Gardens on the Arid Climate

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Abstract. Bahrain is located in the climate of the arid zone which rainfall is low and irregular. This paper discusses the approaches which response to the local context that has been implemented by the government of Bahrain to sustain the quality of the public garden in the arid climate, turning to green. Generally, the approach is an improvement in the central treatment of waste water system plant that used to irrigate the landscaping, agriculture as well as for industry use. These approaches are not the only technologically, but also involves the participation of community to achieve sustainable garden in this country.

Keywords: arid climate, Bahrain, desert garden, sustainable, wastewater

1. Introduction
Bahrain means ‘two seas’ consist of 33 islands which area about 780 km$^2$ is located off the coast of Saudi Arabia in the west and Qatar Peninsula in the east as shown in Figure 1. A long time ago Bahrain was recognised as a centre of pearl trading in the world, as well as the first country where the crude oil discovered in the Gulf region on 1932. Because of the strategic location in the Persian Gulf, Bahrain was under influence of some civilisations in the world such as Sumerians, Persians, Assyrians, Babylonians, Portuguese, Arabs and British.

![Figure 1. Location of Bahrain](image_url)
The Bahrain's location also gives influence into the Bahrain climate which comes from Saudi Arabia, Iraq and Iran. According to the Bahrain’s Meteorological Directorate, Bahrain’s climate is categorised as the arid climate, the rain volume is less than 71mm and irregularly, as well as the average temperature is 17°C-36°C, but sometimes the temperature is extremely more than 40°C and the average of relative humidity is 39%-88%. This climate challenges for plants to sustain for long period. The good maintenance, as well as appropriate approaches, base on the local climate, needs to sustain the growth up and age of plantations. The aim of this study is to understand the sustainable approaches in the garden (public gardens) according to the local context, the arid climate zone. This study has some objectives: (1) Investigate the sustainable approaches in the arid climate zone, (2) Contribute as a reference in a sustainable development in the arid climate, (3) Share information the current technology is using in the vegetation irrigation in arid climate zone.

Generally, the meaning of arid climate is insufficient rainfall volume (less than 250mm) or lack of water to support plantation grow up, a short word called “dry”. This situation is raised because of some factors may be distinguished (Wescoat, 1996): (1) Latitude of the region, (2) Effects of rain shadow, (3) Condition of continental, (4) Ocean temperature, (5) High altitudes and polar latitudes. Excessive evaporation can cause drought on the soil that can inhibit plant growth. This situation becomes a disadvantage for plants to grow for long times. Some actions must be taken to break out of this unfortunate situation.

On the 1980s, the Xeriscape system introduced by Denver Water which means ‘xeros’ (dry) and ‘scape’ (landscape). This dry landscape system saves the water, the environment protection, and cost less in the landscape maintenance (Lyle, 1996). There are seven principles in Xeriscape system gardens:

(1) Plan and design. Inventory and analysis of existing site situation are necessary. All data must collect such as drainage flow, types of soil, existing plants, exposures (including soft scape, hardscape, building, etc). In this point also have to consider the plan and design the future garden such as pathway, hardscape and soft scape area, etc. These components, existing and new development, should be integrated into the whole design of the garden.

(2) Soil improvement. One of the important component in the garden design is soil. The analysis and evaluation of soil condition should be done to understanding the soil characteristics, otherwise, the whole design of garden will be useless. The weak soil or unfavourable to grow crops can mix fertiliser into the soil to improve the soil quality.

(3) Efficient irrigation. Well-planned of placement of sprinkler outlets to irrigate soil or plants directly as well as to avoid runoff waste of water. The grouping of plants with same characteristics also help effectiveness in irrigation network.

(4) Proper plant selection. The low water requirement plants should consider. It does not mean impossible to other plants, as long as planted on appropriate location and not to interplant them with lower water requirements plants.

(5) Practical grass area. The grass is the best separator and watered separately from other plantation such trees, flowers, ground cover, shrubs, etc to decrease irrigation load. The grass area can use for the playground, sitting area, pathway, etc. It also can be replaced by ground cover low water consumption such as rubber material.

(6) Mulching. Mulches are needed to reduce rapid evaporation as well as the surface temperature of the soil. Also, the mulches can increase the aesthetic of the garden in proper materials and placement.

(7) Proper maintenance. The maintenance is not only related to mechanically or equipment and hardscape but also maintenance of the plant (soft scape). Regularly maintenance is needed to maximise implementation of these principles.

In general, the old towns in Arabia consist of narrow pedestrian streets and dense spaces inter-building. By exploiting the movement of the sun there will be shady areas around the building that can be used to create a public garden or private garden. The shady area also can reduce the surface temperature of the soil. Of course, water irrigation still needed to sustain the plants grow. It can use recycle grey water as apply in Bahrain.
2. Method
This study adopted the method that can categorize into two parts: (1) Literature studies regarding the sustainable garden in an arid climate. In this part was carried out to understand several kinds of literature regarding the issues of an arid climate garden, and (2) Investigation of some sites of the public parks and housing neighbourhood in Bahrain, and documentation.

3. Water Resources and Technology in Bahrain
Natural freshwater was utilised in Bahrain for agriculture and domestic purposes. The water was flew freely from the Northern area before 1925 (AQUASTAT website, 2016). On 1976, Bahrain’s government commenced the desalination program of seawater which built desalination plant blended with ground water before supply to consumers (Al Noaimi, 2005). The annual growth of water use in Bahrain is about 8% to 10% (Ahmed, 2010) because of population increase. For fulfil the demand of water, the Bahrain’s Government built a re-use sewage water plant, Tubli Water Pollution Control Centre (Tubli WPCC) which total area is about 320,000 m² (Figure 2) to separate supply of water demand, domestic use and irrigation. This plant uses to recycle sewage water and to irrigate landscape and agriculture, started on 1985.

![Figure 2. Tubli Water Pollution Control Centre](image)

This Tubli plant consists of three types of treatment: primary treatment, secondary biological treatment and tertiary treatment, which divided into some sub treatment functions: the collection chamber, aeration ponds, settling tanks, sludge pumping station, sludge drying ponds, pipes and channels leading to the sea, ozonation facility (added on 1987), filtration complex, and chlorine additives complex for reuse of the treated wastewater for agriculture (Al Noaimi, 2005). Recently, this plant upgraded on the secondary treatment unit, using HYBACS (Hybrid Activated Sludge) technique which deploys SMART TM reactor units that stimulate a special and specific bacteria. This technique has improved the quality of the treated water for agriculture and landscape irrigation as well as decrease the negative impact to ecology and Tubli environment. According to the Blue Water Bio company (the company that create HYBACS system), this system is 40 times faster clean the sludge compared to conventional sludge system. Also this system save time, cost effective, no interruption the existing plant processes during construction of this system, and increase the capacity or performance of treated waste water in the existing plant.

4. Gardens in Bahrain
Similar to another country in the arid climate zone, create and sustain the garden quality are a challenge. The concept of Bahrain’s public garden mostly is for physical relaxation as well as a place for spiritual contemplation. This garden also provided some facilities such as kids playground, grass area for sitting, an open stage for events, sports track (jogging, cycling, walking), café, and visitor parking as shown on Figure 3. In some public garden, also provide specific facility such as family zone where family privacy is keep far away from public activities in the garden. A public garden (Arad Park) is proposed to support marine ecosystem conservation (Figure 4).
Most of the public garden in this country use Xeriscape system which planned and designed garden base in the local context, improvement on soil quality, choosing the appropriate types of vegetation according to the local climate such as Pachypodium, Cactus, Dates, Thyme, Boojum, Acacia, Frangipani tree and Coconut. Applies mulches on the soil and surrounding of the vegetation to reduce excessive evaporation and keep temperature of soil and treated wastewater for irrigation with sprinkler lay on the soil (Figure 5).

The government of Bahrain through the Agriculture Affairs under Ministry of Works, Municipalities Affairs and Urban Planning has made a list of aromatic vegetation able to plant in the local garden (Table 1).
Table 1. List of several Aromatic Plants in Bahrain

| English Name | Latin Name                              |
|--------------|-----------------------------------------|
| Fennel       | Foeniculum Vulgare Miller               |
| Rosemary     | Rosmarinus Officinalis                  |
| Turonj       | Citrus Medica L                         |
| Lemon        | Citrus (L) Aurintifolia Swingle         |
| Blue/Red Gum | Eucalyptus Camaldulensis L              |
| Jasmine      | Jasminum Grandflurum L                 |
| Basil        | Ocimum Basilicum L                     |
| Roses        | Rosa Sp-L                               |
| Indian Jasmine | Plumeria Acutifolia L                 |
| Lemon Grass  | Cymbopogon Citrus Stapf                |

| English Name | Latin Name                              |
|--------------|-----------------------------------------|
| Cummin       | Cumminum Cyminum L                      |
| Parsley      | Petroselinum Sativum Hoffm              |
| Aniseed      | Pimpinella Anisum L                     |
| Sage         | Savia Officinalis L                     |
| Celery       | Apium Graveolens L                      |
| Mary Gold    | Calendula Officinalis                   |
| Mint         | Mentha Viridis L                        |
| Majoram      | Majorana Hortensis                      |
| Thyme        | Thymus Capitataus (L) Link              |
| Germander Mt. | Teucrium Polium L                     |
| Rose Geranum | Pelargonium Odoratissmum               |

The periodical maintenance also applies on this public garden. This maintenance is not only for big public garden, but street green area also do periodical. The main purpose of this maintenance is to maintain quality of public garden. Replacement of dead plants is also part of the maintenance work. Community participation also involve in public planning and implementing of the public garden to ensure the sustainable environment such as attend town meeting in creation and maintenance of public gardens as well as spreading awareness on people’s roles in safeguarding their green spaces.

Figure 5. Irrigation sprinkler lay on the soil
5. Conclusions and Suggestions
Climate has important influence in gardening activities as well as development to achieve sustainable goals which encourage to create appropriate system that can use in local garden development as well as improvement according to the existing situation. One of the appropriate garden system is Xeriscaping have been use in some arid climate regions and has possibility to use at outside of arid climate regions. However, the maintenance is one of the key succes to produce a sustainable and comfortable garden for humans. Water is important element on human life and also create human civilization since years ago. Fresh water is not only consume for human daily life, but also to help the plants growth. Through technology, the using of recycled water can replace fresh water for irrigation and it can save cost for long time. Also, the future research regarding recycle water technology should be encouraged to produce appropriate and sustainable technologies in human life, especially in garden and landscape irrigation use as well as implementation to improve local garden quality.

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