of Physical Planning and Design in 1972, the number of bikes increased from 1500 to 3000 and is expected to reach 5000. Inside the heart of the campus, pedestrian and cyclers share the pathways which are dense, so 3 meters wide with 5% slope or less will be sufficient. Outside the campus boundaries, larger widths are needed in addition to windbreaks, shade provides and lighting for night use. (Dober, 2000, pp. 139-141)

Since cycling is a very clean and healthy way of transportation on campus. Further encouragement needs to be given to this field. It should be ranked as the second priority after the pedestrian movement when designing the pathways. Special lanes and signage system should be provided. Bicycle racks need to be provided at the important spots such as: Main entrances, entrances of buildings, perimeters of open spaces. (UNB Fredericton Campus, p. 83)

Nowadays several campuses are encouraging cycling through different means like: Providing maps, providing showers and locker rooms, providing bikes' maintenance services on campus, offering bike safety classes and sometimes even financial reward for using bike as a sustainable method of transportation.

### d. Vehicular circulation

Campus roads are essential components in the campus composition, very important but shouldn't be dominating the campus landscape. They are better when they are shortest, connecting different spots together with minimal intersection with pedestrian circulation for safety. Roads connect campus entries to exits passing by various destinations. The heaviest volume of traffic is next to the parking areas, secondly by buildings' service docks, pickup and drop off stations. (Dober, 2000, p. 107)

This type of circulation includes all vehicles that have interactivity with the campus. In some campuses, the circulation provided is not compatible with the different vehicles according to use. Mostly the service vehicular circulation needs some criteria that are forgotten during the campus design. Based on that special access, services and emergency routes should be reaching all the areas on campus.

**Bochum University, Germany** Fig. 5**:** The outer roads are connected to the underground parking spaces and then the campus is linked together through pedestrian paths. The designer made the outer roads to pass through high density of greenery since the location of the campus is in an industrial area. (Dober, 2000, pp. 107-109)

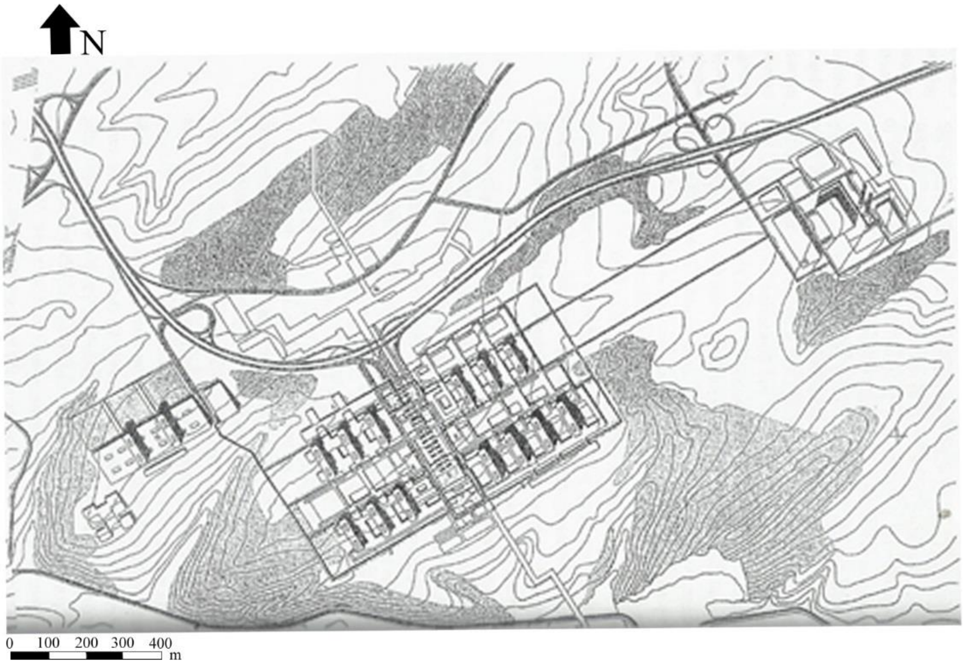



**Fig. 5 Bochum University Campus (Dober, 2000, p. 108)**

**College of San Mateo** Fig. 6**:** This shows another case where a main road loop surrounds the campus and is connected to different parking areas distributed along the loop in addition to drop offs next different buildings. On the contrary to Bochum case, the large surrounding loop is attached to different playing fields, landscaped roads and paths. (Dober, 2000, pp. 109-111)

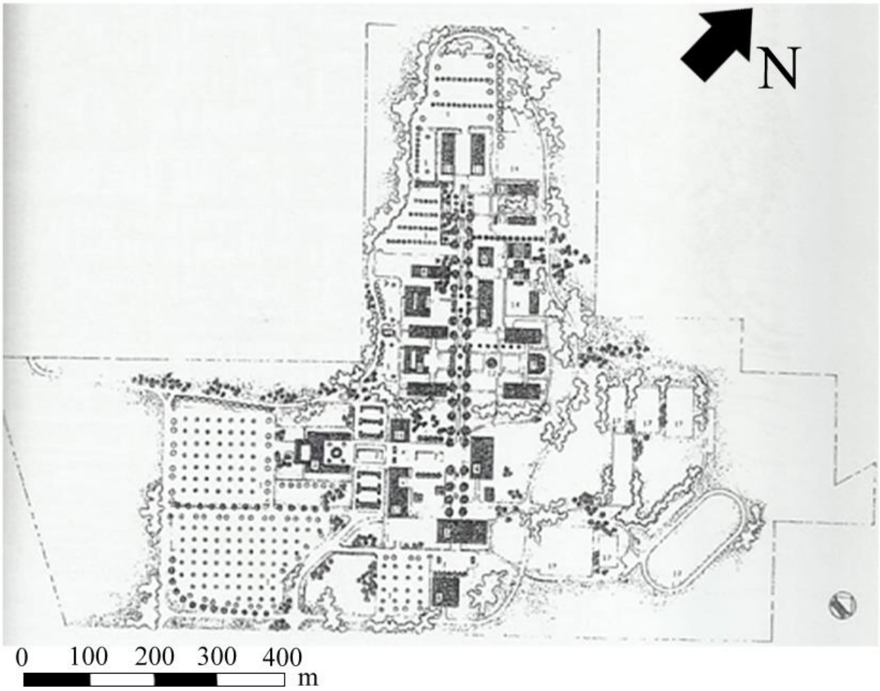



**Fig. 6 College of San Mateo (Dober, 2000, p. 109)**

**University of Guelph, Canada** Fig. 7**:** This case shows another model of hierarchy of roads getting inside the campus. The main road is creating a loop connected to parking areas then secondary roads that connects to the campus buildings and the internal pedestrian roads are capable of carrying service and emergency vehicles. In small campuses, it is easier to provide a connection between the vehicular and pedestrian circulations. (Dober, 2000, p. 111)


**Fig. 7 University of Guelph (Dober, 2000, p. 110)**

## 1.4.1 Criteria for efficient circulation systems and their interaction

### *1.4.1.1 Some criteria for the vehicular circulation*

- The presence of different types of drop off zones according to the different spots: main entrances, building entrances, service zones.
- The provision of spaces as courtyards and internal spaces that can bear the maneuvering of maintenance or emergency cars.
- Efficient lots should be provided for the movement of the garbage or service cars in connection to the spots of recycle bins or workshops and labs on campus.
- Maneuvering all over the campus should support the passage of not only cars but also buses or larger vehicles.
- The presence of internal linkages between parking lots in order to prevent the cases of bottle necks on car ways when searching for parking lots.

#### *1.4.1.2 Separation of pedestrian network from the vehicular network*

There are two different methods to provide a separated pedestrian network; one could be through marking the pedestrian path in a shared street by a different material as well as providing a rough material to slow down the vehicular traffic. Secondly in the case of more physical separation, the walled seats, ornamental fences, bollards or hedges could play the role of physical separation without the visual separation at the same time. (Queen's University, 2013, pp. 79-81)

According to design of some campuses, the problem of intersecting of pedestrian network and vehicular networks is solved by providing a well-designed periphery road serving vehicles and connected to the essential main spots while the interior of the campus is limited only to pedestrian use. (Planning Institute of Australia, Canberra; Australian Local Government Association; National Heart Foundation of Australia, 2014, p. 5)

#### *1.4.1.3 Good connections between shared vehicular and pedestrian circulation*

- Provision of narrow roads that support slower traffic movement and a safer pedestrian amenity.
- Limiting the use of internal car routes by providing less vehicular connectivity and supporting more the periphery vehicular routes to encourage the pedestrian networks which is favorable on university campus.
- Provision of parking on the streets as well as narrowing the roads could be a factor that slows the movement of cars.
- Dense roundabouts are an incorrect choice with the presence of dense pedestrian spots.
- Cul de sacs should be limited unless the connection with other routes is needed while the presence of pedestrian accessibility is available.
- Provision of wide sidewalks and sufficient frequent crosswalks and traffic controls at needed points.

In UNB Fredericton Campus at the crossways, unique type of pillars are introduced to indicate the passage of pedestrians freely within this area, thus the vehicles moving have to be very cautious Fig. 9 and Fig. 8. This has a unique aesthetical value in introducing another indicator rather than normal signage methods.

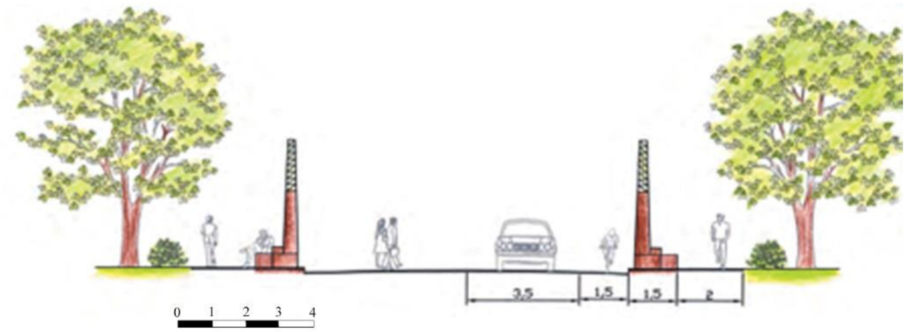



**Fig. 9 Typical Campus Street Section at a Crosswalk in UNB Fredericton Campus. UNB Fredericton Campus Plan P.79**

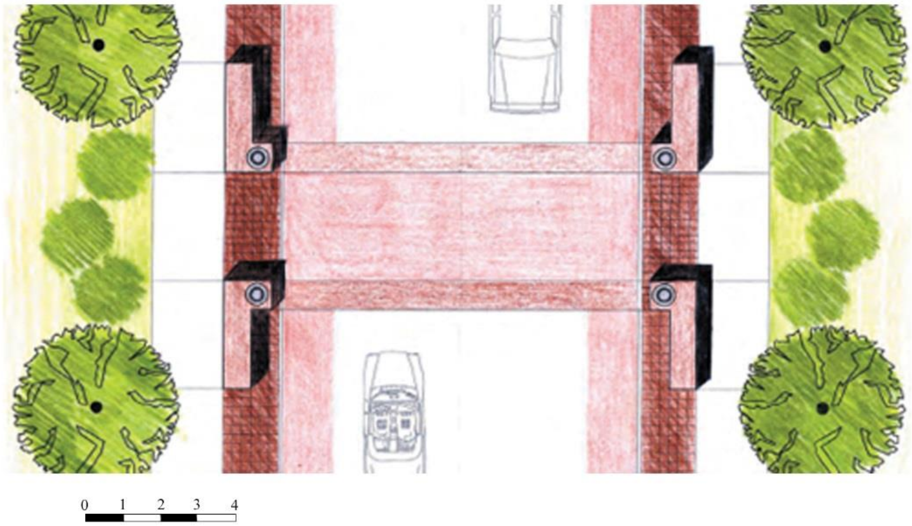



**Fig. 8 Typical Campus Street Layout at a Crosswalk in UNB Fredericton Campus. UNB Fredericton Campus Plan P.79**

### *1.4.1.4 Good designed street complying with different users' needs*

"The streets should place pedestrians, bicyclists and transit users on equal footing with motor-vehicle drivers. This will improve the quality of life on campus by creating streets that are both great public spaces and sustainable transportation networks. Green streets will also embrace innovation to address climate change and promote healthy living.

The needs of pedestrians, people with disabilities, bicyclists, transit users, and motor vehicle drivers should be incorporated into the design of campus circulation routes. Multimodal level of service (LOS) informs roadway design to ensure that streets are shared by all users and not dominated by cars.

Incorporate street trees, rain gardens, bio-swales, paving materials and permeable surfaces, with plants and soils collecting rain water to reduce flooding and pollution. Green design elements promote an environmentally sensitive, sustainable use of the public right-of-way.

Incorporate technology for applications such as intelligent signals, smart meters, electric vehicle sharing, car and bicycle-sharing, wayfinding and social networks for greater system efficiencies and user convenience." (Office of University of Massachusetts Boston Campus Master Planning, 2012, p. 8)

The less the paving is provided the more the use of foot, cycling or other means of transport. The limiting of the vehicular lanes to the minimum according to requirement will limit the impervious surface affecting the water on site. (Thompson & Sorvig, 2007, p. 199). In case of stormwater management, it is preferred that runoff from parking lots could be connected to bioswales that filtrate the water supplied

#### *1.4.1.5 "Desired lines" concept*

Many campuses suffer from the idea of implementation of pathways according to the proposed design, neglecting the usage factor that could adapt and change these fixed designs. That is the core idea that the "desired lines" concept overcome. It is based on not finishing the pedestrian pathways until the campus is used. They start tracking how users usually use certain paths as the most comfortable, shortest, and wide enough. Then the pathways are paved according to these lines that are originated through the majority of the users. (Florida Atlantic University (Davie Campus), 2007)

## 1.5 Spaces

A university campus is not only sum of buildings serving educational functions, but it is a mixture of spaces and buildings. These spaces have the same importance as the buildings, creating the livability, identity and image of the campus. Open spaces should be carefully designed and placed as it is one of the bases for the campus structure that leads to the success or the failure of the campus. University spaces define the campus as the buildings do. (Office of University of Massachusetts Boston Campus Master Planning, 2012, p. 64) When open spaces on campus are well functioning and providing activities and good structure for the campus this sustains the usage and the function of the campus which provides the physical sustainability of the campus.

According to Githens, space organization could be classified into ten compositions Fig. 10: Closed courts, open courts, pyramids, telescope, the T, the cross, avenues closed and open, unsymmetrical on two axes and line.

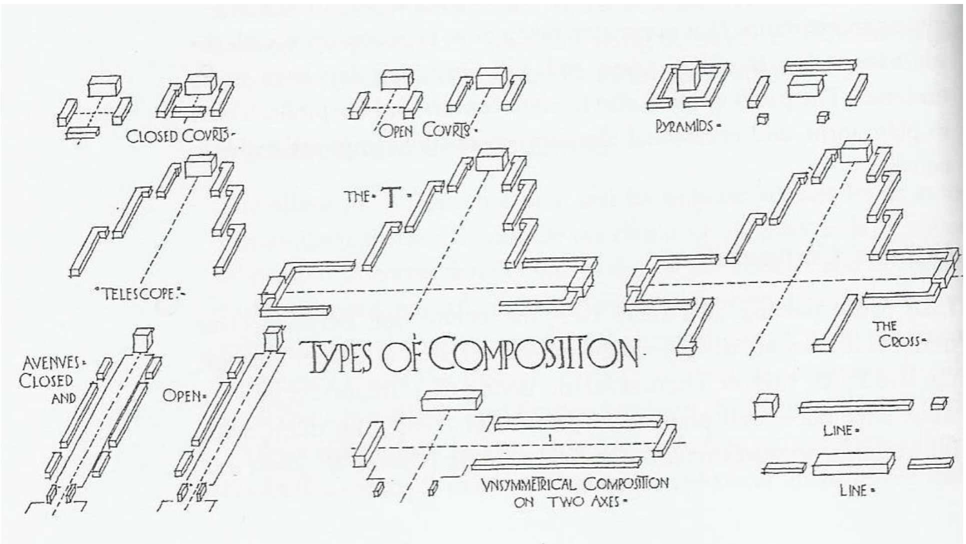



**Fig. 10 Different types of space organization (Dober, 2000, p. 162)**

Buildings should be creating spaces rather than occupying spaces. These created spaces should have the following criteria:

- Providing a space that is used within the boundaries of the campus and not providing spaces to the outside or at dead spots of the land.
- Creating functional, accessible and usable spaces interacting with adjacent buildings.
- Interconnected with the larger structure of spaces on campus.

### a. Hierarchy and organization of spaces

"The concept of hierarchies of open spaces is connected to the idea of catchment areas: depending on the size of an open space and the facilities it provides, different groups of people are willing to travel different distances to visit it." (Stiles, 2013, p. 10)

According to criteria of well-designed open spaces for university campuses, the spaces should have some sort of order and hierarchy with sequence. Each space should have certain identity and importance according to its use related to the rest of the campus. A central space is obvious in nearly all of the successful campus examples. It provides a center point for activities, uses and in many cases it acts as a known meeting point on campus.

There are different descriptive nouns to describe the campus center which includes: grove, quad, lawn, yard, green, oval, square, plaza and mall. (Dober, 2000, p. 158)

Long ago before the campus plaza was of an important effect on campus, the urban plazas of cities were used as points for people to gather for different activities, knowing about different events and socializing. Built on the same concept, the campus plaza has the same use for activities and focal point for events and socializing on campus, as the campus could be considered sometimes as very small city. (Van Yahres & Knight)

According to the thesis concept of connecting different aspects together physical, ecological, individual use and social, not only the factor of size is the deciding factor of hierarchy. A very large space could be lacking connection points or not having sufficient social activities which makes the hierarchy only spatial and not complementing it with the other affecting factors.

### b. **Factors of good urban spaces** (Stiles, 2013, p. 13)

There are three factors affecting the quality of the designed space:

- **Environmental and ecological functions:** Includes services that help and enhance the ecosystem
  - Improving climatic conditions.
  - Noise decreasing.
  - Supporting water saving systems such as: storm water management.
  - Provision of habitat for wild plants and animals.

- **Social and societal functions:** All functions that provide people use and the social interaction between them
  - Providing spaces for leisure and recreation.
  - Creation of spaces that enhance cultural and social interaction through different activities.
  - Provision of spaces allowing interaction with nature.
  - Influencing human health and psychological well-being.

- **Structural and Symbolic functions:**
  - Articulation of spaces, division of different regions, and linkage of the urban fabric.
  - Improving the legibility of the created spaces.
  - Enhancing a sense of place.
  - Creating an identity, meaning and values for different spaces.

### c. Criteria for well-designed campus spaces (Capilano University, 2012, p. 31)

- The enclosure of space by buildings, plants or both, the spaces being undefined make it lose its spatial strength.
- The proportion of the building to the space following the allowed ranges, will be clarified under the title of space enclosure. This supports the sense of human scale and the definition of space.
- A good selection of materials and furniture of spaces, as well as the consistency in this selection which supports the unity and cohesion of the campus.
- The integration between the hardscape and the softscape in open spaces creates integrated, holistic spaces and helps in different uses provision and separation.

### d. Variety in spaces

It could be originated from the presence of different uses: e.g. vehicular, pedestrian...etc. The different activities occurring in the space provides more variety: relaxing, eating, studying....etc. The space should have sort of flexibility to cope according to the changes of activities with time. (Rached & Elsharkawy, 2012, p. 3) In addition to that, extent of vegetation, different degrees of enclosure of spaces, different materials' use are criteria that could help the variety of spaces which in return facilitate the legibility of the campus and the ease of wayfinding.

The activity of the space depends on the shape of the space, i.e. linear spaces enhance walking than other activities. The spaces between buildings are considered efficient when they have enough space and relevant shape that could support the required activities in these spaces. (Abou El Ela, 2004)

**e. Spaces of Educational Use**

The provision of outdoor spaces for educational use is very good serving the concept of student centered learning where the student acquires the knowledge through performance and research rather than being given the information directly through the instructor and this leads to better analysis and comprehension of topics through group discussions. (Peatross & Peponis, 1995) (Bloom, 1956)

## 1.6 Utilities, services and amenities on campus

There are many different utilities, services and amenities that all campus users use daily. The sufficiency of these services and their efficient performance are from the main factors affecting the sustainability of the performance and the design of campus. From these utilities are: Street furniture, provision of parking, stops for taxis or buses, different services' booths.

### 1.6.1 Buses and taxis

Provision of different public transportation on campus or at least spaces for the performance is a beneficial aspect. Users who could not afford private cars could benefit well from these services and at the same time the request for more parking spaces will decrease or be limited which consequently may help to decrease the congestion of campus circulation. The effect of these services are very obvious especially in the case of presence of a large number of visitors on campus. According to these situations, provision of buses' and taxis' waiting areas is very essential. (Queen's University, 2013, pp. 73-74) Some campuses as UNB Fredericton are studying to connect the usage of buses with the provision of discounts on tuition fees for students or adding the bus fees as mandatory for all students as a step to encourage ridership for buses and decrease the need of parking.

As most of the universities having a traffic problem from the used cars on campus. Kansas University proposed the provision of a bus system in order to decrease the number of cars present on campus (White, 2003)

### 1.6.2 Parking

Parking is considered one of the sensitive issues on campus, as they require large lands, which in return affects the efficient use of land. In some cases, surface parking is blocking the entrances and pedestrian flow. Parking should be at a convenient distance from different buildings.

One of the solutions to the parking issue is introducing the idea of carpooling and that could be applied through the administration issuing encouraging laws that convince people more with this idea. Many campuses are using or turning more to the use of underground parking. There are different types of parking on campus:

- **Underground parking:**

Most of the campuses are directed towards the provision of underground parking. It would be very efficient in the future when the amounts of available lands are less, which in return leaves more vacant lands for the academic use or more activities or open spaces. It would be more feasible and safer for a campus to have an underground parking. It is easier to secure the underground parking more than the surface parking. It provides a chance for a better and clearer aesthetical character for the campus without any visual obstruction.

- **Special service surface parking:**

This type of parking is required in the case of handicapped users or very short stopovers. They should be provided as parallel parking lots to the street flow or normal lots very near to the entrance points. A strong discipline should be set in order to control the usage of these parking lots according to the urgent need only.

- **Remote parking:**

Another solution for the on ground parking is the remote parking which could make use of the unused spots on campus. It should be connected to the major destinations on campus. This type will also decrease the traffic on campus and it would be very suitable for users of constant schedule on campus. (Queen's University, 2013)

The excess use of paving for parking is a main factor for the heat island effect on site. Parking spaces with a huge surface of impervious material prevents the replenishing of groundwater resources and may cause erosion or sedimentation in case of flooding or drought. (Thompson & Sorvig, 2007, pp. 198-199).

Regarding the plantation in the parking zone, the vegetation surrounding the parking lot is preferred to be of low height to provide privacy without obstructing the vision. The vegetation on islands could be deciduous species to provide shade and prevent heat island effect. (Carol R. Johnson Assosciates, 2012)

### 1.6.3 Street furniture

Benches, seats, lighting posts, kiosks, trash receptacles, display boards, signs, retaining walls bicycle racks, fencing, and billboards all are campus furniture which are better to be visually unified which gives the campus identity and style. The two most important items of furniture that needs to be particularly overlooked and designed to the best standards are the signs and the benches as they have a great role in serving communication. (Dober, 1992, p. 212)

Landscape furniture on campuses is very essential as it is considered to be used daily by different and many users. All pieces of furniture should be functional, sufficient, comfortable, durable, of good appearance, and easily maintained. To provide a good environment for social interaction, the number of available furniture should be suitable to the number of users. Furniture should be covering all of the campus open spaces designed for social interaction or users' use. For example in Dalhousie University campus there are some general points for furniture around the campus (Dalhousie University, 2010, p. 31):

- Furniture should be compatible with users' movement not blocking any pathways.
- Should be designed according to universal standards in order to suit all different users.
- Bicycle racks should be easily accessible, well lit, well protected from bad weather conditions.
- Campus furniture should support local materials and technologies which is very crucial in the field of sustainability.

Furniture, light fixtures, and signs should give a unique distinct factor that helps the concept of placemaking for the campus.

Detailed criteria for some of the units of landscape furniture (Minot State University, 2008, pp. 25-26):

#### a. Benches

For benches, they are preferred to be made of a strong material as steel that can withstand the intensive usage as well as the weather conditions more than plastic, wood or recycled composites. Benches should be a bit of classical not very trendy as it is supposed to be a part of accessory on campus that should not greatly grab attention but act in harmony with the surroundings. The length and the size of benches is decided according to the usage whether it is for small groups (intimate use) or for large group that needs more length and space. Selection of dark colors is better than bright ones as it is more easily maintained.

### b. Trash receptacles

They should be of strong material to withstand the intensive usage along the years. They should be also of proper size that is suitable for the ease of pickup and maintenance. It would be better if they suit the colors of the other furniture as benches and be of dark colors do sustain the usage.

### c. Bicycle racks

They should be from strong material and of dark color for the same previous reasons for benches and trash receptacles. They should be of simple forms in order not to harm the bikes' frames or the bikes' wheels. Being located at visible positions and the main spaces is a very important point. Another reason for usage of dark colors is to resist the marks made by the bikes parking and the locks used.

### d. Retaining walls

Some of the campuses use these retaining walls as seats. They are made of prefabricated concrete blocks. Sometimes it could be a replacement for the natural stones used in landscape. The useful about retaining walls is that they are so durable and can resist hard weather conditions as well as the availability to produce in different sizes.

## 1.6.4 Lighting

In the USA, lighting is consuming 20% of the local electricity for lighting which is a very large percentage for consumption of energy. Ecological light pollution is the state of affecting the ecological process through provision of extra light. Thus the provision of adequate amount of light not extra and not less is the best solution for a healthy ecological, medical and aesthetical environment and consumes only limited amount of energy. There are some criteria for better light distribution (Thompson & Sorvig, 2007, pp. 293-307):

- The usage of LED light which consume less energy and requires less space.
- Louvered bollards or wall mounted lights are better for walkways and parking areas.
- Adequate lighting is only required for safety, the light is only enough to reveal suspicious behavior or hazards without being excessively bright.
- The use of intelligent lighting that operates according to usage.
- The use of lighting that operates with PV, photocells or clocks or both for better efficient energy consumption.

## 1.7 Conclusion

The sustainability of different physical qualities on campus focuses on the provision of the different physical spaces and urban design elements that could create the most efficient usage and the easy, safe and complying with different needs. The provision of successful physical qualities on campus creates an easy base for acquiring the higher qualities as: ecological, individual use and social qualities. The main highlights concluded for the physical qualities are:

- Priority has to be given to the pedestrian circulation on campus.
- The usage of healthy and clean means of movement on campus has to be promoted on campus.
- Gateways create the first image for the university from the outside.
- The adaptability of different circulations including pathways and parking areas to the usage of users with disabilities is a necessity.
- The compatibility of service vehicular road with the different sizes and design requirements of different services vehicles on campus.
- Different emergency methods should be considered to reach all spots on campus.
- For different roads on campus: narrowing of roads, limiting the speeds and highlighting pedestrian cross-roads are very essential elements.
- The provision of shared streets serving vehicles, pedestrian and cyclists is an optimum solution.
- The provision of sufficient number of parking lots is very essential and it is neglected in many cases. The looped flow of parking spaces prevent any congestion.
- The provision of green means of fast movement on campus as electric club cars is considered a relevant action to save energy and resources.
- To achieve higher compatibility of campus usage, the concept of “desired lines” at the phase of soft opening prior to the intensive use of the campus.
- Consistency, durability, flexibility of furniture has to be achieved to ensure the sustainability of usage on campus.
- Making the campus connected to the public transportation network, enhancing carpooling, replacing cars by buses are all different means to decrease the energy and the usage of resources.
- Sufficiency of parking provision related to the number of users and planning for future extension in case of need through vacant unused lands or underground for newly built facilities.

### 1.7.1 Cross-cutting relations of physical aspects with other aspects

- A system providing a sustainable resource or has a saving or conserving action is a must, but at the same time the users are the main receivers and actors interacting with these systems at least through vision. Therefore it is so important to provide a successful sustainable system with an aesthetical value perceived by the users.
- Vehicular and pedestrian circulation is preferable to have pervious surfaces to enhance proper water saving on site and to connect water runoff to bio-swales for filtration (in case of sufficient rain or water available).
- In the case of presence of wildlife on campus, the connectivity of different spaces and pathways supports the connectivity and strengthening of wildlife.
- As a connection between safety measures and connectivity, the separation between the vehicular circulation and the pedestrian one creates a more healthy and safe campus.
- The unique design and identification of a university gateway, furniture could act as a landmark or a place-making element for the campus. This supports the individual use on campus.
- Not only the connectivity of different pathways is important, but the connection of these pathways to different activities provides the social revival of these spots and could create a good environment for initiation of social interactions.
- Different pathways should have an ecological value by e.g. Use of pervious material (in case of extra water sufficiency), the use of materials to decrease the heat island effect….etc.
- Flexibility of furniture on campus could provide ease of use according to the social setting and interactions in spaces.
- Attachment of parking lots to water collecting systems, rain gardens, bio-swales, or bio-retentions to provide harvesting of water or ground water recharge to support ecological aspects of parking lots on campus.

# 2. Ecological Qualities of Sustainable Campus Landscape

## 2.1 Introduction

Generally any ecosystem consists of biotic (e.g. flora, fauna…) and abiotic factors (e.g. water, soil…). Discussing the ecological qualities on campus, refers to the natural systems on campus including: water, vegetation, soil, materials used in landscape. As the main aim of sustainability is to reduce the usage of resources and at a better extent reach the limit of production of resources. This could be applied through many systems and processes such as the following highlights: water reuse, water recycling, edible vegetation, low water consuming vegetation, improving soil character and use of recycled materials. This is only a glimpse of the used methods of ecological sustainability. 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)

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 chemicals, fertilizers, pesticides, 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. The following Table 1 shows the impact of introducing some natural elements to the landscape, not all could be applied to the case of campus landscape (Mackzulak, 2010):

**Table 4 Some of the main features of landscaping with nature (Mackzulak, 2010)**

| The Main Features of Landscaping with Nature | | |
|---|---|---|
| **Landscaping Feature** | **Description** | **Its I pact on the Environ ent** |
| artificial wetland | provides habitat; cleans runoff; reduces flooding; provides wastewater treatment | contributes to local biodiversity; reduces water pollution |
| biodiversity garden | native plants and shrubs, including flowering varieties and a water source | provides feeding, shelter, and habitat for native birds, amphibians, reptiles, and insects |
| buffer zones | undeveloped and undisturbed areas surrounding lakes, ponds, streams, or shorelines | protects existing habitats and ecosystems; reduces erosion; reduces water pollution |
| drip irrigation | irrigation system that directs a water supply to a specific site, tree, or plant | conserves water; reduces erosion |
| eco-design | structures built to blend with nature and make nature visible | increases awareness of nature; lessens the impact of a structure on native wildlife behavior |
| footprint | minimize the total space consumed by a structure and its landscaping | minimizes disturbance to habitats and ecosystems |
| greenways and open space | undeveloped open space and corridors between open spaces | protects habitats, ecosystems, and wildlife migration routes |
| native vegetation | plantings and lawns made of varieties native to the local region | encourages plant life suited to local climate, rainfall, soils, and wildlife |

| Landscaping Feature | Description | Its I pact on the Environ ent |
|---|---|---|
| natural contour | reducing any changes to hills, slopes, rock formations, or streams | reduces overall environment impact; promotes native vegetation and wildlife populations |
| permeable pavements | porous materials, gravel, or stepping-stone walkways and driveways | reduces runoff; conserves rainwater; nourishes the soil |
| shading | retaining some trees to shade part of the building and the landscape | blocks excessive sunlight exposure and provides cooling; reduces air-conditioning needs; reduces evaporation |
| water catchments | roof, garden, or yard receptacles for catching and storing rainwater | conserves water for use in irrigation, supplying water to wildlife, and some home uses |
| windbreaks | retaining tree stands that provide barriers to wind | reduces heating needs; reduces windblown soil erosion; provides habitat |

## 2.2 Water

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)

### a. Water sustainability on site

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, gray water, and treated black water onsite

These are some of the approaches or examples of application of water sustainability in the University of Oregon, which includes the water systems, used materials and used vegetation on site (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. When appropriate, consider overland flows and ponds to temporarily impound water and allow a slower rate of infiltration.
- Maximize pervious surfaces to permit water infiltration where possible. Make use of the existing pathway network, design paving to serve multiple purposes, and minimize buildings’ footprints.
- Minimize the need for landscape irrigation. Use weather-based irrigation controls to minimize runoff and excess water use. Establish high and low maintenance landscaping zones—group plants with similar water-use needs—and tie into the individual irrigation zones. High-maintenance zones should be around major building entries and high-traffic areas.
- Use natural drainage ways wherever possible.
- When appropriate, make use of gray water and water-saving devices.

- Use plantings that can tolerate low summer watering.

### c. Water cycle on site

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.

### d. Different disciplines and actors affecting water sustainability and efficient utilization on site

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 success of any water saving, collecting, using or reusing systems depend on the installation of the system after the stability of the site. The vegetation coverage should be reached in order to guarantee the application of these systems. The end of the construction phase and temporary irrigation systems on site provides a stable state. The stability includes also the soil in order to avoid the sedimentation process.

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. Some of the selected types of native plants could survive also on the collected water on site. The goal is to limit the water usage on site through the supply from collected water, gray water and waste water. Some of these resources are natural as rain water as well as the ground water which also act in decreasing the consumption. (Calkins, 2012 kindle version, pp. 2235-2244)

## 2.2.1 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 and reduce the loss of the provided water that could be wasted with the runoff.
- Storm water infiltration systems would help in recharging the groundwater and it is important to take preventive precautions into consideration to resist contamination and this also could be of great use to supply water in the times of drought.
- Collected water could be used directly to irrigate planted areas or it could be harvested, stored in cisterns and used for domestic uses as toilet flushing and irrigation which is considered as protection of water resources.
- 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.
- It could support safety from the masses of water that could be dangerous through the distribution of these water sources.
- 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 Fig. 11.

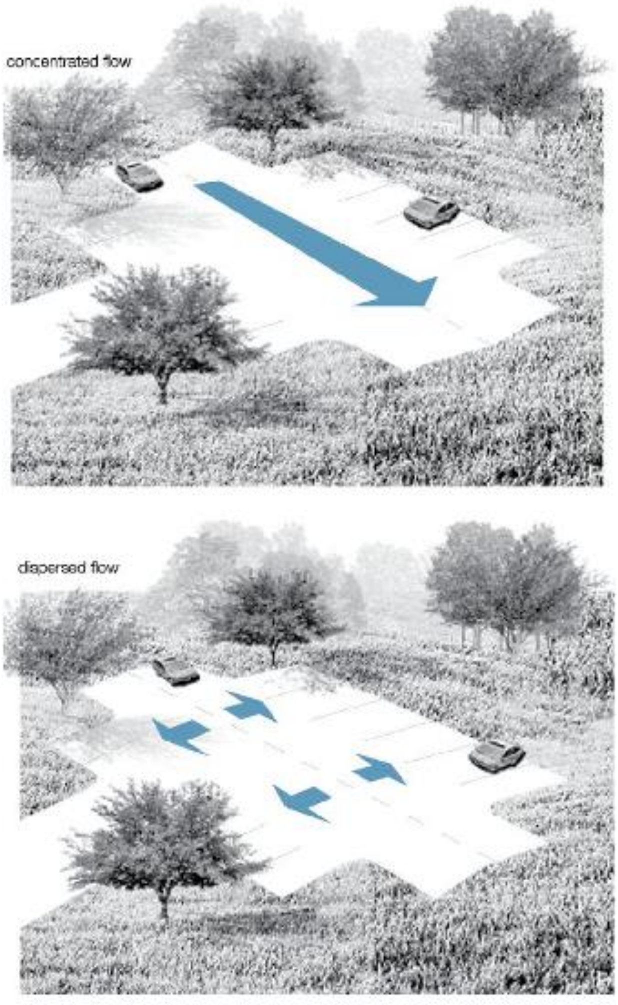



**Fig. 11 The comparison between the concentrated flow of water and the dispersed one (Calkins, 2012 kindle version)**

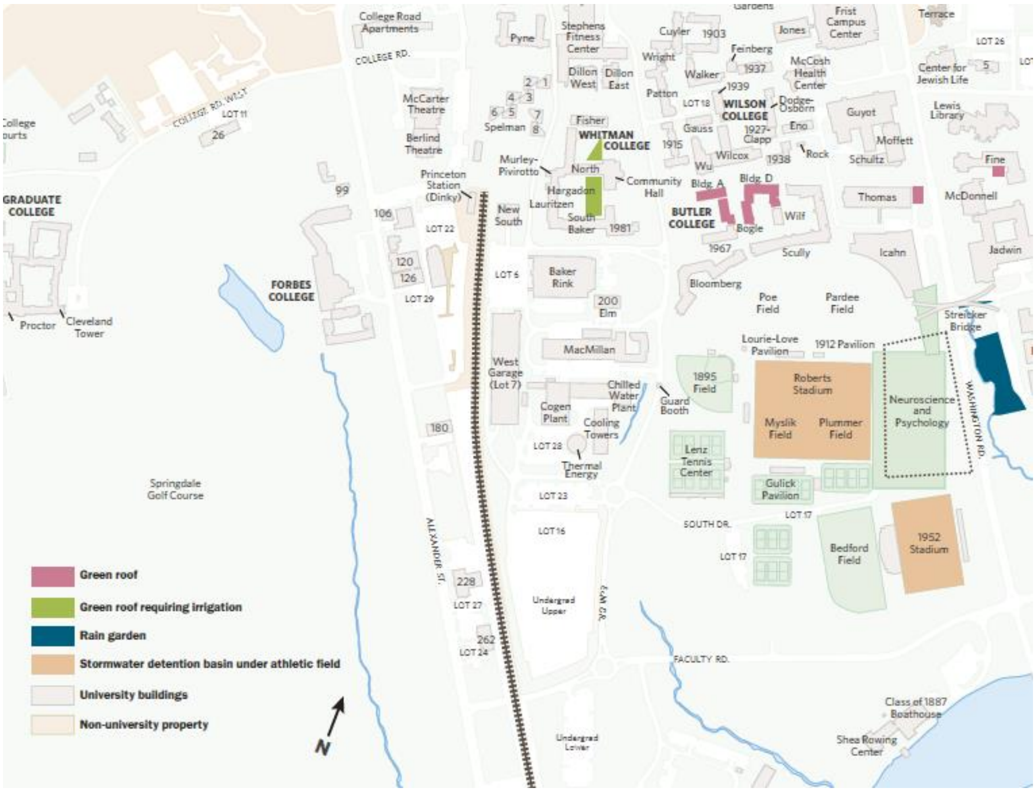



**Fig. 12 Diagrammatic layout showing the introduction of stormwater management techniques on Princeton University Campus**

**Princeton University Campus:** In 2011 Princeton University reported introducing stormwater management systems Fig. 12 to refine the water quality before returning to lakes or water streams. Those systems included: Rain gardens, rain harvesting tanks, porous pavements, and green roofs Fig. 13 (Princeton, 2014). Progress included:

- Replacing 124 parking lot with vegetation creating natural buffer and elimination of source of pollution for available natural water features retrieving the natural setup and mimicking nature.
- 3 bioretention basins filtrate half of the stormwater provided on site from buildings' roof tops and different sources.
- 12000 gallon water tank is used to store water harvested on site to be used for toilets' flushing.
- From the future goals are: Decreasing the coverage of impervious materials on site, working on monitoring system for different ecosystems on site and creating a holistic ecological assessment assessing the natural assets and the habitat regeneration.

**Fig. 13 Green roofs of dormitories of Princeton University, photo by Brian Wilson**

#### *2.2.1.1 Non-point source pollution solution and the usage of Bioretention*

- **Point source pollution:**

"The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture." (United States Environmental Protection Agency, 2012)

- **Non-point source pollution** (United States Environmental Protection Agency, 2012)**:**

- Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas**.**
- Oil, grease and toxic chemicals from urban runoff and energy production
- Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks.
- Salt from irrigation practices and acid drainage from abandoned mines
- Bacteria and nutrients from livestock, pet wastes and faulty septic systems
- Atmospheric deposition and hydro modification.

**Bioretention**: It 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.

Non-point source problem is solved through bioretentions and infiltration on site as it is different from normal detention basins because the pollutants are filtrated from the first flush and that is through the soil or the plants' roots that absorb the phosphorous and nitrogen and the metallic constituents mixed with the collected water are blocked on the upper couple of inches of the soil. According to the development of systems, newer systems are used to filtrate the run off that is through smaller distributed bioretensions - which are shallow basins with permeable soil for infiltration - and infiltration method or the old detention systems could be adapted by modifying the upper inches of the detention system and rip-plowing the basin to restore the infiltration process. (Calkins, 2012 kindle version, pp. 2266-2277)

The bioretentions also helps in decreasing the temperature which may cause thermal pollution of the collected water as the rise in temperature will cause the diminishing of the oxygen which will affect the biodiversity present in this water while the infiltration process through soil and bioretentions prevents the exposure to the sunlight decreases the possibility of thermal pollution. This is also done through the usage of light colored surfaces to decrease the heat exposure as well as permeable pavements which decreases the heat absorption through the exposure to sunlight. (Calkins, 2012 kindle version, pp. 2279-2285)

**University of Missouri:** The University decided to build a bioretention Fig. 14 and Fig. 15 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)


**Fig. 14 The construction board of the project of the bioretention in Missouri (University of Missouri Campus Facilities, 2013)**

**Fig. 15 The final steps of the bioretention project in University of Missouri (University of Missouri Campus Facilities, 2013)**

#### *2.2.1.2 Integration between ecological systems and educational awareness*

Since the university should be a source of application rather than only limiting it to theoretical science. Storm water management should be an onsite application that is obvious to students and space users:

- Adding signs forming a narrative sequence that shows how the process is performed.
- Adding signs Fig. 16 to show the names and the role of different native or riparian plants that are used in the process of storm water collection. How these plants help in filtrating different harmful constituents of the collected water.
- Making different parts of the system obvious and creating an interactive environment so that the space user could get more attached and reach a more understanding of the system.
- Showing some panels that shows a comparison between the case without and with installing the system as well as making the filtrated pollutants visible in order to show how effective the system is.
- Creating different sitting spaces and activities near the system components in order to make it more legible and touchable.

Although that the phenomenon of storm water or rain is not available in all regions of Egypt but the concept of focusing on visual and educational exposure mixed with interactivity is a concept that could be applied with relevant systems such as irrigation systems, water recycling, setting a water budget, edible landscape items and so on in order to apply and settle the culture of sustainable landscape with space users and the students.


**Fig. 16 The small yellow signs at Pierce County Environmental Services, Tacoma, are an excellent example of creating fun education opportunities that lead visitors through the design from one treatment system to another (Calkins, 2012 kindle version, p. 2585)**

**University of Tennessee:** In the development plan for the University of Tennessee Landscape, it is proposed that signs will be added containing scientific and common names of vegetative species used on campus, also the characteristics of the species will be added. Fig. 17 (Carol R. Johnson Assosciates, 2012)

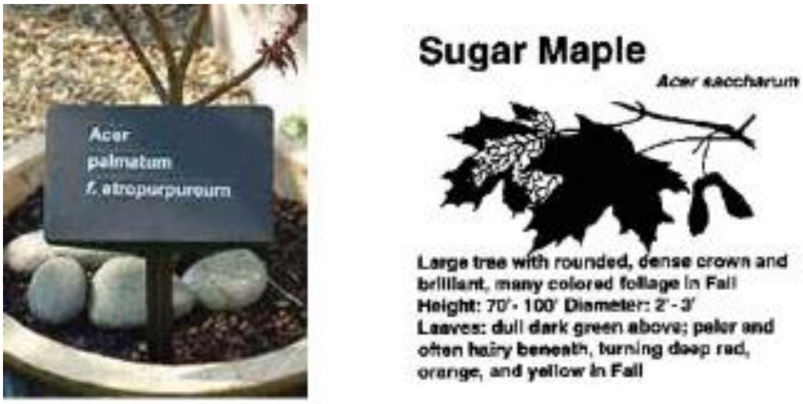



**Fig. 17 Signs with names and characteristics of used vegetative species (Carol R. Johnson Assosciates, 2012)**

### *2.2.1.3 Recreation created by storm water management systems*

Since that recreation is a favorable activity that is based on the interaction with the surroundings while education is a direct message therefore creating an educational process through recreation in many means could support the spread of the intended message. This is the method that is used to spread the idea of sustainability of water through spaces users Fig. 18& Fig. 19. From these steps are:

- Creating unique or emphasized parts of the storm water system in order to act as a landmark or as marked spot. Concentrating the locations next to entrances or at focal points of the landscape design.
- Creating accessibility and interaction to the different parts of the system, where people could climb, discover and get more aware about how they function but keeping always the factor of safety.
- Focusing on using materials and parts that could be moveable or playful without affecting the whole system such as using moveable rocks or giving the control of some dams or directional channels for the users to change.

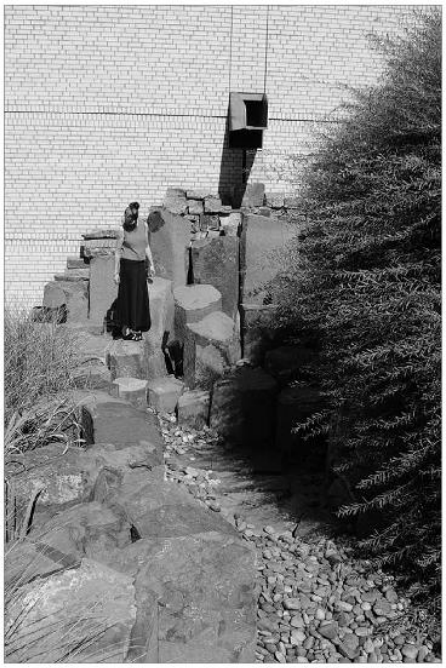


**Fig. 18 The scale and accessibility of the storm water design at the Oregon Convention Center, Portland, OR, is an excellent example or recreation opportunities (Calkins, 2012 kindle version, p. 2602)**

### 2.2.1.4 Safety to be provided surrounding storm water management systems

In order to spread the systems supporting the conservation and production of resources which supports the sustainability, therefore the provision of safety aspects is an essential matter. Some of the safety factors for the storm water management systems are:

- Clearly addressing possibility of touching the water but not swimming in it, drinking or soaking it.
- Providing screening or barriers or bridges in the places of danger or spots that should not be accessible.
- Division of water surfaces into larger numbers of water surfaces in order to reach a safer depth of water, as well as using upper ground cisterns or storing facilities to prevent tumbling and using water brakes that decreases the speed of flowing water or creating some waterfalls for that use.

**Fig. 19 The recirculating rain water system at Tanner Springs Park in Portland, OR, is an excellent of water that is safe and touchable because of the small shallow design (Calkins, 2012 kindle version, p. 2633)**

### 2.2.1.5 *Water management systems to create good public relations*

Paul Selman stated in his book "Landscape as an arena within which science, humanities, and professions can find common ground, and in which vivid social learning can occur about key social and environmental issues" (Selman, Sustainable Landscape Planning- The Reconnection Agenda, 2012, p. 6). Apart from the similarity between this point and the educational target of the design, the main difference is that this aspect gives a clear message or view about how creators of the space or space users give interest to sustainability, application and continuity Fig. 20. From the ideas for creating a good public relation are:

- Adding signs and banners indicating the system used and how it is useful besides making the location noticed such as: At entrances, courtyards or visible in front of windows.
- Applying the intended methods with the newest techniques and making it available in the visible used spaces such as pavements, parking.
- Design the components in an interesting way that grabs the attention e.g. if plans or shrubs are used as a part, they should be well clipped, trimmed and clean as well as creating different intended movements of water to be more obvious and interesting.


**Fig. 20 The signage that accompanies the porous paving and bioretention at High Point Housing, Seattle, WA, is an excellent example of public relations opportunities (Calkins, 2012 kindle version, p. 2666)**

### *2.2.1.6 Aesthetical acceptance of storm water systems*

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) As a matter of aesthetics that has to be looked through while designing, the installed systems Fig. 21 should serve certain aesthetical qualities that attracts the different senses as vision, hearing and tactile. There are some suggestions for this approach in order to reach the acceptance and admiration of the users to these systems:

- Taking into account the visual theories and aesthetical side for the designed components e.g. creating uniformed interesting forms for swales or bioretentions, and usage of artistic forms that could create some sort of figure ground for the movement of water from different levels.
- Creating surfaces that could produce different interesting sounds by water hitting it.
- Giving attention to the used pebbles or stone that could give a pleasant visual design or character.
- Contrast between different architectural materials and the natural elements used such as grass, plants, concrete, stones, steel...
- Always working on the factor of surprise and using the aesthetically pleasant proportions as well as the sequence of the picture that the designer creates.

**Fig. 21 The Courtyard in 1oth@Hoyt, Portland, OR, is an excellent of aesthetic richness opportunities as the rain trail is captivating and easy to follow. (Calkins, 2012 kindle version, p. 2698)**

### 2.2.1.7 *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)

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.
- Decreases the areas of impervious surfaces in parking lots leading to efficient parking lots, streets and introducing impervious surfaces for spots with low traffic.
- 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 rather than turf grass that requires large amount of maintenance.

### 2.2.1.8 *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:

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

### 2.2.1.9 Original natural landscape and vegetation is a way for water saving and stormwater management

"The stormwater benefits of an undisturbed site cannot be overstated. Pre-settlement conditions serve as baseline for performance and water balance that a combination of other strategies strive to emulate. It follows that preservation of intact natural landscape should be a primary goal of sustainable site design. New development should be directed toward previously developed sites in order to minimize the disturbance of intact natural systems and preserve functional natural hydrology. On previously developed sites, restoration of vegetation that mimics the structural and botanical diversity of the native plant community can be an important component of a comprehensive stormwater management strategy." (Calkins, 2012 kindle version, p. 2817 till 2822)

### 2.2.1.10Rain 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.

Rain harvesting systems are collection, storage and reuse of water from rooftops or runoff from impervious surfaces. In most of the cases the stored water is not used for potable uses otherwise it needs filtering to be accepted for potable uses. The main components for these systems are: Collecting area, filters, cisterns, and distribution systems. There are some precautions for the rain harvesting system which works under the gravitational force filling cisterns, barrels or any storage elements even storing in a pond:

- Provide cover to the storage component to prevent animals or insects getting inside.
- Provide fencing or protection to prevent any accidents.
- The conservation of water through any complementary means is very important to support the concept of xeriscaping to make the optimum use of water.
- The water should be treated according to the method that it is collected through. For example runoff from parking lots could contain pollutants that need some filtration through bioretentions first, also water collected from vegetated areas could have some nutrients or constituents that need to be treated first.
- Supply from barrels or cisterns is preferred to be from the side to prevent the drainage that could settle at the bottom.

- The design of the foundations of the saving components as cisterns should be according to weight of the system and the bearing capacity of the soil.
- Make the rain harvesting system visible for the users and design the system to be artfully for sound, reflection and aeration.

**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 as a part of a class project in order to integrate between the education and the practical application Fig. 22. The design consists of installing eve troughs around the building, three collection tanks, a final storage tank, pipes and a monitoring system.  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. 22 A side view of the Horticulture Services Building (Macdonald Campus, Sainte-Anne-de-Bellevue, QC, Canada)** (Adamowski, 2014)

### *2.2.1.11 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. This concept provides the opportunity of mimicking the natural hydrology system which gives it an educational value as well as an aesthetical one due to the availability of different designs, colors and forms. From the other benefits are absorption of water puddles, absence of glare and tires' spray (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)

The following Fig. 23 and Table 5 shows the different materials that could be used as porous pavements with the advantages and disadvantages:

Porous surfaces act as one of the best ways to reuse rainwater and irrigation water. They also reduce runoff to streams. (A) An ecological garden uses stones to create a pathway that allows water to enter the soil. The gardener has planted thyme between these stones. *(Kurt Lawton)* (B) A pebble driveway helps in water recycling much more than a paved driveway. *(Bushnell House)*

**Fig. 23 Different designs of porous pavements (Mackzulak, 2010, p. 152)**

**The University of Rhode Island:** In 2002 and 2003, the university added to porous parking lots in order to collect water runoff from parking lots Fig. 24. 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)

**Fig. 24 Photo showing the parking lot with permeable pavement (McNally, Joubert, & Philo, 2003)**

**Table 5 Some different types of permeable pavements with their advantages and disadvantages** (Mackzulak, 2010, p. 153)

| **Permeable Pavements** | | |
|---|---|---|
| **Pave ent Type** | **Advantages** | **Disadvantages** |
| porous asphalt | uses less petroleum product than non-permeable asphalt | does not hold up in high tra c/high speed roads |
| porous concrete | lowers solar heat gain by city centers because of its light color | concrete is a energy-intensive product to make |
| plastic grids | high strength and provides a way of recycling waste plastic | often require another support layer above or below |
| block or stone pavement (brick, stone, gravel) | appealing looks | expensive and gravel can erode and clog water drainage systems |
| stone lattice | lattice structure allows ample drainage and promotes the growth of grass in the openings | may require extra maintenance |

There are some criteria and restrictions for the use of porous pavements:

- Porous pavements should be used with soils having infiltration rates not less than 0.5 inches per hour.
- The subgrade under the pavement should be flat in order to prevent the down gradient migration.
- The pavement type depends on the traffic density and the desired water capacity.
- The porous pavements should be avoided in the case of slopes and the near the pollution hot spots where the groundwater contamination could cause clogging of system.

#### *2.2.1.12Rain 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.

**Seattle University:** After a 100 year flood in 2006 that flooded different parts on campus. A rain garden Fig. 25 was built to collect water from two streets. Rain gardens hold the water then releases it to the ground water slowly. (Seattle University Campus, 2014)

**Fig. 25 Rain garden on the University of Seattle Campus (Seattle University Campus, 2014)**

### *2.2.1.13Green 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 Fig. 26 ranges from 1 to 6 inches is limited by certain numbers of plants and is more relevant to slopes with performing some modifications Fig. 27. 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)

**Fig. 26 Green roof vegetation (Calkins, 2012 kindle version, p. 2956)**

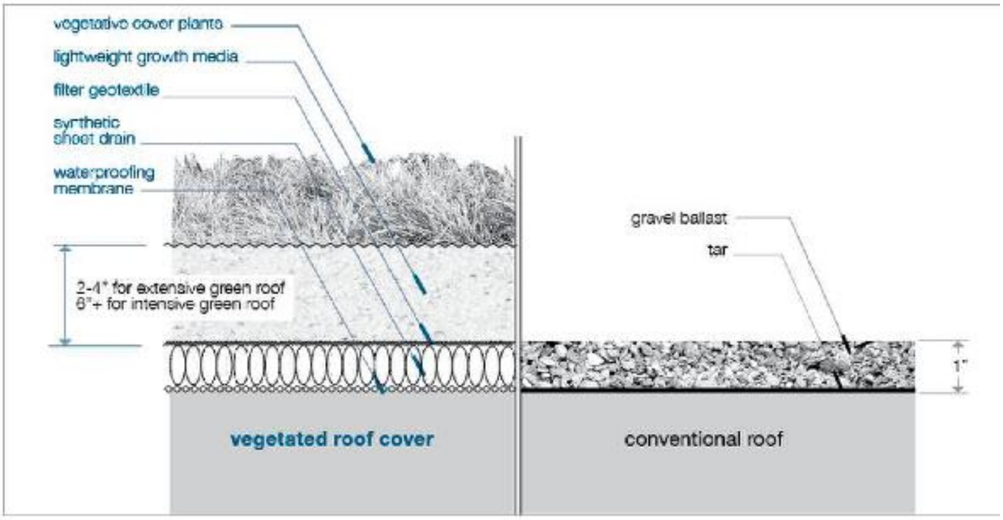



**Fig. 27 Diagram showing the composition of intensive and extensive green roofs (Calkins, 2012 kindle version, p. 2947)**

There are some precautions and limitations for the installation of the green roofs:

- The calculations for the capability of the roof to withstand the weight of the system as well as the growing media depth and rooftop microclimate.
- Determining the accessibility and the visibility of the roof.
- Provision of relevant drainage system in order to function well especially in the case of rain.
- Limitations of the plantation on the edges of the roof to protect against wind shear forces.
- Phasing of introduction: Surrounding projects applying concepts could be a good incentive for better application considering the deficiencies and following best practices.
- Good insulation should be considered.
- Roof plants should be irrigated using drip irrigation in the beginning and aggressive exotic vegetation should be removed.
- The presence of leachate with the harvested water should be managed since it won’t be desirable even the water is used for non-potable uses.

**Carnegie Mellon University:** Many of the roofs of Carnegie Mellon University are planted. In Fig. 28 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. 28 Photo of Doherty Hall and Gates Center green roofs courtesy of Brad Temkin, 2011 (Carnegie Mellon University, 2014)**

### *2.2.1.14Vegetation swales and bioswales*

Vegetation swales Fig. 29 (are channels that are lined with vegetation and act as pretreatment 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 Fig. 30 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

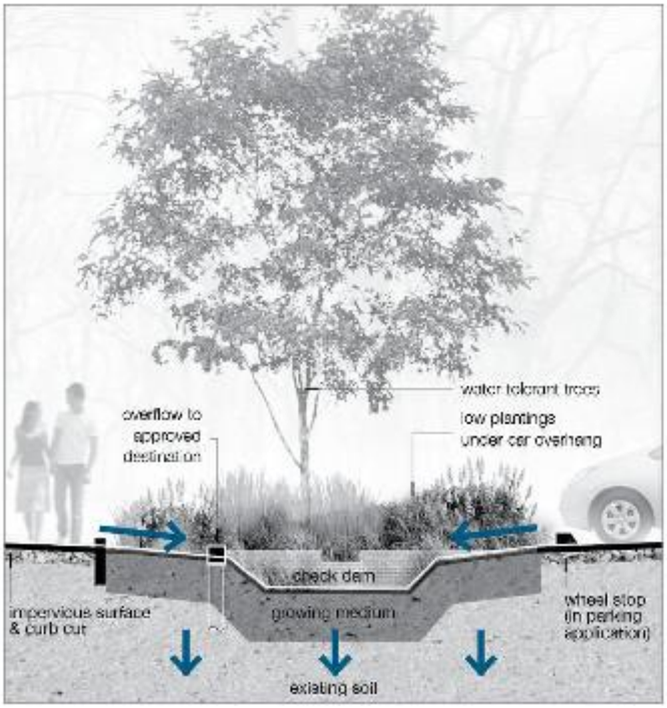



**Fig. 29 Typical vegetated swale (Adapted from Portland BES Manual; Drawn by Simon Bussiere) (Calkins, 2012 kindle version, p. 3224)**

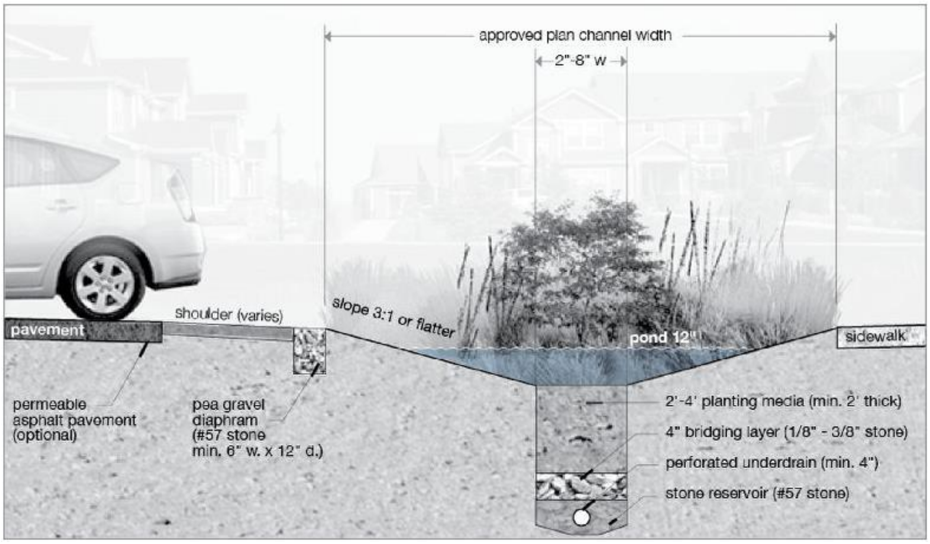



**Fig. 30 Typical bioswale with micropools section (Adapted from Maryland Stormwater Design Manual, drawn by Simon Bussiere) (Calkins, 2012 kindle version, p. 3273)**

**University of Regina:**

The university incorporated the use of bioswales Fig. 31 in the perimeter surface parking lots to clean surface water runoff and to green the parking environment. In (Fig. 26) Bioswales are used in a rural form on the left photo and in an urban form on the right photo. Circulation across the swales can be minimal or numerous depending on the level of activity and do not pose a safety hazard because the swales are very shallow. (DIALOG, 2011, p. 68)

**Fig. 31 Two methods of using bioswales in parking lots on the University of Regina Campus (DIALOG, 2011, p. 69)**

### 2.2.2 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 order to minimize the amount of water consumed for irrigation some sustainable strategies should be applied:

- Growing native plants that are adapted to the climate and the habitat plays a great role in minimizing the plants' water consumption.
- 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 which includes less frequent mowing and watering with deeper techniques as well as overseeding, all these factors will decrease the water consumption of turf.
- Managing to balance between the site water demand and the renewable resources of water (reclaimed, recycled or reused).

- Water delivery, distribution and irrigation methods as well as water features on site play major roles for water conservation.

**Water Budget:**

In the beginning of any project a water budget has to be calculated. This budget includes: The rain water, the site runoff, the gray 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.

**Duke University:** Due to the drought that the campus is subjected to, different measures are applied to landscape irrigation in order to have a sufficient amount of water to overcome the drought (Duke University, 2014):

- Using vegetative species that is drought- tolerant.
- The use of reclaimed water for the irrigation of the athletic fields
- The increase of the size of irrigation ponds on golf course to allow more natural water storage.
- Installing cisterns to provide storage for harvested water.

### 2.2.3 Water reuse and water recycling

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.”

**Gray water**: “is the excess water that runs into household drains connected to sinks, showers, bathtubs, and washing machine rinse cycles” (Mackzulak, 2010, p. 149)

**Blackwater**: “comes from the same sources, plus toilets, and represents any wastewater expected to contain disease-causing microbes.” (Mackzulak, 2010, p. 149)

**Reclaimed water:** "is water that has been treated for uses other than drinking, such as treated wastewater from dishwashers." (Mackzulak, 2010, p. 149)

**Water recycling**: "is generally the reuse of harvested rainwater or treated wastewater for a variety of beneficial purposes, including landscape irrigation, created water features, and groundwater recharge. It can also be used for building processes that do not require potable water quality—toilet flushing, wash-down water, industrial process water, and the like." (Calkins, 2012 kindle version, p. 3554 till 3569)

**Water reuse**: "It is a strategy that entails the identification of potential sources of surplus water available onsite or from a building, targeting potential uses for that water, and then designing the appropriate methods to collect, treat (if necessary), store, and redistribute and deliver that water to the appropriate site and/or building elements." (Calkins, 2012 kindle version, p. 3554 till 3569)

There are some criteria for the deciding the relevant water sources for reuse and recycling of water:

- Potential uses of reclaimed water.
- Availability of human contact with the reclaimed water.
- Possibility of supporting plant life.
- Available sources for reused, recycled or collected water.

There are different sources of reused and recycled water, some depend on rainwater:

- Stormwater from roofs.
- Stormwater from paved site surfaces.

And others are from other means:

- Graywater from buildings (e.g. sink water, laundry water)
- Process water from buildings (e.g. condensate from air-conditioning units or ventilation units).
- Treated wastewater.

**Santa Clara University:** In February 2003, Santa Clara University worked in conjunction with the city of San Jose, to install specialized connections for the use of Recycled Water for irrigation purposes. Within one year, the University achieved the following results (Santa Clara University, 2014):

- April 2003 - October 2004; 570, 257,180 gallons of recycled water used for irrigation.

- Over a 30% decrease in water costs.
- Only two plant species found to be incompatible.
- No ill effects to humans or animals.
- Overall decrease of potable water consumption by 60%.

### 2.2.4 Water storage

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 for non- potable uses (Calkins, 2012 kindle version, p. 3643 till 3674):

- **Surface storage:**

It is a depression in the landscape to store water for irrigation and other uses. It works under gravitational forces but it is subjected to high rates of evaporation but at the same time it provides an aesthetical amenity on campus

- **Cisterns:**

Are water storing tanks or vessels under or overground. Water stored underground is cooler (at ground temperature) which is an advantage for the water quality. Cisterns can be filled by gravitational forces, by pumping or directly from roofs and different surfaces. They are made of metal, concrete, masonry but for the underground it is mostly fiber glass or metal.

- **Modified cisterns:**

They are directly storing water under paved surfaces with open graded gravel suitable for water storage and lined with structural reservoir system. The main advantage is that it could be integrated with different parts of the site consuming no land area.

### 2.2.5 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 main concept is to provide vegetation with minimal or no irrigation needs and mostly to be covered by renewable water resources. As soon as the different landscape elements are managed, the distribution of the water and the different needs could be managed. (Calkins, 2012 kindle version).

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.

#### *2.2.5.1 Different irrigation needs (Hydrozones)*

Different landscape vegetation types have different needs and based on that each group of plants having similar water needs have to be gathered in one zone and accordingly the whole vegetative landscape is divided into different zones called "Hydrozones" and these zones are irrigated with the optimum amount of water according to the climatic conditions such as landscape typology, rainfall, soil dryness, evaporation rates, temperature, and humidity that is managed by a model or a computer program gather data from weather stations on site.

#### *2.2.5.2 Irrigation systems and controls*

The different irrigation systems are:

- **Over ground jets or sprays**:

They are distributed over the ground so each one is covering a certain area with minimal amount of overlap. Inspite of the relative low price of these systems, the evaporation of the water and the surface runoff is significant.

- **Below or on ground drip irrigation systems**:

The below ground system is more efficient that the one on ground, since the plant's water need is mostly focused on the root part. Buried systems need staking as it could harm the soil wildlife. Buried systems could have metallic markers for tracing in case of maintenance. The system is composed of hoses with drip outlets having sensors that limit the water supply according to the need of the plant. The main problem of this system is that it is subjected to clogging and tearing. Filters are added to the start of this system to filter water and prevent system clogging.

- **Furrow or surface irrigation**:

This type of irrigation is relevant for sites with minimal differences of water needs and it is considered saving different materials that consume energy and could produce toxins to be produced. According to this system, the water is directed from source to flood the different areas of vegetation. This type of irrigation doesn't need energy for pumping and it works well to avoid loss of runoff. It is mostly used for agricultural fields.

- **Hand watering**:

This primitive method could be used in the establishment phase and in the supplemental irrigation. This method doesn't cost a lot of money, but the main issue is the proper timing of irrigation and the inclusion of the system requirements in the maintenance plan. It is more relevant for small areas.

**Table 6 Comparison between different irrigation systems**

| **Irrigation method** | **Over ground jets or sprays** | **Below or on ground drip irrigation systems** | **Furrow or surface irrigation** | **Hand watering** |
|---|---|---|---|---|
| **Degree of sustainability** | High | High | Low (certain uses) | Not sustainable |

According to studies fixed time irrigation system could use twice the needed water as no weather conditions are taken into account although attentive hand watering can be more efficient wasting only 10% (Thompson & Sorvig, 2007, p. 181)

The different control systems that could be applied are:

- **Normal manual systems**:

These are normal systems where the operation of the system is manually controlled. It has to be carefully used to provide the needed amount of water without excess.

- **Systems with automatic timers**:

These systems work automatically and could be adjusted according to the seasons and different timing needed. The more developed system is connected to weather systems that could stop the irrigation in the case of rain for example.

- **Smart control systems**:

These systems work automatically according to the different weather factors that are measured through the weather stations and moisture sensors. So these systems provide the most optimum amount of water with the minimal amount of wasted water.

There are some criteria for efficient sustainable irrigation methods (Thompson & Sorvig, 2007, p. 187):

- The concentration on using non-potable water e.g. graywater.
- Making reduction of runoff a priority.
- Design sprinklers or emitters of the same rate for each zone.
- Conduct the periodical maintenance for the whole system.

**University of Tennessee of Knoxville:** According to the university vision, irrigation methods are to be designed according to maximum efficiency and reduction of water consumption. Weather monitors, smart controls and soil moisture sensors are used to increase the efficiency of the system. Centralized control system is used to facilitate maintenance and increase flexibility in system. Water condensation of cooling systems is used to decrease the use of potable water. Promoting stormwater harvesting systems to reduce water used for irrigation using water basins and underground tanks reducing runoff and increasing on-site infiltration.

## 2.3 Vegetation

Although vegetation is considered as one of the fragile items of landscape but it is considered from the most important and effective ones. When the vegetation selected is suitable for the site it could help support the ecosystem. The type of vegetation materials and the way the vegetation is used affects its role in sustainability. This influence appears on two levels:

1- Vegetation enhances the natural processes of different indicators for sustainability such as: improving air quality, water resources, supporting biodiversity and soil resources. In addition to that, vegetation affects social and economic sustainability.
2- The preparation for planting and maintenance has a major effect on the input and the output of the resources.

Many researchers studied the effects of the interaction between the vegetation and the human beings. Some of the benefits are: A good field for inspiration, decreasing mental fatigue, and being a reason for decreasing the rate of crime. As a spiritual connection: Absence of vegetation could be a source of spread of obesity, others assumed that vegetation helps speeding the healing rate. All the previous assumptions show the importance of the vegetation environmentally and socially.

Some studies state that the effect of vegetation on humans emotionally depends on the subconscious perception of the presence of green areas which gives the idea of safety, and on the contrary the absence gives the notion of insecurity due to the absence of natural element, also the fragrance and the acoustics related to vegetation play a role. (Selman, Sustainable Landscape Planning- The Reconnection Agenda, 2012, p. 9)

### 2.3.1 Relevance to the site

In order to reach the best selection of vegetation on site, there has to be a deep understanding for the site qualities before and after construction. Since that the most intended quality from the vegetation is the support of the ecosystem, then it is more obvious and effective in the case of brownfields and greyfields. It is not always correct that the plants that were present on the site are the ones that are relevant as the environment and climate varies a lot. That is the reason that the updated detailed information about the site is very important. (Calkins, 2012 kindle version, pp. 4620-4632)

#### 2.3.1.1 Qualities of vegetation on landscape

There are two main channels that vegetation could affect in landscape:

- **The environmental qualities that the vegetation could provide as** (Calkins, 2012 kindle version, p. 4606):
  - Reduction of the heat island effect.
  - Minimizing the heating and cooling of buildings.
  - Preserve or improve the water quality.
  - The use of sustainable products during cultivation or scheduled care
  - Ensure the interaction between humans and plants.
- **The sustainable consumption or productivity of the vegetation with the environment**

This category could be classified to different points as, some are the prerequisites from SITES rating system:

- Preserving the existing vegetation communities that are having good performance on site.
- Selection of vegetation that is relevant to the surrounding environment and doesn't cause any adverse consequences. It is preferable if the types are productive.
- Selection of types of vegetation that has reduced usage of water.
- Support biodiversity on the site.
- Usage of types that could preserve the qualities of the soil and don't damage it.

#### 2.3.1.2 Criteria for suitable plants' selection

There some questions that should be answered in order to approach the most suitable types of plants to the project:

- Which plant communities are present and in a good situation in the region? This question targets the plant communities that serves the ecosystem on the site.
- What role does each plant play in the vegetative community?
- How strong is the plant and effective in provision of ecosystem services among the plant community that it is present in?
- How prominent is the plant in the vegetative community and why? Checking that the plant is not invasive or has adverse consequences on the site later on.

Then there are some criteria for evaluating the appropriate plants which are (Calkins, 2012 kindle version, p. 4691):

- **Adaptability and environmental tolerance**: Check if the plant can survive in the site with its building conditions on the ground and underground. The assessed properties could be: sun/shade environment, wet/dry soil, amount of salt in soil, pests.
- **Function**: Make sure that the selected species provide the intended ecosystem services that is designed for in the program of the landscape.
- **Plant management**: It is important to know if the plant would be possible to be nursery grown on site, and it is suitable with the maintenance plan of the site landscape, and it is also very important to make sure that this type of plant won't turn invasive through time.
- **Design intend**: If the plant is complying with the intended design function for it on site such as: screening, color, form, falling leaves affecting surrounding functions and spatial definition.

#### *2.3.1.3 Ecosystem services provided by plants*

There are some functions that indicate the ecosystem services that the plant provide (Calkins, 2012 kindle version, pp. 4718-4743):

- **Oxygen production:** Through photosynthesis process where water and carbon dioxide are reformulated to create oxygen and sugar.
- **Carbon Dioxide removal:** $CO_2$ can be locked in plants' tissues and into the soil for hundreds of years.
- **Air pollutants removal**: Compounds as ozone, $SO_2$ and $NO_2$ are absorbed and broken down by plants.
- **Soil pollutants removal:** Plants also eliminate pollutants as saturated or unsaturated metals in soil
- **Transpiration:** Sometimes the removal of groundwater is essential for the environmental health and to decrease the soil salinization.
- **Cooling:** The shade that the vegetation provides on buildings to decrease the radiant heat that is applied on the building and the transpiration effect also decreases the air temperature.
- **Wildlife habitat:** Provision of food and cover for different organisms.
- **Food production:** Plants provide food for human as physical and chemical properties.

Some factors affect the survival of the plant and the ecological services it is providing which are: the soil properties, the water and the air. The balance between those factors have a direct effect on the plant. For example if the soil remains saturated then there is no space for air which leads to the death of the plant and on the other hand when air is exceeding the required limit it blocks the water which leads to desiccation. Since these factors vary from one soil type to the other, the diversity of plants on site on a certain soil type assures the quality of soil since it is allowing different types of plants to adapt.

**Biomass Density Indicator** (Calkins, 2012 kindle version, p. 4750): is an indicator for the ecosystem services. It is generated from the percentages of different vegetation types covering the site and the amount of impervious cover. Historic ecosystem, climate and geographical significant variables are taken into consideration.

## 2.3.2 Vegetation providing ecological qualities

There are qualities that the vegetation could provide not available as chemical of physical characteristics in the plant itself but functions that could be provided or systems that could be enhanced. These functions include: Heat island reduction, energy conservation and microclimate modification, phytoremediation and bioremediation.

### *2.3.2.1 Vegetation for heat island reduction*

This property has three ways to be achieved: replace, cover or remove. Replacement of reflective surfaces by vegetation is a healthy point since the reflectivity of vegetation is higher than many paving surfaces as well as that is increases the evapotranspiration which increases the gaseous water which decreases the temperature.

Another method is to cover these surfaces with vegetation providing shade to reduce heat but the species used for this process have to have some resistive properties to overcome: excess of heat, air pollution, light reflection, increased evaporation and exposure to wind. These plants could be used with parking spaces, western and eastern facades for the direct sunlight, roofs, water bodies and outdoor gathering spaces.

Many processes consume energy which results in the production of $CO_2$ and pollutants as air conditioning or grass mowing. By adding vegetation which decreases the need for these processes then it accordingly removes some of these pollutants or $CO_2$.

### 2.3.2.2 *Vegetation for energy conservation and microclimate modification*

Not only the vegetation could be used to reduce the heat but also they could be used as wind breakers Fig. 32 or as funnels to direct the breeze, therefore vegetation could be used to modify the microclimate to reach the human comfort. According to Wilson and Josiah, to reach the efficient wind breaking property compose the vegetation such that the length should be ten times the height of the tree in its maturity phase (Calkins, 2012 kindle version, p. 4839).

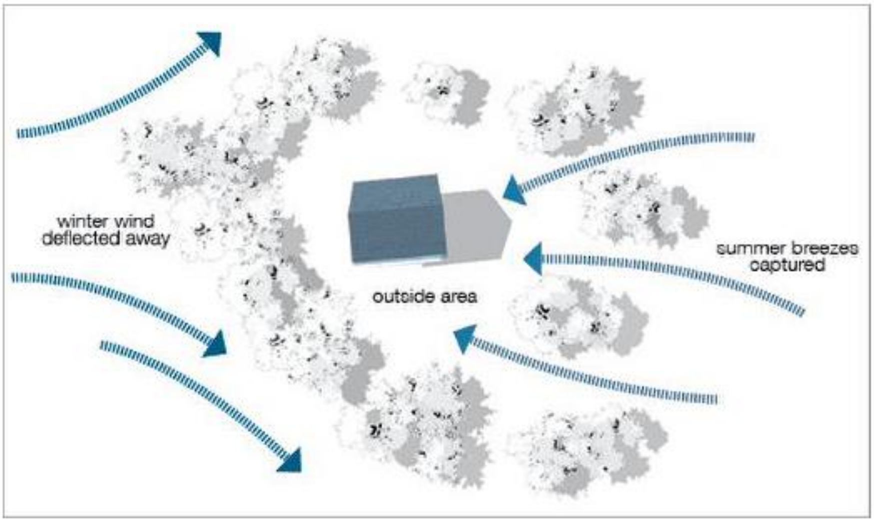



**Fig. 32 Vegetation used for wind breaking and for breeze directing (Calkins, 2012 kindle version, p. 4851)**

Deciduous trees have dual use in very hot or cold regions. In summer, having leaves, they block the sunlight creating shade and decreasing the high temperatures while in winter, as leaves have fallen, they allow sunlight to reach buildings helping in the heating process and decreasing the heating loads Fig. 33.

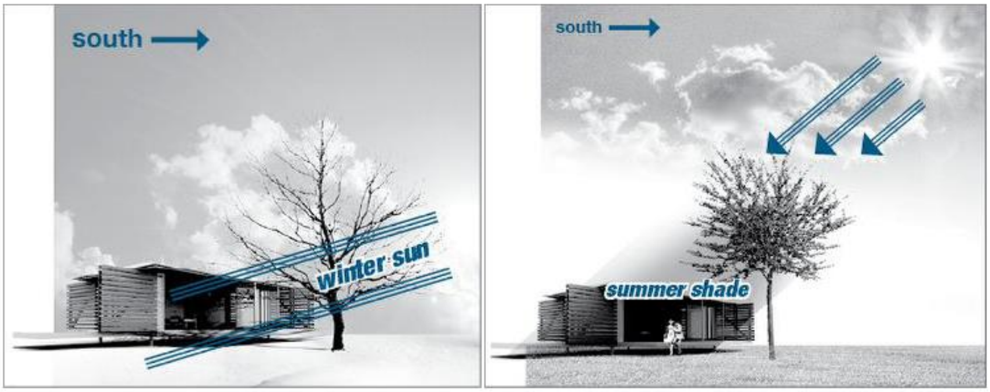



**Fig. 33 The role of deciduous trees between summer and winter (Calkins, 2012 kindle version, p. 4865)**

#### *2.3.2.3 Phytoremediation and Bioremediation*

Bioremediation is the general term for the environmental techniques to provide pollutant treatment or capture. Phytoremediation is the process of storing, degrading or breaking down harmful pollutants through the physiological properties of the plant. Phytoremediation is effective in sites with limited pollution evapotranspiration and nutrient sequestration are the two mechanisms for phytoremediation by plants. The process is performed through the decomposition of the constituents of the polluted water extracting the nutrients needed and accordingly blocking the pollutant molecules. The process could be also symbiotic through the species of plants and the microorganisms present in the soil that breaks down the pollutants. Some techniques recommend the removal or the harvesting of the plants to continue the growth or the uptake. There are different phytoremediation techniques (Calkins, 2012 kindle version, pp. 4904-4913):

- **Rhizoshphere Biodegradation:** which uses microorganisms on or in the plant.
- **Rhizofiltration:** Through the rooting structures of the plant.
- **Phytostabilization or phytotransformation:** blocks pollutants, reduces them or converts them into other substances.
- **Phytoaccumulation or phyto-extraction:** blocks pollutants within the plant biomass.
- **Phytovolatization:** Turns pollutants into inert gases.
- **Phytodegradation:** Destruction of pollutants by the plants tissues.

There are other ecological benefits of phytoremediation (Thompson & Sorvig, 2007, pp. 103-104):

- It is applicable for different types of pollutants: oil, pesticides, and metals.
- It is more efficient for upper soil layers.
- Solar renewable energy is used rather than any other non-renewable energy.
- Cheaper than any other methods and aesthetically pleasing.

## 2.3.3 Vegetation protection techniques

The existing and the new vegetation on site are affecting during the construction or the maintenance phase and they might be subjected to: Abrasion, drilling, compaction, paving, change in water or soil provision, leakage of some pollutants to plants or general disturbance of the plant environment. The existing vegetation on site could be protected according to its rarity, size or if they belong to endangered species. The protection techniques and methods are classified according to the existing and the new vegetation species.

### *2.3.3.1 Protection of existing vegetation*

For existing vegetation on site, there has to be on ground and underground fencing or setting barriers to protect the vegetation. The extent of protection underground should protect the deepest roots extend which is mostly the drip line. Survival of the protected species depends on the strength and the age of the vegetation. The protected vegetation may need extra care: supplemental watering, mulching, pruning, protection against wind and fertilizing. A space has to be provided from the new vegetation as the protected species could be affected due to the crowded roots or canopies. (Calkins, 2012 kindle version, pp. 4943-4967)

### *2.3.3.2 Protection of new vegetation*

Protection of new vegetation species is as important as the protection of the existing ones. There are some steps to be followed (Calkins, 2012 kindle version, pp. 4967-4983):

- The selection of the suitable spaces that is appropriate for the site conditions as climate, space, soil type, availability of water.
- Keeping enough distances for the protection against hardscape, fencing or different structures as well as other species that could have an effect on each other.
- The availability of variety of plant species with different maturity ranges reduces the impact of diseases and pests due to the variety which allows the tracing of

the defect and quick replacement. That is supplemented with taking precautions for the possible pests and diseases.
- Controlling invasive species.

From the other protection techniques on site is the allocation of a VSPZ which a vegetation and soil protection zone that should be protected from construction or development impact as well as including it in the maintenance process of the site. These zones should be separated or fenced with allowing the permeability for wildlife habitats.

## 2.3.4 Sustainable planting design and management

### *2.3.4.1 Using native plants*

Native plants are species that are available originally in the region and adapted to it. In most of the cases native plants are present in a circle of 250 miles (~400 Kilometers). The use of native plants have different benefits as:

- Native species are well adapted to the surrounding environment so accordingly the maintenance needs could be reduced.
- It is the best choice to provide good habitat for the native organisms.
- It gives the sense of place and identity.
- They are more flexible to different conditions and of extremely higher performance more than non-native ones.

The same criteria that is applied for the selection of appropriate plants is applied with the selection of the native species which include: Adaptability, environmental tolerance, intended function, plant management issues and design intention and all were stated previously in details.

Some plants could be native to the region but is not relevant to the intended use on site e.g. doesn't provide shadow, then further selection from the available native plants is needed according to the use. (Thompson & Sorvig, 2007, p. 154)

There are some criteria for identifying the native species from the others:

- The species that are grown in the region without the human intervention
- These species shows lower growth qualities when grown in other environments other than its original.
- The species is not introduced to the site through human intervention.
- The species is associated with other plant or animal species present onsite.

### *2.3.4.2 Xeriscaping*

The concept of xeriscaping is to design the landscape to adapt to survive with the limited amount of water on site and without any supplemental water needs. As well as the reduced water for irrigation, vegetation should survive the absence of other supplemental inputs as nutrients, soil and others.

There are seven principles to apply xeriscaping (Manske & Larson, 2000):

- Plan and design the landscape of the site keeping in mind the limited water resources and direct water excess to vegetation and protect the available vegetation on site.
- Limit the areas of turf grass which requires large amount of water in addition to mowing which leads to more need of water.
- Select the vegetation types that are suitable for the limited amount of water on site.
- Improve the soil quality in order to increase the soil moisture holding capacity.
- Use mulch (inorganic) to save the properties of soil.
- Efficient irrigation using dripping systems rather than spraying at the appropriate time of the day with suitable sun and temperature.
- Maintaining landscape.

The use of grass- which is widely used in the case of many campuses- is not always a suitable choice for places with shortage in water. Other ground covers or native plants could be better with saving water and not using herbicides or pesticides. Even in the case of grass growing, relevant species of grass should be grown according to the climate suitability and water needs (Dober, 2000, pp. 15-16)

**Santa Fe Community College:** Fig. 34 &Fig. 35 is one of the examples of introducing xeriscaping concept to the landscape which is compatible with the desert environment that it is situated in. The use of limited patches of green, decorative paving. Even the xeriscape is creating a factor of place-making for the campus (Dober, 2000, p. 16)

**Fig. 34 Santa Fe Community College , source: http://www.panoramio.com/photo/27612151**


**Fig. 35 Santa Fe Community College School of Arts and Design, source: http://www.panoramio.com/photo/27612180**

### *2.3.4.3 Invasive species*

The U.S. Federal Invasive Species Advisory Committee defines invasive vegetation species as " Are not native to the ecosystem under consideration and that cause or are likely to cause economic or environmental harm or harm to human, animal or plant health". Not all non-native species are invasive, they have to cause harm to human or other species to be invasive. Ex. Porcelain berry and kudzu are ornamental from the humans' point of view but it has a destructive effect on other living organisms causing death (Thompson & Sorvig, 2007, p. 100) . Most of our ornamental plants are nonnative and they are not invasive at the same time. Only 10% of the non-native species in North America are invasive (Thompson & Sorvig, 2007, p. 99). Invasive species grow in an exponential pattern, when it reaches the inflection point it becomes hard to be resisted, that is a reason for the precautious considerations against these species. Normal species doesn't spread from the point of introduction for at least 25 years. There are some organizations that define the invasive species and there are some characteristics that give indication about the invasive species (Calkins, 2012 kindle version, p. 5064):

- They grow very fast, are not easily affected by different impacts: mowing, disturbance, and can easily adapt to different environments.
- They could release some toxins that could affect the health of other species.
- Invasive species could block others from exposure to the sun.
- They produce very large number of seeds which leads to very quick spread.
- They were thought to be limited to climatic regions but they are moving towards north due to global warming.

**Avoiding invasive species introduction to site**: If there is a suspicion towards any of the used species it is better to reject it from the beginning. The invasive species could easily enter the site through unclean used materials, machinery during construction or even by wind, so it is better to have vegetative ground cover or forbs to fill spaces, create a healthy ecological system, and not allowing invasive species to be introduced.

**Combating invasive species present on site** (Calkins, 2012 kindle version, p. 5128)**:**

- **General land management:** It targets the whole land and it is not used for single plants. It could be through burning, mowing, grazing, and sometimes flooding.
- **Targeted mechanical control:** It targets non- herbaceous species that needs mechanical intervention for removal, mainly for species that are not removed through normal other methods.
- **Targeted chemical control:** It is for the species that are not combated through the other methods, so selective herbicides are applied but it has to be licensed to assure its safety.
- **Untargeted biological control:** It is the use of other organisms to eliminate the invasive species on site, e.g. using goats to eliminate kudzu from the site. The main problem of this method is that it hardly can be constrained, as these organisms can eliminate different species totally together without differentiation.

These are the general methods for different types of sites and landscape projects, but in the case of campuses chemical and mechanical methods are prominent to be used and the general management of site might be introduced prior the development of the site.

**University of Tennessee:** As a part of the vision done for the university landscape design and site standards, selection and elimination of vegetation was considered an element of sustainable landscape design of campus. Sustainable Site Initiative which is a major reference in the thesis is considered a resource for all site planning and design on campus. It was proposed that non- planted areas would planted with native meadows Fig. 36 of orange and white flowers or grass species that doesn't require intensive mowing only semi- annual rather than using lawn that requires continuous mowing. Removal of invasive species as kudzu Fig. 37 which is threatening to the birds and insects population in the region. (Carol R. Johnson Assosciates, 2012)

**Fig. 36 Native meadows used instead of lawn**

**Fig. 37 Kudzu plant, an invasive species**

### *2.3.4.4 Sustainable plant production*

It is preferable to deal with plant producer that follow the sustainable methods for plant production reducing the resources. This acts to promote the idea that sustainable practices are desired. Some points give a sign of sustainable performance of plant producers:

- Reduce the use of peat and the use of renewable energy for the production of the planting media and pots.
- Reduce the runoff from irrigation.

- Integrating pest management program.
- Reduction of potable water use and the use of gray and black water.
- The use of recycled organic matter.
- Waste reduction.
- Prevention of growing species that are suspected to be invasive species.
- The use of locally produced seeds is preferred.

### 2.3.5 Salvaged and reused vegetation

The protection of the existing vegetation sometimes is not possible on a pre-developed site, thus the vegetation to be protected has to be moved to another place to be saved. This case is essential for the native species that are not available commercially. This method is applied in case that the vegetation to be protected or the materials holding it could be destroyed or affected by the changes to be done on site. There are some precautions and criteria for the salvaged or the reused vegetation:

- Some salvaged species could cost lots of money and doesn't survive in the end, thus earlier decisions should be done.
- The plants should be moved with good care and caution should be given to the roots as that could affect the plant's survival.
- Feeder roots could be cut but should have a clean cut as hacked or disjointed cuts may cause the infection of the plant.
- The extraction of salvaged species should not cause damage to the site.
- Broken branches during movement should be cut cleanly.
- Good care should be given to the moved plant from the perspective of: water, sunlight, wind protection, protection against pests and insects. In some cases of long periods of movement, temporary planting could be needed.
- Some plants could be totally removed, others could not be removed and can't survive, while cutting sometimes is a better choice for other, thus deeper investigation should be done to decide the relevant case.

### 2.3.6 Special vegetation uses

#### *2.3.6.1 Vegetation for roof gardens*

Roof gardens have a variety of uses, it has ecological which includes stormwater management, providing habitat for wildlife, reducing heat island impacts. (Thompson & Sorvig, 2007, p. 126). Green roofs act as landscape areas for facades that doesn't overlook any view. Green roofs could handle any type of vegetation as far as the planting medium depth is sufficient, but deep rooted species are not preferred due to the size and most of the times the roots affect the sealing membrane. The vegetation species has to tolerate very dry and saturated conditions and can resist low maintenance. Sedums and succulents are the most relevant species to be used for green roofs, although some are preferred on others according to the climate (Calkins, 2012 kindle version, p. 5330).

### *2.3.6.2 Vegetation for food production*

Edible landscaping has three benefits: It reduces the energy consumption used for transporting vegetation used for food accordingly reduces the carbon foot print, provides a sustainable source of food that could be used on site or can be benefited from as a financial source, and the aesthetical value of planted vegetation with the production of flowers and fruits. Most of the used species for that reason are perennial and sometimes are woody species. (Calkins, 2012 kindle version, p. 5441)

**Fig. 38 The food garden in Gary Comer Youth Center in Chicago encouraging youth to produce their sustainable food on site, designed by Hoerr Schaudt Landscape Architects, photo from Scott Shigley (Calkins, 2012 kindle version, p. 5467)**

There are some characteristics for the used species:

- The rate of maintenance of these productive species should be proportional to the other species surrounding, in order not to add excessive care that could be a burden.
- The used species have to perform the normal performance aside including shade, water control, and aesthetics….etc.
- The end product is preferable to be direct rather than going through process of refining to reach a usable product e.g. growing berries rather that wheat.
- Perennial species are preferred that annual ones, since the annual species could cause the disturbance of soil for other species surrounding.
- Should be naturally pest and infection resistant.

**Shenyang Architectural University Campus** (Turenscape, 2014)**:** Shenyang city is in the north of China. The campus Fig. 39 was originally in downtown but due to the excess in the number of students in the middle of the city, the campus had to be moved to the suburbs of the city. Because of the huge population of China, the limited areas as arable lands, thus the integration of the food production with the landscape is very essential.

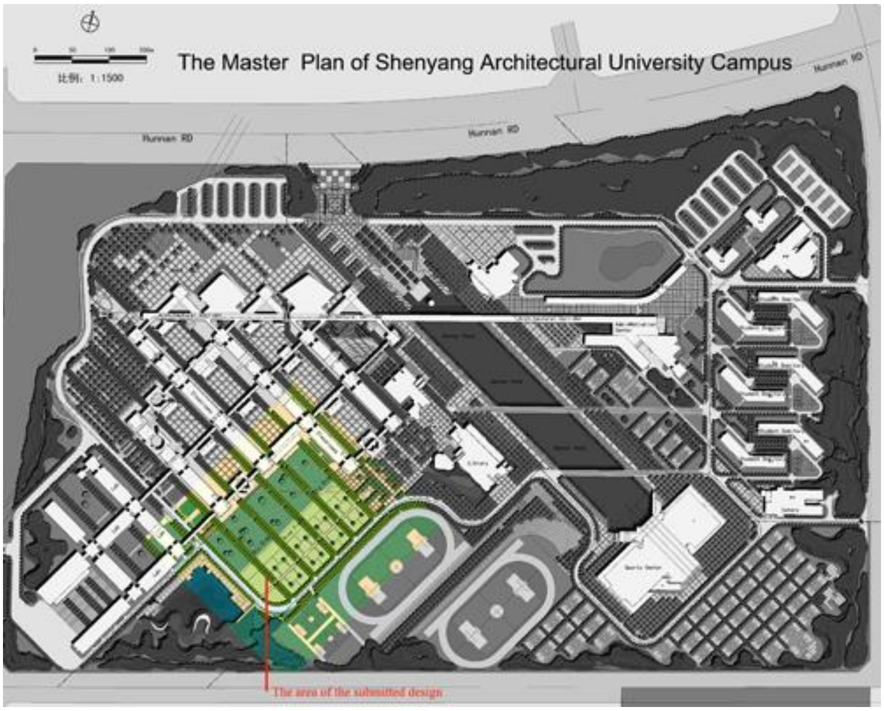



**Fig. 39 The master plan of Shenyang Architectural University Campus highlighting the zone for growing rice (Turenscape, 2014)**

The edible landscaping of the site had three benefits for the project:

- The rice is originally a rice field Fig. 40 and it is known for the quality of rice it can produce and at the same time the irrigation methods of these fields are available and usable.
- The availability of the fields as a ready- made landscape will decrease the budget needed for the landscape for the project.
- The time required for the construction of the project is much limited- as required by the administration of the university- due to eliminating the time that would be elapsed to initiate the landscape of the project Fig. 41.

**Fig. 40 An overview of the rice fields**

The presence of the campus within the fields keep in recognized to include the thoughts about sustainable development in the educational process. Due to the high quality of the produced rice, it became an icon giving an identity for the campus Fig. 42.


**Fig. 41 The process of planting the rice**

**Fig. 42 Reading areas within the rice fields**

#### 2.3.6.3 Vegetation for wildlife habitat

There are four factors that affect the wildlife habitat: cover, food, water and space. The condition for each species differs from the other. There are generic characteristics that attract common species (Calkins, 2012 kindle version, p. 5482):

- Open canopy structure.
- Available flowering and fruiting species.
- Open grown trees with multiple of branches near the ground.
- Rich in diversity of species.
- Some disturbance.

Native vegetative species are good choices for providing habitat for native wildlife in the region. Some steps act as guidance for the provision or the creation of a relevant wildlife habitat:

- Checking the existing corridors and habitats near or passing through the site.
- Examining the potentials and the condition of these habitats whether it will support the biodiversity or not.
- Evaluate the probability of enhancing and supporting these corridors on site.
- Analyzing the existing conditions of these habitats (food, water, cover and space).
- Select and arrange the species that could be brought on site to mimic the characteristics of the natural wildlife on site.

## 2.4 Soil

The soil is the base for several components of the ecosystem, it supports the vegetation that depends on the air and the water. The soil is composed of mineral solids, water, air and organic matter. There are different characters for healthy soils Fig. 43 (Calkins, 2012 kindle version, p. 5784):

- Protect the water quality, reduces the runoff, reduces the contamination of water, and decreases erosion as well as sedimentation and flooding.
- Stores carbon and support micro-organisms.
- Reduce the need for irrigation, pesticides and fertilizers.
- Produce healthy plants and allows the plant to reach its desired size.

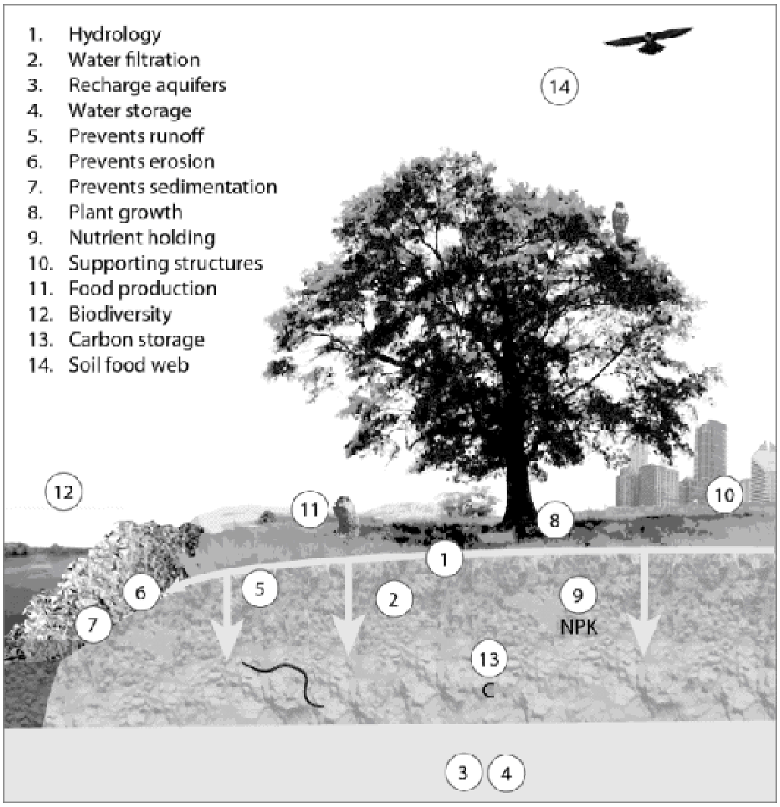



**Fig. 43 Different ecological processes supported by soil (Calkins, 2012 kindle version, p. 5818)**

Some soils have their qualities reduced according to these properties (Calkins, 2012 kindle version, p. 5794):

- Change in grading of soil due to the cut and fill process.
- Compaction and loss of aggregates stability.

- Change in PH value of soil.
- The poor drainage due to compaction.
- Deficiencies with the nutrients content.
- The presence of buried man-made aggregates.
- No sufficient soil for the plant growth.

The main goals of sustaining soil quality on site is to protect good soils on site or improving the qualities of damaged soils.

### 2.4.1 Soil in site assessment

Before working on site, potentials and limitations should be highlighted to show the way to deal with the site. This phase of site assessment should be performed before any buildings or roads could be introduced to the site. There are set of questions to guide to the type and quality of soil (Calkins, 2012 kindle version):

- Where has the soil been disturbed, and in what way?
- Where are the healthy soils? Healthy soils should have a high priority for protection and preservation.
- Where are the soils that can be restored? Or at least set for developing
- Are there areas where the soil is totally absent or where soils are contaminated?

Whether the soil is known to be disturbed- by roads, buildings, excavations, dumps or drainage- or not, the soil survey has to be done. It shows characteristics of soil that can be hidden and not recognized such as pH, soil structure, or drainage. These surveys have to be practical on site in order to reach accurate results to rely on. There are three assessment techniques to reveal the quality of the soil on site (Calkins, 2012 kindle version, p. 5926 till 6036):

- **Land Use History and the Observational Soil assessment**:

"Restoring something implies going back to an original condition. For something as complex as a landscape, knowing what condition was "original" is not always simple. Sites are living, changing entities; both natural succession and human land use change every site over time." (Thompson & Sorvig, 2007, p. 74)

Knowing the history of the site Table 7 could help to highlight the strength and the weakness points of the soil. Old pictures, maps, previous land uses and inhabitants of the land can give an overview about the hotspots to be assessed according to historical problems. Different land uses could give indications:

**Table 7 Soil assessment through site history (Calkins, 2012 kindle version, p. 5937)**

| | |
|---|---|
| Development and construction | Soil can be compacted, disturbed or contaminated. |
| Grade changes, cut and fill | Grades are available in any flattened area on site. Cuts may include revealing of topsoil and fills may contain different aggregates. |
| Areas of materials storage or construction aggregates | Soil may not be equally compacted, PH might be elevated, and areas of instability may be present. |
| Vehicular and pedestrian routes | Compaction, severe or possibility of contamination. |
| Evidence of soil contamination and dumping areas | If toxic chemicals for human or plant are included, then further tests have to be performed. |
| Present and past buildings | Mostly disturbed, depending on the type of construction. |
| Land use of the adjacent site and within the same watershed | Shows the water flow on site. Chance of contamination and erosion. |

- **Existing Vegetation and the Observational Soil assessment**:

The existing vegetation on site gives indication to the land use on site as well as the status of the soil on site Table 8 i.e. yellow leaves could indicate unbalanced PH value of soil, also the growth of certain vegetative species indicate the disturbance of the soil:

**Table 8 Soil assessment through vegetation situation (Calkins, 2012 kindle version, p. 5976)**

| | |
|---|---|
| Nutrients deficiencies indicated by leaves' color | Nutrients deficiencies indicate disturbed soil chemistry, while leaf color indicates compaction, drought or pour drainage |
| Tree decline, dead branches protruding the live canopy | Indicates soil disturbance or decline due to pests. |
| Poor plant growth, suckering species also indicate stress | Indicate the spots of poor soil (i.e. low soil volume, compaction). This shows spots that need soil restoration. |
| Healthy and culturally or ecologically valuable specimens or plant groups | Indicates healthy soil that can be designated as soil and vegetation protection zones. |
| Invasive species | Indicates disturbance. |
| Check for species that grows on its own naturally. | This may indicate good or bad soil according to the species that has to be identified by an expert. |
| Witch's broom, branch dieback or leaf scorching | Indicates salt exposure. Patterns of infection indicates the location of the salt source. |

- **Hydrology and Topography and the Observational Soil assessment:**

Studying the water flow and the topography of the land gives a good help of how to manage runoff, maximize the efficient use of water Table 9. Signs of erosion, flooding or sedimentation show where improved infiltration is needed.

**Table 9 Soil assessment through hydrology and topography (Calkins, 2012 kindle version, p. 6022)**

| | |
|---|---|
| Signs of erosion | Indicates soil compaction, drought or poor drainage. |
| Original topography or flood plain | Shows how the soil will change by the years |
| Impervious surfaces and the path of runoff they generate | Soils that may be subjected to erosion and how to overcome this using stormwater capture. |
| Ponding, slow drainage and wetland plants | Indicates compacted soil or poor drainage or both |

In case of absence of natural water sources on site and the water reaches the site through pipes, a topographic site survey needs to be performed to show the change in the topographic character of the site comparing it to older topographic maps for the site to show the spots of soil disturbance.

## 2.4.2 Soil composition, characteristics and layers

There are different categories of soil (Calkins, 2012 kindle version, p. 5887):

- **Healthy soil**: Differs from one region to the other according to the climate and the type of native soil. For example in arid regions the native healthy soil is more sandy than in other regions, do there are some characteristics for the healthy soil:

- Soil horizon, organic matter, soil pH, salinity, mineral contents are similar to that of reference soil which is the undisturbed native soil in the region.
- Both topsoil and subsoil are not compacted.
- The absence of toxic compounds.
- Existing vegetation represents the native plants of the region.

- **Minimal soil disturbance**: The soil is minimally graded or somewhat compacted for example by heavy foot traffic compaction, but the subsoil hasn’t been compacted.
- **Moderate soil disturbance**: is common around buildings and pre-developed areas with moderate disturbance of soil. Top soil may be absent. If available, it will be compacted exceeding the

maximum allowable bulk densities. Subsoil might be graded due to contouring, cut and fill or high construction traffic.

- **Severe soil disturbance**: It could have the same type of compaction of the moderate disturbance but it includes contamination or being paved over i.e. under buildings, under asphalt or in brownfields.

Soil horizons Fig. 44 show the different layers of the soil which indicates the status of the soil whether it is disturbed or healthy. The soil horizons are composed of the top organic layer with nutrients (O horizon), second layer of topsoil (A horizon) subsoil layers, and lastly the parent material and bedrock. In disturbed soil the topsoil might be removed or destroyed, also it might have buried soil horizons by construction fill.

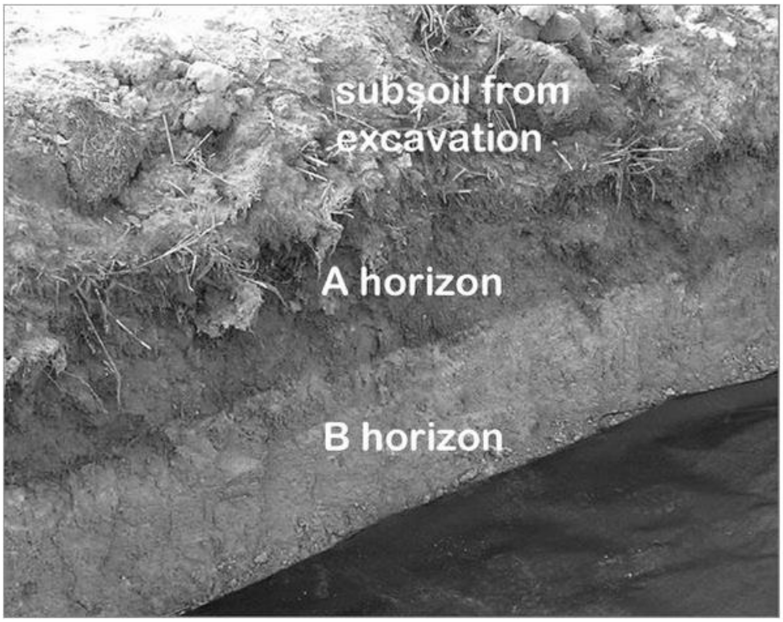



**Fig. 44 A section in excavated agricultural soil showing the disturbed soil (Calkins, 2012 kindle version, p. 5905)**

### *2.4.2.1 Mapping and planning soils data collection and sampling*

This is the phase when the data about the site soils are mapped and documented. Soil sampling should be based on the current condition and the eventual use of the soil. A set of groups for soils should be determined according to conditions that coincide with the soil condition: wet/dry areas, eroded/non eroded areas, vehicular and pedestrian traffic, different plant zones and their growth. The step after is to classify soils into categories that were described previously: healthy, minimally disturbed, moderately disturbed, etc. The step afterwards is to identify locations according to soil characteristics that might be changed: PH elevation, compaction, drainage, erosion, and contamination. After that it is more clear the number of soil samples needed and their locations.

There are two criteria for the soil samples:

- It should be representative of the location being characterized.
- It should not be of composite samples of different tested locations.

To prevent the error of the taken sample in a soil of heterogeneous composition, it is preferable to create a composite sample that aggregates the different characteristics of the soil, and not to have a solely sample that could be different from the surrounding parts.

The steps for taking a sample are (Calkins, 2012 kindle version, p. 6185):

- Removing the upper part covering the soil as mulch or grass.
- Digging till the level required for the sample which is about 20 cm then remove a layer of two centimeters from the side.
- Use a metal push tube to extract the sample, don't mix the soil. For composite sample, different samples are mixed in a sample container.
- Keep the sample out of the sun cooled in a refrigerator or a cold room. Samples should not be collected from wet or frozen soil.

## 2.4.3 Characteristics of soil

Different characteristics of soil are indicated through different tests applied to show the type of the soil. There are different types of tests for each phenomenon. Sometimes if it would be preferable to recheck the results through different tests. Some can be performed on site and others can be performed in lab.

### *2.4.3.1 Soil texture*

Soil has three different types of particles: Sand, silt and clay. Sand is the largest while clay is the smallest. Normally the drainage of the sand is higher than the others. The texture of the soil influences its structural properties as well as its capacity to hold and drain water. The textural class of clay is very high, since a small amount of clay mixed with any other type will lead to a mixture with the major properties of clay. A soil of 20% only of clay is considered a clay soil. Clay has high nutrient and water holding capacity as well as ability to compact and bind to organic matter, since it tends to be negatively charged, but that causes resistance to change in soil pH. Soil texture affects different properties as: Drainage, water-holding capacity, ability to compact/porosity, fertility, growth of plants, modifying soil PH and remediating compacted soils (Calkins, 2012 kindle version, p. 6208).

**Soil texture test:**

The test is supported by a chart Fig. 45 which is texture by feel chart. Take a handful of soil, add some water to it, so it sticks together to form a ribbon with soil, record its length, then follow the texture by feel chart.

Replacing soil texture is not desirable for sustainable sites. It is better to reach a full understanding of site soil, use the available soils and apply some modifications to reach the required qualities.

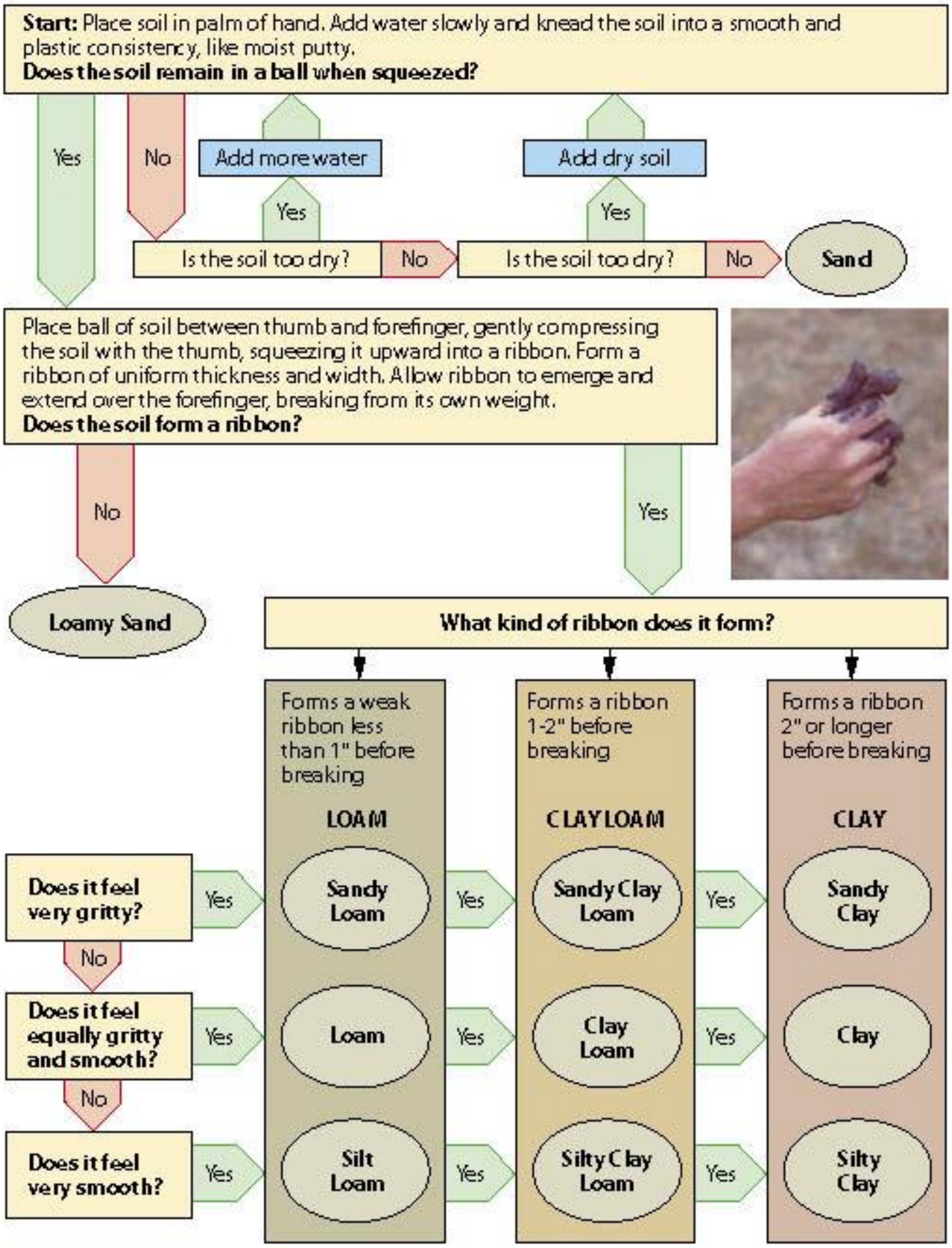



**Fig. 45 Soil texture by feel method, Adapted by Colorado State. Source: (Roadside Revegetation, 2014)**

### *2.4.3.2 Soil organic matter*

The organic matter comes from living organisms, it can be living or dead material. It includes compost, leaf litter and manure. Organic matter is a source of food for micro-organisms that decompose the organic matter providing nutrients for the plants. Organic matter contributes to the soil structure, water infiltration, nutrients and microbial activity. Healthy soils should contain from 3-5% of organic matter. Soils with very high organic matter are more subjected to compaction and ability to compress which is not suitable for areas with high traffic and excess of some types that have high content of salt could be toxic to plants. Some soils have a natural high availability of organic matter such as wetlands. If the soil has a lower content of organic matter, it may be due to the fast decomposition of the organic input to the soil. The amount of organic matter depends on the input, losses and storage (Calkins, 2012 kindle version, p. 6298).

- **Sources of organic carbon in soil:** Includes leaves, roots turnover, microorganisms, micro-invertebrates, soil amendments (compost, manure….). The physical action of these sources would lead to acceleration of decomposition process and the production of the organic matter.
- **Storage of organic carbon in soil:** Free organic matter (which can quickly decompose), protected with aggregates (which is protected from decomposition for decades), and bound to the soil minerals (remains for hundreds of years). The more the exposition to air, warmth and moisture the faster the decomposition process occurs.
- **Losses of organic carbon in soil:** Occurs through release of $CO_2$ produced from microbial respiration. Grading, tilling and soil disturbance leads to the fast release of $CO_2$ from soil.

**Soil organic matter test** (Calkins, 2012 kindle version, p. 6322)**:**

The soil could be tested visually, the darker the soil is the higher the organic matter is present in the soil. Lab tests have to be supported by the level and the place where to get out the sample. Some tests are specific for certain types of crops. The samples taken to be testes have to be stored in a cold place in a temperature around 4°C and test should be performed within 4 weeks otherwise the soil will lose its organic matter. There are three lab tests that could be performed to evaluate the organic matter of the soil:

- **Loss on Ignition method:** The soil is burned to a high temperature losing the organic carbon and the inorganic carbon is left, thus the lost carbon is calculated through subtraction

- **Walkley-Black procedure:** The soil inorganic carbonates are removed by an acid and the organic carbon is removed by wet oxidation. This method is more accurate than the previous one.
- **Dry Combustion:** After the full removal of inorganic carbonates, the soil is burned to a high temperature to remove any left carbon. The carbon content is calculated by weighing and evolved gases are analyzed via spectrophotometry.

From the characteristics that depend on the organic material is the soil structure which depends also on the texture of the soil which creates bond between soil particles creating aggregates. This property affects the water infiltration and drainage. Soil structure takes a lot of time to be formed and it could be easily destroyed by vehicular or foot traffic, grading, excavation or any means of disturbance. (Calkins, 2012 kindle version, p. 6426)

Aggregate stability is the measure of the resistance of the soil to break apart when disrupted by wind or water and resist forming crust and erosion. Mulch could provide protection to soil structure stability. In Fig. 46 the right diagram shows the soil that lost its stability creating a blocking layer preventing water and air from interfering. (Calkins, 2012 kindle version, p. 6442)

**Fig. 46 Two diagrams showing different aggregate stability of soil**

### *2.4.3.3 Soil compaction*

The more the soil is compacted the more it limits the growth of the plants since it decreases the micro- and micro-pores that is necessary for the air exchange, water infiltration and biological activity. Soil compaction is destroyed by vehicular and pedestrian traffic especially when it is wet. Mixing, grading, cutting the soil and construction techniques are sources of compaction. The soil compaction affects: ability of roots to penetrate the soil, drainage, water holding capacity, biological activity, organic matter, resistance of plant to drought (Calkins, 2012 kindle version, p. 6470).

There are two methods to test soil compaction: Using penetrometer for soil bulk density or through dry soil bulk density method. When using penetrometer, it is preferable when the soil is saturated by water through a few days. For hard soil, bulk density method works better. Bulk density is the weight of dry soil divided by the wet volume. A known volume of soil is extracted from site heated at 103°C to 105°C until a constant is reached, the sample is weighed and divided by the volume. Large rocks and roots should be excluded from both the weight and the volume measurements. Soil texture should be identified prior testing the bulk density. Using the soil textural triangle Fig. 47 with the dotted lines indicating the maximum bulk densities, values not to be exceeded are identified according to the soil texture.

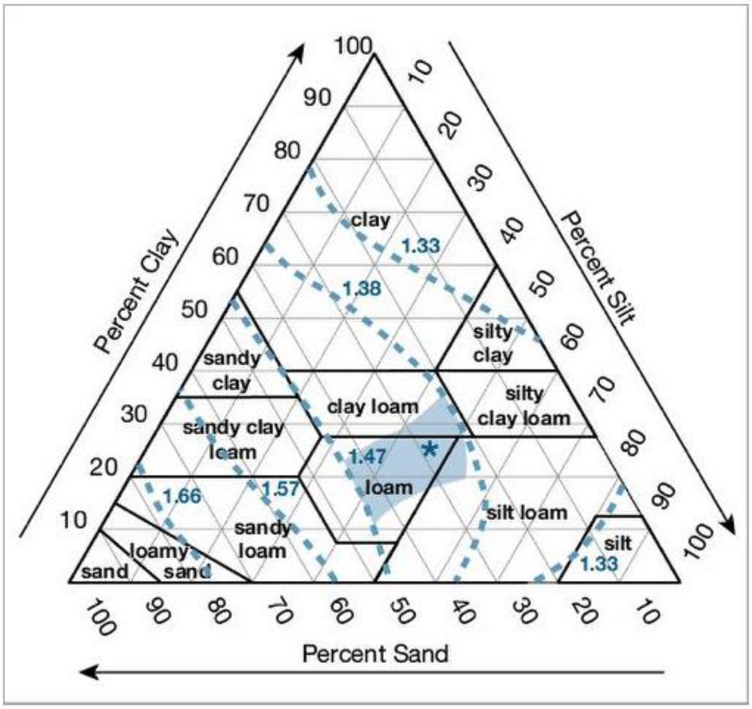



**Fig. 47 A sample for used Soil Textural Triangle indicating maximum bulk densities (Calkins, 2012 kindle version, p. 6520)**

### 2.4.3.4 Soil volume

"Without adequate soil volume for roots and nutrients and adequate surface for water and air to pass through, even the toughest plant is doomed to die, leaving its pit empty a grave like"

Having adequate amount of soil is a basic requirement for a sustainable site. Soil volume is considered an issue in case of soils edged by buildings or pavement, since the plant requires an average amount of soil that provides it with required nutrients, water and is enough for the growth. The soil volume affects (Calkins, 2012 kindle version, p. 6543):

The plant durability, the limit of growth, the plant's health and the irrigation and nutrients' needs. The soil volume is assessed in case the soil surface area is less than $80m^2$ or the least dimension of the planted area is 5m. For areas larger than this limit, testing should be performed in case more than two trees are planted.

The ultimate size of the plant has to be considered to specify the volume of soil required. In case of less soil than needed, the size of the plant won't reach the maximum as well as the plant age and will be limited to the available soil. The minimum required is $3m^3$ of soil for every $5m^2$. In case of trees, 0.06 $m^3$ for every 0.09 $m^2$ in case of trees.

### 2.4.3.5 Soil drainage

The soil drainage is the capability of the soil to allow the passage of water through it. The lack of good soil drainage affects the oxygen movement in soil and could lead to erosion, stormwater runoff and water deficits in lower layers. The soil drainage affects: Water holding capacity, biological activity, aeration level, products of plants, the chance of compaction, air exchange. (Calkins, 2012 kindle version, p. 6575)

Soil drainage is tested by percolation test, where a hole of 12-18 inches depth and 12 inches width is dug. It is better that the soil is saturated with water before the test. The hole is filled with water, then the height of the water is measured, then measured again after 15 minutes to record the difference. Then it is multiplied by 4 to reach the rate in an hour.

If the rate is less than 1 inch per hour, then the drainage is very poor.

If it is between 1 and 4 inches per hour, then it is poor drainage.

If it is between 4 and 8 inches per hour, then it is good drainage.

If it is more than 8 inches per hour, then it is excessive drainage.

After water is partially drained from the soil, some water is left sticking to the soil which is absorbed by the plant. This amount of water depends on the texture of the soil. For sandy soil, from 6 to 10 percent of the water is held and from 15 to 20 percent for clay soil. It is rare for any soil to hold more than 20% of the given water (Calkins, 2012 kindle version, p. 6626).

#### *2.4.3.6 Soil chemical status and nutrient availability*

The chemical properties of soil includes: pH, cation exchange capacity, salt content, and chemical contaminations.

Soil pH value indicates the activity of hydrogen ions (H+) in a solution, the acidity and alkalinity of soil, nutrients availability and toxicity of other elements. Typical soil pH values are between 4 and 9, mostly disturbed soils have pH higher than 7 due the pavement materials, building foundations and so on. Most plants could adapt to the pH of soil between 6 and 7.5 but not all could adapt to higher or lower values which shows the importance of pH value for plant selection. As pH indicates the nutrients availability, iron is mostly rare in soils with high pH value. pH can be measured through: Soil pH meter, Soil pH colorimetric test, or laboratory analysis (Calkins, 2012 kindle version, p. 6633).

There are two types of nutrients that plants need Table 10: macro-nutrients (needed by large amount) and micro-nutrients (needed by a small amount). The unbalance of the available nutrients affects the health and the growth of the plant. Sometimes the excess of nutrients can create toxic conditions.

**Table 10 Shows different types of nutrients required by plant (Calkins, 2012 kindle version, p. 6731)**

| Plant Macronutrients | Plant Micronutrients (Required in trace amounts only) |
|---|---|
| Nitrogen (N) | Iron (Fe) |
| Phosphorus (P) | Manganese (Mn) |
| Potassium (K) | Copper (Cu) |
| Sulfur (S) | Zinc (Zn) |
| Calcium (Ca) | Molybdenum (Mo) |
| Magnesium (Mg) | Boron (B) |
| | Chlorine (Cl) |

Cation exchange capacity (CEC) is the measure of soil fertility. It represents the ability of soil to retain positively charged cations which include many needed nutrients. Clay and organic matter are rich in CEC more than silt or sand (Calkins, 2012 kindle version, p. 6770).

There are two cases of concern related to salt Table 11. It can be either lower than needed which affects the fertility of soil or it can be higher which can affect the plant health causing: Witch's broom, leaf scorch or plant desiccation. There are some species that are tolerant to salty environments that can be used. Soluble salts are measured through electrical connectivity method.

**Table 11 Applying the electrical connectivity method from 1:2 dilution (Calkins, 2012 kindle version, p. 6805)**

| Interpretation | ECe dS/m |
|---|---|
| Low EC (fertility) | < 0.38 |
| Ideal | 0.38 – 0.75 |
| Acceptable | 0.75 – 1.5 |
| Unacceptable (salt injury common) | > 1.5 |

#### *2.4.3.7 Soil contamination*

This property indicates the presence of undesired materials that may be dangerous for the plants or for the human beings. These materials could include: Lead, Cadmium (from paint), Nickel, Arsenic, or Copper Sulfate from herbicides. These contaminants could affect: root or plant growth, appearance of different vegetative species other than the intended, or human health. Dealing with the contaminated soil depends upon the degree of contamination. According to the degree, the soil could be isolated, remediated (using phytoremediation) or replaced. (Calkins, 2012 kindle version, p. 6819)

### 2.4.4 Modification of soils

According to the situation of the available soil serving the surrounding ecosystem or negatively affecting it, the action is planned whether soil has to be replaced or modified according to the integration with other ecological systems on site.

#### *2.4.4.1 Preservation of soils*

Soils with no disturbance and with good health having good properties has to be protected against relocation, contamination and even protecting available vegetation on this soil. Grading, storing, excavating or constructing on these soils have a negative effect on the case of soils to be preserved. In large projects, when topsoil is stored more than a month that could cause a severe effect on the health of the preserved soil since microorganisms die. There are some protection steps to preserve the healthy soil:

- A fence should be set to protect this area from any constructional actions.
- Prevent any vehicular or pedestrian traffic that could affect the preserved soil.

### *2.4.4.2 Rehabilitating soils onsite*

It is the most sustainable method for the usage of soil as it acts on enhancing the properties that the soil is missing or having a defect at. From these properties are: Compaction, pH value, drainage, texture and structure, nutrient availability and biological activity. Amending the soil should not be only for soils surrounding the plants but for the general available soil onsite to prevent any difference in properties that could affect more the soils due to this difference.

From the most common problems of soil is compaction. Mostly soil is compacted during construction phases or in redeveloped areas. The de-compaction of the soil is the solution for this problem and it needs three steps (Calkins, 2012 kindle version, p. 6937):

- Physically breaking down the compacted soil.
- Prevention of re-compaction by limiting traffic and introducing a material (organic matter) to keep the de-compaction of the soil.
- Creating a maintenance program to guarantee the sustainability of the amended soil (aeration, organic matter and clays).

For improving the properties of compacted soil, organic matter is introduced to the lower layers via subsoil and then topsoil is reapplied again. In the case of soil of low quality, radial trenching technique could be used where radial channels are dug and filled with mulch or compost providing a healthier medium for the roots. In case of clayey soil with drainage problems, sand is added to improve the drainage properties of the soil. The sand to be added should be of narrow sizes (from medium to coarse). When well graded sand is introduced, the clay particles fill the gaps between the sand increasing the bulk density and making the drainage problem worse. Also if a large amount of sand is introduced, the nutrient and water holding capacity is affected requiring extra irrigation and fertilization which makes amending using sand is not a sustainable method to improve the properties of soil.

In case of the presence of soluble salts in soil due to irrigation water, de-icing or being near to the sea, the salt could be dissolved by over saturating soil with water in case of good draining soil, that is for the abnormal presence of salts. Other options are considered in the maintenance plan for the soil including irrigation, fertilizing and de-icing. (Calkins, 2012 kindle version, p. 7086)

Amending the soil with high pH value is not sustainable in most of the times especially for fine textured soil and soils with calcareous parent. Since adjusting the pH value requires several amendments then it is not practical to grow perennial species. Plants that could adapt with the present pH value are the most suitable species. Compost acts on neutralizing the pH value of the soil. In cases that a very huge shift of pH value is needed soil burying or replacement is a more sustainable method. Changing pH on a large scale is costly and sometimes unsuccessful.

Most of amendments for soil pH value should be done before introducing the plants. For lowering the pH value of soil, sulfur and it compounds are used while ground limestone is used to increase the pH value of the soil. The amount of amendments to be added depends on the texture of the soil.

In case that soil is missing some nutrients Table 12, that could be due to the pH value or the decrease in the organic matter. The pH value problem could be solved by adding plants that could adapt with the pH value while the organic matter issue could be solved by adding compost or adding fertilizers. There are some criteria for the added fertilizers (Calkins, 2012 kindle version, pp. 7119-7134):

- The use of fertilizers with the specific needed nutrients, and decreasing the use of it in case it is not needed. Avoid over fertilizing as it could cause the damage of the plant.
- Not using fertilizers near water features or at the time of rains or storms. Don't keep extras on the hardscape or the pavements.

**Table 12 Examples of some organic materials that could provide some nutrients (Calkins, 2012 kindle version, p. 7151)**

| Plant Nutrient | Sources |
|---|---|
| Nitrogen (N) | Alfalfa, dried blood, cottonseed, feathers, fish, guano, seafood, urine, manure |
| Phosphorus (P) | Bone meal, bird manure, rock phosphate, vetch |
| Potassium (K) | Kelp, wood ash, seaweed |
| Calcium (Ca) | Egg shells, oyster shells |
| Magnesium (Mg) | Epsom salt (magnesium sulfate) |

The problem of drainage is not losing water from the soil like a sponge and that depends on the soil texture and the solution could be through plant selection, drainage system choice (Grading, sump drains, and underdrainage), radial trenching and amending with sand.

### *2.4.4.3 Using organic matter to amend soil*

In many cases due to soil disturbance the soil loses its topsoil layer. This concept is based on adding different organic matters to the soil in order to improve the characteristics of the soil in case of defect: drainage, compaction, bulk density...etc. Some researchers see that usage of extra amendment for soil could affect the plantation as in the case of some native plants. From these materials are: Mulch, compost, manure, green manure, bio-solids, food waste, peat moss, peat humus, waste from paper mills. Each type is used to enhance a certain property in soil. There are some properties for these additives to reach the best output (Calkins, 2012 kindle version, p. 7007):

- It is better to use local materials available on site and doesn't have an impact on the environment.
- These materials should be applied to the whole site not only at the spots of planting.
- They should be mixed with the soil prior the plantation to prevent disturbance. They could be 18 inches for wooden plants and 12 inches for herbaceous species. The added materials could be from 4-8 % of the soil by the dry weight.
- Checking the effect on pH value of soil and the degree of soluble salts.

From these added materials are (Thompson & Sorvig, 2007):

**Sand:** Which enhances the drainage of the soil.

**Clay:** Improves the structure of the soil.

**Gypsum:** Could be added to soils lacking calcium or affected by soil.

**Wood ash:** good for acidic soils but could increase the existing pH value and could cause salt problems.

**Peat moss:** Could improve the drainage and water holding property of soil.

Scattered construction materials on site could amend soil and be used as planting medium especially if it is left for a long time on site. The reuse of available aggregates on site is not easy and not feasible so it is preferable in the case of availability of materials on site. Some materials contain Nitrogen which needs specific plants to adapt. Other materials are harder to decompose as concrete and have calcium that cause the alkalinity of soil, while others provide phosphorus, potassium and magnesium as red bricks (Thompson & Sorvig, 2007, p. 91)

### *2.4.4.4 Soil replacement and specialized soil*

At certain cases when soil is in a very poor condition and cannot be amended by any means, soil replacement or burying is the only option. The burying of soil could be applied in those cases of soil condition: Soil is extremely contaminated, compacted, with poor drainage, or with high water table near the roots. Water drainage of buried soil should be considered before adding the topsoil. (Calkins, 2012 kindle version, p. 7241).

In some cases when the level of the soil is high, the solution could be by creating berms to cover the poor soil.

From the other techniques used is balancing cut and fill which is burying the soil with poor quality using better soil from an unused area on site following the main sustainability rule of re-consuming available resources rather than consuming new resources and affecting the environment. (Thompson & Sorvig, 2007, p. 85)

**Structural soil:** Soil used under hardscape and pathways should be very well compacted, often till 95% compaction as peak. The soil is a mixture of soil particles and gravel to overcome the loads subjected to the soil. Structural soil requires large volume to function, which is $2ft^3$ for every $ft^2$. The water holding capacity ranges from 7-12 % according to compaction. Vegetation suitable at this environment are those which could withstand the high drainage of the soil. A pervious soil (around 50 $ft^2$ for a tree) should be exposed surrounding the planted vegetation to allow the infiltration of water Fig. 48. As a part of complementing stormwater management system, the structural soil should allow high rates of rates of infiltration of water (>24 inch/hour). The water should be totally emptied through infiltration through 48 hours for the efficiency of stormwater management systems. (Calkins, 2012 kindle version, pp. 7310-7342)

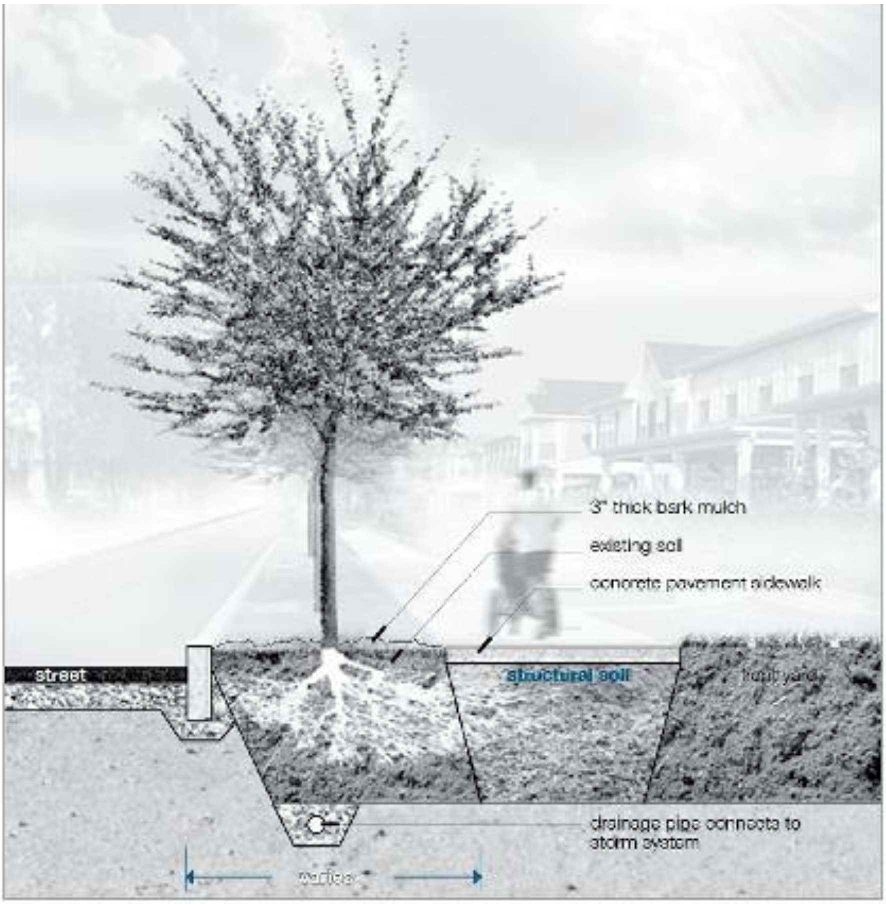



**Fig. 48 Installing vegetation through structural soil on site (Calkins, 2012 kindle version, p. 7358)**

## 2.5 Materials

Recently the material production is not limited to localized productions and limited available materials. Materials' productions are very huge and becoming centralized in a large scale and globally distributed. Materials production is becoming a major reason for resources deterioration according to the Earth Summit in 1992. (Calkins, 2012 kindle version, p. 7496)

Since university campuses' landscape covers a large percentage of the area including hardscape materials, site furnishing elements, thus the sustainability of the materials' used would contribute to the sustainability of the campus landscape in a wide extent.

According to the less talented craftsmen used, the production of toxic materials became a problem raised. Due to the weak environmental regulations in some countries, the materials production shifted to these countries and the transportation of products to different countries escalated the problem of energy consumption and pollution.

According to the previous problems, the closed loop of materials' production became an initiative for solution by recycling materials and decrease production of waste from production. From the other channels for sustainable material production is the use of materials of low impact on the environment and humans' health. Embodied energy is also discussed as a matter deciding the degree of sustainability of materials. (Calkins, 2012 kindle version, p. 7556)Thus materials used for a sustainable site could be classified to:

- **Materials that minimize the usage of resources.**
- **Materials with low impact on the environment.**
- **Materials having low effect on human health:** e.g. not producing volatile gases that could be hazardous on human beings.
- **Materials that help the sustainable design strategies**: e.g. assists reduction of heat island effect, helps the stormwater management systems and prevents the loss of runoff.
- **Materials that have sustainable environmental, social and corporate practices:** e.g. corporate that uses environmental management system, reduces carbon emissions, uses renewable energy or reduces water consumption.

The main factors affecting the sustainability of the materials are the inputs and the outputs in the material cycle Fig. 49. The wider the cycle the more inputs are needed for the material production consuming energy, and resources and at the same time producing substantial waste, thus the less sustainable is the material. The closer the material cycle, the less energy and materials consumed and accordingly less waste is produced and the material is overall more sustainable. (Benson & Roe, 2000, p. 224)

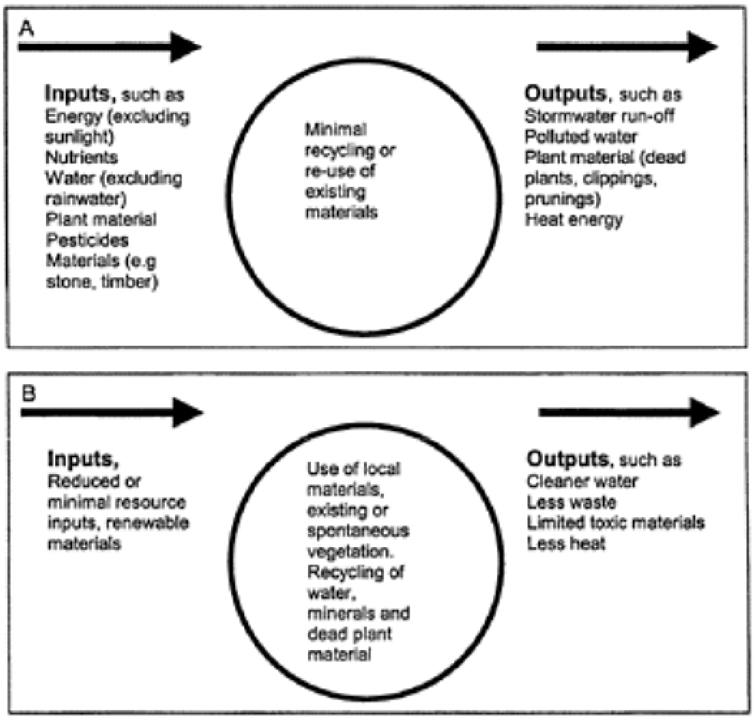



**Fig. 49 A: shows an opened unsustainable system while B: shows a closed more sustainable one (Benson & Roe, 2000, p. 225)**

## 2.5.1 Lifecycle of construction materials

According to ISO 1996, life cycle assessment (LCA) is the compilation and the evaluation of inputs and outputs of and the potential environmental impacts of the product throughout its lifecycle. LCA is comprised of four phases: Goal and scope definition, inventory and analysis, impact assessment and interpretation. The different lifecycle phases are as follows:

### *2.5.1.1 Raw material acquisition:*

The first step of material production is its extraction from nature which sometimes have severe effect on nature itself. Many materials could be consumed for extraction, habitats could be destroyed, and natural ecosystems could be affected i.e. soil erosion that happens due to forests' cutting, dust blocking photosynthesis process due to mining, and sometimes with extraction toxic materials could be produced as in the case of acid mine drainage. The main problem of materials sustainability assessment which differs from one step of production to the other and sometimes could not be compared to each other i.e. a material could cause a great effect on the ecosystem while having a very low embodied energy and has a minimal waste production at the end of the process.

#### *2.5.1.2 Primary processing and refining of material:*

This phase includes very high energy consumption as well as the production rate of wastes is relatively high. The refining of recycled materials consumes and produces less than virgin unprocessed material which highlights the role of recycling in the sustainability of materials. (Thompson & Sorvig, 2007)

#### *2.5.1.3 Manufacturing:*

Just as the previous step, the use of recycled materials decreases the energy, the materials used and the waste. The main concern of the manufacturing step is that liquids and coatings and different materials are used to finalize the product which may affect the humans' health. (Thompson & Sorvig, 2007)

#### *2.5.1.4 Product delivery:*

The main concerns of this phase are: the energy used for the transportation of the product and the materials used for the packaging process i.e. the energy required to transport a truckload for a 350 miles distance is equal to the energy required to produce them and fire them. Since packaging materials are used for a short term of time, then most of the time they are neither reused nor recycled, so it is always better to produce them out of recycled or low quality materials to save energy and resources.

#### *2.5.1.5 Construction, use and maintenance:*

The main effective points of this phase are the durability of the material which leads to the longest performance with the highest efficiency, the possibility of reuse or recycling after the period of usage, and the hazardous effect of some chemicals in the material used, and finally the products using electricity as lights, pumps and controllers that has an effect on the surrounding environment and affects the energy consumption.

#### *2.5.1.6 Final disposition:*

The effect of this phase is from the way of disposition of the material and its effect on the environment whether it is disposed in a landfill or burned in an incinerator or it is the kind of material that could be recycled or reused which is the most sustainable for material disposition. (Calkins, 2012 kindle version, pp. 7689-7705)

## 2.5.2 Impact of materials

As mentioned before during materials production different natural resources are consumed, different emissions, effluents and waste materials are produced having different hazardous effects on the environment and the human health.

### *2.5.2.1 Environmental impact of materials*

There are different environmental phenomena that depend on the production of materials:

- **Global climate change:** The change in the temperatures, the change in sea levels, loss of biodiversity and different changes based on climatic changes are the result of the greenhouse gas from fuel burning and different industrial productions.
- **Diminishing fossil fuel:** Since fossil fuels are non-renewable energy sources that is used for transportation, provision of energy for production and are involved in producing some products.
- **Wearing ozone layer:** As known the ozone layer protects the earth from harmful ultraviolet rays that is harmful for nature and human health. The excess release of hyrochlorofluorocarbons HCFCs from cooling requirements, cleaning agents, steel and aluminum production causes the depletion of the ozone layer.
- **Smog and air pollution:** Due to the fuel combustion, mining, production processes, transport, construction and demolition, and different hazardous gaseous emissions which affects the health and the environment through air pollution and smog.
- **Acidification, Eutrophication and water resources depletion:** Accompanied to the production process, gaseous emissions and effluents are produced affecting the soil and the water resources affecting the living species in soil and in water due to the loss of suitable water sources for consumption.
- **Deforestation, desertification and erosion:** Based on the cutting of forests and building over agricultural lands, different habitats are lost causing the loss of biodiversity, erosion of soil and desertification.
- **Habitat alteration and loss of biodiversity:** The change in the balance of the environment through the air, water or soil pollution. The

requirements for living species sometimes are lost causing the loss of the biodiversity and the change in the habitat.

**a. Embodied energy of materials and products (EE):**

It is the amount of energy required for the production of a material or a product throughout the different production processes including: extraction, refining, manufacturing, use and disposal/reuse. Some materials as stainless steel and aluminum have very high primary energy requirement which would force a high urge of high recycle content to overcome the high initial energy requirement. There are two ways to define embodied energy either: cradle to gate which doesn't take recycling or reuse into consideration or cradle to cradle where reuse or recycling of materials is included. The EE can evaluate just one phase of the production phases or can be accumulated in the case of a product from different types of materials i.e. a bench of wood and steel. (Thompson & Sorvig, 2007)

**b. Embodied carbon of materials and products (EC):**

It is the amount of $CO_2$ produced during the production phases of the material from the extraction till the disposal. In most of the cases when the material has a high EE, it has a high EC except for some special cases. For example aluminum has a high EE but lower EC since in the primary production stages the used energy is hydro-electrical energy which is a renewable energy. The same as the embodied energy, it is classified into: Cradle to gate and cradle to cradle.

There are some limitations on the evaluation using the embodied energy and carbon:

- Different from the material lifecycle assessment, other factors as i.e. the waste of materials, habitat impacts, emissions are not included in the EE and EC calculations.
- EE doesn't differentiate between sources of energy like renewable and non-renewable, but that shows in the value of the EC.
- EE and EC varies according to different factors: country, distance of transport, the way of manufacturing, fuel input and recycled content.
- Since EE and EC are according to the weight or the volume, and densities of materials vary. For example a ton of steel could be compared to a ton of aluminum but when you compare two handrails of these two materials, the aluminum will be of third weight of steel.
- Some other greenhouse gases could have higher effect than $CO_2$ but are not included in EC.

### 2.5.2.2 Human health impact of materials

Human health is affected by toxic materials which are naturally toxic or resulting from the production processes. Many of these materials are the result of different modifications to plastic. The health effect could range from irritation to permanent diseases or others that could cause death. Sometimes the effect of these materials could be neglected since it is not visualized although it has very dangerous consequences on the long run. Sometimes the hazardous effect is indirect when toxic materials leak to the soil or the water features or the soil that could affect human indirectly through food or water. (Calkins, 2012 kindle version, pp. 7871-7886). There are some common hazardous materials affecting health:

- **Carcinogens:** substances that causes or increases the risk of cancer such as Vinyl Chloride, formaldehyde, fumes from chromium, nickel and cadmium.
- **Persistent bio-accumulative toxins (PBTs):** These are substances that persist in the environment or could be included in the food chain. These materials spread easily through air, water and land. These include: Dioxin emissions from PVC and cement, production and finishing of heavy metals as lead, mercury, chromium and cadmium.
- **Reproductive or developmental toxins:** These materials affect the reproductive systems of males and females. Lead and mercury produced from the combustion of fuel are considered from these materials.
- **Highly acute toxins:** These materials targets specific organs and causes fatal damage
- **Endocrine disruptors:** causes an interference with the hormones and could cause some disruptions for the development.
- **Neurotoxin:** These materials affect the nervous system.
- **Mutagen:** These materials cause the changes for genes that could make them susceptible to cancer or defection of cells.

### 2.5.2.3 Living building challenge materials red list

The living building challenge (LBC) is a program for certification which has a prerequisite red list for materials banned to be used, because of their hazard on human health and environment which includes (Calkins, 2012 kindle version, pp. 7894- 7930):

Asbestos- cadmium- chlorinated polyethylene and chlorosulphonated polyethylene- chlorofluorocarbons (CFCs) - chloroprene (neoprene) - formaldehyde- halogenated flame retardants- Hydrochlorofluorocarbons (HCFCs)- lead- mercury- petrochemical fertilizers and pesticides-phthalates- polyvinyl chloride- wood treatments containing creosote, arsenic or pentachlorophenol.

There is an exception if the product is composed of more than ten elements, an element of the red list could be introduced but in the range that it doesn't exceed 10% in weight and volume.

## 2.5.3 Materials' assessment

### *2.5.3.1 Standards, labels and certification systems*

According to the large interest towards the environmental issues and the impact of materials on the environment, ranking systems, labels, regulations and certification systems are generated to help in the selection of the materials. They are created by non-profit organizations, governmental agencies, manufacturers and trade associations. The evaluation criteria varies according to the number of issues it is targeting i.e. recycled content, air quality, energy consumed…etc. There are some examples of these certifications and programs. (Calkins, 2012 kindle version, p. 8174):

EcoLogo, Greenseal, Cradle to cradle certification, Energy Star, SMaRT (Sustainable Materials Rating Technology), and others

### *2.5.3.2 Site and regional assessment for materials*

This phase takes place prior any activity that takes place on site. Checking the structures, materials that could be reused or the materials that would be brought to site, the method how it will be processed and disposed. The second phase is regarding the users, owners and stakeholders and their priorities regarding the materials' impact to be considered, the mode of usage and the maintenance procedure to be performed. The third phase is regarding the environment, the sensitive ecosystem near the site, priorities related to pollution and urban heat islands around the site. (Calkins, 2012 kindle version, pp. 8250-8310)

### *2.5.3.3 Resource efficiency*

The minimal use of materials and resources decreases the impacts on the environment. The less resources used the closer the cycle of the material production is achieved. Still the products of recycling are scarce especially in the case of disassembling rather than demolishing. There are several strategies for minimizing the resources consumption (Calkins, 2012 kindle version, pp. 8326-8439):

**Reduce**: The use of durable and minimum amount of materials, and the reuse of structures present on site or adapt the present structures to the needed uses. Design such that materials could be disassembled and reused again without using extra resources, this concept is known as design for disassembling and deconstruction (DFD).

This concept involves the flexibility of the site design for different designs and changes in the future. The usage of materials with high reuse or recycle potential serves the DFD concept Table 13. Different connections need to be accessible and easy to connect or disconnect to facilitate the phase of dismantling Table 14. Avoid finishes that limits the reuse or the recyclability of the material.

**Table 13 Different materials for DFD concept (Calkins, 2012 kindle version, pp. 8713-8735)**

| |
|---|
| **Relatively Easy Disassembly** |
| Nonmortared unit pavers: concrete, brick, stone |
| Interlocking block retaining wall systems: no mortar |
| Low-impact foundation technology (LIFT) |
| Gravel trench foundations |
| Aggregates |
| Precast concrete elements |
| **Disassembly Requires Some Additional Labor** |
| Unit walls (e.g., brick, stone, CMU) with lime mortar |
| Unit paving (e.g., brick, stone, concrete units) with lime mortar |
| Untreated lumber connected with bolts and screws |
| Plastic lumber |
| Metal structures with mechanical connections |
| **Potentially Reprocessed Materials** |
| Concrete slabs and walls |
| Asphalt pavement |

| |
|---|
| Soil cement |
| Rammed earth |
| Aggregates |
| **Recyclable Construction Materials** |
| Metals: steel, aluminum, stainless steel, copper, iron |
| Wood (not pressure treated) |
| Some plastics: HDPE, LDPE, PE, PP, PS |
| Glass |
| **NonRecyclable Construction Materials and Products** |
| PVC products |
| Treated lumber |
| Some coated metals |
| Composite products (e.g., fiberglass, composite lumber) |
| Mixed-material assemblies that are not easily separated |

**Table 14 Different fixations for site materials (Calkins, 2012 kindle version, pp. 8746-8772)**

| Type of Connection | Advantages | Disadvantages |
|---|---|---|
| Screw fixing | Easily removable | Limted reuse of screws Cost |
| Bolt fixing | Strong Can be reused a number of times | Can seize up, making removal difficult Cost |
| Nail fixing | Speed of construction Cost | Difficult to remove Removal usually destroys a key area of element |
| Friction | Keeps construction element whole during removal | Relatively undeveloped areaStructurally weaker |
| Mortar | Can be made to variety of strengths | Strength of mix often overspecified, making it difficult to separate bonded layers |
| Resin bonding | Strong and efficient Deal with awkward joints | Virtually impossible to separate bonded layers Resin cannot be easily recycled or reused |
| Adhesives | Variety of strengths available to suit task | Adhesives cannot be easily recycled or reused; many are also impossible to separate |
| Riveted fixing | Speed of construction | Difficult to remove without destroying a key area or element |

**Renew**: The use of renewable resources that could be easily replaced by the environment i.e. wood that is certified as sustainably grown and harvested.

**Reclaim and reuse** Fig. 50: The use of materials that could be adapted on site or slightly modified to satisfy the needs. Some costs could be needed to maintain the used materials but it is relatively lower and more sustainable than using new resources.

**Fig. 50 The existing rail structure of The Highline that was reused as a neighborhood park and promenade (Calkins, 2012 kindle version, p. 8454)**

**Recycle**: Concentrating on the use of materials of high recycled content to assure the continuity of using the material afterwards and closing the material's lifecycle.

**Recover**: The disposed materials that can't be used anymore have to be functioned to recover the energy through disposal by producing heat or electricity.

### *2.5.3.4 Material reuse*

The most effective sustainable method of materials on site is the materials' reused known as reclaimed materials. The best materials for the reuse are: Metals, lumber, concrete units, bricks and stones. When reclaimed complete structures are used this could add a historical value to the project which could be considered as a landmark used on site. The main concern of using reused materials is finding the relevant sizes and quantities that could fit the need of the project as well as the distance and the transporting issues for reused materials. (Thompson & Sorvig, 2007)

### *2.5.3.5 Reprocessed materials*

Reprocessed materials are the ones that are broken down or sized down to be reused again. These materials consume less amount of energy than the recycled one. For example, concrete can be reused after crushing instead of gravel, even it has better draining properties than gravel. Reused asphalt acts as a very good base or sub-base for the new asphalt layer. Wood could be used as mulch, compost, erosion control, retaining walls and site furnishing. Reprocessed tires can be used as substitute for gravel, aggregates or stones. They are characterized by their light weight and compressibility. They can also be included in the manufacturing of rubberized asphalt. Since bricks doesn't have clear edges and even they could break more, it is better to use them as whole rather than crushing them. (Calkins, 2012 kindle version, pp. 8904-8951)

#### *2.5.3.6 Recycled content materials*

These are materials that includes a recycled material in its contents. Recycled content materials have a certain extent of resources and energy consumption, less than new virgin materials but higher than that for reprocessed or reused materials as whole. Many of the materials lose their quality when they are recycled except for metals and some plastics. The type or the quality of the recycled content materials depends upon the purity of the recycled content as well as stating the percentage of recycled content included in the material.

#### *2.5.3.7 Materials decreasing heat island effect*

Paving and roofing have great impact on the heat island effect. For paving, as the reflectivity increases or the lightness of the paving color increases, the heating effect decreases. Sometimes when lightness or reflectivity of pavement becomes very high, blurriness of vision may occur as well. Porous paving or composite paving acts also on the decrease of the heat.

### 2.5.4 Different materials

#### *2.5.4.1 Concrete*

Concrete is considered from the materials to be highly and generally used in the landscape. There are some steps to be done that improves the sustainability of the concrete used for ground pathways (Calkins, 2012 kindle version, pp. 9139-9177):

- Adding some additives to increase the reflectance of the concrete and accordingly reducing the heat island effect.
- Recycled materials can be used to decrease the use of new raw materials in the mixture.

- It could be used without finish which acts to resist the weather conditions.
- Concrete could be made porous to allow infiltration and groundwater recharge.

### *2.5.4.2 Aggregates and stone*

The same as concrete even more, aggregates and stone are widely used as ground cover or as constituent for concrete and asphalt. They could participate in a sustainable landscape through some guidelines (Calkins, 2012 kindle version, pp. 9179-9232):

- Focusing on local aggregates and reclaimed ones to decrease the energy consumed for the production and for the transportation.
- Aggregates can create porous environment for the use of infiltration and groundwater recharge.
- Applying the concept of design for disassembly. Using stones within cages as gabions or attaching recycled aggregates by minimal mortar as for urbanite.

### *2.5.4.3 Asphalt*

Asphalt is considered from the materials that is not environmentally friendly due to the emissions during production and the non-renewable resources used. There several points to improve the sustainability of asphalt (Calkins, 2012 kindle version, pp. 9251-9312):

- The use of recycled aggregates as constituents of the asphalt mixture.
- The production of the asphalt under a lower temperature provides more durability of asphalt, lower energy for production, as well as less emissions during production.
- Increase the permeability of asphalt to support infiltration and ground water recharge.
- Provision of shading on used asphalt increases its longevity as well as decreasing the heat island effect.
- Introducing recycled asphalt to the process of producing new one.

Since asphalt is from the materials of high usage and covers large areas of landscape, different modifications to reach better properties have to be introduced. Due to the dark color of asphalt, it is a material that absorbs a lot of heat. Different colored granules could be added to the mixture giving the asphalt different color to reduce the heat absorption. Other paints could be used also to give a color to the asphalt composed of sand, cement and acrylic polymer binders. The added materials to the asphalt doesn’t affect its porosity.

#### 2.5.4.4 Brick masonry

Although brick production consumes a lot of energy (embodied energy), bricks last for very long time and can be reused again. Bricks consume less energy for production than concrete blocks, even the source of energy is natural gas which is cleaner than coal in the case of concrete blocks. The main factor affecting reuse of bricks is the minimal use of mortar or the use of lime mortar to facilitate the reuse of bricks.

#### 2.5.4.5 Plastics

Plastics are getting more and more common in use and included in many items of landscapes even as complementary or finishing material in many cases. Although many plastics have hazardous impact on the environment and human health but the effect vary from one type of plastic to the other. The higher the recycled content in the used plastic, the less use of virgin resources and the less waste produced. Polyethylene and polypropylene have very low effect on environment than others as PVC, ABS and polystyrene.

#### 2.5.4.6 Metals

Metals are considered a more durable material than wood, concrete or plastics. Metals also have endless recycling opportunity. At the same time, the production and mining of metals consumes large amount of energy, and produces a lot of emissions and toxins. There are some factors to be taken care of to provide more sustainable metals:

- Use of metals under the concept of design for disassembly, i.e. use of bolted connections rather than welded ones for later reuse.
- Avoid toxic coating of metals. Powder coating is better than solved based ones and mechanical coating is preferable than chemical one.
- Reuse available recycled metals to reduce the energy consumed and emissions produced.
- Smooth and horizontal finishes are better to prevent corrosion and accumulation of contaminants.

#### 2.5.4.7 Bio- based materials

Bio-based materials are the ones including renewable agricultural, forestry materials, marine or animal materials. These materials are defined by their feedstock’s harvest within a ten-year growing cycle. The material is considered bio-based when it contains 90% or more biomaterial content. These materials have very high potentials:

- All are biodegradable, and they don’t create hazardous waste materials.
- Makes a good use of the agricultural waste rather than being burned.
- Don’t have polluting emissions and high embodied energy as from the petroleum based products.
- Their costs are lower than conventional materials.

There are minimal drawbacks of these materials:

- Could lead to diversion from food production from arable lands.
- They are exposed to weathering, moisture and UV degradation.
- Data about their environmental effects is still limited.

Some examples of the bio-based materials are:

- **Jute, coir, straw and recycled fibers for erosion control, re-vegetation and mulching:** Can be used instead of plastic products to protect soil from erosion, mulching the soil and could be kept to amend the soil. Straw mulches may be a source of unneeded seeds that helps the spread of invasive species.
- **Bio- based products in concrete and pavement application:** Could act as aggregates and binders in the composition of concrete or asphalt.
- **Bamboo products:** Could replace wood, steel, concrete or plastic. It is characterized by very fast growth even 25 times greater than timber. Bamboo is also used as reinforcement in the concrete. Bamboo could be attacked by insects thus curing should be considered after harvesting
- **Straw bales**

#### *2.5.4.8 Wood*

Wood is considered a good natural material since it is renewable, grown with sun inputs and consumes low energy in manufacturing. Wood is versatile- can be customized-, salvageable, reusable and recyclable. The defects facing using wood is the unsustainable ways of collection and production which leads to deforestation. Some strategies need to be followed for a better sustainable wood:

- Use flexible modes of fixation that allows easier reuse of the wood again.
- Use certified wood which assures the quality and the replacement of the used wood in nature to reduce impacts on nature.

- Use of reclaimed wood which decreases the use of virgin wood resources
- Use of decay resistant wood to assure the longevity of the used product, and limit the use of toxic preservatives.
- Avoid the contact of wood to wet or soil areas to achieve durability.

## 2.6 Conclusion

This chapter is considered the largest according the importance of the ecological factor in the achievement of sustainability on a university campus. Decreasing any emissions, or hazard on the environment is the base. The main focus of ecological sustainability is the reducing the consumption of resources and energy. The higher extent of achievement is reaching a level where the landscape is being productive rather than only consuming. Closing the natural cycle of water, vegetation, soil or materials is a very essential target for sustainability. There are some basic highlights essential for the ecological sustainability:

**Water:**

- Returning the setup of different natural systems and processes to its original state in nature.
- Cleaning water onsite, water harvesting, minimizing use of potable water and decreasing water consumption, minimizing runoff, reusing water, promoting infiltration, and groundwater recharge are different methods to achieve water sustainability.
- Non- point pollution is solved using bio-retentions.
- Compost blankets act to enhance the soil properties, prevent soil erosion, adjusts soil PH value.
- Increasing the surface area of pervious surfaces leads to reduction of runoff and supporting infiltration.
- Creating a connection between channels for runoff and the existing vegetation to decrease the consumption of water.
- When water systems are exposed to public, strong safety measures should be applied to ensure the good quality of water and the security of users.
- Rain gardens with vegetation used have to withstand water and drought since it doesn’t have a drainage system.
- Green roofs used on buildings support: Minimizing runoff, decreasing heat island effect, supporting biodiversity, and could provide edible landscape.
- Vegetative and bioswales work the same as rain gardens and bioretnsions but in the form of channels.

- Using native plants, applying natural pest management and limiting chemicals, limiting turf grass and applying less mowing, using relevant irrigation methods, and minimizing leakage are all methods for water conservation.
- Water harvesting, using gray water, using treated water onsite are methods for recycling and reusing water.
- Optimum case that is always the target of any site is to reach the point where the supply is higher than the demand.
- Different water storage systems could be applied: Surface storage as lakes or pools acting as reservoirs, cisterns, or modified cisterns as volumes underground surface saving space and providing infiltration.
- Irrigation systems should provide the optimum amount of water needed without extras to prevent the waste of water. Dividing the site into hydrozones facilitate grouping plants of same water consumption in zones for efficient irrigation.
- Efficient maintenance and using a good control system for irrigation has a great role to limit leakages and accordingly water consumptions.
- A water budget should be set for the project to plan the storage requirements, vegetation types, water features.

**Vegetation:**

- For creating a sustainable landscape, vegetation should have an ecological benefit: Decreasing water consumption, supporting biodiversity, improving soil quality, reduction of heat island effect, improve water quality…etc.
- One of the sustainable aspects is to keep and save natural vegetation species on site.
- Adequate plant selection depends on: Tolerance and adaptability to the environment, having an ecological function, ease of maintenance (nursery growing- no conversion into invasive), should have a design intend (shading-screening- wind breaking…etc.)
- Vegetation could limit heat island effect through: Increasing vegetation than pavement or covering with groundcover limiting evapotranspiration, providing shade in parking lots, western and eastern façade.
- Deciduous trees could block intense sun rays in summer and allow direct sunlight for heating in winter.
- Phytoremediation is a sustainable way to get rid of pollutants by symbiotic action where the plant breaks or absorbs pollutants as nutrition and cleans the soil.
- Extra care should be given to salvaged plants on site: Supplemental watering, mulching, pruning, protection against wind…etc.

- New vegetation care should include: relevance to site, keeping sufficient distances from hardscape, allowing different maturity ranges to facilitate defect or disease detection, controlling invasive species if available.
- Adding vegetation and soil protection zone to protect the properties of the valuable zone only allowing wildlife accessibility if available.
- Use of relevant native plants onsite compatible with the required use provides better performance of vegetation.
- Appling xeriscaping concept is a major sustainable concept for arid regions including: Limiting grass and its maintenance, mulching, efficient irrigation, using low consuming vegetation, and improve soil quality.
- Dealing with wide spreading invasive vegetative species onsite through earlier detection and relevant method of combating.
- Methods of sustainable production of vegetation include: Using local seeds, limiting use of peat, natural pest management, and use recycled organic matter…etc.
- Vegetative species for green roofs need to tolerate dry and saturated conditions as sedums and succulents.
- Benefits of edible landscaping include: Sustaining food source, decreasing energy for food transport, and the aesthetical value they provide. The used species are preferred to be: Perennial, produces directly without need for extra refinement, have natural pest and infection resistance.
- Supporting a wildlife habitat through the provided vegetation is considered a sustainable method serving the environment.

**Soil:**

- The main goal for soil sustainability is to protect the good healthy soils onsite and improve the qualities of damaged soil.
- Assessment of available soil (healthy- can be restored- contaminated) prior construction has to be applied through ( Site history- Vegetation on site- Hydrology and topography)
- Taking different samples representing different spots onsite and represent soils with heterogeneous composition.
- Replacing soil isn’t desirable for sustainable sites, amending soil is considered better than replacement.
- Soil texture, organic matter, soil compaction, soil volume, PH value, nutrients availability and contamination needs to be assessed onsite.
- Mulch could be used to prevent the erosion of soil.
- Radial trenching with compost or mulch, mixing soils of different textures, and de-icing of soluble salts are different methods of amending soil.

- Any amending of soil should be introduced before adding plants. Local materials and available materials on site are preferred for amending.
- Soil replacement has to be very limited and applied in very crucial cases and preferred to be from the same site.

**Materials:**

- For reaching the sustainability of materials, resources and energy consumed in the material life cycle should be minimized to the highest extent.
- Using virgin resources for production, transportation, disposition of materials and the energy related to these aspects are factors that severely affects the sustainability of materials.
- Embodied energy and embodied carbon are strong factors affecting the sustainability of materials.
- Red list elements should be totally abandoned in landscape materials' selection.
- Certification of materials gives a good indicator for their sustainability of the process of production of the material.
- The use of renewable materials (ex. Bamboo or wood), application of DFD (Design for disassembly) and using materials having recycled content to reduce the used resources and energy is from the main fields of application of sustainability of materials.
- Using reused, reprocessed and recycled or recycled content materials are better for the environment than using new virgin materials.
- Durability, having an ecological benefit (infiltration- reduce heat island effect…etc.), susceptibility to DFD, being locally produced, possibility of recycling are all elements to guide to the selection of relevant sustainable material. Bio-based materials are from the most sustainable materials to be used since they are renewable, doesn't consume a lot of energy for production, can be disposed without polluting.

### 2.6.1 Cross-cutting relation between ecological qualities and other qualities

There are many cross – cutting relations between the ecological qualities and the other physical, individual and social qualities:

- The designer could use the water system on site to provide sort of connectivity between different spaces, defining axes for the project, and highlighting importance of certain spaces.

- The exposure of the sustainable water systems acts on spreading the idea of sustainability supported by an educational process through banners and plates that clarify the process and act as good public relations for the idea of sustainable landscape.
- The adaption of the water systems to certain aesthetical values increases the individual as a user to be accepting these systems as pleasing setup mixed with awareness. The process that water go through could be a nice aesthetical view that users could enjoy as well as the sound of the moving water that could be relaxing and favorable for the human ear.
- As an ecological aspect providing a good spot for social qualities is that a dry detention area from the storm water system could be a field for playing in the time interval between storms as well as it would entertaining spot for the gathering of users to follow the track of water trail.
- The usage of special native plants with distinguished visual character plays the role of wayfinding landmarks as well as giving the campus a certain identity.
- The usage of porous pavements is considered as a simplified model for natural hydrology which has an educational value as well as the social individual quality due to the availability of different types and forms creating a pleasing aesthetical value.
- Edible landscaping having dominant types of vegetation can give a cultural identity to the campus as in the case of Shenyang Architectural University Campus as well as spreading awareness about agricultural processes.
- Old trees existing on site could be a source of character and identity for the campus
- Soil compaction is destroyed by vehicular and pedestrian traffic.
- Reused structures or materials add a social/historical value to the site. Complete structures could be unique and used as a landmark that helps in the wayfinding process
- Water systems available on site could act as a mean to support biodiversity (vegetation or wildlife), thus achieving a double ecological function.

# 3. Individual Use Qualities of Sustainable Campus Landscape

## 3.1 Introduction

Every landscape differs according to three elements. The physical environment which includes the site, the vegetation, the country and so on. The people who interact on this landscape according to tastes, traditions and social conditions. The third element is the interaction of both which highlights the purpose for which the landscape is made, and this shows the importance of the individual use to show the operation of the landscape. (Dober, 2000, p. 3)

"Environment is so significant to human functioning that a person must first construct an understanding of the immediately surrounding environment before he or she can construct a personal identity" (Saari, 2002) The interaction between the user and the environment acts as an added experience since the environment contains the physical and the social setting to the user especially in the type of projects that the end-user (student) is in the phase of identity formation and taking the responsibility of himself after his family being responsible for him.

## 3.2 Legibility and Wayfinding

Wayfinding is an active process that involves the movement through space, reading surroundings and interacting with this space. Thus the process of wayfinding involves physical, mental, and emotional senses. (Dober, 2000, p. 112)

Way finding is represented through the navigability where the user could easily reach his destination even if it is unknown, and depends on three main criteria: First on the user if he can identify his location. Second if the user could find the route to his destination. The third depends on how the commuter can accumulate experience from the process of way finding. (Foltz, 2014)

The first criterion could be assessed through the user's ability to locate where exactly he is, knowing the name of the standing spot or marking it by a unique visible feature. The second criterion is seen through the correct or false choice of the user in choosing the way to move through according to the available guiding signs and directions. The third criterion depends on imageability that is assessed through the availability and proper design of elements of mental map of Kevin Lynch: landmarks, nodes, edges and regions.

There are some principles for effective wayfinding techniques (Foltz, 2014):

- Each part should have a certain identity to separate it from others.
- Landmarks is used to mark way for users and to create memorable points in different areas.
- Provision of well-designed clear walkways, having a clear start, middle and end.
- Separate project into different regions different from each other visually.
- Don't provide a lot of way options in order to decrease the possibility of losing the way.
- The provision of maps and signs in the spots of directional decision making.
- Provision of clear sighted in order to perceive the way easily and catch the way identifiers easier.

## The beginning of wayfinding techniques

After the cold war in the 1960s the topics about legibility and way finding started to become more popular as the complexity of urban spaces increased. Some writers as Kevin Lynch and Romedi Passini started to discuss the basics of way finding and its definitions. Kevin Lynch explained that way finding is related to the image of the place created according to the sensation and the memory. (Gibson, 2009, pp. 13-14) In the current days it is rare to feel the anxiety resulting from the feeling of getting lost or losing your way due to the presence of maps, street numbers, routes and physical landmarks. On the scale of smaller projects including urban spaces the same way finding criteria has to be applied.

"When people attempt to navigate a place for the first time, they face a series of decisions as they follow a path to their destination. There is a sequential pattern to this way finding process- in effect, a series of questions that people ask themselves along the way. Before starting the design process, the way finding consultant must anticipate visitor patterns, understand that logic, and apply it in the planning phase. Then work can begin on a framework for the way finding design program" (Gibson, 2009, p. 18)

The design of a way finding system depends on three factors: The heads or the controller of the organization, the clients or the users that will be dealing with these spaces and the type of the environment that the system will be designed for.

### 3.2.1 Way finding strategies

The strategies of way finding are four, they are based on some urban planning factors: districts, streets, connectors and landmarks as shown in Fig. 51 . The districts are different parts that can be identified or classified according to a common character that separates these districts as different parts. The streets are linear separators as corridors or pathways. The connectors are considered as different paths that meet at a point or a node. The landmarks are any purely obvious space markers that could be a building or a gate. As soon as the designer identifies these physical elements through the scenario of usage then it is much easier to set a way finding program.

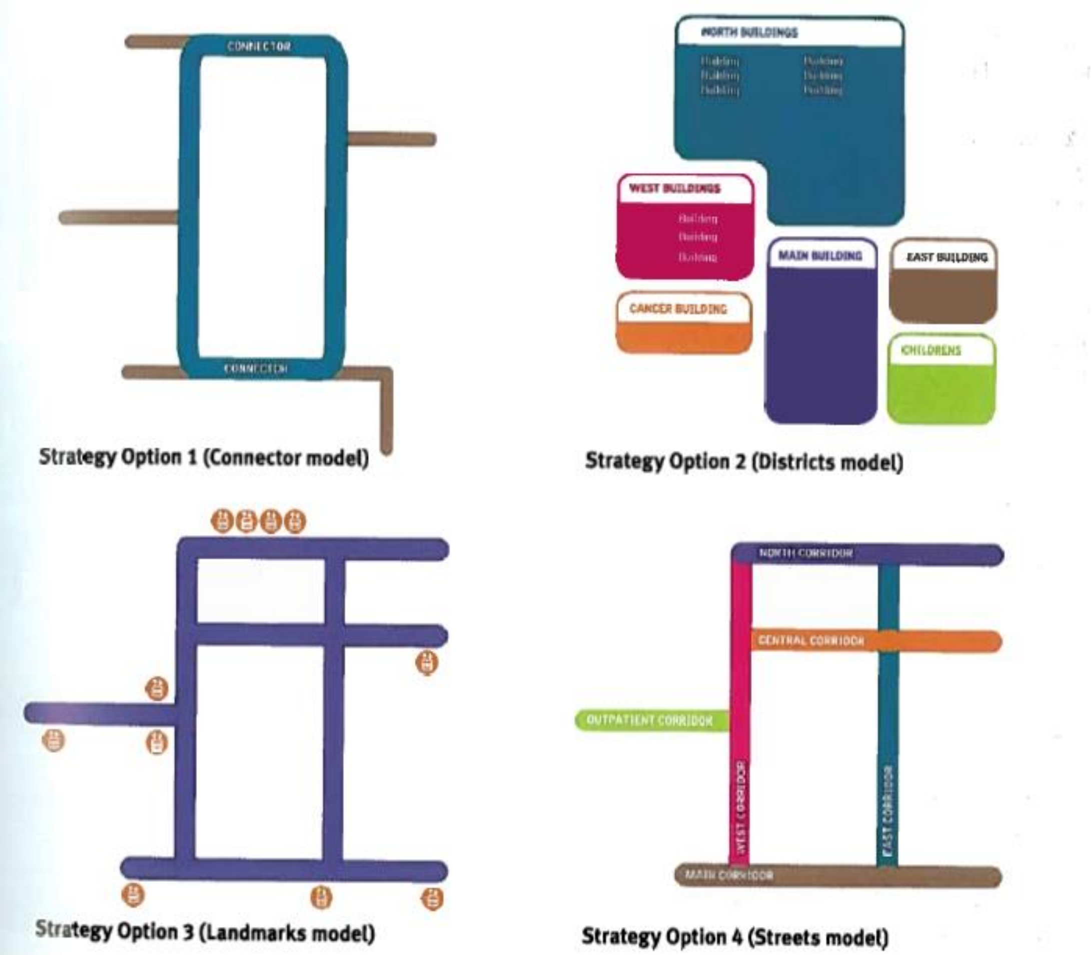



**Fig. 51 Diagram showing the different strategies of way finding (based on a hospital project) (Gibson, 2009, p. 45)**

### 3.2.2 Process of design

The designer starts by studying the nature with observation and documentation of the spaces and the obstacles that might face the way finding plan. Then comes the study of the circulation patterns of the project users in addition to identifying the corridors, landmarks and gathering points. A strong study of the project plans takes place at this phase. After that comes the phase of interviewing of users which gives the idea of how people perceive the spaces, directions and where are the strength points and weak points. This will clarify the hidden items that only the users could feel. The output that the designer produce after analyzing the different components and interviews is set of maps showing the proposal of different signs that could direct the users and they are separated according to the types of circulations: pedestrian and vehicular as shown in Fig. 52 & Fig. 53

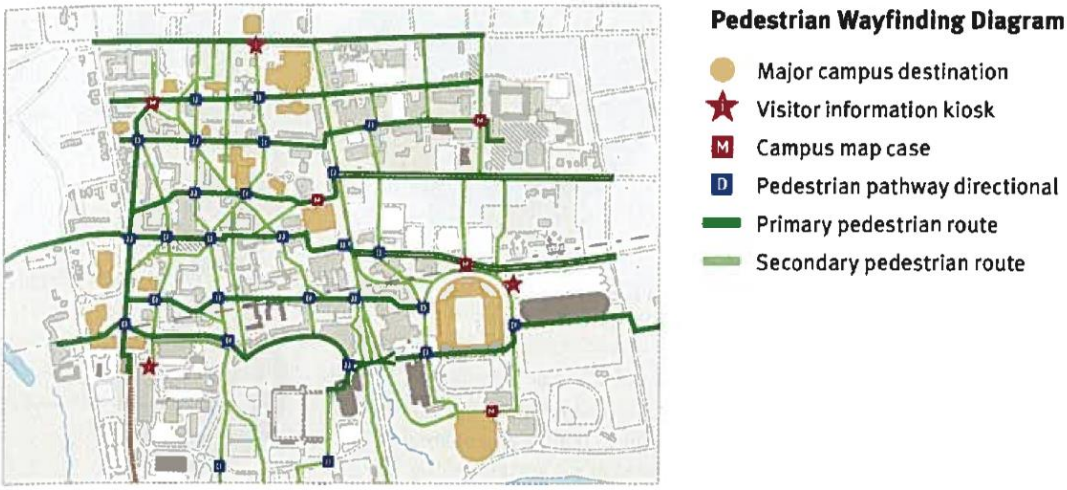



**Fig. 52 Pedestrian Way finding Diagram for Princeton University (Gibson, 2009, p. 43)**

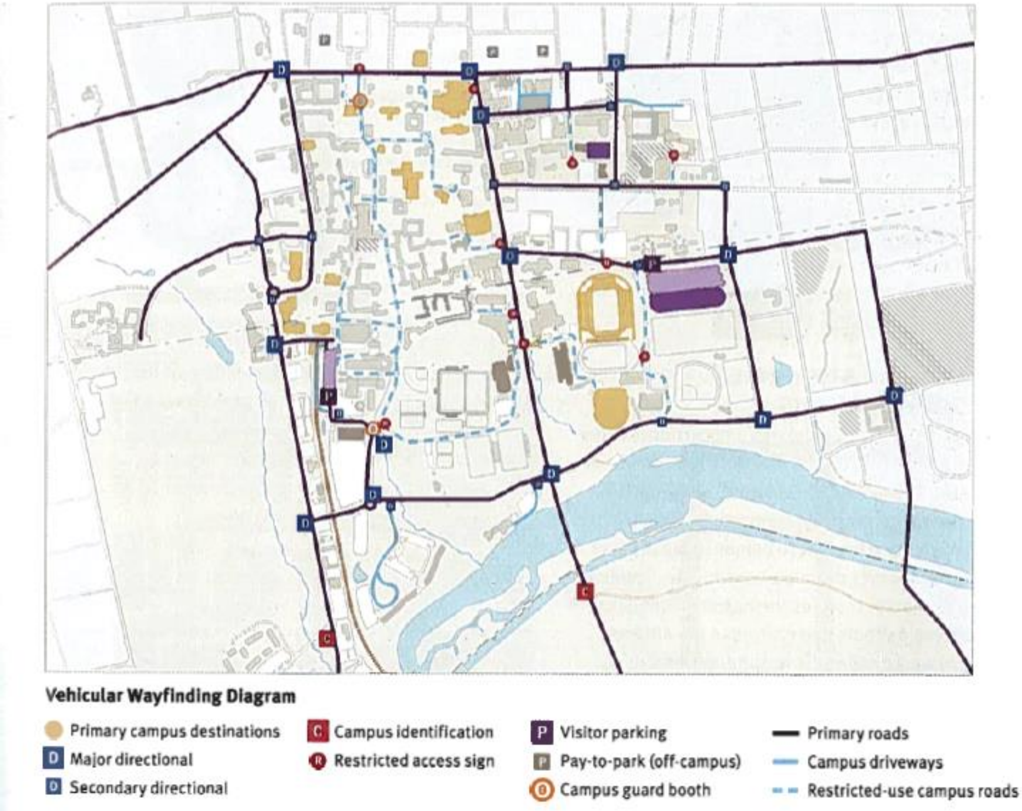



**Fig. 53 Vehicular Way finding Diagram for Princeton University**

**source: Gibson, David. Way finding Handbook. P. 43**

### *3.2.2.1 Different types of signs*

There are four types of signs that may be used on the exterior part of the campus which are:

- **Identification signs**:

It is a visual marker that identifies the function of a building, a gateway, entrances and exits of different buildings. It gives the first impression about the visited building. It is the type of sign that shows the transition from one space to the other. It might include the logo of the building as well.

- **Directional signs:**

It gives the user the basic directions to the destination needed to move from one point to the other. It could take the shape of arrows or symbols giving the sense of direction. The message from this type is to facilitate the movement between spaces.

- **Orientation signs:**

It is located mostly at the boundaries of the project, entryways or the basic focal points. It is accompanied by a map for the whole site with a unique highlight showing the position where you are and its location from the whole site.

- **Regulatory signs:**

This type of signs show the regulations of the place (do's and don'ts). This type of signs should be easily and quickly read to perform its role. The message behind these signs should be sent in a friendly polite way as it is directed towards the space users.

### 3.2.3 Some criteria for the way finding signs and designs

The quality that the way finding targets is easily reading and moving through the different parts of the campus such as: plazas, pathways, entrances, and different buildings. It is preferable when the style of the signage systems reflect the identity of the place as this factor acts as a branding way for the place. An example for that is the signs used for Yale University, known for the blue color that in fact people see as a reflection for the prestigious position of the university. In addition to that the created typeface called "Yale Street" had an added value. Emulating a contemporary style from the "Collegiate Gothic" with the previous factors served the support of the campus identity through the way finding system used. There are some criteria to provide an efficient way finding system:

- The signs should be located in a strategic position that serves an easy way finding system, and the indicator for that is that every user could reach his destination.
- The signs should be readable and easy to understand. Each sign should be modified according to its use, i.e. the sign seen by a walking person would differ from the other seen by a person using a car.
- The typeface size, weight, and spacing affect that users could read and understand the sign. This also depend upon the distance and the situation that the person will be in while reading the sign, e.g. "The ADA (Americans with Disabilities Act Compliance) defines parameters for selecting typefaces to ensure that they are readable for people with compromised vision. The ADA regulations require letters and numbers on signs to have a width-to-height ratio

between 3:5 and 1:1 and a stroke width-to-height ratio between 1:10 and 1:5." Fig. 54 (Gibson, 2009, p. 80)

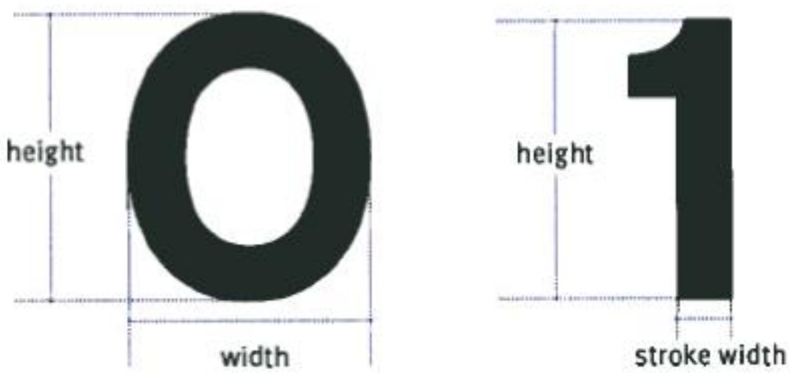



**Fig. 54 Showing the numerical figures proportions (Gibson, 2009, p. 80)**

- The color of text and the background is a very important item that could affect the legibility of the sign. The basic factor that affects this factor is the contrast between the text and the background.
- When a symbol for a sign is very attached to the identity of the project and very unique, this could work as a placemaking factor itself (landmark).
- The designed way finding system has to comply with fire and safety codes.
- In case of large urban projects, the signs are designed and installed in a district of the project until the end users are satisfied and then the system is extended to cover the whole project.

### 3.2.4 Sustainability linked to wayfinding

Sustainable methods and designs are becoming more popular and clients are more aware about their sustainable choices which affects the consumption of resources and has an economical effect as well. Sustainability needs education to spread its bases and effects but in return it has strong beneficial environmental impact and economical effect as the value of resources increases by time thus the usage of optimum and limited amount of resources will be healthy from the environmental and the economical point of view. The methods and designs are:

- According to the field of sustainability, the materials used for manufacturing the signs and maps might be of a recycled materials but has to be of a material that is environmentally friendly which uses the minimum amount of clean energy, part of a renewable material, a material that doesn't affect the ecosystem or could be recycled whether upcycled or downcycled. Examples of these materials are: 3form Ecoresin, Paperstone, EverGreen fabrics, Lightblocks, Alkemi and Plyboo.

- The efficient way finding designer should produce an exact needed number of signs in order reach the optimum usage of the material and at the same time not a less number than needed as it would be of a higher cost to retrofit this shortage.
- Flexibility of components of signs is a good option which gives the opportunity that the sign could be replaced in different positions according to the change of spaces or reused.
- Choosing the position of signs according to the maximum use of natural daylight rather than using artificial lighting.
- Even the sustainability regarding the deconstruction of signs plays an important role in recycling or reusing resources, i.e using bolts and nuts for fixation rather than concrete cast in place or other unrecyclable methods.

## 3.3 Safety

Designed spaces should provide users with safety. Safety is divided into two fields: Safety from hazardous elements whether it is noticed or unnoticed i.e. signs next to construction areas, notifying if plants are sprayed with hazardous chemicals, sign indicating crossing areas for pedestrians cutting vehicular routes. All the previous examples are cases that the user should be notified of for the sake of preventing accidents .Secondly, feel of safety by providing an environment that is comfortable for users without the fear of using, staying or approaching the space i.e. dark spaces that give the feeling of being uncomfortable, pathways with high density of vegetation that gives the fear of being isolated, and spaces that are isolated without any public surveillance. All the previous examples show the effect of factors that could only give the emotional and psychological feeling of fear without the tangible factor of hazard.

### 3.3.1 Safety through design criteria

The safety measures for all landscape elements should be provided according to the correct design and the idea that all users- disabled or not- could use these elements easily without any hazard or being uncomfortable.

There are different hazards that should be taken into consideration (Deasy & Lasswell, 1985, pp. 38-39):

- **Clearance hazards**:

It is very important to take into consideration the height that allows the passage of people under any built structure.

- **Object hazards**:

This include sharp edges or any element that could cause harm i.e. plant, sign post, screws…etc.

- **Collision hazards**:

Signs and alerts have to be done to prevent any collision between vehicles and pedestrian.

- **Stability hazards:**

One of the main causes of injuries, could be due to the absence of factors that prevent stumbling due to slippery ground, unclear difference of levels or even the absence of handrails for stairs as a support for old people.

### 3.3.2 Safety through individual perception

University campuses are special social cases since they have different age groups with different backgrounds and the stranger-to- stranger relation is more possible which could introduce a sense of emotional fear when the factor of comfort is not present. The presence of huge green and open spaces that could also sometimes have a sort of hiding spaces makes the campus landscape a source of emotional fear unless the design is providing good lighted places with good surveillance. (Nasar, Fisher, & Grannis, 1993)

"Perceptions of personal safety, as well as actual safety, influence the extent to which places and spaces are used. The design of streets and places can reduce crime and anti-social behaviors making places and spaces feel safer, which in turn can enhance the physical, mental and social well-being of community members. The presence of pedestrians, the thoughtful design of housing, other buildings and public spaces has the potential to increase natural surveillance, which improves safety and feelings of safety. This is one of the key principles of 'Safer Design' or 'Crime Prevention through Environmental Design" (Planning Institute of Australia, Canberra; Australian Local Government Association; National Heart Foundation of Australia, 2014)

"Amenity and safety of spaces are accomplished through creating a desirable view where buildings' opening overlook to provide good surveillance of the street and the activity within, thus producing a safe space." (Newman & Kenworthy, 1999)

In general space user tends to mix between prospect (ability to see, and to get a good view of the space for interaction) and refuge (possibility of privacy and being hidden from the surrounding people) (Appleton, 1975). In case of crime, these concepts are used to the extremes where the criminal is highly hidden and having a detailed overview of the space where attack will take place. Even limiting the possibility of escape provides a higher state of control for the criminal. Thus, a mixture of light, surveillance and possible means of escape routes are essential for providing emotional safety. Herzog and Kropscott in 2004 highlighted that the lack of defining landmarks, and low level of ease of movement gives a negative predictor of perceived danger.

At some spots as parks, crime rates are less than other public and private areas but at the same time the provision of well-designed shrubs and trees that prevents isolation is always preferred by different users to feel safe, although there are no factors that could lead to crime. Another mean to cover this emotional factor is to encourage and inspire activity and intensity of use. (Burgess, 1994)

There is a margin between providing general safety through fences and boundaries and reaching a limit of isolation that could lead to the change from a defensible space to a defensive design that could make a crime easier to commit. (Thompson I. H., 2000, p. 147)

Other elements of infrastructure as signs, lighting systems, seats, shade and shelters increases the possibility of usage and accordingly social interaction which decreases the chance of psychological fear of place.

A case of crime was committed in San Francisco College in the daylight due the presence of a stairway hidden by a big shrubbery that made this spot somehow hidden or isolated. The same accident was repeated and the college took responsibility due to the delay to cut off this shrubbery to provide surveillance or to provide any mean of alert for people passing from this part. (Nasar, Fisher, & Grannis, 1993)

There are some consideration to be taken care of to enhance an emotionally safe space:

- Design different pedestrian pathways overlooking different spaces to provide surveillance and the same for buildings and car parks and preventing any isolated spaces.

- Providing clear sightlines and good lighting for different pathways and ensure that vegetation is pruned to prevent any blockage of sightlines and provide surveillance.
- Different security systems and surveillance as cameras, security points should be applied to different spaces in order to make the users secured when using different spaces on campus.
- Design spaces in a way that provides variety of uses to enhance the social presence for a long time to give the feeling of security.
- Decrease the use of underpasses that prevents the natural surveillance.
- Locating bus stops at spots separated from blocking fences or walls that could prevent the natural surveillance.

According to (Nasar, Fisher, & Grannis, 1993) any object higher than 45cm (shrub, wall…etc.), wall of minimum 1.8 $m^{2,}$ and trees of trunks (branches are included in case of evergreen trees) over 91cm are considered as a hiding obstacle. A distance of 4.5m from any obstacle is considered enough distance to deal with any threatening situation of fear. This dimension was based on testing through three females moving at night and indicating comfortable distances of feeling secure. This distance also complies with proxemics indicating 3.6 as enough distance for evasive action.

## 3.4 Territoriality and identity

From the different place-making tools, four of them are applied to the case of campuses: Style, materials, landscapes and landmarks. Any campus that could be worth remembering as a design should one or more of these elements. The essence of a university campus giving it a certain identity is based on both the institutional factor that the university is presenting and the image that is formed in the mind from interacting with this place. “You try to arrange architecture and landscape, new and old, on the site so as to serve and symbolize the goals and objectives of the institution” (Dober, 2008)

As an example for that is the usage of bricks in different forms on Duke University Campus as a style unifier. The effect of previous factors should act on vision, symbolism and aesthetics as the three dimensions for superior results for identity of campus. (Dober, p. 14&112)

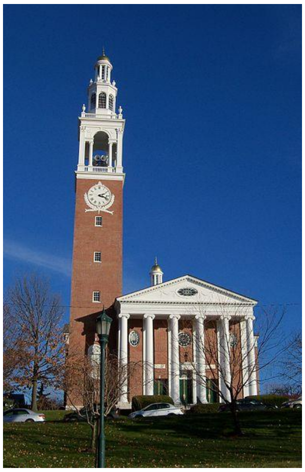
### 3.4.1 Placemaking by buildings and building elements

As defined in the dictionary, landmarks are prominent features that identify a locale. There are five landmarking techniques which includes: Buildings, architectural elements, monuments, color and special spaces. Some landmarks are designed to be identified and standing out others start to acquire their properties from usage, special occasions or historical background. The same visually, some landmarks are eye catching due to its grand or unique shape while others could be unique according to their strange appearance that the eye couldn't ignore them. (Dober, 1992, pp. 13-14)

As an example for a landmark as a building, the academic building in Fisk University Fig. 55 shows the value of an old two storey brick building that holds history in itself since the whole site of the university is considered National Historic Site. Fisk University was known to be a university for black people. The academic building was known to be a library that was designed by two earliest America's black architects- Moses and Calvin McKissick- and currently contains historical paper with the university functions. The building is awaiting the third renewal process to sustain its value creating a special sense of place. (Dober, 1992, p. 18)

**Fig. 55 Academic building of Fisk University (Fisk University, 2014)**

Another example for buildings as landmarks creating a sense of place is the case of the University of Vermont. Three buildings on campus give the sense of continuity of the architecture of the building with the change in the internal usage keeping the same architectural style from outside. Billings building **Error! Reference source not found.** which was converted from a library into a student center without any change from the outside. The same for William's building Fig. 58 which was converted from a science building into a building of arts and anthropology keeping the same gothic architectural style. And Ira Allen Chapel Fig. 57which was changed from a religious building into a concert and lecture hall. (Dober, 1992, p. 18)



Other buildings are not of a monumental scale but owns their place-making

**Fig. 58 William building on Vermont Univ Campus**

**Fig. 57 Ira Allen building on Vermont University Campus**

**Fig. 56 Billings building on University of Vermont Campus**

factor through their historical background. An example for that is the Manasseh Cutler Hall Fig. 59 on Ohio University Campus. It is known for being the oldest college building in the Old Northwest, and it is named after the minister of New England who wrote the charters of the university. (Dober, 1992, p. 22)

**Fig. 59 Manasseh Cutler Hall in Ohio University (Ohio University, 2014)**

Different building elements, when very obvious and eye catching are abstracted and used as logos for the campuses which accordingly become landmarks that the campus could be identified with. Examples for that are: Restored towers of Northwest Missouri State University, the spire of Mc Donough hall in Saint Joseph College, steps of Lowe Library in Columbia University Fig. 60, Tower of University of California in Santa Barbara Fig. 61 known as the tallest tower in Santa Barbara.

**Fig. 60 Steps of Lowe library in Columbia University**

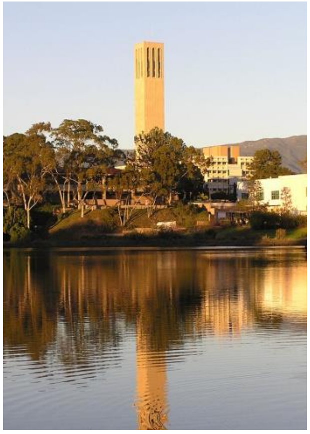


**Fig. 61 Tower of University of California in Santa Barbara**

Colors play a great role on campus, some colors widely used on campus are associated with creating a clear identity or landmark for the campus. Example for that is the purple color for New York University Fig. 62. The color takes place in some architectural elements, banners, and even garments for graduation and athletic events. The red color of Muhlenberg College Fig. 63 is another example for how can color create a campus landmark. (Dober, 1992, p. 34)


**Fig. 62 The purple color of New York University**

**Fig. 63 The crimson color of Muhlenberg College**

### 3.4.2 Landmarks of landscape elements

Different landscape elements are constant including: Rocks, plants, water, terrain, and man-made structures. There is no change in these basic elements and alone they can't create a landmark or a place making factor. The composition of these elements creates the landmark. The good design gives a clear and unique landmark and acts as an edge between authentic and artificial design. A successful landscape that has a mark has to be like a code that is unique. These codes could be changed during time according to the different time settings. The site arrangement plays an important role and the relation between elements acting as foreground or background. The different designs have to keep the time factor in mind and how different elements may be affected by time. Different unique landscape elements not only become landmark for the campus but also could become a representing logo for the university.

Sometimes when the site is having a unique geographical feature, it can be used in favor of creating an identity for the campus landscape and enhances place-making. As an example, Minot State University that used the natural features related to glaciers and ice features to give a vernacular and unique identity to the campus. Coulees that are formed from glacial flood water in addition to the buildings have defined different paths and social areas on campus. Glacial erratic Fig. 64 are utilized as sculptures, sign foundations, benches and other site amenities. Eskers, moraines and potholes, and ice drags are other different natural features that can be utilized when developing the shape, pattern and topography of campus outdoor spaces. (The Clark Enersen Partners, 2008, pp. 7-9)

**Fig. 64 Glacial Erratics used over Minot State University campus landscape (The Clark Enersen Partners, 2008, p. 4&9)**

Also spots with unique sculptures or artwork that could be related to the environment gives a defined identity to the campus as in the case of Minot State University campus Fig. 65 when the designer made use of sculptures resembling icebergs that suits the surrounding environment. (The Clark Enersen Partners, 2008, p. 24)

Places with ceremonial values on campus could also add value to the identity of the campus. A flagpole, formal entrance, main round-about…etc. All these elements could be unique and identify the campus when they are linked to historical occasions or ceremonial events. These factors could lead those scenes to be logos for the university or even the mind image that people could link the campus to.

**Fig. 65 The integration of icebergs as sculpture with the landscape design elements (The Clark Enersen Partners, 2008, p. 36)**

Outdoor art elements are becoming more popular. It is either pure artistic elements or related to the university. In some cases the grouping of these artistic elements outdoor creates an open outdoor museum or art figures are uniquely placed having a certain value or history for the campus. From the known examples are: The heroic scale monuments in MIT, the abstracted sculpture that decorates the lawn behind the oldest building in Princeton University, and smile provoking scissors in Arizona State University. (Dober, 1992, p. 201)

### 3.4.3 Style as a factor of place making

Style of different elements on campus is the generation of different forms creating a vocabulary that is normalized and repeated according to design and the materials used. The style is less tangible than other elements and has a visual and aesthetical impact. The style of a campus acts as indicator of the institutional presence. (Dober, 1992, p. 39)

There are different types of styles of campuses:

- **Monoform:**

It is the campus that has one style that is unified and normalized over the whole campus. As Princeton University (collegiate gothic style), Scarborough College (contemporary style).

- **Metamorphic:**

It is the campus that has an abstracted style from an original one that is adapted to the time and the available craftsmanship. Duke University West Campus and Stanford University are examples of this style type.

- **Mosaics:**

It is the campus that is composed of different styles together without having a unique defined style. Bowdoin College is an example for this type.

## 3.5 Aesthetics on campus

"Appleton (1975) gives the habitat theory an aesthetic dimension by stating that satisfaction, experienced in the contemplation of landscape, stems from the spontaneous perception of landscape features which, in their shapes, colors, spatial arrangements and other visible attributes act as sign stimuli indicative of environmental conditions favorable or unfavorable to survival. The theory begins by identifying environmental perception as a key to all adaptive behavior." (Ramanujam, 2006)

Appleton states that human have the same perception of living creatures towards their habitat and this theory is known as “habitat theory.” He explains how some of the aspects that we perceive are likely to be needed more immediately than others, particularly those that relate to self-preservation from sudden, unexpected danger. Since the first impression gives the indication of evaluating the whole aesthetical qualities, creating attracting scenes of beauty is highly important and first impression is highly attached to factors of safety and feeling at ease. The first is the opportunity to keep open the channels by which we receive environmental information (All the senses are involved, but in considering “ landscape” we are naturally most concerned with the sense of sight and therefore can be justified in using the word “seeing” to describe this process). The second is the opportunity to achieve concealment, and this gives us the twin bases of our simple classification of “prospect” and “refuge” (Appleton, 1975). The previous theory had a huge impact on the aesthetics of architecture and landscape.

Aesthetical qualities of landscape are not only indicating beauty or visual amenity only but it is also indicating the functioning of the landscape system. Valuing the aesthetics is objective that it can't be normalized or set according to rules. Some people consider the variety and complexity of landscape indicate the ecological functionality of the landscape system while others connect green and natural environments to wellness and mental health. An example for the variable perception of the proposed landscape items is the residents of Gigha Island in Scotland calling their wind turbines as "The dancing ladies" due to their belief that their aesthetical value is acquired through their functionality apart from their monstrous and gigantic profile. Thus, the aesthetical evaluation of landscape varies according to the people perceiving the landscape and also differs according to the time and the location of the landscape.

The role of vegetation appears in a study performed on the University of Jordan where users prefer spaces with shade provided by vegetation, i.e. graduates and seniors prefer sitting under a group of old pine trees that has historical value on campus where they enjoy silence comfort and shade. Almost unanimously, these studies have shown that vegetation was one of the most powerful elements in enhancing personal preferences and that trees and vegetation played a special role for people (De Groot, 1992; Francis, 1982; Kaplan, 1983; Naveh & Lieberman, 1993; Ulrich, 1981; Vining, Daniel, & Schroeder, 1984). (Abu-Ghazzeh, 1999)

Vegetation according to (Olmsted, 1865) "employs the mind without fatigue and yet exercises it; tranquilizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system"

Natural elements provide different characteristics that have good impact on the person perceiving the natural scene (Lau & Yang, 2009, p. 56):

**Being away:** Not the physical setup is the intended meaning but the emotional feeling is the one that gets grabbed to the beauty of the nature forgetting the stressful environment of living.

**Fascination:** The variety of colors, natural order and even the sequence of natural processes provides the surprise and the pleasing effect on the receiver.

**Extent:** Entering a garden that could cause the total change of the surrounding environment and the senses of the receiver are grabbed with the scenery conveying the feeling of miniature and extent.

**Compatibility:** The natural settings, most people function with the least effort which make people function better and acquire mental benefits. Natural settings are also the best for practicing different activities: sports, eating, socializing…etc.

### 3.5.1 Visual Character

The first source for creating a visual character for a campus is looking ahead to the surrounding environment. The physical composition and surroundings of the site that gives a uniqueness of the site is the main source of inspiration to the designer helping him to set the scenario creating the visual character of the campus. This value of the site is more valid in the case of a new site than in an existing one. From the examples in this matter is the new campus of the American University in Cairo. The selection of the new site came based on heading to the edge of the metropolitan expanding city and at that spot the Egyptian desert with its unique vastness and essence was the main source of ideas. Another case is the location of F. W. Olin College of Engineering that is surrounded by rolling topography, dense trees, wetlands and springs as well as remnants of old stone walls and regional gas transmission line. All these factors gave certain features for the visual character of the college (Dober, 2000, p. 72).

## 3.6 Conclusion

The output of this field of sustainability targets the ease of use and the continuity of success of the used and planned systems to perform efficiently for the users.

**Wayfinding:**

- The user should easily locate himself, reach his destination and experience a unique movement that could give an unforgettable navigability that keeps a memorable image in mind.
- The designer should focus on the legibility of nodes, landmarks, districts and pathways or connectors.
- Minimizing the available options for navigation makes the system precise and easy.
- Users, decision makers and the environment are the three poles that have a great input in designing the wayfinding system.
- For the efficiency of the system, several factors have to be considered:
    - Selection of position of signs.
    - Readability of signs and compatibility with codes.
    - Relevance with safety and fire measures.

Elements of wayfinding complying with environmental and economical sustainability:

- Recycled and bio-based materials to be used to manufacture signs' components.
- Applying the disassembly concept for the change or the reuse of the system's elements.
- Making use of daylight for lighting the signs better than electrical consumption.

**Safety:**

- Physical hazards have to be taken into consideration from the design initiation.
- Surveillance, lighting and suitable dimensions of shrubbery or trees are from the main factors for the creation of a safe place emotionally.
- The balance between the prospect and the refuge is the source of giving the feeling of safety.
- Activation of spaces through social interactions provides a good feeling of safety.

**Identity:**

It is the definition of the image of the entity in minds and what would identify this institution if it passed through the mind. Several elements could enhance the composition of this image: (Unique or historical buildings- special style- landscape elements- architectural landmarks- colors- used materials). The designer's role is to create through his designs the needed clear image for the user to perceive and keep in the mind.

**Aesthetics:**

Elements creating beauty include natural scenery: water, greenery…etc. Appling the methods of visual design could help achieving the aesthetical values too. Evaluating aesthetics is not manageable due to the difference in taste from one person to the other.

# 4. Social Qualities on Sustainable Campus Landscape

## 4.1 Introduction

According to Paul Selman’s paper “What do we mean by sustainable landscape?” Different opinions in defining social sustainable landscape were revealed. Some stated that it is related to decision making and participation and access (Moore- Colyer & Scott, 2005), others are into the interaction between the person and the surrounding environment and how it is perceived and understood including navigability and use (Olwig, 2005) and this accompanied by the feeling of security and safety which is related to the individual use quality discussed previously. On a higher level of abstraction, social sustainability is identified by the social relationships between people such as friendship, group membership…etc. defined by the surrounding physical items of landscape and surrounding uses which was rarely tackled in research. These items together perform the entity of the social sustainability of landscape.

Kenney believes colleges are losing their sense of community for seven reasons: a loner lifestyle, busy lives, suburbanization of the physical campus layout, residential trends away from dormitory-style living, faculty and student commuting, erosion of community dining, and increased diversity of constituencies on campus. Campus designers must provide a safe and comfortable place for commuter students to integrate into the campus community. (Kenney, Dumont, & Kenney, 2005)

According to the definition of social sustainability from Hawke Research Institute discussion "A life-enhancing condition within communities, and a process within communities that can achieve that condition." There are some indicators complying with this definition, some of them are concerning the non-physical social aspect which is discussed: (McKenzie, 2004)

- " A system of cultural relations in which the positive aspects of disparate cultures are valued and protected, and in which cultural integration is supported and promoted when it is desired by individuals and groups." Based on this statement providing a healthy social space served by the physical space may lead to the social sustainability of campus outdoor spaces. Since the statement is very wide for larger scales, public participation and cooperation for decision making could act as a strong role in the direction of social sustainability.

- " A system of cultural relations in which the positive aspects of disparate cultures are valued and protected, and in which cultural integration is supported and promoted when it is desired by individuals and groups."
- "A sense of community responsibility for maintaining that system of transmission."

- "Mechanisms for a community to collectively identify its strengths and needs."
- "Mechanisms for a community to fulfill its own needs where possible through community action."
- "Mechanisms for political advocacy to meet needs that cannot be met by community action."

"Although the design professions work with different materials and employ different techniques to solve their problems, they share their only client-the human race- in common." (Deasy & Lasswell, 1985, p. 9) Mostly to the landscape architects, planners, and architects the functionality of the space is in the first place, but at the same time the space couldn't function properly without taking the social aspect into consideration. Social interactions are the fuel which activates the space and allows it to perform its function. A space without social interactions is useless. "The quality of campus is recognized by its sense of place and the activities occurring within it." (Dober, 2000) That gives a great importance to the social relations between different users on the campus.

When studying the social factor on campus, other points have to be included as the cultural environment or the ethnological character. Internally inside the university we have at least two social groups: Faculty and workers or administration. The cultural and social differences between these two groups and the other groups that could be included: undergraduate, graduate, part-time, alumni, scientists and researchers have to be separated when studied. (Waite, 2003, p. 84) These factors also could change according to the location of the campus. The cultural character of the campus differs and has a cultural reflection of the country and the society and the social standard it is located in.

According to studies about interaction between humans and the surrounding landscape, the interactions of different users together are included as a source of effect on the landscape and being affected by it at the same time: "Transactional theories complement information processing theories. Both emphasize the way in which people construct their perceptions of the landscape in cognitive maps. However, transactional theories emphasize that people do not stand apart from the landscape, but rather are participants in the landscape in a situation of “mutual influence”. Ittelson’s (1973) transactional framework for the study of environmental perception is summarized in the following list of considerations excerpted from Sell et al. (1984, p. 71-72):

1. Landscapes surround. They permit movement and exploration and force the observer to become a participant.

2. Landscapes are multimodal. They provide information that is received through multiple senses and that is processed simultaneously.

3. Landscapes provide peripheral information. Information is received from behind the participant as well as from in front, from outside the focus of attention as well as within.

4. Landscapes provide more information than can be used.

5. Landscape perception always involves action. Landscapes provide opportunities for action, control and manipulation.

6. Landscapes call forth actions. They provide symbolic meanings and motivational messages that can call forth purposeful actions.

7. Landscapes always have ambiance. They are almost always encountered as part of a social activity, they have a definite aesthetic quality, and they have a systemic quality. These considerations clarify that human beings act in and on landscapes, as well as landscapes providing information and experiences to people." (Nassauer, 1995)

In many cases human behavior is considered unpredicted intuitively as the reaction differs according to the case as well as that the human character is included as well. There are some outlines that could be set that logically and by multiple applications showed the success to fulfill a good environment that users could easily interact and build up social relations within.

As an example of unpredicted human behavior: People were complaining from the noise in an office. After the office was quieted, they started complaining of the voices of people using their telephones. Although people's voices were not as high as the equipment's' noise, but the voices were a more distracting factor for people surrounding. (Deasy & Lasswell, 1985, p. 11) This could have another pattern in another office, and that shows that human behavior cannot be normalized. Building on that, guidelines and criteria discussed later as social qualities are general ideas that change from case to the other and that is shown more through the empirical part.

Many social aspects are very similar to each other that it is hard to separate them or distinguish them solely as for example: friendship formation and group membership or personal status and territoriality. Each has a certain character but they affect each other as they are based upon human nature. (Deasy & Lasswell, 1985, p. 18)

### Different types of social interaction

According to Peter H. Mann social interactions are classified into three types (Mann, 1954):

- **Manifest interaction:** This happens when a social group agrees or have a fixed plan for meeting each other and spending time. Considered as planned group event such as: Performances, receptions, or demonstrations.
- **Latent interaction:** It occurs when two strangers meet and interact according to necessity that appears. An example for this type is a costumer's dealing with a vendor or a visitor asking for directions.
- **Spontaneous interaction:** It is an accidental interaction that occurs between people knowing each other but without planning for such a meeting. An example for that is a coincidence between friends or a student-professor on the spot encounter.

## 4.2 Friendship formation

As a definition for friendship formation: "Friendships are formed on the basis of shared interests and backgrounds. As interests, hobbies, family, or careers change, people become open to new friendships that are then formed are largely affected by opportunity. People make friends from contacts at school, at work, in their neighborhoods, and at clubs and social gatherings. Contact is an indispensable part of the process" (Deasy & Lasswell, 1985, p. 18)

By all means there is no way to literally encourage friendship but there are some criteria for space design to create an environment that could encourage social connection rather than creating an uncomfortable environment that could cause people to abandon these spaces, feel unsafe or feel that their privacy is being broken through.

According to the studies of social relations in colleges' dormitories, offices and housing projects. Proximity plays a great role in initiating social connections. Mostly people choose their friends from the circle surrounding them. In offices, studies showed that workers had 39% of their work friends in the range of 12ft around. As the distance increases the percentage decreases. Only 11% were friends in the range of 36ft. Even the percentages of friendship between roommates was 90% in case of sophomore dormitories and 86% of senior years had their roommates as friends from their freshman dorms. It is not only about the physical closeness, it is the functional closeness that causes the interaction. An example as a reflection on landscape, two spaces could be visually connected but separated by a grid like fence which is not a strong barrier but at the same time it limits the social interaction. Physical closeness is present but social is not. The same is applied for two attached spaces, but one is only elevated than the other, a non-physical separation is created. Thus the landscape architect could set a scenario for the spots that he enhances for social connections and the other that should not.

According to Granovetter, when person "A" knows person "C" and person "B" also knows "C". In that there is some sort of common time that "C" spends with "A" and "B" together, this leads to a high tendency for a friendship to initiate between "A" and "B" (Granovetter, 1973, p. 1362) . This concept goes with Homans' idea that the more mutual interactions that members are exposed to, the more that they could initiate a friendship connection together.

On the other hand, not all the campus users could be of one type or homogeneous. Some people could be very social, having a large scale of friends on different levels of strength of those friendships. Others could be a little bit less social limiting their circle of groups to certain groups only or a small limited amount. Some of the people also are a bit much less social than the others, they may be included in different social occasions, but mostly they are not taking place and prefer to remain as audience. Based on the different levels of sociability, minorities with minimal social connections preferring some sort of extra privacy need some sort of spots of isolation, relaxation or privacy. These people may like to spend time reading, meditating, enjoying the nature...etc. alone. These aspects should be taken into consideration by the landscape architect while designing in order to provide a design suitable for the most.

### 4.2.1 Some criteria for friendship formation in open areas and walkways

There are several conditions that could be applied to parks to enhance friendly contact and the points could be used as guiding points for outdoor landscape areas on campus:

- Making activity areas visible from the perimeter of different parts of the open space. Parts with activities could be elevated or not hidden by green areas which facilitate the visual accessibility and attract people passing by.
- Create more shortcuts that could provide intensive traffic enhancing social connectivity thus the chance of friendship.
- Making walkways intersect with zones of activity which could make the commuter take the position of a spectator increasing the social connection.

- Provision of sort of spots that accommodate performances ready for spontaneous performances or activities gathering people around. This could be applied for centered plazas or main spines where students could perform or announce about their activities or even create fairs that could engage people passing by.
- Provision of seats by entrances and nearby each of the available activities as well as that the flexibility of seats in organization gives the possibility of creating different number of seated groups according to the need.

Eye contact is the start point of any social connection. It is considered rude to neglect a short saluting conversation at least when two people see each other accidently, and that is mostly the case on walkways. Thus it is important to take into consideration some criteria for walkways:

- Provision of a small space for standing away from the pedestrian flow of the walkway for a short talk.
- Provision of seats outside the traffic flow as a mean of social connection and provision of a place to rest.

## 4.3 Group membership

The state of being part of a group or not is a factor that gives identity to the person. Group membership is considered as an extension for the friendship formation and this shows the social nature of the humankind. In general most people are tending to be part of small groups as it is easier for interaction and as a result of small social groups, members could easily represent themselves as well as taking decisions and a better field of participation. (Rached & Elsharkawy, 2012)

Studies show that 71% of the groups in public places contain 2 individuals, 21% contain 3 members, 6% contain 4 members and only 2% contain 5 members or more. (Deasy & Lasswell, 1985, p. 20)

Since people prefer to gather in small groups, then it important in landscape to provide seats with a composition of small number of units. Also in large group gathering such as parties, receptions, and fairs, people tend to be moving around and as a result social groups change in size frequently. Thus the landscape designer should keep in mind the flexibility of seats according to group formations. Groups are generally composed in the spots where activities with social interaction occurs. Then it is required to add to the concept of positional social connectivity for friendship formation the presence of a social activity that fosters the formation of groups and social membership.

In hot dry regions as Egypt, the provision of shaded parts in outdoor areas is an essential factor that could enhance users to reach their comfort zone and interact more easily and freely creating a healthier environment for social connections as group membership and friendship (Rached & Elsharkawy, 2012, p. 7).

### 4.3.1 Informal social centers on campus

Students usually engage themselves with different social groups to give some identifications to themselves. It is not a territorial identification but it is a place where they could see and sit with friends maybe several times a day Fig. 66. Sometimes these places are related to studies as classes' corridors or outdoor spots related to certain labs and others are related to a specific landmark: A certain tree, the entrance of a certain building or even steps of a known staircase. These spots are spontaneously selected which could cause problems with the usage of the project, so it is better that it would be initially planned serving the needs of the users. There are some criteria that could help in planned provision of these spots. These criteria are (Deasy & Lasswell, 1985, p. 98):

- It would be better linked to the main circulation system. If it is away, then an attracting activity needs to be added to compel the users from their daily circulation movements.
- It is most likely to be successful at crossroads, major destinations or conjunctions with food services.
- Seats and tables need to be added to these spots.
- Shelter against the sun or the bad weather has to be added.

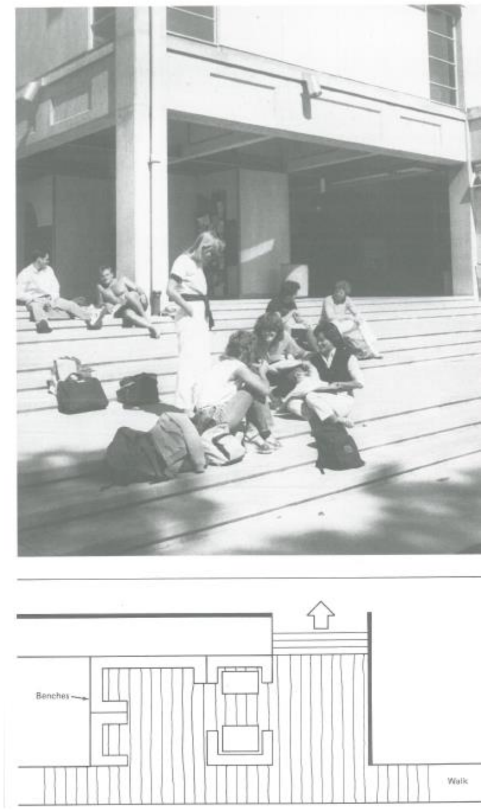



**Fig. 66 The informal social centers spontaneously created, and the provision of seats limiting these centers to spots other than the ones blocking the pathways. Source: (Deasy & Lasswell, 1985, p. 99)**

As a matter of cultural differences, some societies prefer or feel more comfortable setting some sort of differentiation of groups' presence or interaction according to gender. Discrimination is not the case but privacy and the issue of being conservative is the idea behind group separation or not.

## 4.4 Communications

Communications is considered a human nature that people perform in order to understand the surroundings, to exchange information, to understand the attitude of surrounding people and to express thoughts and ideas. The role of the landscape architect is to provide the suitable ambient for these communications to occur easily and comfortably. The designer should focus on several factors:

- The provision of suitable ambient conditions that facilitate and foster communications between people.

- Provision of clear and readable signs (covered in individual use qualities) in order to support the communications between the institute and the user to clarify different zones, buildings and activities. The design of different spaces and the visual representation of each space indicating its usage. Thus every space is communicating its message directly.

There are several points in order to provide a suitable ambient for social communications:

- In places with traffic density, provision of a side standing zone is essential for facilitating commuters' communications.

- Places known for being a spot of gatherings should be provided with seats. Flexibility of seats to be suitable according to preferences. If it is not flexible, it is preferable to be distributed at 90 degrees to enhance the communication between people.

- Sufficiency of light and provision of appropriate color of light. This matter helps the clarity of communicating people rather than focusing only on the tables or different items of furniture.

- Minimizing or separation of different activities that could cause noise interference blocking the smooth communication between the different users.

## 4.5 Identity and territoriality as a social quality

Identity can be defined as the sense that people make themselves through their subjective feelings based on their everyday experiences and wider social relations (Knox & Marston, 2004). The process of place creation has a great impact on the formation of the individual identity as well as the group collective identity. Through the place affiliation, the individual and the group initiate their identity tied to the place created and that depends on the strength of this affiliation and how they tie themselves to it. (Kyle & Chick, 2007). That could act as social identity that is tied to the physical space.

In another study in 2004, Stedman et al. examined the image of the identity for a social group that lived around a national park in Canada where people were identifying themselves according to the social relations attached to these places, memories and social bounds that were contained in these places rather than the physical properties of these places. (Kyle & Chick, 2007) That point highlights the pure social definition of territoriality and identity that could generate from pure social connections.

Kennedy sees that the university campus is losing its social identity because of many factors: humanity in general is tending to sole lives, life is getting busier, suburbanization of physical campus spaces, less community gatherings and huge amount of diversity. He is proposing that students mostly not living in the student dorms lead that the students are not involved or attached to the social identity of the campus. Then it is essential, that the campus should enhance and allow gatherings in order to support this social identity of the campus community.

Territoriality is one of the factors of human behavior and its relation to the community surrounding as well as the place possessed or used. Territoriality is considered temporary as it is different from pure ownership. A student on campus should have a territorial aspect feeling that he for example possess a seat in classes, has his own storage space. Although it is not ownership as it changes from one batch to the other but this type of territoriality creates a sort of identity that the student acquires alone or as a part of a group, team or an activity group.

Reflecting on the surrounding landscape, groups and individuals should have their sense of territoriality towards their campus' open spaces. Having tendency to use or occupy certain spaces that is comfortable for the activity they are doing. e.g under a specific tree, in a specific courtyard, next to a specific building or on a large lawn space providing a large space for certain activities. Participation of the users in the planning process on campus is one of the main factors affecting the feeling of territoriality. (Deasy & Lasswell, 1985, pp. 28-29)

## 4.6 Different Social Distances

In different cultures and societies, individuals would always like to keep fixed distances between themselves and the surrounding people. These distances or spaces vary according to the interaction, the situation and the social affinity between the people dealing together. These distances vary according to different cultures and traditions. The different distances are (Deasy & Lasswell, 1985, pp. 20-25):

### a. Intimate distances

It is the shortest distance and it ranges from direct contact to 18 inches. It includes family, lovers, children, very close friends. The presence of strangers in such a distance is not comfortable for any person. In some cases such as dense queues, elevators, in a bus or in a subway, the person comes to a state of being static in stressful phase like a cocoon that remains until the high density phase is over.

**b. Personal distances**

These are the normal spaces between different people. Exceeding these limits by strangers are not accepted socially. It ranges from one, one-half feet to four feet. It is the distance in the case of stretched arms.

**c. Social distances**

It ranges from 4 feet to 12 feet. It is the distance for different public interactions. The lower range from 4-7 feet tends to be less formal than the more formal range from 7-12 feet. The less formal range includes working environments or social gathering. The more formal would be limited to formal work meetings. Starting the range of 10 feet as a distance being away, the worker could continue working in the present of the client, guest or employer and it is not considered rude. The distances 12-25 feet are considered non-involvement where the passing person could continue movement without having to stop and exchange greetings.

## 4.7 Spatial separation due to social characteristics

“Physical performance in any social interaction can be read as classed behavior. Who greats whom, who touches whom, who initiates introductions are all dimensions of class” (Barratt, 2011). People are classified according to the class bubble that they belong to. Users who are of the same intellectual, and economic level are grouped and share experience together. Students are classified sometimes on campus i.e. athletes, geeks, parties, politicians…etc. Some of these categories are present in all campuses and others are limited to certain ones. Segregation according to these factors is not healthy and people who could adapt to different levels are more social and could easily interact. The field work explores the factors and different cases that could create different social bubbles and could lead to special segregation (Barratt, 2011, pp. 12-14)

Different spatial order of people in different spaces give a strong indication about the cultural differences between different groups and gives a strong background about the social and behavioral level these groups belong to. (Hillier & Hanson, 1984)

Distances are factors that appear to be controlling the interactions socially, but it is not the case for social space. In social space similarities in social standards, common activities and interests are the factors that cause attachment and interaction between different people. The physical connections seem to be the factor leading to social interactions, although physical proximity could only lead to accidental interactions according to this physical situation. Not only the social standards affect the social interactions, but also the hierarchy of the community present in the physical space and the position of each individual formulates the social groupings in real from a pure social perspective. (Bourdieu, 1989)

To understand the social connections and interactions on a large scale, it is very important to understand the social structure and connections on a small scale or on the scale of small groups which gives an incremental picture of social environment on a larger scale and this is considered as grading from micro social scale into macro social scale that includes political, societal and community interactions. (Granovetter, 1973)

As an example to the social separation of different social groups, in the faculty of engineering, Ain Shams University, one of the inner courts attached to the cafeteria is called “CH” referring to Christians. Most of the Christians are present there. That doesn’t mean that other religious groups should not be present but it shows the spatial separation according to different social characteristics. The same is applied to the American University in Cairo, some spots are assigned as the “Gucci corner” having the fashionable students that are maniac about brands.

## 4.8 Gender differences affecting social quality

Not all universities are the same regarding the gender differences issue. The segregation and difference according to gender mainly depend on whether the university is public or private, the culture of the region or country.

According to a study on the University of Jordan, men are dominant in all spaces on campus while women are staying in corners and hidden spots than those men sit in. This shows that men are more dominant than women which forces the designer to create variety of spaces that suites and provide comfort for both. (Abu-Ghazzeh, 1999).

This is not the case in many of the contemporary university campuses now in Egypt. The social segregation according to gender is not present anymore. The only separator is the kind of activities that could be preferred by a certain gender than the other i.e. sports and that is not present in many cases.

## 4.9 Public participation and its impact

According to Hillier and Hanson (1984) who state “plazas cannot be designed without the functional uses determined by the social groups who will use it." (Hillier & Hanson, 1984) And also Relph discusses the importance of a sense of place. He proposes that places matter to people and must be constructed through the involvement of people who live and work in them (Relph, 2002). These two statements indicate how important public participation in landscape design is. People in general like the feeling of having control and decision on what they live in or deal with. An effective way of gathering info about the requirements of the users and a step towards getting them involved is through surveys, observations and interviews. When people are more involved they get more involved to accept, protect and improve the service they get since they are part of controlling it.

"There has to be a participatory campus planning process, involving representatives from campus constituencies likely to be affected by the study outcomes. The collegial process defines the list of improvements. And of course people have to be realistic about degrees of urgency and site realities" (Dober, 2008)

According to (United Nations Environment Programme, 2013) , primary stakeholders are the staff and the students, and within those classifications particular groups and individuals are included as:

University leadership (President, Heads,….)- Key operational departments- Academic experts in sustainability- Staff associations- Students' associations- Student clubs-Alumni- Public and private sector funding bodies- Families of students – local community where the university is situated.

The definition of public participation is the unpaid voluntary activities undertaken by users of the project that influences the governmental or decision making side according to the democratic accountability. Public participation is mostly performed for landscape regeneration projects. It is performed through "stakeholders" which are representatives of different groups interested in the current state of the project or the change that may occur. (Benson & Roe, 2000, p. 294)

Participation is not only about including users or their opinions, it is about setting the idea that users are responsible for their projects and their decisions and they are controlling their own conditions. Application of participation methods proved success to fulfill users requirements as their opinion is the nearest to the solution since they are most attached to the real situation (Abedi & Mahdavinejad, 2011). Not only does participation provides success of project, but also provides the success of different groups cooperating together, attachment to the space and sustaining the success of the project by the involvement of users in different decisions. (Benson & Roe, 2000, p. 323).

There are some indicators of the success of the participation process. These indicators come from answers to questions that show signs of success or failure of the process:

- Does the number of participants vary along different events? Or is the required number achieved and increasing?
- Have common goals and targets been identified or settled upon?

- Does the digestion of the project occurs? (i.e. less time to present the whole case and outcomes?)
- Have the process created a sense of ownership through participating representatives?
- Has the project achieved obvious results on ground?

Although the participation process is very essential and important, many landscape architects reject it, put some suspects on its efficiency and some claim that they can't perform it except in a very limited group. Others think that they are not well trained or adapted to deal with the participation procedure. (Thompson I. H., 2000, p. 161)

## Types of public participation (Thompson I. H., 2000, pp. 130-132)

**Charrette:** It is a way of temporary participation that involves different stakeholders but has a quick end and considered as brainstorming sessions more than participation process. This technique could last for days or even for weeks.

**Workshops:** Are similar to charrette process but is more time limited, more focused and can be included in longer participation process

**Planning for Real:** This method involves building a three dimensional model of the case to be discussed and the input from different groups are applied on a physical scale

**Design Game:** It is with the same system as "Planning for Real" but is used for the inclusion of a larger number of people.

**Public Meetings:** These are useful in case of needing an approval about a decision. The problem is that it can be driven by a small group of people and other could be silent with active participation.

**Steering group:** In this process, the designer or the design team is subjected to representatives that have regular meetings in the design and implementation phases. The benefit of this system is that it applies transparently the needs of the user.

**Focus group(s):** These methods are applied quantitatively through surveys that have fixed answers to choose from. The other method is qualitative one through interviews and open ended questions to know the feedback from the side of the users

**Community Forum:** It is a meeting for the community activists that discusses the community issues. This method couldn't reach discussions turning to actions except with more ends directed organizations.

## 4.10 The relation between physical spaces and social interactions

According to a study done on the University of Jordan, 80% of the campus participants prefer non-academic outdoor spaces related to recreational activities. In the selection of the majority, uniqueness of the space combined with the activities they like to practice. (Abu-Ghazzeh, 1999)

The social interactions are enhanced in spaces supplied with facilities i.e. shade, seats, food outlets, good view...etc. The distance of reaching the spot also is directly proportional to the presence of activity in this space. The interconnectivity of spaces as well the presence of activities plays a great role in the revival of the social interactions in the space. Disconnected spaces or uncomfortable spaces i.e. not well lit, has a repelling action for social qualities.

## 4.11 Conclusion

- Visibility and connectivity of activities could act on creating a good environment that accordingly could enhance social interactions.
- Flexibility and provision of seats attached to users' dense zones would also act to enhance social interactions.
- The provision of suitable ambiance and shelter to protect from bad weather conditions is essential for ease of communications and social gatherings.
- Provision of sufficient light and proper color of light supports better communication between users at night time.
- Creating a balance on campus between the availability of crowded social spaces and spaces complying with privacy and sole usage is essential in order to be serving different users' preferences.
- Participation of users in the design of the campus landscape is highly crucial because the users could touch and deal with matters that the designer could not perceive from his position.

## 4.12 Generation of basic checklist, questionnaire and questions for interviews

By the end of the theoretical part the checklist that would be used for the empirical part is generated. The checklist was based on literature available, experience from different campuses and reports for sustainability audits and finally the list was revised according to the points of the SITES rating system. The used checklist was in the same format as the final one provided in the conclusion. The elements were classified into: acquired, partially acquired, not acquired, not applicable to the case and an extra slot was added for the proof or comments. This list was discussed with a landscape expertise for validation before the empirical phase.

The design of the questionnaire and the questions for the interviews (Appendix A) were applied. For the interviews, the questions were organized according to the same organization of the thesis' topics. The questionnaires (Appendix B) was based on more basic and defined issues that require large numbers to describe and analyze. The interviews were used more for further details achieved from the interviewees.

## 4.13 Cross cutting relations between 4 studied qualities

The attached table shows the possible cross-cutting relations between the 4 qualities discussed previously in the theoretical part and their possibility of interaction and affecting each other. By the end of each of the studied cases, this cross-cutting table is applied. The red stated points are the negative points. The black indicate positive common points. In the case based tables, the green points are specified to the case. The underlined points indicate that they are different from the checklist.

Table 15 Cross cutting relations between 4 studied qualities (Kindly check the folded table)

# PART 2 EMPIRICAL PART

# 5. Case Studies: American University in Cairo, German University in Cairo & British University in Egypt

## 5.1 Introduction

Three recent contemporary university campuses were analyzed as case studies. The aim of analyzing 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. AUC (New campus) was opened in 2008, BUE in 2005 and GUC in 2003. 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: Largest is AUC which is 1052183 $m^2$, GUC is 577000 $m^2$ and BUE is 27000 $m^2$. 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.

New Cairo and Sherouk including cases are considered as arid environments having rare amounts of rain annually. The temperatures are highest on average in July, at around 27.5 °C. January has the lowest average temperature of the year. It is 12.5 °C. The least amount of rainfall occurs in May. The average in this month is 0 mm. With an average of 7 mm, the most precipitation falls in January. The variation in the precipitation between the driest and wettest months is 7 mm. During the year, the average temperatures vary by 15.0 °C.

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

## 5.2 British University in Egypt (BUE) Fig. 67

According to the university statistics, the number of enrolled students on campus were 3916 for year 2012. The needed sample was 94 based with 10% margin of error. 53.3% were males and 46.7% were females. Most respondents were students, therefore the workers and academic staff minimal results were based on interviews.

The samples Fig. 68 are mostly covering different departments and buildings on campus according to the capacity of each department.


**Fig. 67 BUE campus map**

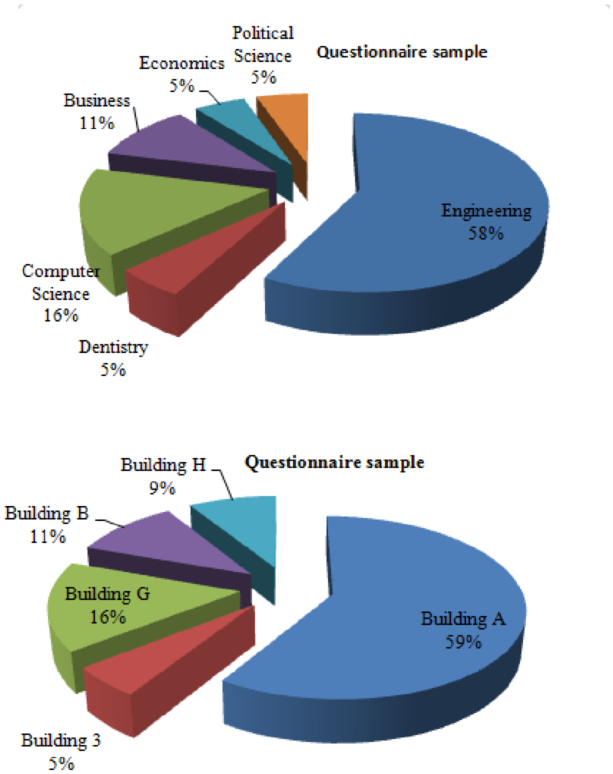



**Fig. 68 BUE's questionnaire samples according to buildings and departments**

## 5.2.1 Physical qualities on campus

### a. Connectivity:

The campus is composed of one axis starting after the main icon on campus which is the auditorium with the Colonial styled dome and continues in the middle of the campus having buildings of different schools on both sides. The main axis is split in many different levels that are ascending towards the end of the campus from the main gate. These pathways are supported by ramps to facilitate the movement of all users. The campus connectivity to the outside is achieved through three gates that are currently active: The main central gate and other two side gates on each side are the most active on the campus now. According to questionnaires, the majority of campus users suffer from the very long distances of walking on campus but still consider it walkable Fig. 69 & Fig. 70. One of the main highlighted point is that the newly opened food court is very far to most of the campus since it is located at the far end of the campus.

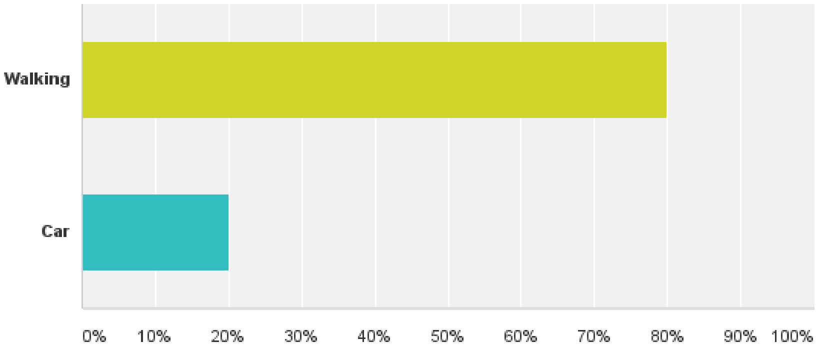



**Fig. 69 BUE respondents' preferred mean of movement**

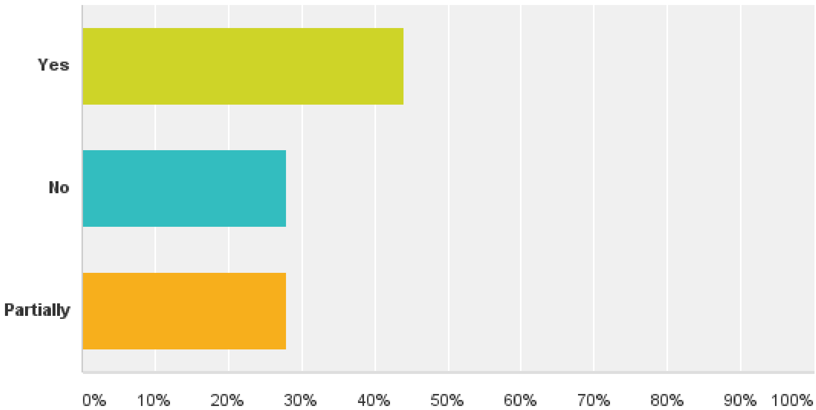



**Fig. 70 BUE respondents' being tired of campus movements**

The connectivity between the pedestrian circulation and the vehicular circulation are fine. Only the vehicular road present is a slow flow road only for parking of staff and is cutting the campus once before the start of the pedestrian axis. Different pathways on campus are interlinked together creating good connectivity between different pathways.

**b. Gateways:**

The gates are indicating the parts for entrance, but the logo of the university is only placed on the main gate. The other gates only share the common Colonial architectural style Fig. 71.

**Fig. 71 Side gates on BUE campus**

**c. Different circulations on campus** Fig. 72**:**

Pedestrian circulation is having the priority on campus. Consistency of flooring materials on campus is achieved which visually bonds different pathways together. Mostly all users suffer from the lack of shading devices on campus. The provided pathways are not sufficient when compared to the number of students that is exceeding the capacity of the campus. The main spine of the campus is highly activated since most social activities (student activities, food booths, building entrances) are located on this main spine.

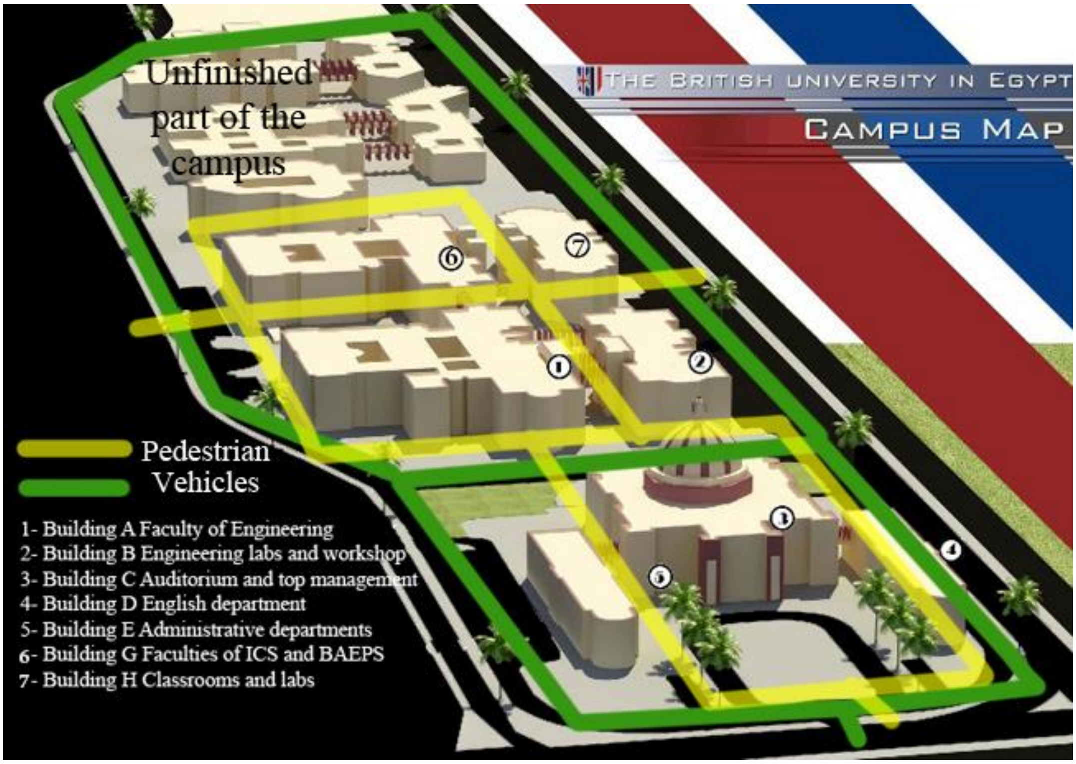



**Fig. 72 Different circulations and buildings on BUE campus**

For vehicular circulation, drop offs are not provided except for the main ceremonial building. The absence of separate circulation as well as specific areas for services separated from the internal circulation loop used by the staff on campus since only vehicular circulation for staff is supported on campus. The width of the internal roads are very narrow that barely could allow the passage of large scale of service vehicles as trucks.

Cycling is not available on campus and would be a bit hard to apply on campus due to the narrow pathways and the large slope differences between different zones. Apart from these obstacles, users would prefer to cycle on campus. Fig. 73

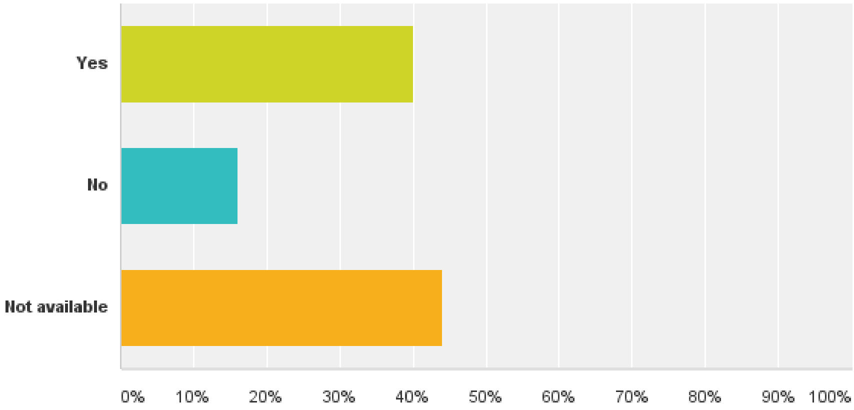



**Fig. 73 BUE respondents' cycling preference**

### d. Spaces:

No pure main space is available on campus. The scarcity of available spaces enhancing social interactions, mostly depending on the only garden present on campus, the food court and athletic area, otherwise other available spaces are narrow linear spaces, implicitly created by kiosks on the main spine of the campus. Even the space provided at the food court is not sufficient for the amount of users on campus. Many undedicated, not having a hierarchy, small spaces in front of the buildings are mostly used by many students as it is the space near to different lecture halls. The absence of enough shading devices and mostly the enclosed spine by buildings is shaded partially by them. Most of the large spaces are partially enclosed by buildings and some are opened to the outside Fig. 76. The absence of any open spaces dedicated for university staff. According to all these aspects, users prefer indoor spaces to outdoors Fig. 75.

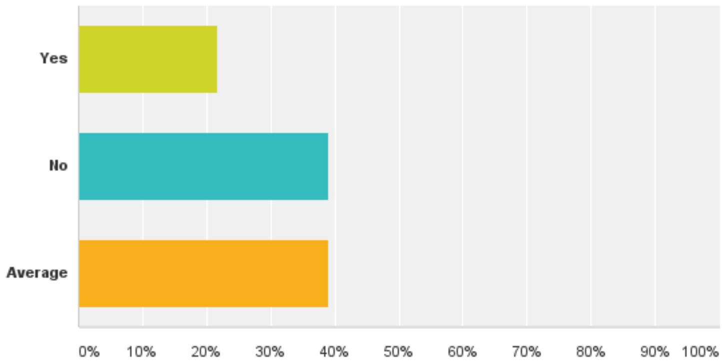



**Fig. 74 BUE respondents' answers regarding available active spaces**

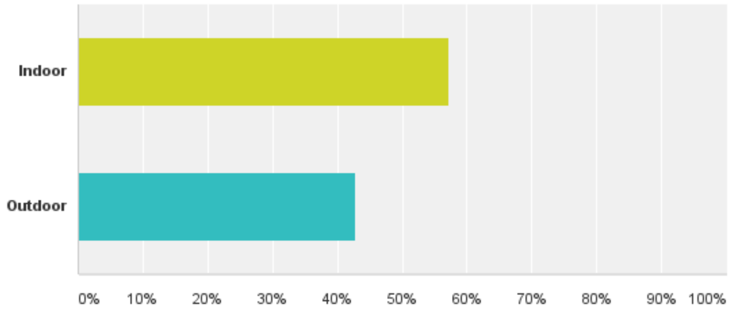



**Fig. 75 BUE respondents' preference between outdoor and indoor spaces**

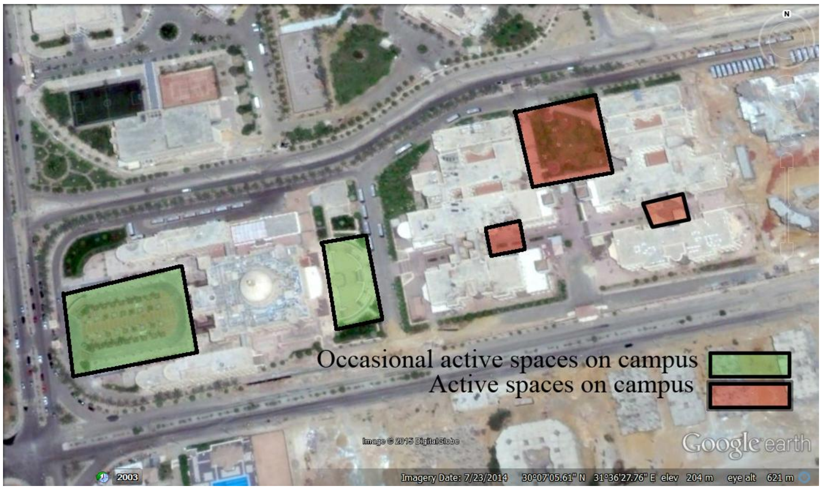



**Fig. 76 Different spaces on campus**

### e. Facilities:

According to SITES measures, water and wastewater infrastructure were provided before building the campus as Al Sherouk was provided by complete infrastructure before the operation of the campus, 7 service elements are located in the same building within less than 0.8 km from the campus, but it was built after the campus, and an informal stop for microbuses is initiated in front of the campus.

No renewable resources of energy are used to generate electricity on campus. Absence of any initiative for garbage separation or recycling on campus, also no facilities as: drinking fountains, emergency call boxes…etc. are provided on campus.

The absence of any parking for students inside the campus which doesn't provide any chance to minimize the car use by carpooling incentives and as well as creating a traffic jams outside the campus boundaries. An underground parking Fig.

78 is created under the auditorium area in order to make better use of spaces. This parking is used for ceremonial events and for the staff in the addition to the vehicular loop around the campus where staff could also park Fig. 77. All parking for staff is free of charge, so there is no incentive for staff to go for carpooling. The only chance to decrease the use of cars is the provision of the university buses covering a large network and available for staff and for students. Usage of buses is higher than cars which is better environmentally Fig. 79

**Fig. 78 The entrance of the underground parking from the main gate**

**Fig. 77 Side roads used as staff parking**

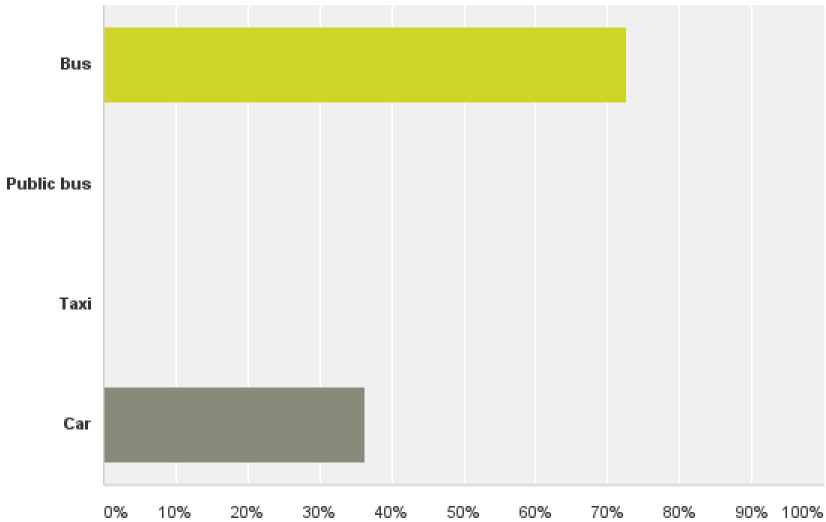



**Fig. 79 BUE respondents' means of reaching campus**

**Fig. 80 The inconsistency of street furniture**

Street furniture don't have a consistent style, neither are considered to be of local materials Fig. 80. Many of the street furniture are very heavy and are not flexible for movement. Above all these matters, furniture is not well allocated according to a design to support the ease of use by the users. Majority also indicate that they are not comfortable to use and not enough Fig. 82 . Many places on campus lack shading devices Fig. 81.

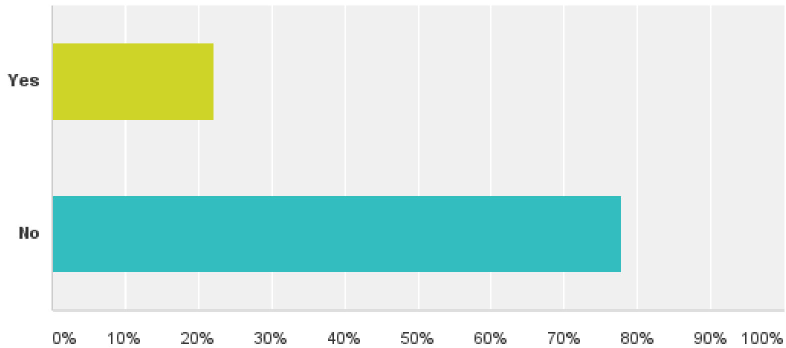



**Fig. 81 BUE respondents' opinion regarding shading on campus**

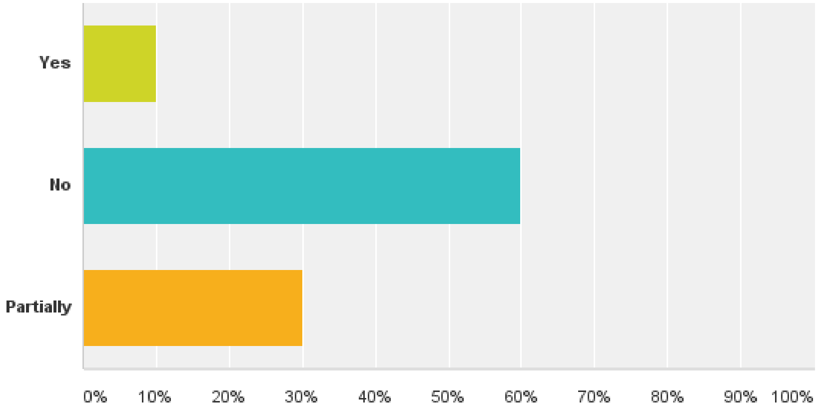



**Fig. 82 BUE respondents' opinion regarding sufficiency of street furniture**

In the new phase, new LED lights are used to reduce the amount of energy used for lighting. Fig. 83

**Fig. 83 LED lights used next to the food court**

## 5.2.2 Ecological qualities on campus

### a. Water:

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.

**b. Vegetation:**

Most of the vegetation used onsite is purely for the aesthetical preference. None of the used species are having an ecological value as well as none of the used species are native to the region. All the species are the common ones that could be used and adapt to site environment without taking into consideration of the water consumption of the used vegetation. Only productive palms are grown on site, but the product is not well used as a food resource to be used locally or to be sold in the market. Also lemon trees are planted on campus without taking into consideration whether they would be productive or not. They are used only for the aesthetical value of the vegetation. Users don't notice any sustainable ecological factors on campus landscape except minimal amount indicated the fruit trees in bad condition Fig. 84

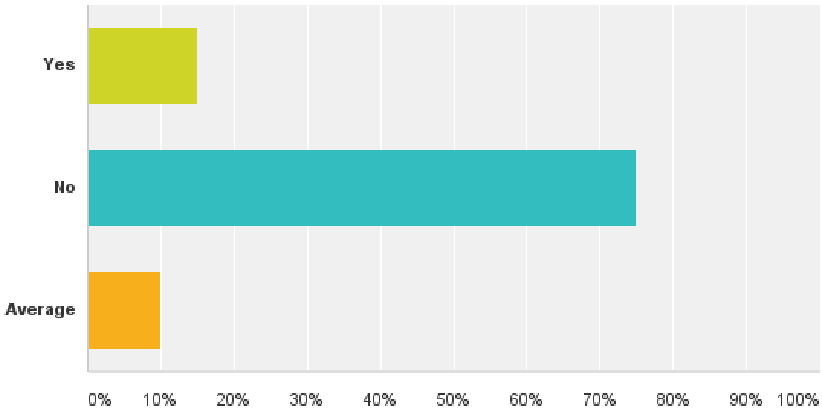



**Fig. 84 BUE respondents' opinion regarding availability of sustainable ecological measures**

There isn't a nursery on campus for the sustainable production of different vegetative species on campus. Invasive species that may appear on campus are always of a weak origin, that it dies just through cutting as well as the planted species are well inspected before planting on site to prevent the spreading of any pests, diseases or invasive species. All seeds used on site are locally produced in Egypt or onsite. Most of the used species are perennial species to provide a good image for the campus all over the year. Most of the used fertilizers are synthetic. Only a small amount of compost is used. None of the plants on site are salvaged from the pre-constructed site, since it was a desert without any available vegetation. The used grass is Brisbane 10 which is from America but it is accommodated to the site. Some parts are having the same grass, although it should be Tifway to overcome the intense pedestrian movement Fig. 85.

**Fig. 85 On the right, Brisbane with high pedestrian movement and on the left side without movement**

### c. Soil:

Most of the soil tests to approve the suitability of the soil are not made on site. Soil is amended by the use of manure and if it doesn’t work soil is replaced by local sand from Al Sherouk which is suitable for the selected vegetation Fig. 86. Compost is used but in limited way because of the high cost. Compost is not locally produced by the campus. None of the construction materials are used for the amending of the soil.

**Fig. 86 The use of sand as a growing medium for vegetation**

### d. Materials:

The detailed measures of sustainability for materials e.g. wood certification, EE & EC, recycled content, bio-based materials…etc. are not taken into consideration for the landscape of the campus. Some of the rubble work for building retaining walls is using the stones and rocks resulting from the cut and fill on site.

None of the red list of materials which are banned internationally are used on campus. Some of the used materials can be reused again as the interlocking blocks and the wooden pergolas that could be disassembled and relocated and reused. The durability of many of the materials is not well considered since many of the flooring is having damages that is related to the climate or the soil. Fig. 86

**Fig. 87 The wearing of many flooring materials on campus**

## 5.2.3 Individual use qualities on campus

### a. Wayfinding:

The campus is completely without any outdoor signs. The campus is not defined into definite spatial zones except that the buildings are given different letters to be identified although the similarity between these buildings are very high.

People don't frequently lose their way due to the small size of the campus Fig. 88 , but for a new comer it is hard to find the way easily without any efficient wayfinding system.

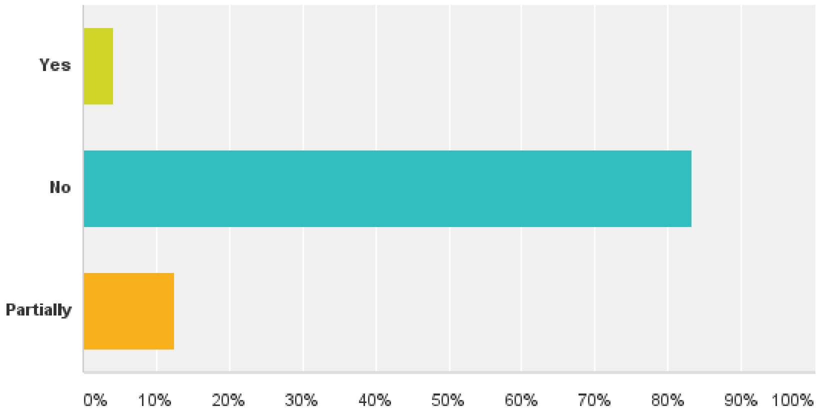



**Fig. 88 BUE respondents' answers to losing way on campus**

Most of the landmarks Fig. 89 on campus are related to spaces associated to common activities e.g Beano's is the most known kiosk on campus providing food and drinks located on the main spine, the only garden present on campus is another landmark associated by sitting on the lawn, chatting, playing or using the food outlets located on the garden. The Auditorium's dome is the only physical landmark that is prominent on campus.

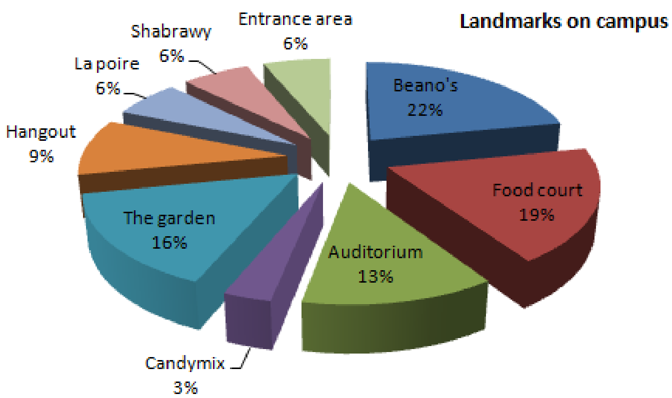



**Fig. 89 Landmarks on BUE campus according to questionnaires**

### b. Safety:

No physical hazards are present on campus except for the steps leading to the only garden on campus Fig. 91 and Fig. 90 . All the steps are broken and all users complained that they stumble on these steps. The construction site of the following phase of the campus is directly opened to the existing one. This may lead to physical hazard or the emotional feeling of being unsafe.

Regarding emotional safety, many complain that more lighting is needed on campus, but the security guards and security cameras are totally covering the whole campus.

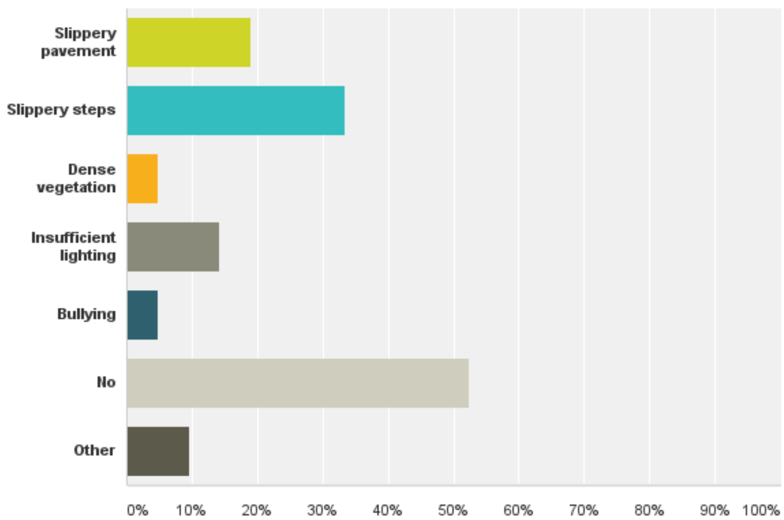



**Fig. 90 BUE respondents' answers regarding safety measures**

**Fig. 91 BUE's broken steps that causes stumbling**

### c. Identity:

The main factor that give the BUE an identity are the colors of buildings, the classical colonial style and the uniqueness of the dome of the auditorium Fig. 92. The landscape doesn't give an identity to the campus due to the minimal use of the landscape elements.

**Fig. 92 The unique Colonial style, colors and auditorium's dome**

### d. Aesthetics:

The users are not fully satisfied with aesthetical qualities of the campus Fig. 93 & Fig. 95 . The lack of green spaces was the main reason Fig. 94.

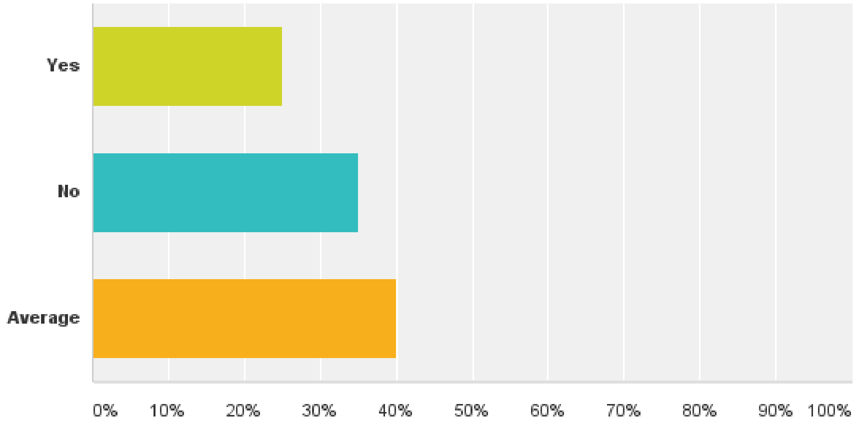



**Fig. 93 BUE respondents' answer regarding uniqueness of campus**

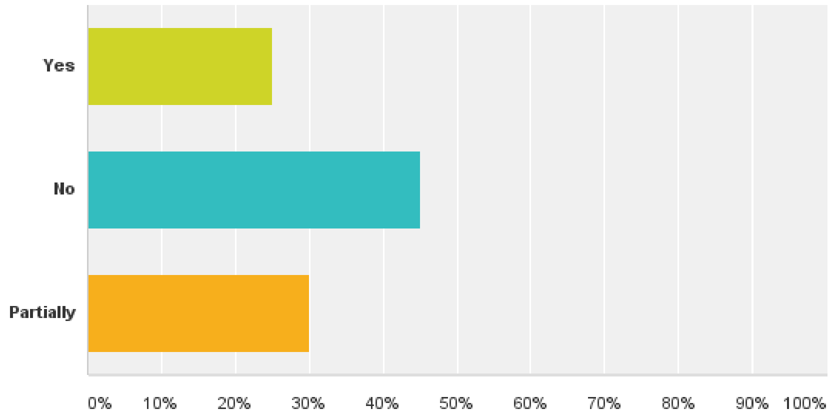



**Fig. 94 BUE respondents' opinion regarding sufficiency of vegetation**

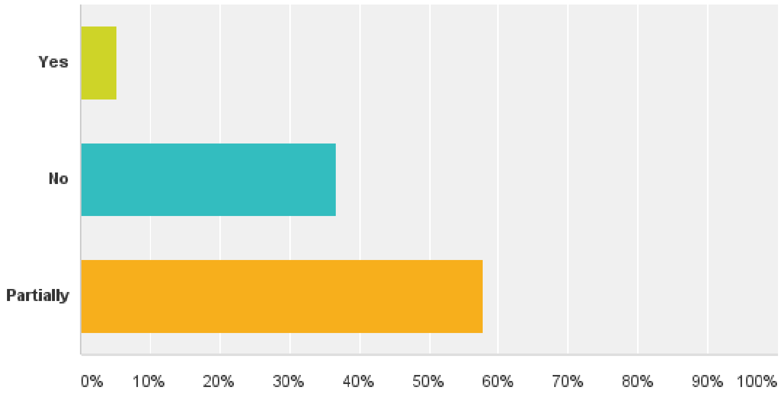



**Fig. 95 BUE respondents' satisfaction with landscape**

## 5.2.4 Social qualities on campus

According to the social qualities on the BUE campus, most groups are mixed in gender, no spatial or social separation is taking place on campus according to gender. The majority of students and staff are more into not spatially separating between different facilities serving the students and the staff since it is very healthy for the educational process. A small minority of the students prefer some separation from staff to have some privacy.

None of the open spaces on campus are complying with the personal privacy of the students in case they need some separate time for reading, studying, or being isolated from the surrounding people. Many spots are known according to the studying majors e.g. the spaces near mass communication is called "Las Vegas" since all the students related to that major are seen to be very fashionable. Another part near "Auntie Anne's" a shop for food, many people are abandoning this area since they associate it with strange or not very well behavior. This part is a bit hidden and not under good surveillance from the university.

Many students are associating their social events to the places where green open spaces are available on campus which is the garden, the only one present on campus and others associate it with the spaces attached to the pool. These are the places where they mostly gather for social events or partying. Some students describe their social identity as being one of the best campuses having student activities on it, and on the contrary the staff is calling the campus "BUE club" due to the large number of events organized on campus.

The most performed outdoor activities are: walking, sitting, participating in student activities or sports. The most socially abandoned spots on campus are: The Roman area which are several steps that are used for events, and in the absence of events they are vacant due to the absence of any attached activity or shading. Many students consider Beano's (A kiosk present on the main spine of the campus) as a known landmark on campus but at the same time many consider it as the worst space and the common reason is due to the lack of spaces to sit and the crowded environment that is always surrounding this spot. Most students describe the food court as being the worst experience to walk since it is located at the far end of the campus.

The best social space according to questionnaires Fig. 96 appeared to be the small spaces between buildings since it is close to the lecture places which provides short movement and the space is small creating a cozy feeling.

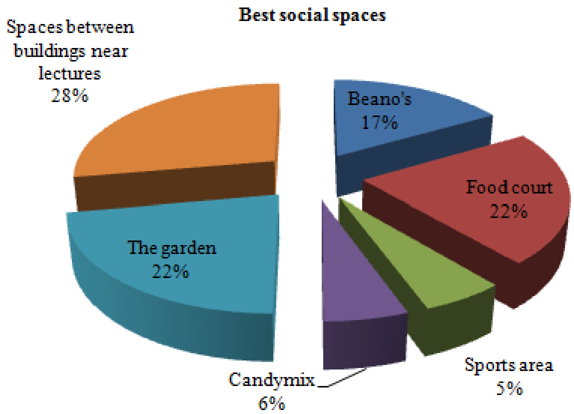



**Fig. 96 BUE's best social spaces according to questionnaires**

The most abandoned space on campus is "The roman area" which a couple of steps that don't have sufficient shading and misses any activity that revives the space

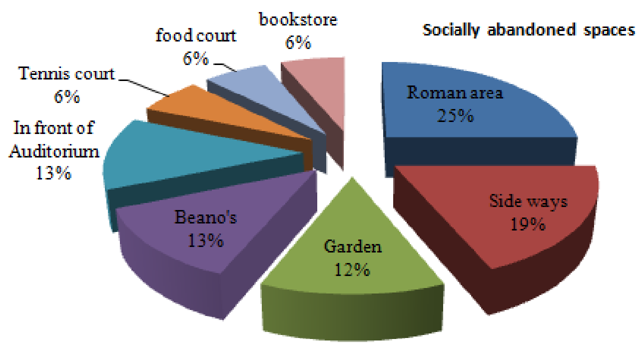



**Fig. 97 Socially abandoned spaces according to questionnaires**

### 5.2.5 Conclusion for BUE campus

- Most services are not proportionate to the number of users on campus.
- The sustainable measures for vegetation are not taken into consideration, although some are applied on site without any good consideration given to the output or the produced resources.
- The area of green areas, shading, number of street furniture is not enough related to the number of users.
- The campus design focuses on the provision of buildings rather than providing good and healthy open spaces since most of the users prefer indoor activities and even cannot find open spaces that could support some sort of privacy.
- The opportunity provided of reusing of onsite used interlocking blocks and other materials on campus is taken into consideration as a chance to save costs but the ecological effect is not taken into consideration.
- The type of study and behavior of students give a strong value on campus defining different social spaces.
- The size of provided activity should be corresponding to the number of users, otherwise it will be a repelling space rather than an attractive one.
- A common outdoor food court on campus should be in an intermediate spot on campus in order to be reachable from different parts on campus.

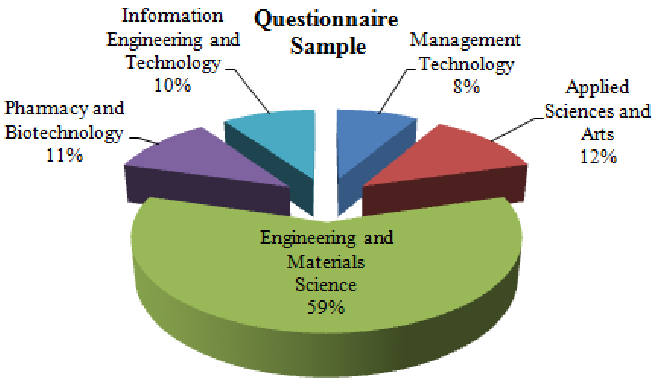
### 5.2.6 Cross-cutting relations for BUE campus

Table 16 Cross-cutting relations for BUE campus (Kindly check the folded table)

## 5.3 German University in Cairo (GUC) Fig. 98

According to GUC statistics, the number of enrolled students are 10000 students. A sample of 95 person was needed which gives 10% as a margin of error. The number of collected responses was 110. 44% were females and 56% were males. As seen in Fig. 99 the sample was distributed among buildings and departments according to the different shares.


**Fig. 98 GUC campus map**



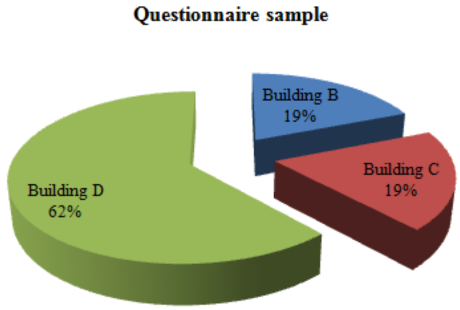




**Fig. 99 GUC's questionnaire samples according to buildings and departments**

## 5.3.1 Physical qualities on campus

### a. Connectivity

The campus is not based on the concept of axes of movement as the other studied campuses. It is basically composed of spaces created from the form of the buildings and the connection of these spaces together as well as semi-public spaces to the back and the front of the campus buildings. The pedestrian network is unclear apart from the different provided spaces. The campus is composed of large network of vehicular roads that is rarely used only in case of service or emergency. The pedestrian act as islands in between. Fig. 100

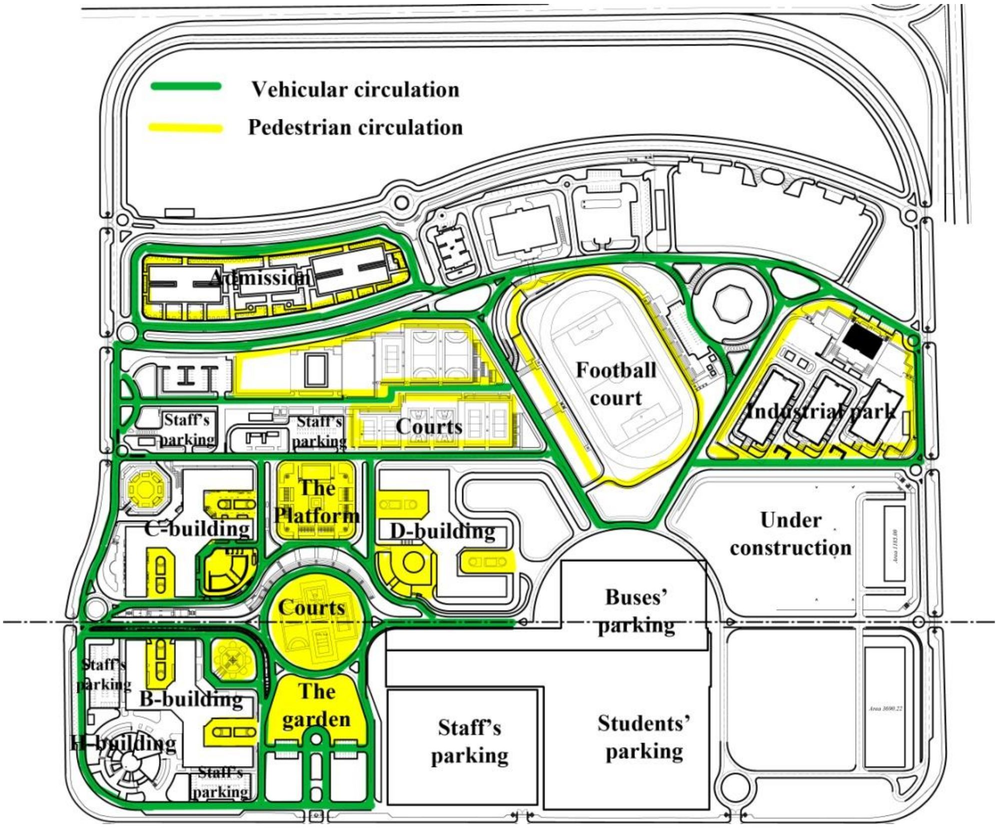



**Fig. 100 Different circulations and buildings on GUC campus**

Balance between pedestrian and vehicular movement is sort of achieved by blocking most of the vehicular circulation from entering the campus but the main design was providing normal vehicular roads on campus. All circulations on campus are supporting the usage of disabled users. According to questionnaires, the campus is walkable but partially tiring Fig. 101& Fig. 102

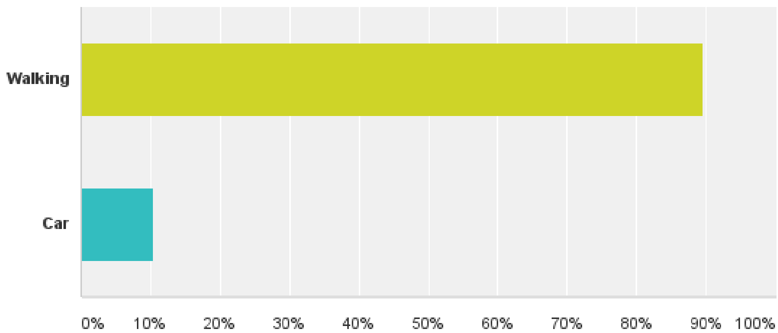



**Fig. 101 GUC respondents' preferred mean of movement**

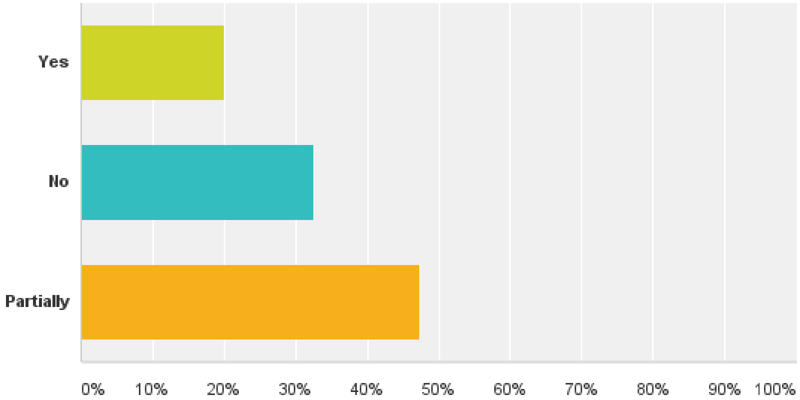



**Fig. 102 BUE respondents' opinion regarding movements being tiring**

The connection of different spaces is not well achieved for all the campus. The industrial park, exams area (administration) are abandoned from the other parts of the campus including the main educational buildings B, C, and D Fig. 100. The presence of several levels on campus created large number of steps to create connection between different parts.

### b. Gates

8 Gates are currently operating on campus. All gates have a unique and uniform design and color Fig. 103. Only the main gate and another gate has the large logo and name of the university while the others have only numbers. The type of each gate is not identified on the gate.


**Fig. 103 Gates of GUC campus**

### c. Different circulations on campus

Since vehicles are blocked to enter on campus pedestrian movement on campus is safe and smooth but according to the design the asphalt was to be used as internal roads. This didn't give priority for pedestrian movement on campus. Although paths are limited but they are of consistent materials. The large coverage of normal asphalt without any porosity limited the ability of creating an ecological value. Regarding provision of activities between indoor and outdoor, it is not present, but some sports fields are present in the center of the campus creating some activity. According to questionnaires, many spots are lacking shading.

Cycling is not applied on campus but due to the large coverage of asphalt the introduction of cycling may be easier. All interviewed users approved that cycling will shorten distances but has to be managed according to the number of users, firm regulations to provide safety and ease of use. The majority of respondents indicate the preference of cycling but the absence of opportunity Fig. 104.

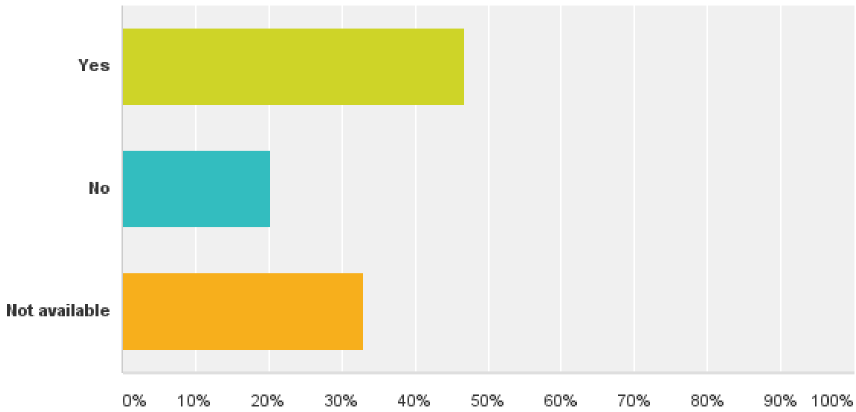



**Fig. 104 GUC respondents' preference of cycling on campus**

Regarding vehicular circulation, some drop offs are present but not covering all important spots. The provided circulation is common for use and for service. Service is not separated but points of garbage collection from each building is hidden. Roundabouts are partially provided but not creating any problems since vehicular circulation is limited. Only for the two northern parking areas and other two next B-building for staff only are connected but for students it is only parking. Fig. 100

**d. Spaces**

Different activities are supported by open spaces on campus: Sports' area, eating area, and places to hangout next to buildings. Most of the spaces are enclosed by buildings or booths. The presence of a central space but it is shifted to the north which makes it far from some buildings than the others. The hierarchy of spaces or attachment of spaces to a common spine are absent. Some spaces that are at the back of the buildings are mostly detached from the rest of the campus, also the main garden is abandoned since it has only two pergolas but without any other activity, Fig. 100. Although the garden is more aesthetically pleasing than other spaces but for example semi-courts of buildings are more vivid. According to user, outdoors is preferred than indoors and active spaces are sufficient Fig. 105& Fig. 106.

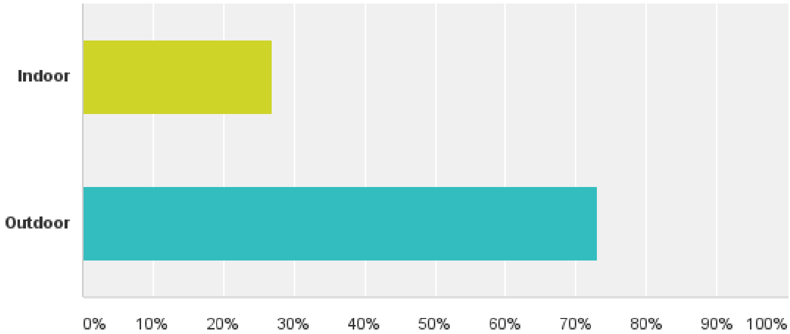



**Fig. 105 GUC respondents' preference between indoor and outdoor spaces**

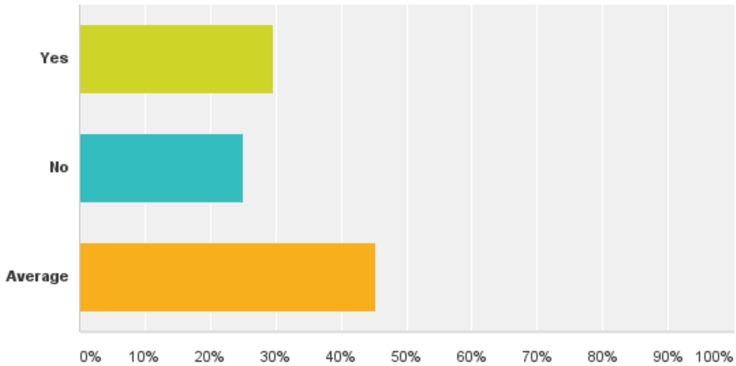



**Fig. 106 GUC respondents' answers regarding available active spaces**

### e. Facilities

The parking provided on campus for students is far related to many buildings of the campus since it is located at the corner of the land. The insufficiency of parking lots and far parking spots are the most indicated problems of parking Fig. 107. Parking lots for disabled users is provided on campus Fig. 108.Vegetative species providing shade for parking are not available, only small shrubs and cacti are available Fig. 109

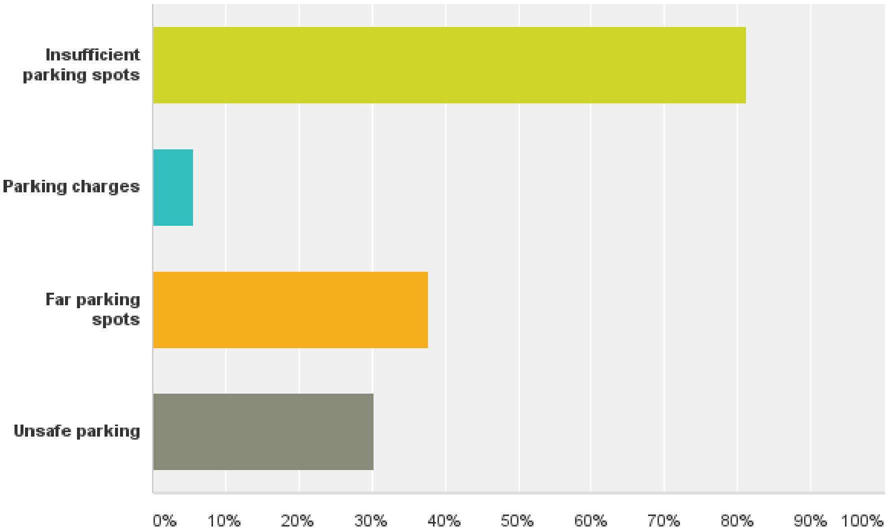



**Fig. 107 GUC respondents’ opinion regarding parking on campus**


**Fig. 108 Parking lots for disabled users**

**Fig. 109 Short shrubs and cacti at parking lots**

The usage of buses is higher than cars, but the percentage of car usage is nearly equal to the uses of buses. Reduction of car usage is required for lower consumption of resources and energy.

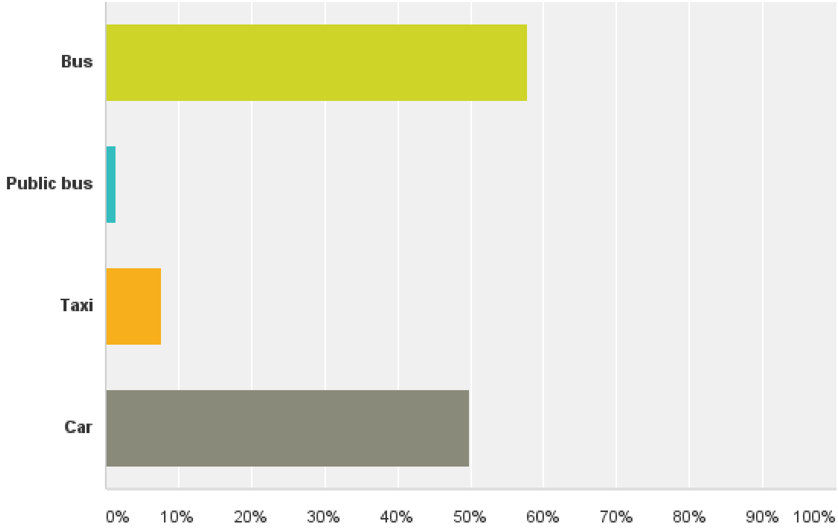



**Fig. 110 GUC respondents' means of transportation used**

Regarding street furniture on campus, most of the provided chairs are aluminum chairs and the use of local materials is limited and the numbers are not sufficient Fig. 111 . Flexibility of movement of most street furniture made it easy to reorganize furniture according different social gatherings. The sufficiency of shading systems compatible with the climate is absent Fig. 112. The consistency of style of street furniture is not achieved. LED lights are provided onsite but the amount of light is not enough according to different users Fig. 120

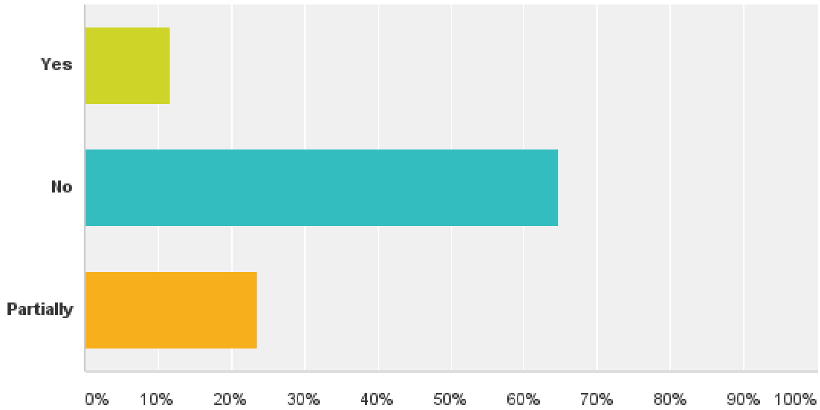



**Fig. 111 GUC respondents' opinion regarding sufficiency of street furniture**

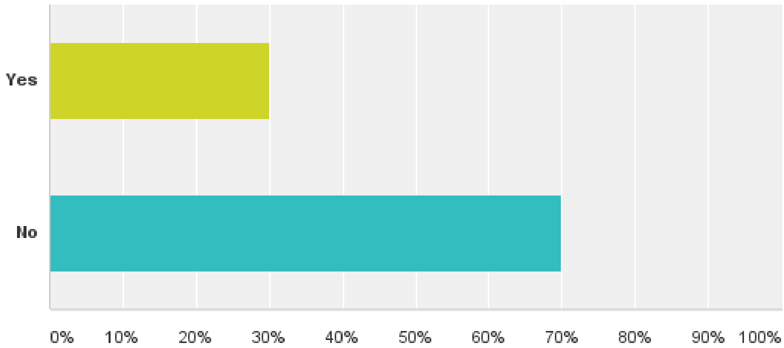



**Fig. 112 GUC respondents' opinion regarding sufficiency of shading on campus**

There is a clear policy to cover all the electricity needs through solar energy but is still not applied.

## 5.3.2 Ecological qualities on campus

### a. Water

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. 113

**Fig. 113 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 Fig. 114

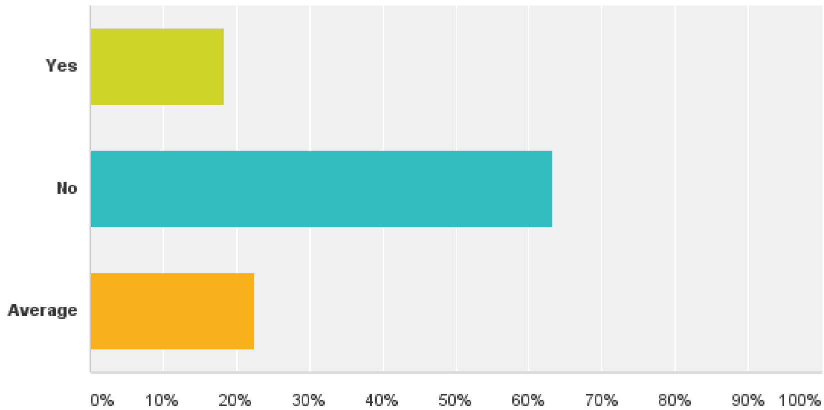



**Fig. 114 GUC respondents' opinion regarding availability of sustainable ecological measures**

### b. Vegetation

Having an ecological benefit, some plants are used to promote the stability of the soil on slopes, also using low water consuming species as cacti has a strong ecological effect.

A local nursery is available and provides 50% of the plants' requirements. Regarding reusing materials for cultivation, plastic containers previously used for buses are cut and reused as vessels for growing plants. The same is for wide watering pipes that are cut and reused for planting in.

Vegetation on site have different design intends next to the aesthetical value. Cypress trees are planted in the northern and north western direction to act as wind breaking elements. Special species are used to create fences with dense vegetation and others to provide shade.

Turf grass is limited on campus, species with limited water consumption, and efficient irrigation are some elements complying with the concept of xeriscaping. Landscape being productive is applied by growing plants producing spices that are used locally by food outlets on campus, also productive date palms are used on campus. Turf grass species on campus as Paspalum 10 and Tifway are originally native to America but is regionally appropriate to the Egyptian environment.

The idea of producing compost on site was presented and the administration was worried that it may create unpleasant odor but soon it will be implemented on campus.

**c. Soil**

Since the soil on campus is sandy soil, the organic matter is low and the soil needs amendments. Some of the soil tests are not applied and are based on individual experience. Soil amendments are not totally performed prior the introduction of vegetation, but the measures of prevention of replacement of soil are applied as much as possible.

**d. Materials**

Most of the measures of sustainable materials are mostly not applied on campus. Some of the materials are Egyptian and locally produced i.e. some of the wooden benches are manufactured on campus Fig. 115, stone and gravel, and petrified wood extracted from site and limitedly used.

**Fig. 115 Wooden benches produced on campus**

Some of the leftovers of some materials on campus are collected, reused and reassembled for other projects rather disposing it. The use of interlocking blocks at many spaces gave the opportunity of easy maintenance by disassembling and reassembling of flooring.

## 5.3.3 Individual qualities on campus

### a. Wayfinding

Most of the interviewed users confirmed that the zones of the campus are classified according to the different buildings and prominent uses B, C, D, industrial park Fig. 118 and sports' area. Each building is accompanied by the spaces known according to the same names. The absence of proper directional signage Fig. 116 on campus leads to the difficulty of wayfinding. Apart from that the campus areas are limited and names of building are indicated on them, the similarity between the building shapes creates another difficulty but according to questionnaires losing way around campus is not common. Most of landmarks on campus are associated to uses as food outlets, main plaza…etc. The most prominent landmarks according to users are: Am Saad which is a kiosk next to the central sports' courts, the platform which is the central plaza for the campus, and U of the B-building which is the enclosed space next to B-building

**Fig. 116 Directional signs on campus**

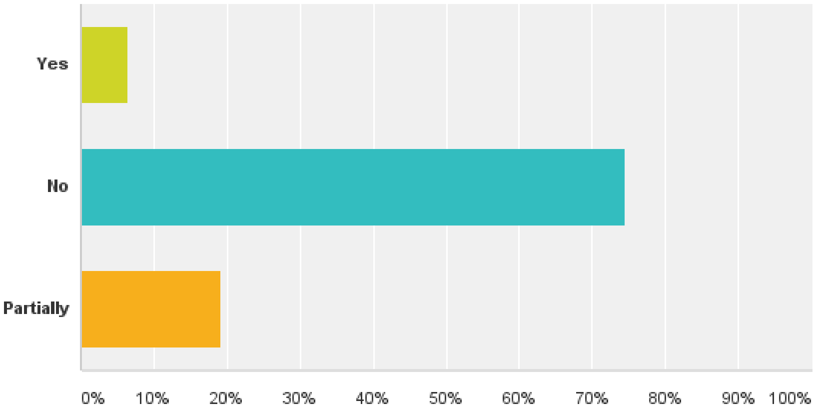



**Fig. 117 GUC respondents' regarding losing way on campus**

**Fig. 118 Industrial park on campus**

The most prominent landmarks Fig. 119 according to users are: Am Saad which is a kiosk next to the central sports' courts, the platform which is the central plaza for the campus, and U of the B-building which is the enclosed space next to B-building

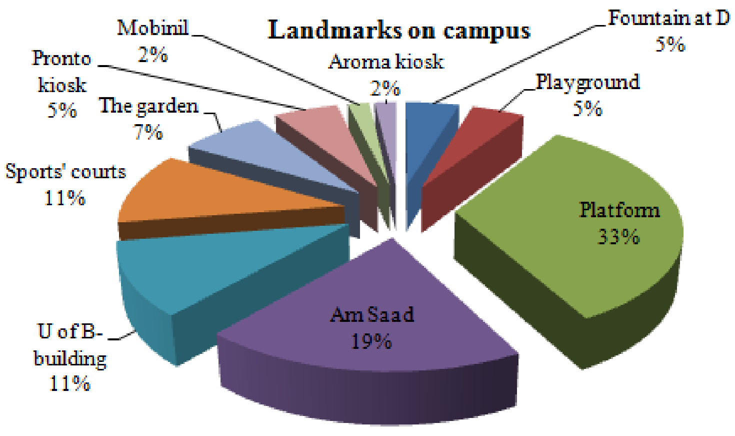



**Fig. 119 Landmarks on GUC campus according to questionnaires**

### b. Safety

The absence of any physical or emotional hazard on campus except for the insufficient lighting as indicated by the users. The surveillance provided by activities is mostly available except for the back spaces of the buildings. The campus is totally covered by cameras.

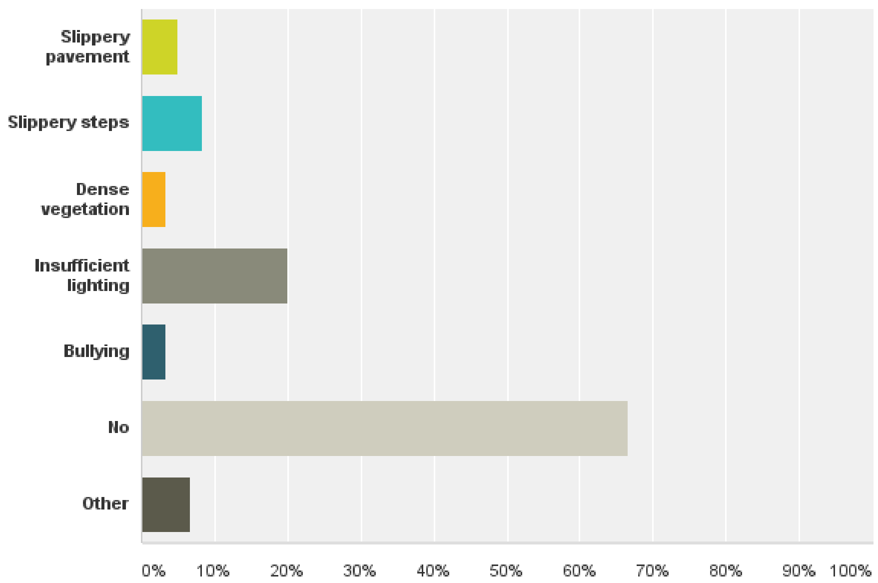



**Fig. 120 GUC respondents' answers regarding safety measures**

### c. Identity

The main identity of campus is created by the unique form, color of buildings as well as the spatial composition created by buildings. The unique design of buildings is not favored by most of the users, even some users resembles it to a hospital Fig. 121. The campus doesn't have a unique style or even landscape elements creating a certain identity except for the wide use of cacti which is noticed by the minority of the users.

**Fig. 121 The façade design of most GUC buildings**

### d. Aesthetics

Most of the users don't feel that their campus is unique Fig. 122 & Fig. 123 which indicates sort of lack of aesthetics on campus which is variable according to users but at the same time users indicate the sufficiency of vegetation on campus Fig. 124 . The large number of slopes and the absence of clear pedestrian network, large surface area of asphalt may be the reason. According to users, the most aesthetically pleasing spots are: Terrace of D overlooking the fountain, the garden and the football court. The common feature between the three is the presence of a natural element.

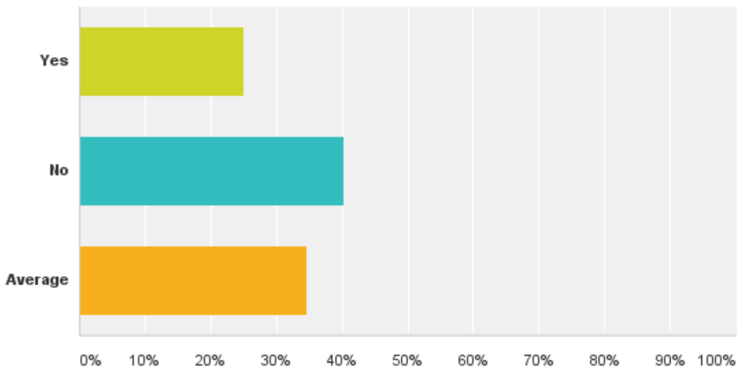



**Fig. 122 GUC respondents' regarding spatial uniqueness of campus**

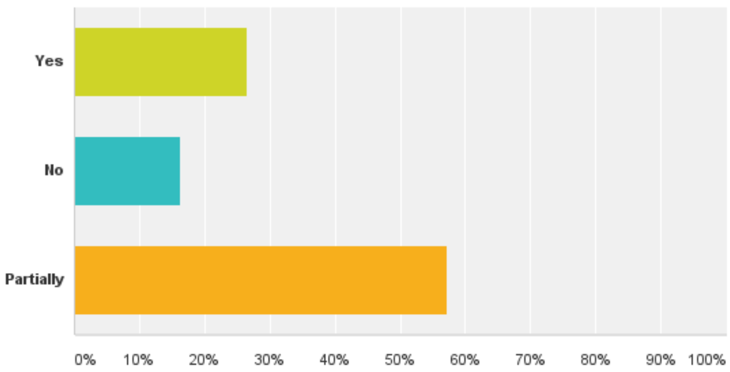



**Fig. 123 GUC respondents' satisfaction with campus landscape**

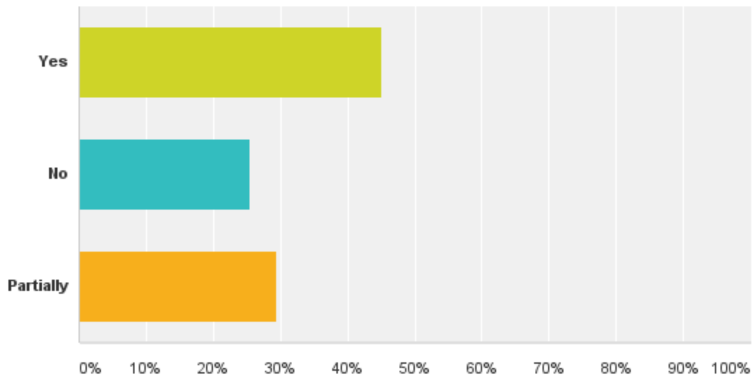



**Fig. 124 GUC respondents' regarding vegetation sufficiency on campus**

## 5.3.4 Social qualities on campus

As the other examples, social spaces are not separated according to gender. Academic staff connection to the landscape is very minimal. There is no outdoor space provided for the academic staff. There is no separation between the academic staff spaces and the students' spaces. Some academic staff's opinion is that some sort of provision of separate outdoor spaces for staff is required since they have limited time to buy food or do any activity.

The social identity that was common between the interviewees from the students is that GUC is known for its hard educational system and the highly qualified graduates. For the academic staff, the social identity is the very good bondage between the GUC staff community creating good friendship. Academic staff have a frequent event "Coffee Break" where most of the members gather to chat and mingle. Staff members relate that connection to the very good selection of the members.

The presence of special social groups associated to certain spaces is not noticeable on campus, but groups are gathered and could be spatially and socially identified according to different disciplines of study. The physical design of campus supported this organization due to the presence of semi-public spaces associated to each of the building sector.

The most social spaces on campus Fig. 125 are: "The platform" Fig. 126 considered as the central plaza gathering many food outlets and a place for many of the university activities. U-shaped spaces of different buildings Fig. 126, since they are the closest spaces to different classes, the availability of seats and shade.

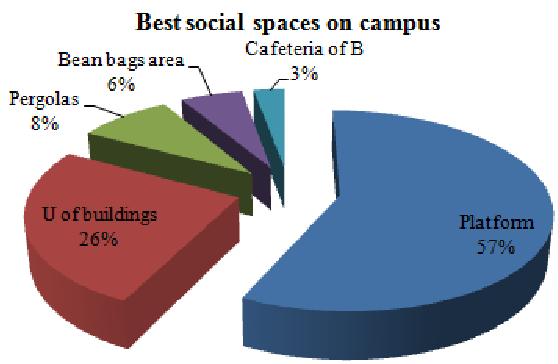



**Fig. 125 Best social spaces on GUC campus according to questionnaires**

**Fig. 126 The Platform on the left and D Building U-space on the right**

The most socially abandoned spaces on campus are:  The back of the "C" building which is totally disconnected from the other spaces, having no activities. The football stadium Fig. 127 is abandoned since it is used based on sports events only, no activities to revive the area and the far distance from the main university buildings. The last is the industrial park Fig. 118 which is associated to educational manufacturing facilities, thus no activities to gather users and the position of it is very far located at the corner of the land.

**Fig. 127 The football stadium on campus**

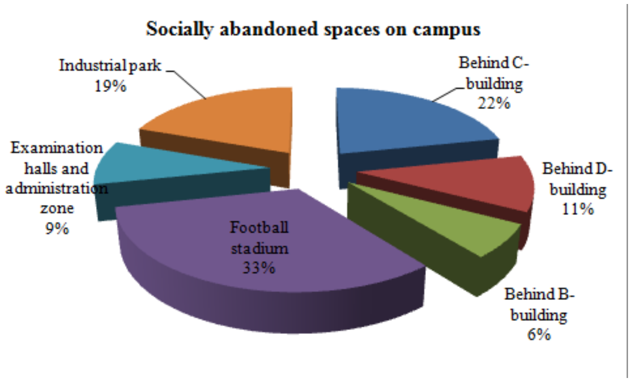



**Fig. 128 Socially abandoned spaces on GUC campus according to questionnaires**

### 5.3.5 Conclusion for GUC campus

- The absence of a clear pedestrian network. The widespread of asphalt roads killed the presence of a strong pedestrian network.
- The long distances of separation between different buildings or uses creates sort of isolation of these uses.
- Concentrating parking lots in one zone creates very long distances for users.
- The main garden lacking places of activity and places to sit caused it to be abandoned and not efficiently used.
- Using cacti in a wide range is a very essential step to decrease the water consumption on campus.
- The usage of computerized control system for irrigation is very important to limit any leakage of water.
- The presence of a nursery promotes the local fulfillment of vegetation needs saving energy and resources.
- Amending soil was having the higher priority than replacing soil.
- Sustainability of materials is not taken into consideration intentionally except for using local gravel and stones and reusing leftovers of furniture for other projects.
- No unique architecture or elements are used to create landmarks, it is mostly through uses and spatial definitions.
- Neither style nor landscape elements are creating an identity for the campus.

### 5.3.6 Cross-cutting relations for GUC campus

Table 17 Cross-cutting relations for GUC campus (Kindly check the folded table)

## 5.4 The American University in Cairo (AUC)

According to AUC statistics of 2013, the number of students on campus were 6642 person. The required sample is 95 person taking 10% margin of error into consideration. 112 respondents were received. 53% were females and 47% were males. Most of the respondents were students, therefore minimal representation of other users was deducted from interviews. The respondents are distributed among the majors and buildings according to the actual share of each.


**Fig. 129AUC campus map**

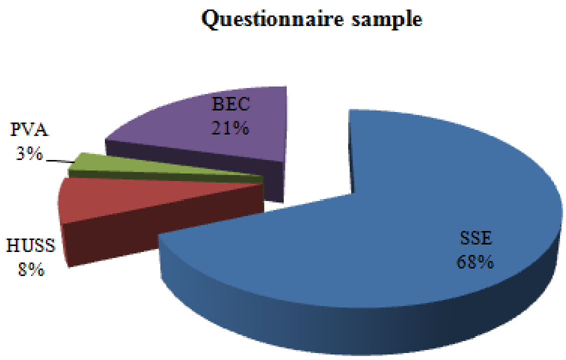



**Fig. 130 BUE's questionnaire samples according to buildings**

## 5.4.1 Physical qualities on campus

### a. Connectivity

The campus is composed of four axes, three connected axes, enclosed by buildings that are connected to each other starting from the main gate (AUC portal) and ending by the service gate next to the dorms and having the main plaza of the campus in the middle. The other axis is passes through the main big garden on the campus starting from the main gate and ending at Bassily the main auditorium on campus. The main enclosed three axes are connected by links to connect to each parking area distributed along these axes. The campus is totally accessible for disabled users. The campus is connected to the outside through five gates. Gate one is the main gate, allowed for visitors, and gate 3 is the service gate Fig. 133. According to users, the campus is walkable and not so tiring which indicates the good connectivity.

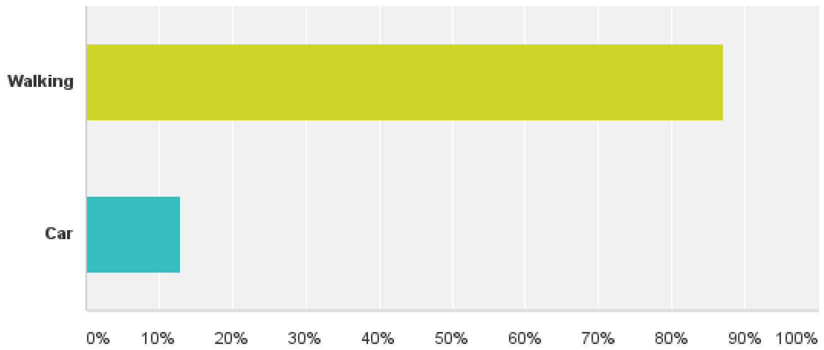



**Fig. 131 AUC respondents' preference of walking to using car**

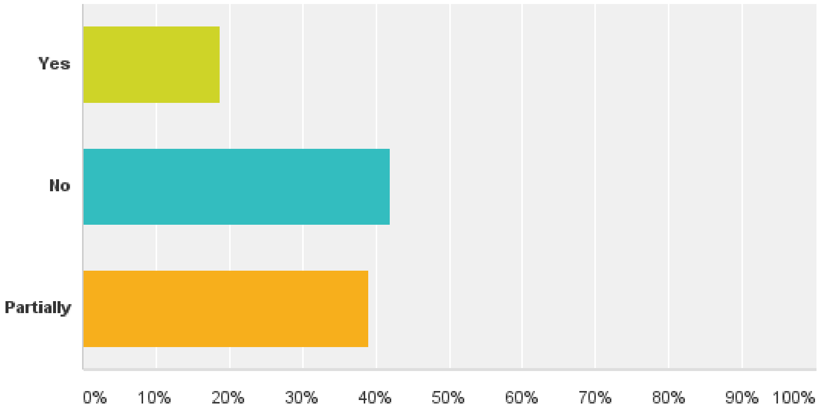



**Fig. 132 AUC respondents' opinion finding walking not tiring on campus**

A balance is created between the vehicular and the pedestrian circulation is achieved since the vehicular circulation is not allowed inside campus but there is a vehicular loop that surrounds the whole campus and access is provided at different spots accompanied by parking to provide short connections to different parts on campus. Fig. 133

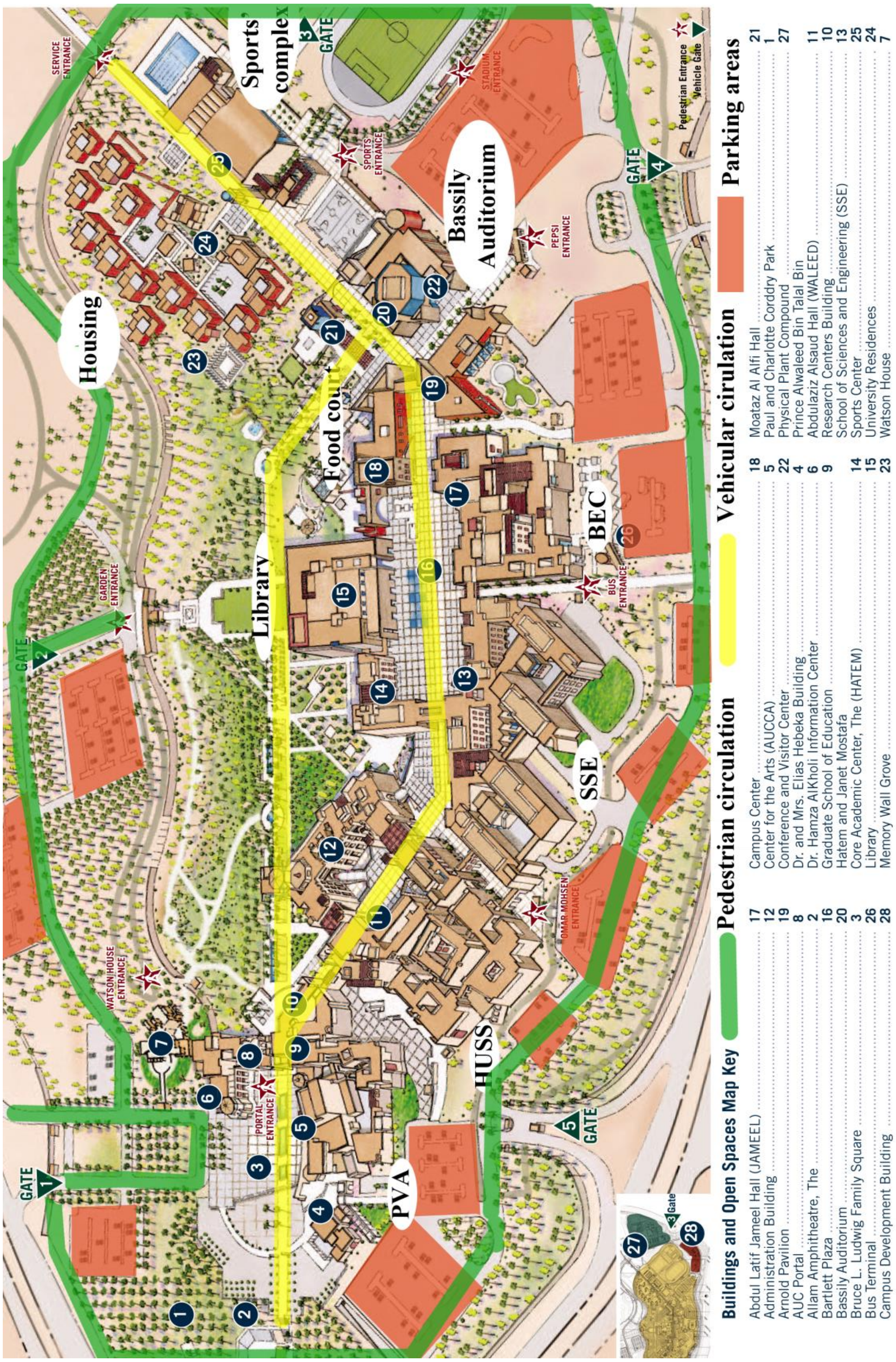



**Fig. 133 AUC map showing buildings, pedestrian and vehicular circulation and parking areas**

### a. Gateways

All gates on campus are having the same design, materials and style. All gates have unified signs indicating the number of the gate, type of the gate Fig. 134 & Fig. 135 & Fig. 136 & Fig. 137. The university logo and name are present on each gate. The name of the gate is obvious also on the pedestrian gate. The main gate “1” (for visitors) is more emphasized to be more welcoming and representative.


**Fig. 134 Photos for the main gate of the AUC and the service gate**


**Fig. 135 One of the pedestrian gates attached to the main garden**

**Fig. 136 Consistency of style and design of different gates**

**Fig. 137 Consistency of style and design of different gates**

### b. Different circulations on campus

The vehicular and the pedestrian are totally separated as stated only very safe crossings with emphasis at the pedestrian crossing points by providing bumps, zebra lines, narrow and limited roads and speed is limited on campus roads. The material used for vehicular roads having pedestrian crossing is not smooth to prevent speeding up. Drop off zones are divided along different zones of the campus to reach all the parts. All parking areas are connected along the provided vehicular loop to prevent congestions during searching for parking lots between different parking areas. Regarding service circulation on campus it is hidden and limited to a certain gate, separated from the different circulations. An underground tunnel is provided to achieve higher scale of separation Fig. 138. The vehicular circulation supports different types and sizes of vehicles. Ecological factor is partially considered in providing pervious pavement for parking areas providing groundwater recharge but without actual steps for further use of runoff or infiltrated water even if on a small limited scale.

**Fig. 138 The entrance of the underground tunnel**

Different pedestrian circulation on campus have a unified visual design Fig. 139 keeping the natural sandy colors as the main color scheme for the campus. All pathways are proportionate to the number of users. All pathways and spaces are intentionally designed to be of bright colors to decrease the heat island effect and all the used materials are local ones which are ecological advantages for the design of the pathways. Most pathways are attached to activities, main entrances of different buildings, or classrooms with outdoor surveillance creating connectivity between the indoor and the outdoor which revive the spaces. All Pathways are wide enough to accommodate emergency vehicles even vehicular roads support larger emergency vehicles to reach different spots on campus. Electrical club cars have access to all pedestrian pathways and spaces to facilitate movement.  The main issue is the insufficient provision of shading.

**Fig. 139 Unified visual design of paths and spaces**

Cycling is provided on campus. A long path surrounding the campus is provided for cycling with spots with bicycle racks Fig. 142 at some points but not covering all regions. It is mostly used by foreigners. The track is not included within the enclosed spaces of campus only connected at minimal points. Also not all parts of cycling track is well shaded or well-lit at night for use. Awareness and measures of encouraging cycling on campus are not available. Based on high cycling preference of many users Fig. 140 and presence of basics, encouragement and awareness are simpler.

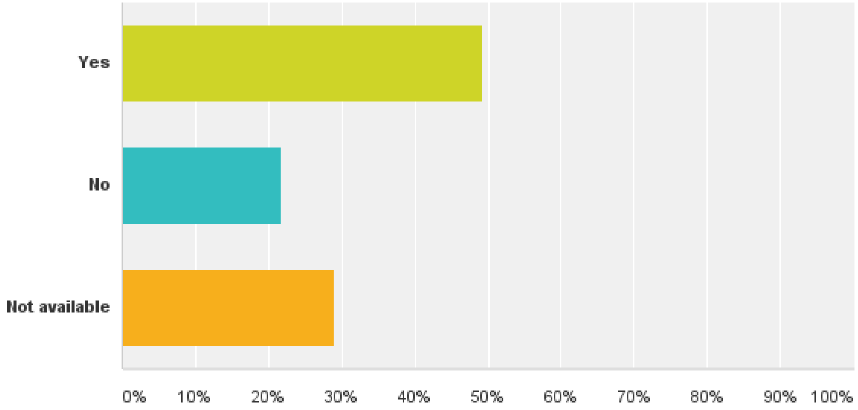



**Fig. 140 AUC respondents' preference of cycling**

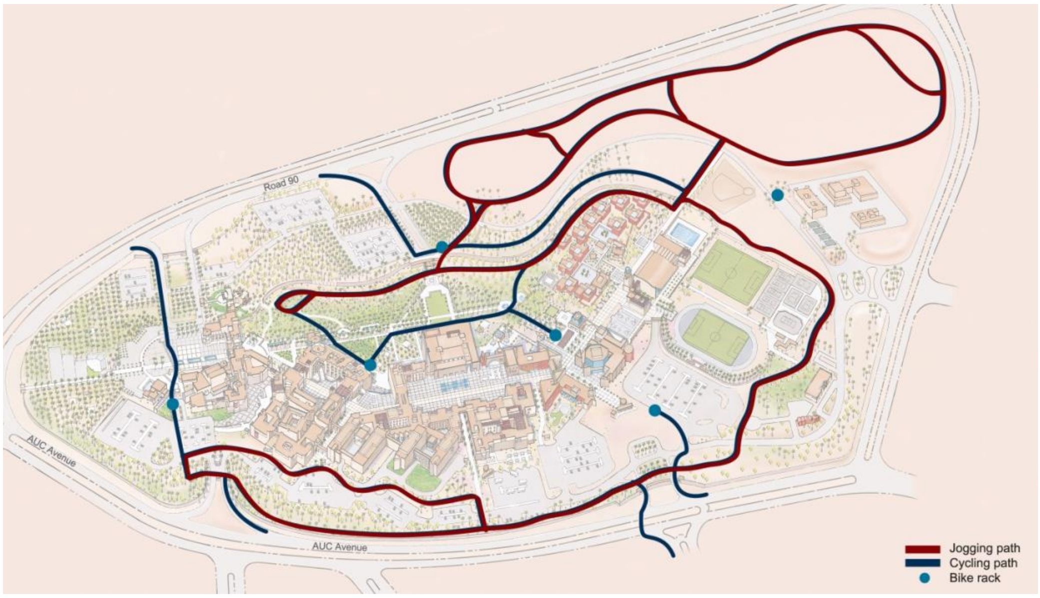



**Fig. 141 Cycling (blue), jogging (red) paths, and bike racks (blue points) in AUC**

**Fig. 142 Bicycle racks at important points on campus**

### c. Spaces

Most of the spaces are linked together through the axes on the campus. Hierarchy of spaces is achieved, all spaces meet at the main central space (Bartlett Plaza) Fig. 145 which contains the main activities, clubs (student activities) and different performances taking place on campus on normal days. All spaces have consistent materials, style and identity. Most users indicate sufficiency of active spaces and they prefer outdoor areas over indoor areas Fig. 143 & Fig. 144.

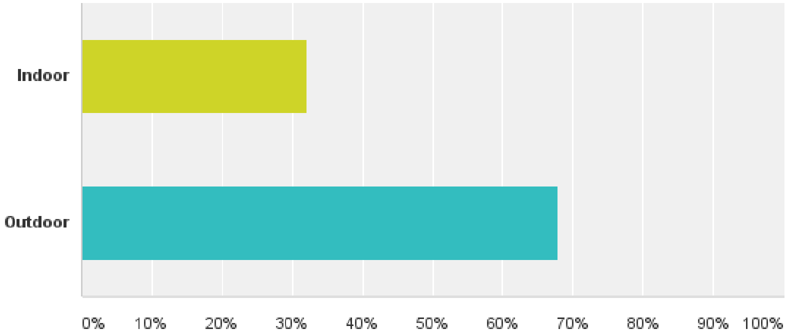



**Fig. 143 AUC respondents' preference of outdoors to indoors**

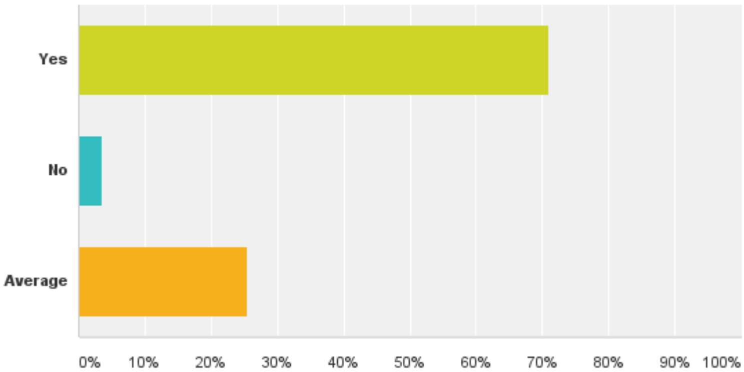



**Fig. 144 AUC respondents' opinion regarding sufficiency of active space**

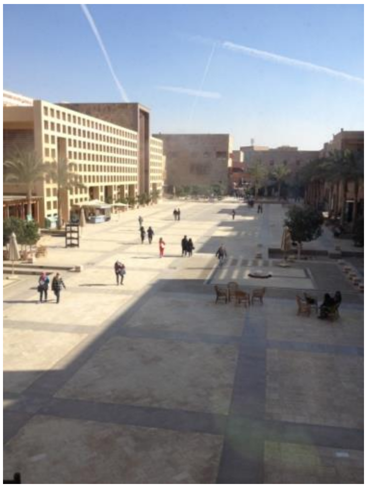


**Fig. 145 Bartlett Plaza the main central space on AUC campus**

All spaces have good enclosure without having claustrophobia or inhumane large scaled spaces. A very large garden is provided along one of the axes providing connection with the nature. Due to the large size of the garden and the minimal number of activities and food outlets, many spots of the garden are rarely used. Most of the spaces are enclosed by buildings or vegetation. Least used spaces are mostly the internal courts missing activities or some minor spaces present at the back of the buildings outside the main spine of campus.

### d. Facilities

Regarding parking spaces, the number of provided parking lots are not enough Fig. 148 which leads to the provision of extra parking on remote unused land. Parking lots are divided all around the campus to provide near parking spots for all users but is still far for many users **Error! Reference source not found.**. The main reason is the incremental increase in the number of students. As an improvement action to decrease the number cars to suit the available lots and to save energy, carpooling is enhanced by cutting of parking charges by the application of carpooling. Safety measures by providing low heighted vegetation surrounding parking areas is applied. All trees' types on parking areas are deciduous to block direct sunlight in summer and allow warmth by sunlight in winter Fig. 146. All parking spaces are supported by parking lots for disabled users Fig. 146. Some drop offs on campus could be used to receive taxis inside campus but provision of a spot to connect to the public transportation system would save many of resources.

According to users, the usage of cars is higher than buses Fig. 147 but methods of carpooling is acting on decreasing the number of cars.

**Fig. 146 A photo of parking lots of disabled users and deciduous vegetation in parking areas**

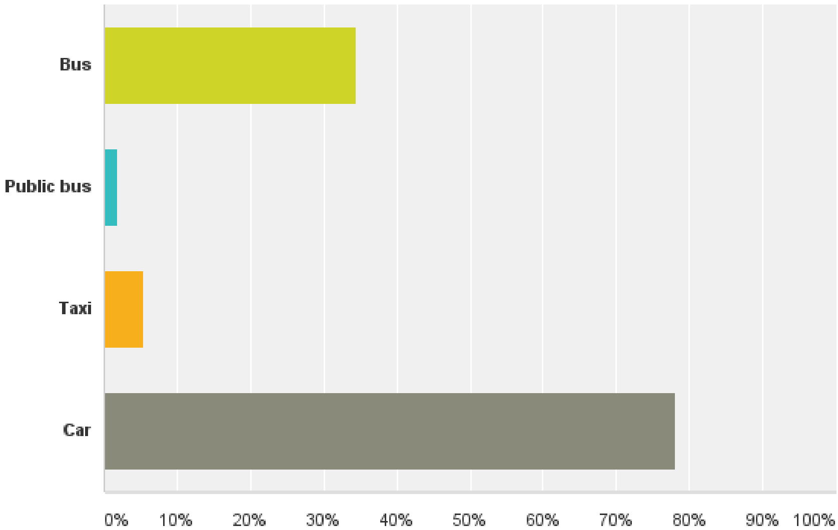



**Fig. 147 AUC respondents' mean of transportation**

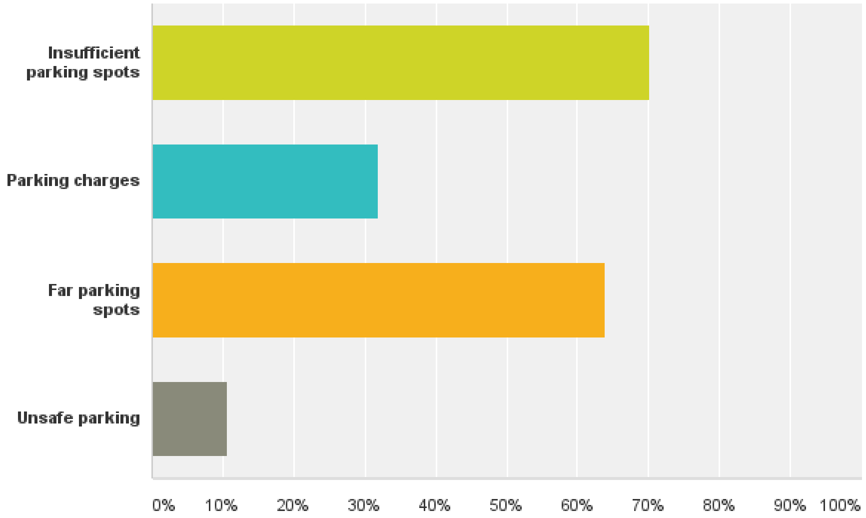



**Fig. 148 AUC respondents' opinion regarding parking problems**

Regarding the street furniture on campus, most of the materials used are durable local materials e.g. Rattan, sand stone and marble are all local ones Fig. 150. Most seats and chairs used are movable to provide flexibility of arrangement. According to most users interviewed, the street furniture is comfortable to the required extent and sufficient. The designs, colors and styles of street furniture is mostly unified all over the campus. Different services as bicycle racks, emergency call boxes are available on campus Fig. 151. Sorting of garbage is applied on campus and different types of garbage bins are present on site. Fig. 152. Regarding shading provision, nearly half of the respondents find it insufficient and mostly provided by trees.

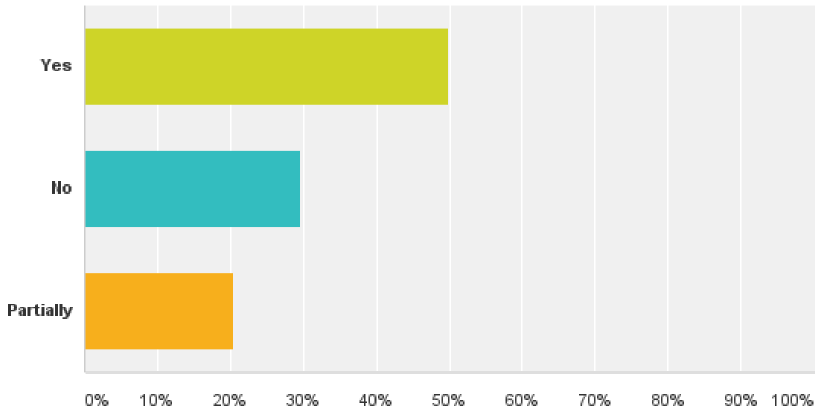



**Fig. 149 AUC respondents' opinion regarding sufficiency of street furniture**

Fig. 150 Rattan flexible chairs


Fig. 151 Emergency call boxes and cameras

Fig. 152 Hidden garbage collection point linked to service tunnel

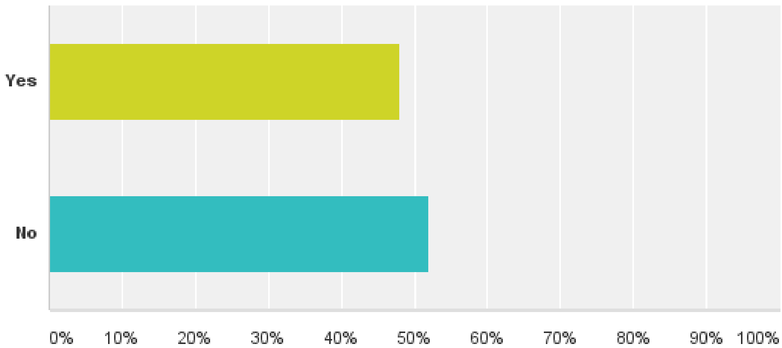



Fig. 153 AUC respondents' opinion regarding shading provision

Regarding lighting on campus, all lights used on campus are LED lights consuming low amount of energy. A limited scale initiative in RISE (Research Institute for Sustainable Environment) where the parking lights are powered by photovoltaic cells Fig. 154. On campus at night, all usable spaces are provided with sufficient light and different moving spaces have minimal amount of light enough for movement.

**Fig. 154 PV cells used to generate electricity for lighting parking lots at RISE**

Infrastructure and services provided for the site as water and wastewater were publicly provided from the beginning only connections were added. The nearest center for services at the beginning of the operation of the project was in the 1st district around 7 km away.

## 5.4.2 Ecological qualities on campus

A deep study , that costed 240,000,000 dollars was performed by DDC (Desert Development Center) in AUC before any phase of the project where different sections where analyzed for the land to check the similarities and the differences between the different parts of land. This study included the integration of different disciplines e.g. ecologists, landscape architects, geologists…etc. to reach the optimum and the best decisions regarding water, soil and vegetation.

### a. Water

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. 155 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. 155 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.

### b. Vegetation

Planted area on campus is equal to 55 feddans. 8000 trees are present on campus. All vegetative species used on campus were thoughtfully selected to be of the very low in the case of consumption of water. Even turf grass used is Paspalum 10 which is regionally appropriate and has low water needs. Setting the design where soil surrounding trees is covered by ground covers decreasing the consumption of water (~15%) by limiting evaporation. Some of the used species are desert species that highly adapt to the desert tough environment. Tamarix, Acacia Farnesiana and Acacia Laeta are some of the trees that are native to the Red Sea zone and could adapt to tough environment. As for other ecological and design benefits, some Tamarix trees are used for wind breaking on site in a very small scale. Also Atriplex plant is used to desalinate the soil to refine the soil qualities on campus. Canopy of trees are used in parking lots to provide shade and in some internal courts of buildings as fulfilling design intends for vegetation. According to the relevance to the site, species on the northern part of the campus are selected to resist wind, while on the southern side resisting direct sunlight was the main target. All vegetative types used are homogenous without any clash, harmful effect or the presence of invasive species. Since 15-20% of species on campus are wooden species which don't produce seeds and accordingly possibility of being invasive is very limited.

Most of users notice the growth of edible vegetation on campus and the efficient methods of irrigation as measures of ecological sustainability of landscape.

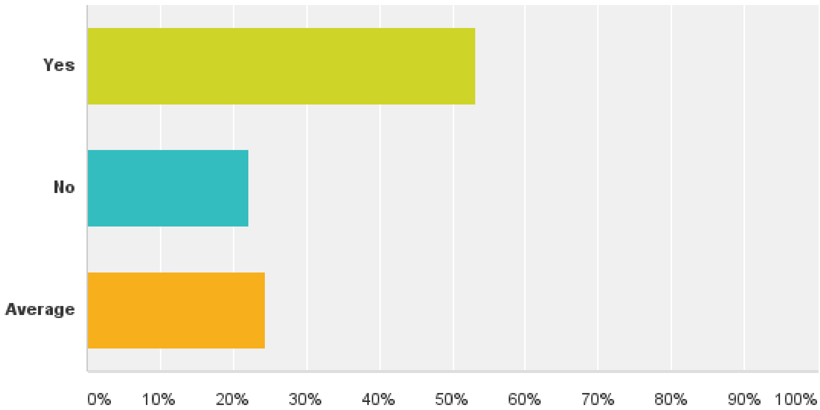



**Fig. 156 AUC respondents' opinion regarding availability of sustainable ecological measures**

As a sustainability measure, compost is produced locally onsite. Plants pruning remains, dead vegetation and unused fruits are used in the production of local compost for AUC. Chemical tests were performed to ensure the high quality of the resulting compost. Productivity of landscape was one of the measures to be applied. Different fruits are grown on campus e.g. Oranges, Grapefruit, Apricots, lemons, dates from palms…etc. These fruits are of high quality according to chemical tests performed. They are not used neither as food products for campus nor as resource to be sold on campus. These products are intended to be directly used by campus users to create a sense of territoriality on campus. The available nursery on campus covers more than 50% of the vegetative needs onsite, but it misses a green house.

Green roofs are only applied on RISE building as a model, providing edible vegetables on a very small scale that don't need deep medium for growth Fig. 157. Over the faculty lounge, the roof is also planted but not edible species. No considerable vegetation were salvaged only limited amount of bushes are kept onsite.

**Fig. 157 Green roof for vegetables over RISE building**

Regarding maintenance, most pots and plastic bags for different cultivation materials are from recycled materials. Peat is banned to be used outdoors. Still chemicals are used for fertilization and pest management. Non- toxic methods as the use of bio-enemies were applied as "Red weevil Pheromone Trap".

Serving the wildlife or the biodiversity on a small scale wasn't taken into consideration. The provision productive vegetation with flowers or fruits, and having branches near the ground with ground covers made it good for creating environment supporting butterflies, bees and birds unintentionally, even a kestrel falcon made a habitat and had offspring on campus.

### c. Soil

As previously mentioned, detailed studies were performed before the project. According to the results, most of the soil layers were homogeneous and not affected by any contaminants. The soil doesn't have calcareous layers or hard layers, sandy and very low in organic matter which is the common feature of native surrounding soil.

According to the different tests performed, the drainage of the soil was very high and this was solved through system of irrigation, the used vegetative species and amending the soil. The soil was alkaline. Leaching was applied to overcome the salt issue through radial irrigation which decreases the salt in the soil. Clay wasn't added at all, according to regulations. Different amendments were applied to treat the soil (over watering- composting…etc.)

**d. Materials**

All materials selected for site where evaluated to have no effect on human health and the least effect on the environment. All materials used for outdoor flooring were bush hammered and of light colors to decrease the heat island effect. Most of the granite and marble are maintenance free to reduce the costs. Most of the used materials are local materials. Granite and basalt are from Aswan, marble and sandstone are from local vendors and sources. Also stones and aggregates are local, petrified wood found onsite and was blocking construction was used onsite as landscape barrier Fig. 158.

**Fig. 158 Petrified wood used as landscape element**

The concept of design for disassembly is applied with marble, interlocking blocks, moveable gravel and stones. Metallic benches are bolted instead of welded Fig. 159 and all metallic materials are coated electro-statically to resist corrosion and accumulation of contaminants. All these materials are to be reused again. EE & EC were taken into consideration during materials selection. Production firms of materials used on campus applying sustainable measures were not taken into consideration during the selection phase. Recycled materials are not used on campus in terms of furniture or fixed finishes, but sorting trash is performed on campus and different contractors are responsible to perform recycling or disposal.

**Fig. 159 Bolted benches**

## 5.4.3 Individual qualities on campus

### a. Wayfinding

Most of the campus users classify the campus into zones including: Sports complex, academic buildings and the gardens. Also users distinguish the zones according to the change in some elements of style, since each building is distinguishable from the other but having homogenous common style.

Most of the interviewed users lost their way in the beginning when they first dealt with the campus and they found the signs are not very easy neither to read nor the names of the places are the common names known among users. According to questionnaires, wayfinding is fine Fig. 160 except for HUSS building Fig. 173

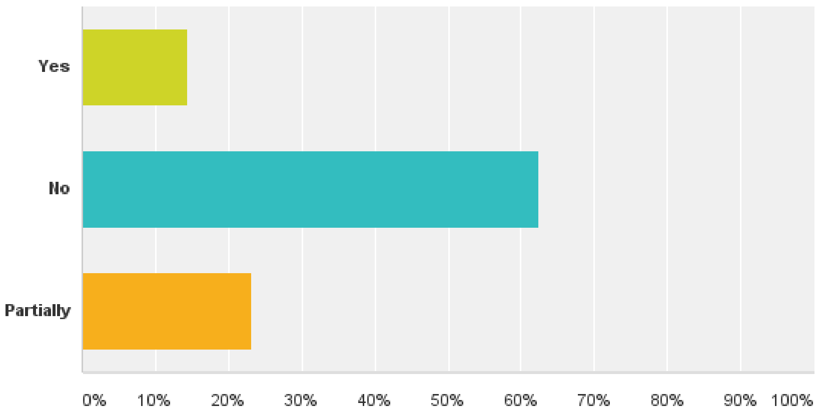



**Fig. 160 AUC respondents' opinion regarding losing way on campus**

The designer succeeded in creating landmarks that could be memorable on campus. The three most selected landmarks Fig. 161 through questionnaires were:

The library which has the most dominant architectural figure on campus acting as a landmark Fig. 162. The steps where sitting places are available next to "Quick" which is a food store even this place is known for students who mostly like to show off. The plaza is another choice where most of the activities take place, student clubs' booths are present, seats are available and food outlets are present.

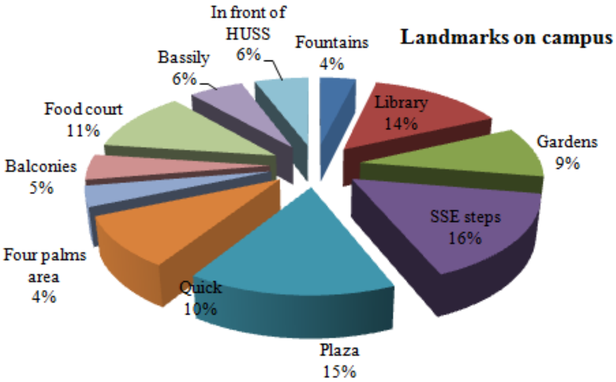



**Fig. 161 Landmarks on AUC campus according to questionnaires**

**Fig. 162 Library on AUC New Campus**

Regarding the wayfinding signs, the used materials are not very compatible with the climatic conditions and need better enhancement. Most of them are complying with fire and safety codes being inflammable and mostly near fire-fighting water outlets. None of the signs are from recycled materials but flexibility of signs is partially achieved having fixed concrete bases and signs could be bolted or freed complying somehow with DDF concept.

### b. Safety

Regarding physical safety, it is partially achieved since in the initial design very narrow water channels were designed in the plaza area which lead to many stumbles and accordingly they were all covered with metallic covers Fig. 163 .

**Fig. 163 Covered water channels**

Regarding emotional safety, most of the places are fine except for the gardens at night are a little bit dim than required Fig. 164. Decreasing the consumption of energy for lighting may be the reason. Some spaces as internal courts and hidden sitting zones in the gardens are not used due to the absence of connection to the flow or the different activities. The campus is totally covered by cameras Fig. 151 and periodical patrols provides security.

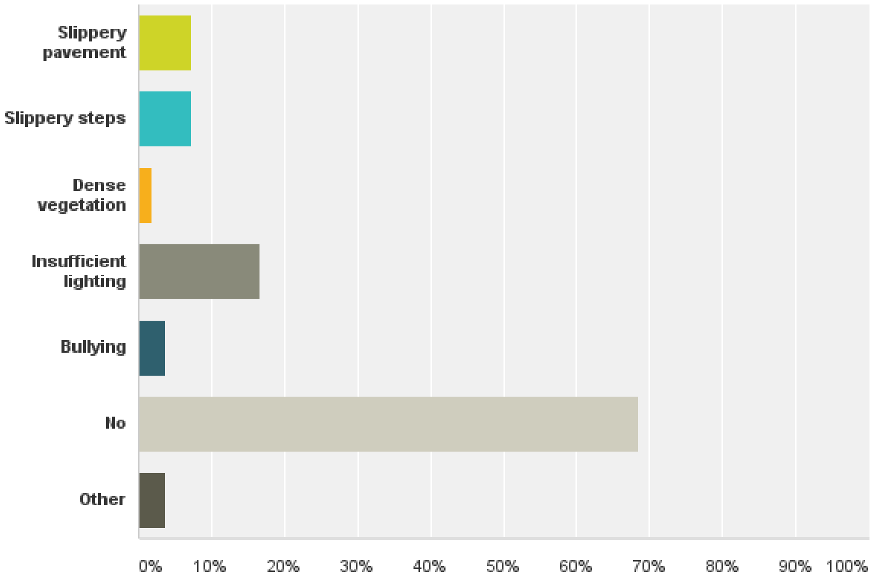



**Fig. 164 AUC respondents’ opinion regarding safety measures**

### c. Identity

A very strong identity is created for AUC through the large scale, the very prominent palette of natural colors suiting the desert environment, and unique architectural style creating a modern oriental Islamic style. Landscape elements has a strong role to create an identity for the campus. The use of date palm trees (~1200) and growing pure Egyptian trees in courts of parcel 5 gives the feeling of oriental sense sustaining the culture of indigenous landscape.

### d. Aesthetics

Most of the users preferred natural landscape to artificial one. The scenery of the garden with the presence of different tree types and the lawn made the best scenery for most of the users. According to questionnaires Fig. 165& Fig. 166& Fig. 167 most of the users are satisfied with the outdoor environment consider the campus spatially unique and the sufficiency of natural landscape elements.

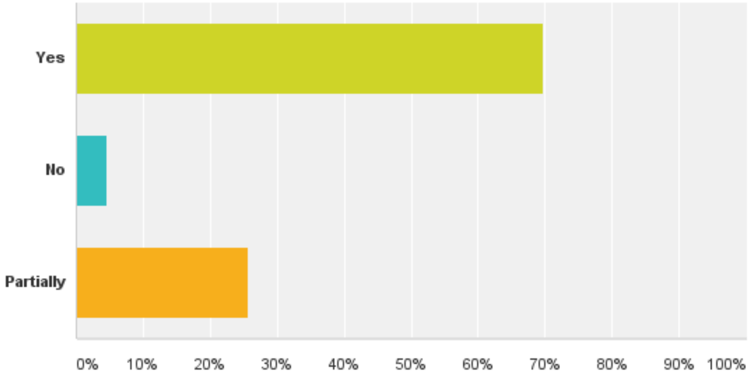



**Fig. 165 AUC respondents' satisfaction with the outdoor environment**

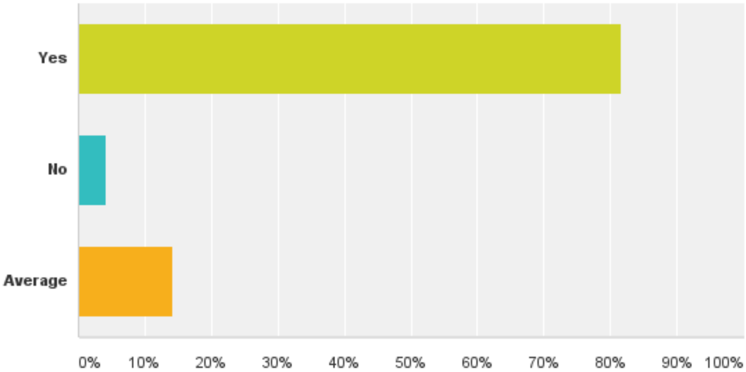



**Fig. 166 AUC respondents' opinion regarding spatial uniqueness of campus**

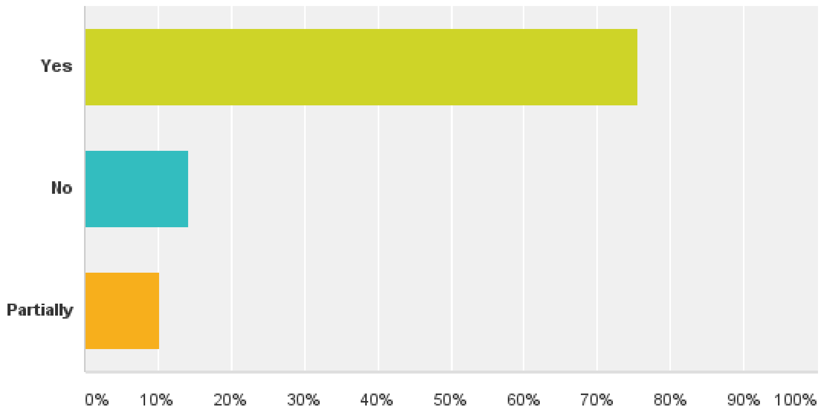



**Fig. 167 AUC respondents' opinion regarding sufficiency of natural landscape elements**

### 5.4.4 Social qualities on campus

As the previous two cases, the social and spatial classification is not according to gender. All staff interviewed see it essential to have common spaces with students to enhance a healthier educational process. The social interaction between staff and open spaces is limited. They have their internal lounge space without any outdoor space for social interactions. Workers are totally segregated from the social interactions on campus. They have only limited spaces for having breaks or eating which is totally separated from the rest of the users and the space for resting is attached to the underground tunnel. It is a bit unfair to prevent any outdoor connections for only being categorized as workers on campus.

It is common between different universities that students of the same major are associated with a certain social character, even that could be spatially separated at some point. On AUC campus, PVA students are associated with being sort of hippie or unique since they are the students related to arts. HUSS students are also associated with being unique with loud voices since they are the students studying literature. This supports that idea that mostly group membership or friendship formation is associated to having something common spatially or socially. Another example is the Gucci corner where students that are bonded to showing off with fashion could appear

The common social identity that most of the interviewed users highlighted was the diversity of community of the AUC since it includes different social standards, students from various educational systems and even foreigners. Also, as mentioned by interviewees, the educational system has a strong influence in shaping the students' characters in a unique way that is not present in another university. The student representation in all phases, stages and decisions is taken into consideration.

Regarding participation in the decisions regarding the outdoor spaces or landscape was only performed for different users on campus prior the construction of the campus but after the operation of the project no participation is taken into consideration.

According to the conducted interviews, the majority confirmed that the large scale of the campus made easy for the presence of spaces complying with the privacy. Many students indicated the vacant areas in the gardens and the façade with perforated blocks next to the library where users could sit inside these blocks Fig. 168.

**Fig. 168 Library screen blocks**

The most social spaces according to the conducted questionnaires Fig. 169 were: “The steps” having a place to sit, next to “Quick” Fig. 171 providing snacks. “The Bartlett Plaza” includes most of the activities happening on campus, exposed to food outlets and has seats. The balconies Fig. 170 have shaded areas, provide exposure to the people passing. The fourth is “The garden” which provides the best setup for enjoying the nature, sitting on the lawn, and shaded by the trees.

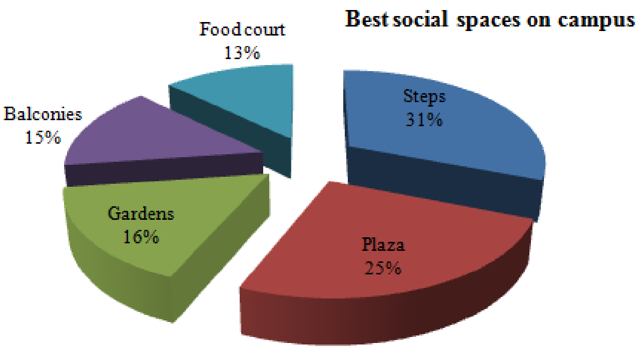



**Fig. 169 Best social spaces on AUC campus**

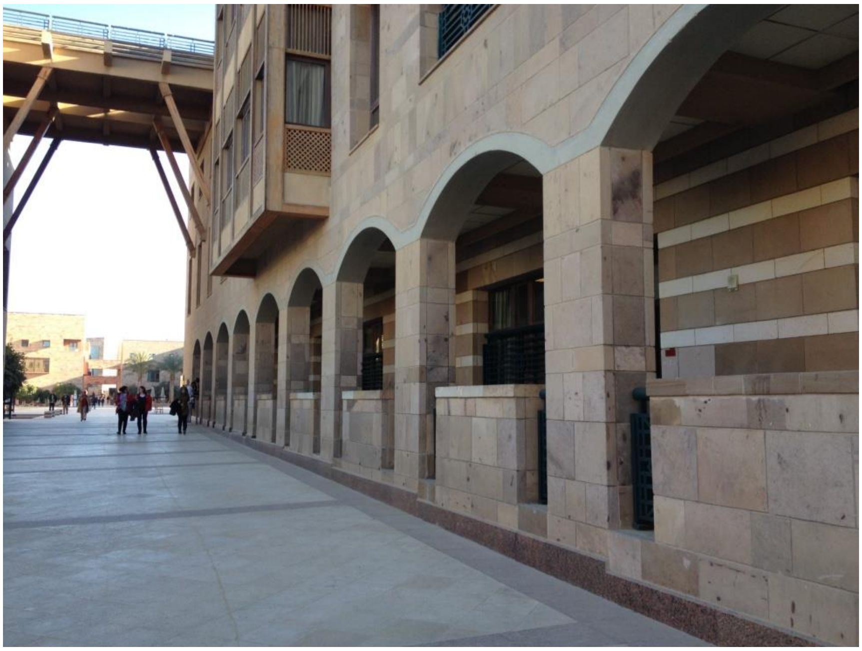


**Fig. 170 AUC balconies next to SSE**


**Fig. 171 Quick snacks outlet**

Based on questionnaires, the most socially abandoned spaces Fig. 172 are: PVA which is considered at the end of the campus spine, with minimal amount of shading and absence of activities. HUSS building Fig. 173 since it has a problem with way finding due to the similarity between different spaces from the aspect of architecture and hierarchy. The hidden parts of the gardens are also abandoned due to the absence of strong connection to the flow of traffic and activities.

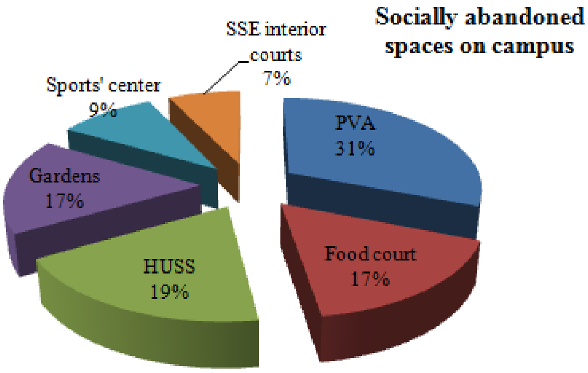



**Fig. 172 Socially abandoned spaces on AUC according to questionnaires**

**Fig. 173 Very similar different internal courts of HUSS**

### 5.4.5 Conclusion for AUC campus

- The connection between different uses and buildings through clear axes served the strong connectivity of the campus.
- The separation between vehicular and pedestrian circulation, normal vehicular circulation and services supported the efficiency and the safety of each circulation system.
- The use of electric cars for fast internal movement of staff on campus is a very good idea to decrease the vehicular movement and conserve resources wasted for frequent service movement on campus as well as providing an easy fast way of movement in case of emergency.
- Although partial coverage by cycling is provided on campus. Awareness and spreading of culture need to be widened and enhanced.
- The idea of planting roof tops and generating electricity from solar energy is limited to RISE office. It needs to be extended to be applied to different parts on campus.

- The clear ecological factors taken into consideration (low water consumption, light flooring, recycling…etc.) puts the campus on a higher position in the improvement of the sustainability of the campus.
- Far or isolated spaces need better activation in order to perform more efficiently.
- Repetition of style and detailed design of different neighbored spaces creates a sense of losing the way i.e. HUSS building's spaces.
- Safety measures need to be considered from the beginning (i.e. water channels that caused stumbling before coverage).
- The unique style, architecture and landscape elements succeeded in creating a story identity for the campus.

### 5.4.6 Cross-cutting relations for AUC campus

Table 18 Cross-cutting relations for AUC campus (Kindly check the folded table)

## 5.5 Comparative analysis of the three case studies

### 5.5.1 Schematic percentages according to checklist

The following charts Fig. 174& Fig. 175 are just indication to compare the situation of different aspects fulfilling sustainability of landscape on the three campuses. Apart from the cycling situation but generally water and materials are the least considered aspects according to the generated list. Each point of the list had a unit value and the partially applied points were considered as half a unit, while the not applicable points were eliminated. No physical calculations are indicated. Only a comparative indication is required to give an overview of the different cases to each other and according to the checklist deduced.

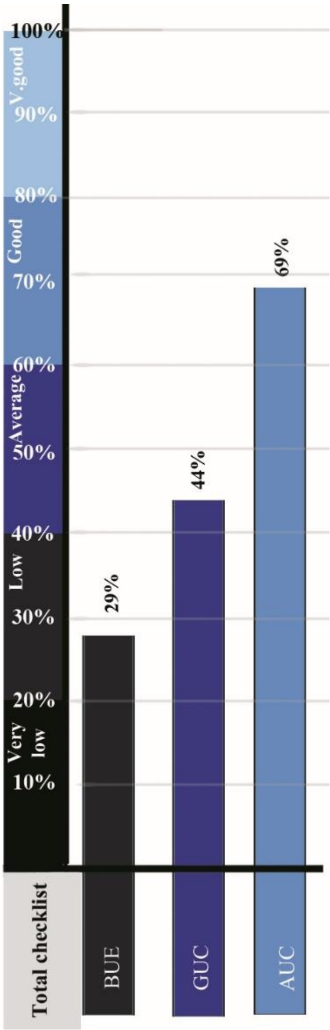



**Fig. 174 Categorizing achievements of total checklist for BUE, GUC& AUC**

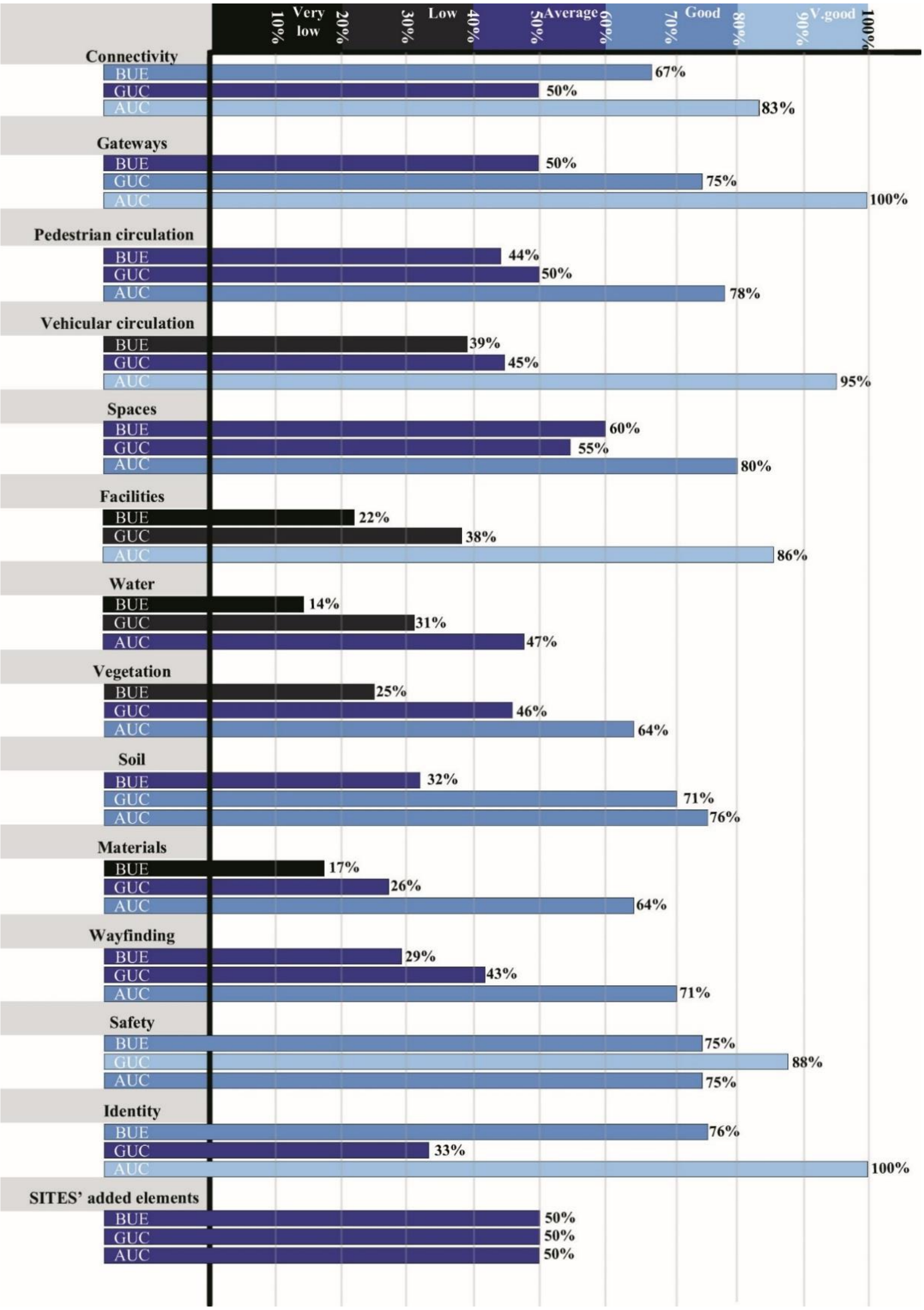



**Fig. 175 Categorizing achievements of divided checklist for BUE, GUC& AUC**

**Connectivity:** GUC has the least achievement because of the major issue of vehicular circulation (asphalt) interfering the internal circulation of the campus which had drawbacks for different aspects for pedestrian circulations rather than the benefits, also the dead parts behind the buildings were a negative point. For BUE and AUC the far spots on campus was from the main negative affecting points.

**Gateways:** BUE and GUC lacked the presence of the logo on all gates, the clear appearance of the use of the gate.

**Pedestrian circulation:** The low achievement for BUE was due to the narrow width of the main path, limited accessibility for emergency and the long distances to reach essential targets. Ecological factor was low for all.

**Vehicular circulation:** BUE had the least achievement due to the narrow width of roads for services and the absence of dedicated outdoor parking, only parking on the sides of the roads. Ecological factor was low for most except partially for permeable parking floor for AUC.

**Spaces:** BUE and GUC lacked the presence of a pure centralized space that is in the center to be easily reached by all. GUC had interfering vehicular circulation which weakened the network connecting spaces.

**Facilities:** Absence of parking areas for students and the insufficiency and the lack of comfortability for the street furniture were the main reasons for the low achievement of BUE. All lacked the connection to the public transportation network.

**Water:** The absence of any water collection systems, greywater recycling and wastewater recycling were main lacks for all cases. Using efficient methods of irrigation was a strength for all. BUE and GUC lacked the use of computerized control systems.

**Vegetation:** BUE is using vegetation only for the aesthetical purposes. GUC and AUC take vegetation water consumption more into consideration. The use of chemicals for all is still considered as an issue. The productivity of vegetation is limitedly considered in AUC.

**Soil:** Most of the soil assessments are performed according the personal experience. The AUC had the most detailed surveys, reports and studies. In all cases amendment is preferred more than replacement. Compost is used in all cases but only locally produced on AUC campus.

**Materials:** All cases exclude the red listed materials. The use of recycled materials, materials with recycled content, reused materials, and reprocessed materials is not available in any of the cases. Also the application of DFD is not clearly applied in all cases.

**Wayfinding:** BUE & GUC didn't have an efficient wayfinding system which led to the low achievement. AUC had a designed wayfinding system but still isn't very useful for the users.

**Safety:** AUC had a solved problem of narrow water channels that caused stumbling and BUE had the problem of some broken stairs which caused a low achievement compared to GUC.

**Identity:** AUC had an oriental desert identity that was obvious in all designs and the same for the Colonial style of BUE. GUC didn't have a strong identity except for the color.

**SITES' added points:** For all cases arable lands were saved by building in the desert and building within the spots for future development having basic infrastructure. Supporting any ecosystems, habitats or species were not taken into consideration.

### 5.5.2 Comparison of the three campuses

This Table 19 includes the main highlights of application of sustainable measures and major defects on the three cases.

- Major sustainable measures
- *Major defects*

**Table 19 General comparison of all case studies**

<table>
<tr><th colspan="2">Element of comparison</th><th>BUE</th><th>GUC</th><th>AUC</th></tr>
<tr><td rowspan="8"></td><td rowspan="2">Connectivity</td><td colspan="3">Accessibility for disabled users</td></tr>
<tr><td>-Only one very long axis connecting the campus.<br>-Only one very slow road cutting pedestrian areas.</td><td>-Unclear network for pedestrian.<br>-Excess of minimal used vehicular network.</td><td>-Four connected axes creating good connection of campus.<br>- Total separation between vehicular and pedestrian.</td></tr>
<tr><td rowspan="2">Gateways</td><td colspan="3">Unified style and design of gates</td></tr>
<tr><td colspan="2">-Logo and name are only indicated for the main gate only</td><td>-Presence of logo, name and the type of the gate.</td></tr>
<tr><td rowspan="3">Pedestrian circulation</td><td colspan="3">Consistency of style and design of used materials</td></tr>
<tr><td colspan="3">Lack of shading in many spots</td></tr>
<tr><td>-Paths are not wide enough related to the number of students.<br>- Some parts are not covered in case of emergency</td><td>-Excess of asphalt<br>- According to design vehicles had the priority on campus.<br>-Emergency vehicles are accessible to different spots.</td><td>-Bright colored and rough flooring to decrease heat island effect. (ecological value)<br>- Paths are wide enough to allow emergency vehicles' access.</td></tr>
<tr><td>Cycling</td><td>-No cycling is provided on campus and no chance that it could be introduced.</td><td>- No cycling is provided on campus<br>- The large asphalt coverage could support future introduction</td><td>- Limited cycling loop is provided.<br>- No sufficient connection to campus core.<br>- No provision of encouraging facilities.<br>- No enough shading or lights for night use.</td></tr>
</table>

<table>
<tr><th colspan="2">Element of comparison</th><th>BUE</th><th>GUC</th><th>AUC</th></tr>
<tr><td rowspan="4">Physical qualities</td><td rowspan="2">Vehicular circulation</td><td colspan="3">The absence of ecological value with the asphalt roads on campus</td></tr>
<tr><td>-Limited drop offs<br>-Roads partially supporting different types of vehicles.<br>- No separate service circulation.</td><td>- Vehicular circulation is supporting different types of vehicles<br>-No separate service circulation.</td><td>-The presence of drop offs at important spots on campus.<br>-Total hiding and separation of services by an underground tunnel.<br>-Connection of all parking lots to prevent bottle necks.<br>- Partial (unused) porous interlocking blocks at parking areas feeding ground or surrounding retentions</td></tr>
<tr><td rowspan="2">Spaces</td><td>- The absence of a central space.<br>- Minimal spaces providing interaction with nature.<br>- Minimal pure spaces (mostly paths)</td><td>- Presence of a central space. (Not purely centered )<br>-The absence of hierarchy or purely structured connection of spaces.<br>- Some unused spaces at the back of the buildings<br>- The garden is a bit abandoned due to the lack of activity</td><td>- Presence of a central space.<br>- Garden provides good interaction with nature.<br>-Partial interconnectivity of different spaces to the main campus axes.<br>- Some spaces are not activated since they are hidden or detached.</td></tr>
<tr><td colspan="3">-Most spaces are enclosed by buildings or greenery<br>- Humane proportions of designed spaces<br>- Consistency of materials, styles and identity of spaces</td></tr>
</table>

<table>
<tr><th colspan="2">Element of comparison</th><th>BUE</th><th>GUC</th><th>AUC</th></tr>
<tr><td rowspan="4">Physical qualities</td><td rowspan="4">Facilities</td><td colspan="3">-Water and wastewater infrastructure was provided at a near distance from the beginning of the project<br>-Flexibility of some of the street furniture<br>-No connection to the public transportation system<br>-Not enough parking</td></tr>
<tr><td>-Absence of parking lots for disabled</td><td colspan="2">-Provision of special parking lots for disabled users</td></tr>
<tr><td colspan="2">-No action to decrease the use of cars except buses provision.<br>- No efficient vegetation to decrease heat island effect at parking lots.<br>- The absence of consistency of furniture.</td><td rowspan="2">-Bio-degradable and local materials for furniture.<br>-LED lights<br>-Initiative for using PV cells<br>-Provision of services as bicycle racks and emergency boxes<br>- Sorting of bins for recycling.<br>- Supporting carpooling.</td></tr>
<tr><td>-Absence of parking for students.</td><td>-Far parking spot for many parts of the campus</td></tr>
</table>

<table>
<tr><th colspan="2">Element of comparison</th><th>BUE</th><th>GUC</th><th>AUC</th></tr>
<tr><td rowspan="4">Ecological qualities</td><td rowspan="3">Water</td><td colspan="3">-Efficient means of irrigation: Mostly drippers and some sprinklers<br>-The use of compost blankets<br>-The use of treated water for irrigation<br>- Water storing systems are provided<br>- Limited areas of turf grass on campus and less mowing<br>- No means of harvesting runoff<br>- No use of graywater, wastewater or blowdown water for irrigation<br>- The absence of exposed sustainable systems for spreading awareness</td></tr>
<tr><td colspan="2">-Different disciplines were not included in the water system initiation<br>-Manual control systems of irrigation</td><td>- Different disciplines were included in the water system initiation.<br>- Control systems are computerized as well as alerts for leakages.<br>-Limiting curbs and gutters on parking lots to allow flow of runoff to vegetation.<br>- Presence of retention basins (but without the use of harvested water)</td></tr>
<tr><td></td><td colspan="2">-Vegetative species are distributed according to hydrozones to decrease the loss of water.<br>-Selection of vegetative species according to water consumption (Wide spread of cacti in GUC).</td></tr>
<tr><td>Vegetation</td><td>- The used vegetation on site is only for the aesthetical qualities.(No design intends)<br>- Not all grass used was appropriate to the use intend.</td><td colspan="2">-The presence of a nursery on campus that covers large percentage of vegetative needs.<br>-Very limited, not considerable, vegetative species naturally grown on site were kept.<br>- Most of the used vegetation are having deign intends (wind breaking- fencing- shading…etc.).<br>- The limited use of bio-enemies for pest management to limit the use of chemicals.<br>- The use of limited appropriate species of turf grass and replacement by ground covers.<br>-Some species have an ecological value (salt elimination- supporting sloped soil- low water consumption</td></tr>
</table>

<table>
<tr><th colspan="2">Element of comparison</th><th>BUE</th><th>GUC</th><th>AUC</th></tr>
<tr><td rowspan="5">Ecological qualities</td><td rowspan="2">Vegetation</td><td colspan="3">-The used species are relevant to the site.<br>-The absence of usage of peat except indoors.<br>- Most of the used species are grown from seeds locally produced.<br>-Some edible species are grown on campus (Mostly not used as resource or a strong source of food on campus).<br>- Many chemicals are still used as fertilizers and pesticides.<br>- Invasive species are not identified in the Egyptian context.</td></tr>
<tr><td></td><td>-The use of reused plastic containers and wide irrigation vessels as growing containers</td><td>-The manufacturing of local compost on site.<br>- The limited use of some native species.<br>-Vegetation setup is indirectly supporting biodiversity.<br>- The limited introduction of green roofs (edible-aesthetical)</td></tr>
<tr><td rowspan="3">Soil</td><td colspan="3">-Amending of soil is applied more than replacement of soil.<br>-Local soil is mostly used with additives.<br>- No construction materials onsite are used as amending method for soil.<br>- Common soil is sand which is very low in organic matter and high in drainage</td></tr>
<tr><td>-Local sand is used as base soil.</td><td></td><td rowspan="2">-Mulching is used to prevent evaporation and soil erosion.<br>-Detailed and comprehensive tests and assessment for soil are applied.<br>-Leaching is applied with radial drip irrigation to wash salt from soil.</td></tr>
<tr><td colspan="2">- Compost is not produced on site.<br>- Many of the soil tests are not applied and are based on experience.</td></tr>
</table>

<table>
<tr><th colspan="2">Element of comparison</th><th>BUE</th><th>GUC</th><th>AUC</th></tr>
<tr><td rowspan="4">Ecological qualities</td><td rowspan="4">Materials</td><td colspan="3">-None of the red listed materials are used on campus.<br>-Interlocking blocks is used which in many cases could follow (DFD).<br>- Some aggregates from site were used in landscape i.e. retaining walls.<br>- Production firms applying sustainable measures in production wasn't taken into consideration.<br>- Sustainability of asphalt is not taken into consideration (recycled content-porosity)<br>-Recycled, reprocessed or reused materials are not used(except for compost)</td></tr>
<tr><td colspan="2">-E.E and E.C for materials are not taken into consideration.</td><td rowspan="2">-High reflectance, roughness and light colors of materials to decrease heat island effect.<br>-Maintenance free materials.<br>- E.E &E.C were taken into consideration during selection.<br>- Most materials used are locally produced.<br>- The use of bio-based materials i.e. rattan chairs.<br>-Recycle vegetation trimmings to produce compost.<br>-Disposed exhaust from electrical plants is used for heating.</td></tr>
<tr><td rowspan="2">-Irrelevant not durable outdoor flooring was used.</td><td>-Some materials are locally produced (wooden benches)</td></tr>
<tr><td colspan="2">-Use of petrified wood on site as landscape element.</td></tr>
</table>

| Element of comparison | | BUE | GUC | AUC |
|---|---|---|---|---|
| Individual Use qualities | Wayfinding | *-No use of recycled materials for signage* | | |
| | | -Zones of campus are classified according to buildings.-<br>*-Most landmarks are associated according to uses not unique buildings or landscape elements*<br>*- Very minimal useless signs (only GUC) are provided.* | | -Zones are classified according to buildings, spaces associated, and different architectural design and style.<br>-Some landmarks are associated to unique buildings or landscape elements.<br>- Flexibility of signs for reuse.<br>-Inflammable materials and complying with safety measures<br>*- Most of directional signs are not easy to read or follow due to different names* |
| | Safety | *- Broken steps causing stumbling.*<br>- Cameras are covering most of the campus *(Very limited spots are hidden)* | *- Hidden spaces behind buildings are not activated.*<br>-Cameras and patrols are covering all campus.<br>- No physical or emotional hazard | -Cameras and patrols are covering all the campus.<br>*- Some internal courts and parts of gardens are not well activated.*<br>*- Narrow channels that cause stumbling on plaza.*(solved and covered) |
| | Identity | - Colonial style, colors and unique auditorium's dome is creating the identity.<br>*- No unique landscape elements creating identity.* | .*-Not admired shape of buildings.*<br>*- No certain style and no unique landscape elements.*<br>- The color and the spatial composition of buildings creates the identity. | - Natural sandy colors gives a desert identity to the campus.<br>-Palms and some Egyptian trees gives the feeling of originality of orient.<br>- Style of architecture gives the modern oriental Islamic style. |

# Conclusions and Recommendations

## Classified checklist

The checklist was generated from theoretical bases (literature, reports, assessments, master plans and SITES ranking system. Validation and editing were performed by landscape. Analyzing the case studies was partially performed through the list which lead to the final classified format giving comprehensive indication to the situation of the sustainable landscape in Egypt (desert new communities)

**Color code for classification for each case**

| | |
|---|---|
| Applied | |
| Partially applied | |
| Not applied at all | |
| Not applicable | |
| Needs deep investigation of design | |

**Color code for classification for aggregation**

| | |
|---|---|
| Applied in all | |
| High partially applied (i.e.2 full cases &1partial case OR 2 applied & 1 not applied case) | |
| Medium partially applied (i.e.1 full case & 2partial cases OR 1full case & 2 not applied cases OR 1full case & 1 not applied case & 1 partial case) | |
| Low partially applied (3 partial cases OR 2 partial & 1 not applied case) | |
| Not applied in most (2 not applied cases) | |
| Not applied in all | |
| Not applicable | |
| Needs deep investigation of design | |

| **Connectivity** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Safety of paths. (lighting- accessibility-suitable for disability) | | | | |
| Permeability of pedestrian network (short links- numerous intersections - minimal dead ends). | | | | |
| Balance between vehicular and pedestrian networks. | | | | |

| **Gateways** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Uniformity in the design of different gates. | | | | |
| Indicating the presence of the campus (place-marker). | | | | |

| **Pedestrian circulation** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Pedestrian are having the priority in campus design of circulation. | | | | |
| Pathways varying from 1.52 to 4.5 meters (proportionate to the amount of users). | | | | |
| Consistency of visual design of pathways and bypaths. | | | | |
| Separation or solving of pedestrian- vehicular connections. | | | | |

| **Pedestrian circulation** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Pathways having an ecological value serving the environment. | | | | |
| Attaching pathways to activities or connection between indoor and outdoor to provide revival and security. | | | | |
| Paths should accommodate the accessibility of emergency vehicles. | | | | |
| Good protection of pathways according to the climate. | | | | |
| Application of "desired lines" concept to make sure that the used paths are the best option. | | | | |

| **Cycling circulation** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Provision of bicycle lanes with signs that are minimum 3 meters and of 5% maximum slope. | | | | |
| Provision of shading and lighting for night use of bicycle lanes. | | | | |
| Provision of bicycle racks at the important spots of the campus. | | | | |
| Offering of encouraging facilities of cycling on campus (i.e bicycle services- awareness classes. | | | | |
| **SITES rating system added point**: The cycling network should be located no further than 1.2 km from the project entrance and spanning for about 8.05 km in length. | | | | |

| **Vehicular circulation** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| The presence of drop offs at the important spots. | | | | |
| The separation of the service circulation from the main vehicular circulation. | | | | |
| Roads should support different types of vehicles as buses or trucks. | | | | |
| The internal connections between different parking areas to prevent bottle necks for cars' way while searching for parking lot. | | | | |
| Provision of narrow and slow roads to provide safe pedestrian movement. | | | | |
| Limiting roundabouts and cul de sacs. | | | | |
| Highlighting physically the spots of pedestrian crossing. | | | | |
| Provision of shared streets including pedestrian, bicycles and cars. | | | | |
| Efficient hidden parking lots for garbage and services should be provided. | | | | |
| Incorporate ecological solutions to vehicular roads to serve the environmental sustainability. | | | | |

| **Spaces** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Prevention of space initiation to the outside or at dead spots on campus. | | | | |
| Accessibility, functionality and interactivity of spaces. | | | | |
| Interconnectivity of spaces with the whole network of spaces on campus. | | | | |
| Presence of central space for activities. | | | | |
| Consistency of materials, styles and identity of spaces. | | | | |
| Presence of spaces enhancing social interactions. | | | | |
| Humane proportions of designed spaces. (enclosure and heights) | | | | |
| Variety of uses and activities of different spaces on campus. | | | | |
| Definition of spaces using buildings or vegetation. | | | | |

| **Facilities** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Availability of buses' and taxis' stops. | | | | |
| Carpooling support or availability of access to public transportation. | | | | |
| Solution of parking problems (if available) by remote or underground parking. | | | | |

| **Facilities** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Availability of parking lots at reasonable distances on campus. | | | | |
| The presence of special parking lots for disabled people. | | | | |
| Provision of low heighted vegetation surrounding parking areas in order not to block vision. | | | | |
| Provision of deciduous trees on parking islands to prevent heat island effect. | | | | |
| Flexibility of furniture and durability of materials. | | | | |
| The use of local materials to produce the site furniture. | | | | |
| Compatibility of furniture to users' movement without blocking any movement axes. | | | | |
| Comfortability and suitability of furniture to different users. | | | | |
| The provision of adequate amount of light without extras that only consumes energy without being beneficial. | | | | |
| The usage of LED lights. | | | | |
| The usage of intelligent lighting or lighting operated by clocks, PV cells or photocells. | | | | |
| **SITES rating system added point:** The project should be situated within 0.8 kilometers of walking distance from seven basic services as bank, restaurant, post office,…etc. (Each should have a separate entrance- not more than half of the no. could be located in the same building-only twice of each service types could be counted- each should counted once even if it provides several services) | | | | |

| **Facilities** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| **SITES rating system added point:** The site should be maximum about 152.4 meters away from publicly provided water and wastewater infrastructure. | | | | |
| **SITES rating system added point:** A bus stop or streetcar stop should be provided at a distance of maximum 0.4 km or 0.8 km from a public transport stop**.** | | | | |
| **SITES rating system added point:** Provision of seats for five percent of the site users | | | | |
| **SITES rating system added point:** Provide services to support site users during physical activity. (e.g., drinking fountains, bicycle racks, emergency call boxes) | | | | |
| **SITES rating system added point:** Sorting of garbage for recycling and providing different trash bins according to the material**.** | | | | |
| **SITES rating system added point:** The use of renewable sources of energy to provide electricity needed for the landscape. | | | | |

| **Water** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| 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. | | | | |

| **Water** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| 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. | | | | |

| **Water** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| 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. | | | | |

| **Water** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| 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**.** | | | | |

| **Vegetation** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| The used vegetation has an ecological benefit and supports the ecosystem. (air quality- water consumption and quality- biodiversity- soil quality) | | | | |
| The vegetation types are relevant to the site. | | | | |
| The use of sustainable, recycled or organic products for cultivation and maintenance. | | | | |
| The vegetation types are checked to be not of the invasive types for the site and won't turn into one by time. | | | | |
| The vegetation types were checked to be grown on site in a nursery | | | | |
| The vegetation are fulfilling design intends. | | | | |
| Some vegetation are used to reduce the heat island effect in parking. | | | | |
| Using vegetation for the purpose of wind breaking or microclimate modification. | | | | |
| Application of phytoremediation concept through used vegetation types to purify collected or recycled water. | | | | |
| Protection of useful salvaged vegetation initially present on site (pruning-supplemental watering-mulching-fertilizing-protection against wind). Separation new from old vegetation when re-cultivating. | | | | |
| Availability of variety of vegetation with different age ranges which reduces the impact of diseases and facilitates the tracking of defects. | | | | |
| Keeping enough distances from hardscapes, structures that could affect the vegetation. | | | | |

| **Vegetation** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Use of relevant native plants on site fulfilling the required design intentions | | | | |
| Application of the xeriscaping methods in landscape (limited use of turf grass-use inorganic mulch to save soil properties-vegetation with limited consumption of water-better soil quality to increase moisture holding capacity- efficient irrigation- maintaining landscape) (If climate is relevant) | | | | |
| Abandoning the use of invasive vegetative species (spread very fast- produces large amount of seeds- cause harm to other living organisms) | | | | |
| The use of locally produced seeds | | | | |
| Reduce use of peat and use planting media and pots from renewable energy. | | | | |
| Salvaged plants if moved (according to case) should be subjected to: Clean roots and branches cuts- good care - early assessment of situation before moving | | | | |
| Use of green roofs for: stormwater management or habitat for wildlife or reducing heat island effect or provide edible products | | | | |
| Using species that could tolerate dry climates and low maintenance for green roofs (succulents and sedums) | | | | |
| Use of edible vegetative species as a resource for the university campus | | | | |
| Characters of edible species: (perennial- direct production rather than refining- non-excessive maintenance- normal function aside) | | | | |

| **Vegetation** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| The provision of vegetation that supports wildlife habitat: (open canopy- flowers or fruits-branches near the ground-diversity of species- disturbance) | | | | |
| Introducing vegetation after stability of site (absence of loss of plants) | | | | |
| **SITES rating system added point:** Plant at the optimal season for your region to reduce or eliminate the need for watering for establishment. | | | | |
| **SITES rating system added point:** If turf grasses are to be used, they should be regionally appropriate and minimize post-establishment requirements for irrigation. | | | | |
| **SITES rating system added point:** Provision of VSPZ (vegetation and soil protection zone) to protect healthy and special vegetation and soil onsite | | | | |
| **SITES rating system added point:** Vegetation is used to provide shade to east, west, and southern facades to decrease the cooling loads of the building | | | | |
| **SITES rating system added point:** Recycle excess vegetation generated during land-clearing to produce compost, mulch, erosion-protection measures, or other site amenities. | | | | |
| **SITES rating system added point:** Minimize the use of synthetic fertilizers and pesticides that have a dangerous impact on human health or environment | | | | |
| **SITES rating system added point:** Identify and select plants from nurseries that actively implement better business practices to reduce damage to the environment and conserve resources | | | | |

| **Vegetation** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| The used vegetation has an ecological benefit and supports the ecosystem. (air quality- water consumption and quality- biodiversity- soil quality) | | | | |
| The vegetation types are relevant to the site. | | | | |
| The use of sustainable, recycled or organic products for cultivation and maintenance. | | | | |
| The vegetation types are checked to be not of the invasive types for the site and won't turn into one by time. | | | | |
| The vegetation types were checked to be grown on site in a nursery | | | | |
| The vegetation are fulfilling design intends. | | | | |
| Some vegetation are used to reduce the heat island effect in parking. | | | | |
| Using vegetation for the purpose of wind breaking or microclimate modification**.** | | | | |
| Application of phytoremediation concept through used vegetation types to purify collected or recycled water. | | | | |
| Protection of useful salvaged vegetation initially present on site (pruning-supplemental watering-mulching-fertilizing-protection against wind). Separation new from old vegetation when re-cultivating. | | | | |
| Availability of variety of vegetation with different age ranges which reduces the impact of diseases and facilitates the tracking of defects. | | | | |
| Keeping enough distances from hardscapes, structures that could affect the vegetation. | | | | |

| **Soil** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Soil assessment applied to site before working on it, classifying soil (disturbed- healthy- can be restored- contaminated). | | | | |
| Soil assessment through (site history- vegetation situation- hydrology and topography). | | | | |
| Introduced synthetic water circulation to site should be assessed according to the effect on the soil properties. (If available) | | | | |
| The properties of the present soil are similar to that of the native healthy soil**.** | | | | |
| Checking that topsoil and subsoil are not compacted in addition to the absence of toxins. | | | | |
| Take soil samples covering different soil types on site. | | | | |
| Apply soil texture test. | | | | |
| Range of organic matter complies with 3-5% according to performed test of organic matter value of soil**.** | | | | |
| Assessment of soil volume would be performed for areas less than 80 $m^2$ or the smallest dimension of the planted area is 5m. 3 $m^3$ is required for every 5 $m^2$ and 0.06 $m^3$ for every 0.09 $m^2$ in case of trees. | | | | |
| Percolation test is performed to assess the drainage of the soil. 12-18 inches hole is dug and filled with water and the water height is measured and measures again after 15 mins. The rate per hour is the height difference multiplied by 4. If less than 1 inch/hr then the drainage is very poor. If between 1 and 4 inch/hr then the drainage is poor. If between 4 and 8 inch/hr then the drainage is good.If more than 8 inch/hr then the drainage is excessive. | | | | |

| **Soil** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Checking the suitability of the plants to the PH value of the soil. Typical soils' PH value ranges from 6 to 9. Colorimetric or laboratory tests should be applied. | | | | |
| Application of electrical connectivity method to check fertility: Less than 0.38 dS/m is a low fertile soil. 0.38- 0.75 dS/m is an ideal soil. 0.75-1.5 dS/m is an acceptable soil. Higher than 1.5 dS/m is an unacceptable soil. (salt injury) | | | | |
| Protecting preserved good and healthy topsoil from any constructional action or pedestrian and vehicular traffic. | | | | |
| Amending and rehabilitating problematic soils on site: de-compaction for compacted soil- radial trenching with mulching or composting for soil lacking organic matter- over watering soil for abnormal salt amounts in soil- adding sand to clayey soil having drainage problems. | | | | |
| Amending of soil should be performed before planting and used materials are preferred to be local ones. | | | | |
| Some amendments of soil could be extracted from onsite construction materials: Gypsum and concrete for calcium-phosphorus, potassium and magnesium from red bricks | | | | |
| Soil that can't be amended can be buried replaced by other healthy soil onsite in limited cases. (If available) | | | | |
| Vegetation next to structural soil should be of type that resist high soil drainage. | | | | |
| **SITES rating system added point:** Making use of food waste in the process of creating mulch or compost | | | | |

| **Materials** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Materials shouldn't have effect on human health or on the environment. | | | | |
| Production firms is preferred to be applying sustainable measures in production. | | | | |
| Materials should help the sustainable design strategies. (i.e. prevents loss of runoff- reduces the heat island effect…etc.) | | | | |
| Materials are preferred to have a recycled content. | | | | |
| Materials used are preferred to be local in order to decrease the energy consumed for transportation. | | | | |
| Packages and packing materials should be of recycled or low quality materials in order to minimize the use of resources. | | | | |
| It is preferable that used material would be durable and could be recycled**.** | | | | |
| The material should have the least embodied energy and carbon.(EE &EC) | | | | |
| These materials should not be used: Asbestos- cadmium- chlorinated polyethylene and chlorosulphonated polyethylene- chlorofluorocarbons (CFCs)- chloroprene (neoprene)- formaldehyde- halogenated flame retardants- Hydrochlorofluorocarbons (HCFCs)- lead- mercury- petrochemical fertilizers and pesticides- phthalates- polyvinyl chloride- wood treatments containing creosote, arsenic or pentachlorophenol. If the material is composed of more than ten elements, these materials could be used but not more than 10%. | | | | |
| Applying concept of design for disassembling and deconstruction, that the used materials could be reused. | | | | |

| **Materials** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| The use of renewable resources that can be easily renewed by the environment (i.e. certified wood). | | | | |
| The disposed materials that cannot be used again are better to be used to produce electricity or heat through disposal. | | | | |
| The use of reclaimed materials that were used previously in other projects to decrease the consumption of new resources. | | | | |
| The use of reprocessed materials that could be broken down or sized down to be reused again. | | | | |
| Using materials that decrease the heat island effect | | | | |
| Characteristics to improve the sustainability of concrete (additives to increase reflectance and decrease heat island effect- recycled content- raw finish to resist weather- porosity for better infiltration and groundwater recharge) | | | | |
| For aggregates and stones, to improve their sustainability: (Local or reclaimed ones- porosity for better infiltration and groundwater recharge- applying disassembly concept using gabions or minimal mortar for connection as in case of urbanite) | | | | |
| For asphalt, to improve its sustainability: ( recycled asphalt or recycled - porosity for better infiltration and groundwater recharge- production under low temperature provides better longevity as well as less emissions- additives to increase reflectance and decrease heat island effect) | | | | |
| Red bricks could be reused with the use of minimal amount of mortar or the use of lime mortar, and has lower embodied energy than concrete. | | | | |

| **Materials** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| The higher the recycled content in plastic the less resources consumed and waste produced. Polyethylene and polypropylene have very low effect on environment than others as PVC, ABS and polystyrene. | | | | |
| Metals are more durable than wood, concrete or plastics. For better sustainable metal : Design for disassembly (bolted better than welded)- mechanical coating better than chemical -reuse of used metal- smooth and horizontal finishes to resist corrosion and accumulation of contaminants) | | | | |
| The use of bio-based materials (10 years feedstock cycle- 90% or more are bio-material content) instead of non-renewable ones as bamboo, jute, and straw bales. | | | | |
| For a more sustainable wood: (certified wood- flexible modes of fixation for reuse- reclaimed wood-decay resistant wood-limit use of preservatives | | | | |
| **SITES rating system added point:** Use and conserve existing resources and reduce waste by maintaining existing structures and paving in their existing form before construction (If available) | | | | |
| **SITES rating system added point:** Compost or recycle 100 percent of vegetation trimmings on site for use in nursery operations or for sale to the public. | | | | |
| **SITES rating system added point:** Where possible, balance cut and fill volumes, and reuse existing soils and rocks in the proposed site design instead of specifying and importing new materials for the project | | | | |

| **Wayfinding** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| The campus should be divided into zones to facilitate legibility. | | | | |
| Provision of landmarks to create memorable points. | | | | |
| Provision of sufficient signs and maps in the positions of decision making. | | | | |
| Signs should be readable according to regulations. | | | | |
| The presence of contrast between the text and the background of signs. | | | | |
| The designed wayfinding system has to comply with fire and safety codes. | | | | |
| Sustainability of used signs: (Recycled materials- flexibility of fixation and disassembling e.g bolted rather than welded- efficiency in the number of signs). | | | | |

| **Safety** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Absence of different types of hazard: Clearance hazard- object hazard- collision hazard- stability hazard. | | | | |
| Provision of surveillance or different activities over different spaces. | | | | |
| Provision of security systems, cameras and sufficient lighting. | | | | |
| Keeping a distance of 4.5 m as defensive distance from any obstacle. | | | | |

| **Identity** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Creating an identity through buildings, building elements or colors. | | | | |
| Creating an identity through landscape elements. | | | | |
| Creating an identity through style. | | | | |

| **Points added from SITES rating system** | BUE | GUC | AUC | **Aggregation** |
|---|---|---|---|---|
| Protection of farmlands or arable soils. | | | | |
| Protection of any 100 years floodplains. | | | | |
| Protection of any aquatic ecosystems including wetlands or deep water habitats. | | | | |
| Protection of habitats for threatened and endangered species. | | | | |
| Redevelop previously developed sites. | | | | |
| Locate project in existing developed site. | | | | |

# Conclusions

### General

- Sustainability of landscape is still not considered a major issue, the hypothesis is proven to be correct except for very few initiatives like that of the AUC. Otherwise, the majority still target the economic benefit on a much higher scale i.e. landscape sustainability is not taken into consideration at the initial phases of the project design. It is worth mentioning that most of highly effective systems of sustainable landscape have to be planned before the construction and the operation of the project even if certain improvements could be done at later stages.
- According to analysis, cycling and ecological measures are the least applied.
- The sustainability is implicitly considered from the economical point of view of the project. The ecological aspects affecting the nature are rarely or extremely limited in the case of consideration.
- Universities should be aware that fulfilling sustainable landscape measures could be expensive in the beginning but it has great revenues and durability for the future. Above all saving the environment for coming generations is the highest goal. That is a strong reason why AUC had the higher achievement with sustainable measures when it was considered before the beginning of the project.
- The construction of all new campuses on desert lands is a good start for creating new communities away from the dense areas and protecting arable lands and moving development away.
- The public awareness of sustainable landscape issues is very limited. Spreading awareness is needed more.

### Physical

- Linear urban designs of campus are not preferable due to the very long distances created e.g. BUE.
- In all studied campuses the separation of pedestrian and vehicular circulation are taken into consideration but some didn't consider that issue from the initial plans and designs and took it into consideration through the operation i.e. GUC.
- The provision of sufficient active spaces for interaction with nature is limited i.e. BUE and GUC. The successful cases should provide seats, shades, activities…etc. in order to ensure the efficiency of use of these natural open spaces i.e. AUC.

- The culture and awareness of cycling is very limited. In case of provision, users are still of limited numbers.
- Most of the studied cases had parking problems due to the insufficient amount of parking due to the increase in the number of students more than available parking lots.
- The concept of providing outdoor educational spaces is still not very common and applied in a very small scale especially for field studies.
- According to the studied cases, provision of sufficient shading compatible with the desert environment is mostly not considered.
- In many of the studied cases the lack of facilities is due to the increase in the number of students (parking and street furniture).
- Better connection with public transportation points need to be initiated on new far campuses as AUC, GUC, BUE. This idea would limit the use of cars and even limit or balance the resources used to provide private buses.

**Ecological**

- 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.
- In all the studied cases, the introduction of vegetation on site takes place during the construction phase due to the supposed extra costs. Setting and applying firm regulations to prevent growing plants during construction phase since many species could be affected and die which is an environmental and economic loss.
- Chemicals are still widely used for fertilizers and pest management. Limited use of bio-enemies are used in AUC to defeat some pests.

- The absence of the documented information regarding invasive species in Egypt.
- In all studied cases, phytoremediation concept wasn’t applied due to the absence of large water features that could make use of the filtering properties by plants.
- The revival of limited wildlife or species on campus is not taken into consideration. Good and healthy environment is provided that in turn could sometimes unintentionally could support biodiversity without intended considerations.
- Checking the situation of the soil wasn't very accurate since most aspects should be performed before operation and aren't obvious afterwards. Many cases indicate the absence of detailed assessment of soil according to sustainable measures and most depend on individual experience without detailed records.
- The use of reprocessed materials, others with recycled content, and application of DFD are still not popular in Egypt or used in very limited terms.
- The use of the huge amount of useful solar radiation is very limited. Only limited initiatives are applied to generate electricity for landscape lighting through PV cells or photocells but the absence of wide actual intervention.

**Individual use**

- The importance of wayfinding system is neglected in most campuses. The applied systems are not taking the efficiency and the accuracy of the used system. Although adding an efficient wayfinding system requires a strong economic support but provides the sustainability of ease and comfort interaction with the campus. BUE and GUC lacked any attempt for an efficient usable wayfinding system. AUC had a better application but still not helpful for most users.
- None of the studied campuses is taking into consideration the use of recycled materials for the wayfinding systems which consumes large amount of materials.
- The usage of unique architectural style, elements or colors give the campus a unique identity and memory that is kept in mind.
- Creating landmarks depended mainly on architecture and style more than on colors and landscape elements.

**Social qualities**

- The most social spaces according to the studied cases were mostly related to the provision of food, protection (shading), a place to sit and an opportunity of easily seeing people around.
- Groups sharing common majors mostly have certain social identities and sometimes a certain physical appearance.
- Many of the common unsocial spaces are related to the very far distances to reach, the isolation from the connected areas, absence of facilities or the feeling of being uncomfortable.
- Public participation is very essential neglected aspect that needs to be taken into consideration not only before application of the project but also during the operation phase, since the users are the ones who will be using the spaces not the designers.

## 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
- Wider field of using organic and non-toxic elements as pesticides and fertilizers better than chemical substances and governmental inspection could enhance this point.
- 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.
- Considering support of biodiversity (wildlife) while designing of landscape will widely have a healthy effect on ecosystems especially in case of endangered species.
- BUE and GUC are incomplete campuses, better systems fulfilling sustainable measures could be applied and taken into consideration in the next phases.

AUC still have land for future extension, better and more enhanced sustainable measures could be added in these extensions.

- 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.
- Recycling of materials and using materials with recycled content need to be more considered and regulated in order to save resources and energy.
- Encouraging use of native plants, identifying invasive species and checking the benefits of use of native ones is highly recommended.
- The concept of providing only aesthetical forms of landscape only without considering the side effects on water, resources, energy, maintenance,…etc. need to be changed. Each landscape design should be relevant to the available environment.

# Further Research

- Data regarding the water sustainability is available in the field of stormwater management for rainy environments. Very few data for water sustainability is available for arid and semi- arid regions, and the use of minimal amount of water provided by rain or seasonal storm. Further research is needed in this field.
- Further research could be applied to highlight and define list of invasive species for Egypt to prevent the hazardous effect on the ecosystem.
- Research need to be performed on people perception and awareness regarding sustainable measures of landscape.
- Detailed research and accurate calculations is needed to adapt the “SITES” rating system to the Egyptian case.

# References

Abedi, M., & Mahdavinejad, M. (2011). Community-Oriented Landscape Design for Sustainability in Architecture and Planning. *Procedia Engineering*, pp. 337-344.

Abou El Ela, M. S. (2004). A Sustsainable Landscape for a Livable Urban Fabric. *Al Azhar University Engineering Journal*.

Abu-Ghazzeh, T. M. (1999, November 1). Communicating Behavioral Research to Campus Design : Factors Affecting the Perception and Use of Outdoor Spaces at the University of Jordan. *Environment and Behavior*, pp. 764-804.

Adamowski, J. (2014, September 25). *Water Collection System*. Retrieved from Mc Gill University Web site: http://www.mcgill.ca/sustainability/water-collection-system-sp0015

American University in Cairo. (2013, November). Our Carbon Footprint 2.0. Cairo: American University in Cairo.

Barratt, W. (2011). *Social Class on Campus- theories and Manifestations.* sterling, Virginia: Stylus.

Benson, J. F., & Roe, M. H. (2000). *Landscape and Sustainability.* London and New York: Spon Press.

Bloom, B. S. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals.* Green, New York: Longmans.

Bloomberg, L. D., & Volpe, M. (2007). *Completeing your qualitative dissertation.* Sage Publications.

Bourdieu, P. (1989). Social Space and Symbolic Power. *Social Theory*, 14-25.

Burgess, j. (1994). *Future of Urban Parks and Open Spaces: Politics of Trust-Reducing Fear of Crime in Urban Parks Working Paper 8.* Comedia.

Calkins, M. (2012 kindle version). *The Sustainable Sites Handbook: A Complete Guide to the Principles, Strategies, and Best Practices for Sustainable Landscapes.* John Wiley & Sons, Inc.Hoboken, New Jersey.

Capilano University. (2012). *Capilano University-Campus Conceptual Development Plan.*

Carnegie Mellon University. (2014, September 26). *Environment at CMU*. Retrieved from Carnegie Mellon University Web site: http://www.cmu.edu/environment/campus-green-design/green-roofs/gates-center.html

Carol R. Johnson Assosciates. (2012). *Campus Landscape Vision and Site Standards.* Tennesse, Knoxville: The University of Tennesse Knoxville.

Cloke, P., Cook, I., Crang, P., Goodwin, M., Painter, J., & Philo, C. (2004). *Practicing Human Geography*. London: SAGE.

Creighton, S. (1998). *Greening the Ivory Tower: Improving the Environmental Track Record of Universities, Colleges and Other Institutions.* Cambridge, MA: MIT Press.

Dalhousie University. (2010). *Dalhousie University- Campus Master Plan-Framework Plan.*

Deasy, C., & Lasswell, T. E. (1985). *Designing Places for People.* New York: The Whitney Library of Design.

Development, P. I.-2. (Oct. 5, 2000. Updated Sept. 2005). *Sustainable Development Plan, University of Oregon.*

DIALOG. (2011). *University of Regina, campus master plan.*

Dober, R. P. (1992). *Campus Design.* John Wiley & Sons, Inc.

Dober, R. P. (2000). *Campus landscape functions, forms, features.* John Wiley & Sons.

Dober, R. P. (2008). Heritage, Identity and Campus Design. *Converstions on Jesuit Higher Education*, 22-24.

Duke University. (2014, August 3). *Duke Sustainability*. Retrieved from www.duke.edu: http://sustainability.duke.edu/campus_initiatives/water/conservation.html

Fisk University. (2014, October 10). *Fisk University History*. Retrieved from Fisk University Web site: http://www.fisk.edu/about/history

Florida Atlantic University (Davie Campus). (2007). *Landscape design guidelines - Florida Atlantic University (Davie Campus).*

Foltz, M. A. (2014, March 4). Retrieved from MIT Computer Science and Artificial Intelligence Laboratory | MIT CSAIL: http://www.ai.mit.edu/projects/infoarch/publications/mfoltz-thesis/node8.html

Gibson, D. (2009). *The Wayfinding Handbook - Information Design for Public Spaces.* Princeton Architectural Press.

Granovetter, M. S. (1973). The Strength of Weak Ties. *American Journal of Sociology*, 1360-1380.

Hannah, G. G. (2013). *Campus Planning and Design: The Academic Landscape.* Arizona: Landforms.

Hillier, B., & Hanson, J. (1984). *The Social Logic of Space.* Cambridge: Cambridge University Press.

Johnson, L., & Castleden, H. (2011). Greening the campus without grass: using visual methods to understand and integrate student perspectives in campus landscape development and water sustainability planning. *Royal Geographical Society*, 353-361.

Kenney, D. R., Dumont, R., & Kenney, G. S. (2005). *Mission and Place : Strengthening Learning and Community Through Campus Design.* Westport, Conn: Praeger Publishers.

Knox, P., & Marston, S. (2004). *Human Geography.* Upper Saddle River NJ: Pearson Education, Inc.

Kyle, G., & Chick, G. (2007). The Social Construction of Sense of Place. *Leisure Sciences*, 209-225.

Lau, S. S., & Yang, F. (2009). Introducing Healing Gardens into a Compact University Campus: Design Natural Space to Create Healthy and Sustainable Campuses. *Landscape Research*, 55-81.

Mackzulak, A. (2010). *Environmental Engineering: Designing a sustainable future.* New York: Hermitage Publishing Services.

Mann, P. H. (1954). The Concept of Neighborliness. *American Journal of Sociology, 60*, 163-168.

Manske, L. L., & Larson, J. C. (2000). *Xeriscape Ornamental Perennial Grass Trial for Low Water Use Landscaping.* North Dakota: Dickinson Research Extension Center.

McKenzie, S. (2004). *Social Sustainability: Towards some definitions.* Magill, South Australia: Hawke Research Institute- University of South Australia.

McNally, C., Joubert, L., & Philo, L. D. (2003). *The University of Rhode Island's Permeable Parking Lots: A Case Study of Alternative Pavement Materials.* Rhode Island.

Ministry of Water Resources and Irrigation. (2014). *Water Scarcity in Egypt: The Urgent Need for Regional Cooperation among the Nile Basin Countries.* Cairo: Ministry of Water Resources and Irrigation.

Minot State University. (2008). *Minot State University Landscape Master Plan, Design Development Submittal.*

Mohamed, S. O. (2013). Greening the Existing Buildings as a Priority for Tackling Climate Change and Energy Crisis. Cairo University.

Moore- Colyer, R., & Scott, A. (2005). What kind of landscape do we want. *Landscape Research*, 501-523.

Nasar, J. L., Fisher, B., & Grannis, M. (1993, October). Proximate physical cues to fear of crime. *Landscape and Urban Planning*, pp. 161-178.

Nassauer, J. I. (1995, August). Cuture and Changing Landscape Structure. *Landscape Ecology*, pp. 229-237.

Newman, P., & Kenworthy, J. (1999). *Sustainability and Cities: Overcoming Automobile Dependence.* Washington, DC and Covelo, California: Island Press.

Office of University of Massachusetts Boston Campus Master Planning. (2012). *Architecture and Landscape- Tools for creating a cohesive, beautiful, productive, accessible and sustainable campus environment.* Boston.

Ohio University. (2014, October 10). *Athens Campus: map & tour*. Retrieved from Ohio University Web site: http://www.ohio.edu/athens/bldgs/cutler.html

Olmsted, F. L. (1865). *The value and care of parks.*

Olwig, K. (2005). The Landscape of "customary" law versus that of "natural" law. *Landscape Research*, 299-320.

Peatross, F. D., & Peponis, J. (1995). Space, Education and Socialization. *Journal of Architectural and Planning Research*, 366-385.

Planning Institute of Australia, Canberra; Australian Local Government Association; National Heart Foundation of Australia. (2014, September 23). *Healthy Spaces and Places.* Retrieved from www.healthyplaces.org.au: http://www.healthyplaces.org.au/site/connectivity_full_text.php

Planning Institute of Australia, Canberra; Australian Local Government Association; National Heart Foundation of Australia. (2014, October 21). *Healthy Spaces and Places*. Retrieved from www.healthyplaces.org.au: http://www.healthyplaces.org.au/site/safety_and_serveillance_full_text.php

Princeton, U. (2014, August 3). *Stormwater Management*. Retrieved from Princeton Univetsity: http://www.princeton.edu/reports/2011/sustainability/conservation/stormwater-management/

Queen's University. (2013, June 16). *Queen's University Campus Plan 2002*. Retrieved from Queen's University Web site: http://www.queensu.ca/camplan/reports/cplan02.html

Rached, I., & Elsharkawy, H. (2012). The Role of Open Spaces in the University Campus in the Egyptian Context. *Designing place*, (p. 7).

Ramanujam, P. (2006). Prospect- Refuge Theory revisited: A Search for Safety in Dynamic Public Spaces . The University of Texas at Arlington.

Relph, E. (2002). *Theory in Landscape Architecture.* Philadelphia: University of Pennsylvania.

Richard P. Dober, A. (2000). *Campus Landscape Fuctions, Forms, Features.* New York: John Wiley & Sons, Inc.

Roadside Revegetation. (2014, 7 23). *Roadside Revegetation*. Retrieved from www.nativerevegetation.org.

Saari, C. (2002). *The Environment:Its role in Psychosocial Fuctioning and Psychotherapy.* New York: Colombia University Press.

Santa Clara University. (2014, September 28). *Recycling of Water in Santa Clara University*. Retrieved from Santa Clara University Web site: http://university-operations.scu.edu/facilities/sustainability/recycling_water/

Seattle University Campus. (2014, September 27). *Grounds and Landscaping: Seattle University Campus Gardens*. Retrieved from Seattle University Web site: http://www.seattleu.edu/grounds/gardens/

Selman, P. (2008). What do we mean by sustainable landscape? *Sustainability: Science, Practice & Policy*, 23-28.

Selman, P. (2012). *Sustainable Landscape Planning- The Reconnection Agenda.* Routledge.

Stiles, R. (2013). *A Guideline for Making a Space- Joint Strategy Activity 3.3.* Vienna: TU Wien.

The Clark Enersen Partners. (2008). *Minot State University Landscape Master Plan.* Minot.

The Sustainable Sites Initiative. (2009).

The Sustainable SITES Initiative. (2014). SITES v2 Rating System for Sustainable land design and development.

Thompson, I. H. (2000). *Ecology, Community and Delight- Sources of Values in Landscape Architecture.* London and New York: E & FN Spon.

Thompson, J. W., & Sorvig, K. (2007). *Sustainable Landscape Construction : A Guide to Green Building Outdoors (2nd Edition).* Washington, DC, USA: Island Press.

Tresidder, M. (2005). *Using GIS to Measure Connectivity: An Exploration of Issues Field Area Paper,School of Urban Studies and Planning, Portland University.*

Turenscape. (2014, July 19). *Turenscape*. Retrieved from A Chinese landscape firm: http://www.turenscape.com/english/projects/project.php?id=324

UN, G. A. (1987). *Brundtland Commission.* The United Nations Department of Economic and Social Affairs (DESA).

UNB Fredericton Campus. (n.d.). *UNB Fredericton Campus Plan.*

United Nations Environment Programme. (2013). *Greening University Toolkit.* United Nations Environment Programme.

United States Environmental Protection Agency. (2012, August 27). *United States Environmental Protection Agency- EPA.* Retrieved 11 2, 2013, from United States Environmental Protection Agency Web site: http://water.epa.gov/polwaste/nps/whatis.cfm

University of Missouri Campus Facilities. (2013). *Install New Bio-Retention Basin Near SE Corner of Stewart and Providence.* Missouri: University of Missouri.

University of Oregon, 1999-2000 Development, Policy, Implementation, and Transportation Subcommittee of the Campus Planning Committee (CPC). (Oct. 5, 2000. Updated Sept. 2005). *Sustainable Development Plan, University of Oregon.*

Van Yahres, M., & Knight, S. (n.d.). *Creating A Picture Perfect Campus:The Successful Campus—Look Good or Look Out!* Virginia.

Waite, P. S. (2003, March- May). Applying a Model of Sustainability on Cmapus. *Planning for Higher Education*, pp. 82-87.

White, S. S. (2003). Sustainable Campuses and Campus Planning- Experiences from a Classroom Case Study in The University of Kansas. *International Journal of Sustainability in Higher Education*, 344-356.

# Appendices

# Appendix A (Interviews)

**Questions for interviews of**

**"Sustainable Landscape of University Campus Urban Design"**

**Groups:** Students, professors, high board, and workers

**Legend:**

**P: physical properties of campus landscape**

**E: Ecological aspect of campus landscape components**

**I: Individual use of campus landscape**

**S: Social quality of campus landscape**

## 1. Students:

- Main users (huge mass) and performing the highest usage on campus especially the campus landscape
- Distributed between different years, undergraduate and post graduate.
- Might differ according to gender.
- The proposed method is surveying by questionnaires then selection of some for interviews.

**Proposed questions:**

Basic data: Name, age, department, year

P: How much does it take you to reach your essential destinations by foot (define the origin and the target). (Mapping is an option).

P: Do you prefer to do some movements by car (where? Please also specify whether it is arriving and leaving or internal circulation on campus)

P: What do you think of cycling on campus? (What are the pros and cons?)**What are the essential requirements?**

P: Do you see that the number of different landscape elements (trees, plants, paths, plazas, furniture……) are enough on campus? (Please answer for each element) **If not where?**

**P: Do you find any spots where vehicular circulation is clashing with pedestrian circulation?**

P: Are there any places that are abandoned or totally not used? If so, then why? And could you indicate where the main lacks are?

P: Do you find that the open spaces are sufficient on campus and covering all needed activities? If not please state what is missing)

P: Do you use a car? Do you park inside the campus? Do you find a parking spot easily? When you park is it mostly next to your destination?

P: Do you feel that the campus spaces are enough and functioning efficiently? Or does it need more space? If so could you please identify?

P: Are the street elements of landscape (street furniture) comfortable? If not please state the reason, are they enough and covering all spaces? If not where are the spaces that are lacking them?

**P Do you miss a taxi stop on campus? Any other public transportation?**

E: What kind of sustainable materials used on your campus? What materials you see possible to be modified or replaced by sustainable materials?

E: Are there any sustainable vegetation on your campus? Why are they sustainable?

E: What sustainable measures for water applied on your campus landscape? Which other measures could be applied or modified?

Please answer the same question for: soil, the selection of the site of the university.

E: Do you notice any dominant species of animals or insects on campus? Do you know any measures for supporting biodiversity on campus landscape?

I: Are there spots that are not safe on campus (Please specify where and why? Also classify your answer into two parts: one dealing with safety according to safety physical measurements provision and the other according to social and emotional safety)

I: What are the items on landscape that could compose the best scenery on campus?

I: What is preferable artificial landscape or natural landscape? And why?

I: Can you classify your campus into zones? What cause the difference between these different parts?

I: Did you easily find your way on campus in the first year (between buildings not inside) If not why?

**I: Are directing signs legible (easy to read and easy to follow)?**

**I: Please state three outdoor landmarks on campus**

S: Could you please state in descending order three of the best places of gathering? (Add more spaces till the external spaces are 3). Why are these spaces special?

S: Do certain activities make people more social and help group formation? Where? And how?

**S: Are there spots where people not very social gather? Where?**

S: Are there some spaces associated with the presence of some groups? (If available, please give examples)

S: Where are the spots where people could easily, freely and friendly communicate and meet?

S: How large are friends' groups? Mixed? Males only? Females only?

**S: Are some spaces separated according to gender?**

**S: Do you participate in any of the decisions regarding outdoor spaces or landscape?**

S: Are there spaces ´which doesn't comply with your privacy? If so, which and how?

S: Is the separation of students' public spaces from professors' public spaces necessary? Why?

S & I: What makes the campus unique and gives it some identity? Building? Landscape elements? Social relations? How? Do you feel that you possess a certain identity according to your connection to the campus? If available, could you describe this identity?

## 2. Professors:

- Interacting more with buildings. Mostly with parking and a little bit with spaces associated to buildings.
- Differ according to different faculties, departments and disciplines.
- Can be approached better through interviews.

**Proposed questions:**

P: Is it easy to go from one destination to the other on campus? Is the car needed at certain points?

P: What is the main function for open spaces that are associated to buildings? Is it functioning correctly? Are the enough from the area point of view?

P: Should the parking of professors be separated from public ones? Why?

P: How near should parking lots be near to working places?

E: From your background , which of these items has sustainable measures on campus? How? Which are not? Why? The item are: water- site- materials- vegetation- soil- biodiversity.

I: How many times do you use landscape spaces per day? For what reasons? Where are the most visited places?

I: Was it easy to reach your office from the first time you used the campus landscape? Why?

**I: Are directing signs legible (easy to read and easy to follow)?**

**I: Please state three outdoor landmarks on campus**

S: Do you see that common outdoor spaces between professors could initiate a healthy social relationship? If so where and how?

S: Should the professors normal activities (food, resting, ……) be separated from students? Why? And how?

S & I: What makes the campus unique and gives it some identity? Building? Landscape elements? Social relations? How? Do you feel that you possess a certain identity according to your connection to the campus? If available, could you describe this identity?

### 4. Workers:

- A large unnoticed mass that interacts daily with students.
- May use different types of circulations, entrances and exits
- Deal more with services….
- Differs according to their jobs: security, food court workers, cleaners, gardeners…….
- Don't have a direct usage of landscape but could be more deeply attached to the formation and working on landscape.
- Can be approached through questionnaires, then through interviews.

**Proposed questions:**

P: Do you find the number of services' entrances sufficient? Do some services' provision require cars? Do the vehicular routes intersect with pedestrian routes?

P: Are the storages sufficient? Are they well distributed along the campus? Is there is a lack, where is it?

E: Do you help with the provision of any of sustainable measures for any of these items on campus landscape? How?

The items are: Water- vegetation- soil- landscape materials

I: Is it easy to reach your work spot on campus landscape? If you faced some problems with that, where and what is the solution?

I: Do you see any physical or social drawbacks regarding safety on campus landscape (from the work place point of view)?

**I: Please state three outdoor landmarks on campus**

**I: Are directing signs legible (easy to read and easy to follow)?**

S: Are there spots that you prefer as a place for gathering on campus landscape? Where and why?? Is it open for public too?

# Appendix B (Questionnaire)

-Was titled to each case

- Name (optional):
- Major (In case you are a student):
- Contact number (for interview):

- Please state the name of building you belong to on campus
- Do you prefer walking or using the car on campus?

  - Walking-car

- Would you prefer cycling on campus?

  - Yes - No – Not available

- Do you consider your daily walk on campus tiring?

  - Yes - No – partially

- Do you lose your way at some parts of the campus? If yes, where?
  - Yes - No – partially

- Please state three of the most important outdoor landmarks on campus.
- Please state three of the most socially abandoned spaces on campus.
- Do you have any public transportation point on campus
  - No-Taxi-Buses-Public buses-Other (Specify)

- How do you go to campus?
  -Bus-Public bus- Taxi- Car- Other (Specify)
- Do you have a parking problem on campus? If yes, why?
  - Insufficient parking – Parking charges – Far parking spots- Unsafe parking- Other
- Do you prefer indoor or outdoor activities on campus?

  - Indoor - outdoor

- Are active open spaces enough on campus?

  - Yes - No - partially

- Do you have any safety issues walking around campus? (psychologically or physically) Please state spots and reasons

  - Slippery pavement – Slippery steps – Dense vegetation- Insufficient lighting- Bullying- No- Other

- Do you consider your campus spatially unique? If yes, what makes it unique? (outdoor)
  -Yes- No- Average

- Do you consider natural elements of landscape (trees, plants, flowers, water.......) enough on campus? If not, where?

  - Yes - No - Partially

- Do you find sufficient shading on campus? Please state what provides shade (trees, pergolas, concrete shading devices,…etc.)
  - Yes- No
- Please state the best and the worst open space on campus, and state why?

- Do you see any elements of sustainable landscape on campus (e.g. Growing vegetables or fruits, water efficient irrigation systems, recycled materials used in landscape...etc.) If yes, could you please state what is available?

  - Yes- No- Average
- Do you participate in any of the decisions regarding campus landscape?
  - Yes - No – Average
- Do you have any outdoor working spaces on campus? If yes, where?
  - Yes- No
- Could you please state the most aesthetically pleasing outdoor spot on campus?
- What makes it the most aesthetically pleasing?
- Do you consider the landscape street furniture (benches- seats- lighting fixtures- receptacles.......) enough? If not, where?

  - Yes - No - partially

- What is the common outdoor social activity you do on campus?
- Where are the best three social outdoor spaces? And state why?
- Are you satisfied with your outdoor campus environment? If not, what are you missing?
  - Yes - No - partially

# هيكل البحث

| المحتويات | المنهجية | الأهداف | | الهدف الرئيسي |
| --- | --- | --- | --- | --- |
| فكرة عامة | | تعريف تنسيق الموقع المستدام للحرم الجامعى | الجانب المادي | الوصول إلى مجموعة من المبادىء التوجيهية و التوصيات متوافقة مع الاستدامة البيئية/ الإجتماعية لتنسيق الموقع الخاص بالحرم الجامعى و تصنيفها طبقاً للحالة المصرية. |
| الفصل الأول | مراجع<br>مراجعة تقارير<br>المنهج الاستدلالى | تسليط الضوء على الجوانب المادية و الملموسة ، والمكونات الحضرية لإستدامة تنسيق الموقع للحرم الجامعى. | الجانب المادي | |
| الفصل الثانى | | توضيح مكونات تنسيق الموقع الإيكولوجى الصحى مع توضيح الطول و الحافظة على الموارد و الإنتاج بدل من الإستهلاك. | الجانب المادي | |
| الفصل الثالث | | وصف العلاقة التبادلية بين المستخدم و عناصر تنسيق الموقع مع توفير الراحة الفعلية و النفسية من خلال التفاعل مع الحرم الجامعى. | الجانب الإجتماعى | |
| | | فهم العلاقة بين الهيكل الإجتماعى و التفاعل فى الحرم الجامعى | الجانب الإجتماعى | |
| الفصل الرابع | التجميع التحليلى | استنتاج المبادىء التوجيهية و التوصيات الأولية ، و العلاقات التبادلية بين الأربعة عناصر الخاصة بالدراسة و الإضافة من خلال نظام التصنيف "SITES". | | |
| الفصل الخامس | الدراسة التحليلية و الميدانية | تحليل حالة إستدامة تنسيق المواقع فى الجامعات المصرية. | | |
| | التحليل المقارن+ المنهج الاستقرائى | استنتاج تأثير الفراغ المادى على الفراغ الإجتماعى المحتوى. | | |

### ٦,٢,٢. البيانات و المعلومات الثانوية

**أ. المقابلات**

تكون المقابلات فى المرحلة التالية للإستبيانات لفهم أكثر تعمق و توثيق بعض الظواهر و الدخول فى التفاصيل و الإطلاع على على الآراء و الأفكار المختلفة من خلال من يتم إجراء المقابلات معهم.

الأسئلة يتم تجميعها طبقاً للمواضع المشتركة من مفهوم المتلقى و يتم تصنيفها طبقاً الجوانب الأربعة التي يتم دراستها.

**أ. الاستبيانات**

الاستبيانات تأتى فى الفترة قبل إجراء المقابلات التفصيلية. منهج الاستبيانات يعتمد على الحصول على كم كبير من المعلومات و اللآراء التى يكون من الصعب موافاتها من خلال المقابلات. هذه النتائج يتم تحليلها إحصائياً للوصول أهداف و استنتاجات للرسالة.

**ب. الملاحظة و الرفع**

الرفع يتم مباشرة من خلال الموقع و ذلك لرصد الجوانب المادية و التصميمية التى تحلل و تعطى مؤشرات لنجاح و كفاءة عمل تنسيق الموقع للحرم الجامعى. هذا الجانب يعطى مؤشرات مباشرة دون الحاجة إلى مؤشرات مركبة من أكثر من عنصر للوصول إلى نتائج.

## ٧. الهيكل البحثى المختصر

**فكرة عامة: -** الحرم الجامعى المستدام

- الفراغ المفتوح كعنصر من عناصر الحرم الجامعى المستدام و أبعاده

**الفصل الأول:** الجوانب المادية و التصميمية الملموسة لتنسيق موقع الحرم الجامعى المستدام

**الفصل الثانى:** الجوانب الإيكولوجية لتنسيق موقع الحرم الجامعى المستدام

**الفصل الثالث:** الجوانب الخاصة بتعامل المستخدم مع الفراغات المحيطة لتنسيق موقع الحرم الجامعى المستدام

**الفصل الرابع:** الجوانب الإجتماعية لتنسيق موقع الحرم الجامعى المستدام

**الفصل الخامس:** الحالات الدراسة : الجامعة الأمريكية بالقاهرة ، الجامعة الألمانية بالقاهرة ، الجامعة البريطانية فى مصر

**النتائج و التوصيات**

### ٥,٢. حدود الدراسة

- تتبنى هذه الرسالة حدود عريضة تشمل النظرة الشمولية و التكاملية للإستدامة البيئية و الإجتماعية لتنسيق الموقع. الجوانب الخاصة بالحسابات و التفاصيل التقنية لم يتم التطرق لها.
- إتجاهان من الإستدامة تم دراستها و هما البيئى و الإجتماعى و لم يتم التطرق للجانب الإقتصادى.
- البيانات العلمية محدودة فى مجال إستدامة تنسيق الموقع للحرم الجامعى. أول إصدار لنظام تصنيف المواقع طبقاً للإستدامة "SITES" فى ٢٠٠٩ و ثانى إصدار فى ٢٠١٤.
- نظراً لاتساع مفهوم الاستدامة فالدراسة تكون نوعاً ما غير كاملة طبقاً لمفاهيم أخرى.
- مقياس النطاق الإجتماعى المدروس يحدد بالمجتمعات المستخدمة للحرم الجامعى و ليس المجتمع ككل.
- دور العمارة يتوقف عند الطراز و الجزء الخارجى المكون للفراغات. تفاصيل التأثير المعمارى لم تؤخذ فى الإعتبار.
- الدراسة تمت طبقاً للحرمات الجامعية المبوبة و ليس المتكاملة و الممتزجة بالمدينة.
-

## ٦. المنهج البحثى

### ٦,١. المناهج المطبقة

الجزء الأول يتبع المنهج الاستدلالى للوصول إلى قائمة المبادىء التوجيهية الأولية من خلال المراجع النظرية، التقارير و الأمثلة الجيدة. التوثيق للقائمة تم عن طريق خبير فى مجال تنسيق المواقع. الجزء الثانى قائم على الدراسة التحليلية و التحليل المقارن للوصول إلى البيانات المبنية على الحالة الدراسية. تم استخدام المنهج الاستقرائى للوصول إلى النتائج النهائية والتوصيات.

### ٦,٢. تحصيل البيانات

### ٦,٢,١.البيانات و المعلومات الثانوية

البيانات الثانوية هى التى تم تجميعها من المراجع و الكتب و تم تحليلها كقاعدة نظرية للبحث. تنقسم البيانات الثانوية إلى جزئين: الأول يشمل التقارير و الدراسات التطبيقية لتقييم أداء و وضع خطط لاستدامة تنسيق الموقع فى الحرم الجامعى. يتم تحليل و تطبيق هذه البيانات طبقاً للحالة المصرية.

الجزء الآخر يشمل جوانب نظرية عامة عن التصميم العمرانى، التصميم المستدام لتنسيق المواقع، تعامل المستخدم و إدراكه للفراغات المحيطة ،و التفاعلات الإجتماعية بين المستخدمين.

- فهم العلاقة بين الهيكل الإجتماعى و التفاعل فى الحرم الجامعى

- استنتاج المبادىء التوجيهية و التوصيات الأولية ، و العلاقات التبادلية بين الأربعة عناصر الخاصة بالدراسة و الإضافة من خلال نظام التصنيف "SITES".

- تحليل حالة إستدامة تنسيق المواقع فى الجامعات المصرية.

- استنتاج تأثير الفراغ المادى على الفراغ الإجتماعى المعنوى.

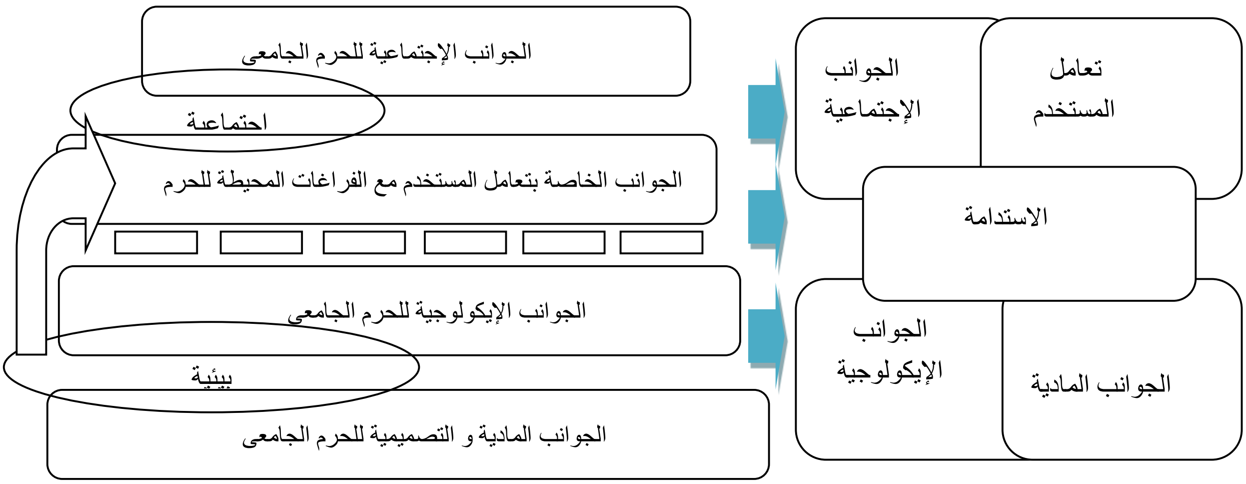
## ٥. مجال و حدود البحث

### ٥,١. مجال الرسالة

هذه الرسالة تنقسم إلى جزئين: الجزء الأول مبنى على الجانب النظرى، و الثانى مبنى التحليل المقارن حيث أن البحث يستحيل أن يكون تجريبى بكل جوانبه.

- الجوانب المادية و التصميمية الملموسة، و الجوانب الإيكولوجية تحت مسمى الإستدامة البيئية.
- الجوانب الخاصة بتعامل المستخدم مع الفراغات المحيطة و الجوانب الإجتماعية تحت مسمى الإستدامة الإجتماعية.

يهدف البحث إلى شرح كل جانب من الجوانب على حدا ثم الوصول إلى العلاقات التبادلية بينهم. الوصول إلى مجموعة من المبادىء التوجيهية و التوصيات التوصيات لتنسيق الموقع الخاص بالحرم الجامعى و يتم مناقشة الجوانب الإجتماعية بشكل محدود نتيجة الإختلاف من حالة لأخرى.




**شكل ١ الجوانب الختلفة للإستدامة المتناولة فى البحث**

تنسيق الموقع، جدول لكل حالة يوضح العلاقات التبادلية بين العناصر المختلفة للدراسة ظاهراً للسلبيات و الإيجابيات، تصنيف المباديء التوجيهية و قوائم المراجعة الخاصة المستنتجة طبقاً للتطبيق من خلال دراسة الحالات.

## ٢. المشكلة البحثية

تعد الحرمات الجامعية مشاريع ضخمة التأثير على البيئة و المجتمع. تبعاً لمشكلة قلة الموارد عالمياً و مصر فى الوقت الحالى على الأخص. الإستدامة البيئية ضرورية و محور بحثى عالمياً. بما أن الناتج الأساسى للجامعة هو نشر المعرفة و بناء الشخصيات ، لذلك فإن الاستدامة الإجتماعية ضرورية لتكوين بيئة صحية للمجتمع توفر تفاعل بشرى صحى.

تدور مشكلة البحث حول نقص الإهتمام تجاه الاستدامة فى الحرمات الجامعية المصرية. يوجد بعض المبادرات و لكن تأثيرها ضعيف نسبة لأعداد الجامعات. مازال تنسيق الموقع فى كثير من الجامعات يصنف على أنه جانب ثانوى مكمل و ليس عنصر أساسى فى تصميم الحرم. إنعدام وجود مرجعيات و قوائم استرشادية لتحيقيق إستدامة تنسيق الموقع و هذا يعد عنصر ضعف تحاول الدراسة مواجهته من خلال الأمثلة العالمية و خطواتها المتبعة.

## ٣. فرضية البحث

يفترض البحث أن الإستدامة البيئية و الإجتماعية مهملين و لا يشكلوا عنصر أساسي فى تنسيق الموقع للحرم الجامعى. بعض الخطوات المحدودة تطبق و لكن ليس بهدف الإستدامة. بعض العناصر يمكن إضافتها و البعض الآخر لا يمكن لعدم توفره قبل بداية التشغيل بهدف تحقيق إستدامة تنسيق الموقع.

## ٤. أهداف البحث

### ت. الهدف الأساسى

الوصول إلى مجموعة من المبادىء التوجيهية و التوصيات متوافقة مع الاستدامة البيئية/ الإجتماعية لتنسيق الموقع الخاص بالحرم الجامعى و تصنيفها طبقاً للحالة المصرية.

### ب. الأهداف الثانوية

- تعريف تنسيق الموقع المستدام للحرم الجامعى

- تسليط الضوء على الجوانب المادية و الملموسة ، والمكونات الحضرية لإستدامة تنسيق الموقع للحرم الجامعى.

- توضيح عناصر نجاح إستدامة تنسيق الموقع للحرم الجامعى و تسليط الضوء على الأمثلة الجيدة.

- توضيح مكونات تنسيق الموقع الإيكولوجى الصحى مع توضيح الحلول و الحافظة على الموارد و الإنتاج بدل من الإستهلاك.

- وصف العلاقة التبادلية بين المستخدم و عناصر تنسيق الموقع مع توفير الراحة الفعلية و النفسية من خلال التفاعل مع الحرم الجامعى.

## ١. مستخلص البحث

تهدف هذه الرسالة للوصول إلى مجموعة متكاملة من المباديء التوجيهية و قوائم المراجعة الخاصة بعوامل استدامة تنسيق الموقع للحرم الجامعي. تمكنت الرسالة من تسليط الضوء على حالة تنسيق الموقع للحرم الجامعي لبعض الجامعات الجديدة فى مصر و التأكد من مدى تطبيق مباديء الاستدامة الخاصة بتنسيق الموقع.

ترتكز الرسالة على أربعة جوانب مؤثرة على تنسيق الموقع المستدام. الجوانب هي: الجوانب المادية و التصميمية الملموسة، الجوانب الإيكولوجية، الجوانب الخاصة بتعامل المستخدم مع الفراغات المحيطة و الجوانب الإجتماعية. التكامل بين هذة الجوانب يغطى إتجاهين من إتجاهات الاستدامة و هى الاستدامة البيئية و الإجتماعية. الجانبان الأولان للدراسة يستهدفا الخصائص العمرانية والكفاءة الوظيفة لتنسيق الموقع للحرم الجامعى بالإضافة إلى خدمة و حماية البيئة الطبيعية. الجانبان الثانيان يشملا العنصر البشرى و هو المستخدم.

تشتمل الأربع فصول الأولى على المعلومات النظرية من خلال المراجع و التقاريرو الأمثلة المتميزة الموضحة لتطبيق عناصر استدامة تنسيق الموقع و مردودها على حالة تنسيق الموقع للحرم الجامعى. تشمل الجوانب المادية واتصميمية الملموسة فى الدراسة على: عوامل الإتصال، الحدود و البوابات، عناصر الحركة المختلفة، الفراغات و العناصر الخدمية و التكميلية. يركز هذا الجانب على كفاءة وظيفية و كيفية الوصول إلى أفضل الحالات. تشمل الجوانب الإيكولوجية على: العناصر المائية، العناصر النباتية، التربة و الخامات. يركز هذا الجانب على تقليل استهلاك الطاقة و الموارد، دعم و حماية البيئة و الرجوع إلى الأصول الطبيعية و الإقتباس من الطبيعة. تشمل الجوانب الخاصة بتعامل المستخدم مع الفراغات المحيطة على: نظام سهولة الوصول للمواقع و المسارات، الأمن و الهوية. يركز هذا الجانب على سهولة الحركة و التفاعل و الاحساس بالهوية والإنتماء للمستخدمين. تشمل الجوانب الإجتماعية على : تكوين الصداقات، العضوية فى المجموعات، التواصل، الفصل المكانى طبقاً للعوامل الاجتماعية، الإختلافات طبقاً للجنس، المشاركة الفعالة و تأثير الفراغ المادى على الفراغ الإجتماعى المعنوى.

المناهج المستخدمة تعد استدلالى للجزء النظرى للو صول إلى تجميع العناصر المختلفة لإضافتها إلى المباديء التوجيهية و قوائم المراجعة الخاصة. بعض العناصر المرتبطة تم اقتباسها من نظام "SITES" لتقييم و تصنيف المواقع المستدامة. عملية توثيق القائمة تم من خلال خبير فى مجال تنسيق المواقع. تم استنتاج الاستبيانات و أسئلة المقابلات من خلال الجزء النظرى للاستعمال فى الجزء العملى. تم استنتاق جدول يوضح العلاقات التبادلية بين العناصر المختلفة للدراسة طبقاً لإتجاه الاستدامة الشمولى و التكاملى.

تم إختيار ثلاث حالات الدراسة – الجامعة الأمريكية بالقاهرة (AUC)، الجامعة الألمانية بالقاهرة (GUC)، الجامعة البريطانية فى مصر (BUE) - على أساس الحداثة مما يجعلها أكثر قابلية لتطبيق مبادئ استدامة تنسيق الموقع. تختلف أحجام الثلاثة حالات و تتشارك فى البيئة الصحراوية. تم تحليل الحالات طبقاً للملاحظة مصاحبة لقائمة المراجعة الخاصة المستنتجة و ذلك من خلال مقابلة المختصيين بإدارة تنسيق الموقع لكل حرم. تم توزيع الإستبيانلت من خلال الإنترنت و إجراء بعض المقابلات لإستكمال الصورة من خلال المستخدمين.

طبقاً لحالات الدراسة تم استنتاج أن استدامة تنسيق الموقع مطبقة جزئيا فى مجالات محدودة خاصة الجوانب الإيكولوجية. أما الجوانب المادية واتصميمية الملموسة فهى جيدة خاصة فى حالة الجامعة الأمريكية طبقاً لكفاءة التصميم. تعد الجامعة الأمريكية الوحيدة فى أخذ عوامل الاستدامة فى الإعتبار قبل التنفيذ و أثناء التشغيل. كثير من العوامل يجب أن تؤخذ فى الإعتبار قبل التنفيذ مثل أنظمة المياة، العناصر النباتية و التربة. الجانب المادى يكون الدافع وراء تطبيق أى من عوامل الإستدامة و الجانب الإيكولوجى لا يؤخذ فى الإعتبار. من خلال الدراسة تم الوصول إلى مقارنة شاملة موضحة الجوانب المحققة و العيوب طبقاً لعناصر إستدامة

كلية الهندسة

جامعة عين شمس

# تنسيق الموقع المستدام فى التصميم الحضرى للحرم الجامعى

اسم الباحث

**م. أحمد إبراهيم عمرو**

بكالوريوس الهندسة المعمارية، جامعة عين شمس ٢٠١٠

معيد بقسم التصميم و التخطيط العمرانى، كلية الهندسة، جامعة عين شمس

**أعضاء لجنة الحكم**

**أ.د. أيمن حسان أحمد محمود** التوقيع
أستاذ تنسيق المواقع، قسم الهندسة المعمارية
جامعة القاهرة

**أ.م.د. أحمد عاطف فجال** التوقيع
أستاذ العمارة المساعد، قسم الهندسة المعمارية
جامعة عين شمس

**أ.د. شيماء محمد كامل** التوقيع
أستاذ العمارة ، قسم الهندسة المعمارية
جامعة عين شمس

**أ.د. جيرمين فاروق الجوهرى** التوقيع
أستاذ تنسيق المواقع، قسم التصميم و التخطيط العمرانى
جامعة عين شمس

تاريخ مناقشة البحث: / / اجيزت الرسالة بتاريخ: / /

ختم الإجازة:

الدراسات العليا:

موافقة مجلس الكلية: / / موافقة مجلس الجامعة: / /

جامعة عين شمس

كلية الهندسة

قســـم الهندسة المعمارية

# إقـــرار

هذا البحث مقدم إلى جامعة عين شمس للحصـول على درجة الماجسـتير في الهندسـة ، تم إنجاز هذا البحث بقسم الهندسة المعمارية ، بكلية الهندسة - جامعة عين شمس من عام ٢٠١٢ إلى ٢٠١٥.

هـذا ولم يتم تقـديم أي جزء من هـذا البحـث لنيـل أي مؤهـل أو درجـة علميـة لأي معهـد علمي آخر.

**و هذا إقرار مني بذلك ،،،**

**التوقيع : أحمد إبراهيم عمرو**

**الاسم :**

**التاريخ : / / 2015**

قسم الهندسة المعمارية

كلية الهندسة

جامعة عين شمس

# تنسيق الموقع المستدام فى التصميم الحضرى للحرم الجامعى

اعداد

**م. أحمد إبراهيم عمرو**

بكالوريوس الهندسة المعمارية، جامعة عين شمس ٢٠١٠

رسالة مقدمة كجزء من المتطلبات للحصول على درجة الماجستير فى الهندسة المعمارية

تحت إشراف

أ.د.

**شيماء كامل**

أستاذ العمارة

قسم الهندسة المعمارية

كلية الهندسة

جامعة عين شمس

أ.د.

**جيرمين الجوهرى**

أستاذ تنسيق المواقع

قسم التصميم و التخطيط العمرانى

كلية الهندسة

جامعة عين شمس

أ.د.

**يوهانس هامهابر**

أستاذ الإدارة العمرانية و الإقليمية

ITT

جامعة كولون للعلوم التطبيقية

جامعة عين شمس

القاهرة، مصر

2015