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Evaluation and Design of Most Efficient Irrigation System Forwater Scare Region

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Abstract:
This paper presents a case study fordesign of most efficient landscape irrigation system for a public park located in Aziziya, Holy Makkah. The Aziziya Park (Khataten Garden) is spread in an area of 4.43 hectares and located in between the main roads of heavy traffic. The Aziziya Park provides the families, children, old age people and fitness enthusiastic an atmosphere to relax, walk and enjoy. The Aziziya Park (Khataten Garden) which is always full house plays very important role in recreational activities for residents and visitors of Holy Makkah. The widespread amount of greenery spread in park requires huge amount of water daily to keep it green and pleasant to eyes. The park has some patches where plant/grass has died due to supply of water less than required. Holy Makkah receives around 10 million pilgrims annually which put enormous pressure on water authority. Thus study is made to evaluate the most efficient technique to irrigate the water. The study shows that rain water and TSE water effectively can be used for irrigation without any water required from water authority.

Keywords: Land coefficient (K_L), TSE (grey water), Landscape irrigation, Drip and sprinkler.

1 INTRODUCTION

Saudi Arabia has made a great progress in almost all aspects of development;however the availability of water for domestic use has been problematic. Saudi Arabia is the only country in the world without any perennial river. It is, therefore, very important to study available water resources in Saudi Arabia and develop master plan to conserve it. The water demand is increasing day by day while water resources are at constant level. Holy Makkah city receives millions of pilgrims every year thus imposing huge amount of pressure on water authority to meet the demand. Multibillion dollars construction activities going in Holy Makkah city also requires substantial amount of water on daily basis. Climate of Holy Makkah is influenced to a limited extent by the relatively high altitude of the mountains, especially where rainfall is concerned, and an annual average rainfall between 30mm and 300mm is recorded. The rate of evaporation, however, is very high, because of the cloudless sky and high temperatures.While worldwide water consumption is rising at double the rate of the population, the amount of freshwater remains at only 2.5 percent of the world's water resources. Rainfall replenishes much of the water we use; however, it is predicted that by 2025, eighteen countries will use more water than can be replenished [1] [2].Climate changes occur annually, often, and in different regions of the world. Various regions will experience floods, droughts, earthquakes, or tornadoes at any one time. While little can be done about these climatic events, we can reduce their impact through planning and preparedness. Builders in California are required to adhere to building codes and build structures that can withstand low-level earthquakes. Dams and levees help prevent flooding. Rainwater collection, and storage can also reduce the impacts of drought, storm water runoff, and peak flow levels as well as reliance on ground and surface water, also lower nonpoint source pollution, allow groundwater to recharge, and promote water conservation and sustainable practices [3][4].Water can be conserved through proper xeriscaping (landscaping) and by choosing the ideal native plants for desired locations. The collection of storm water from parking lots and other surfaces, storage in basins, swales or other watersheds, and distribution to plant beds by predesigned French drains, berms,curbs, spillways, depressions, micro basins, and aprons will also conserve water and reduce runoff and its associated problems [5].Wastewater is composed of 99.9% water and 0.1 % of other materials (suspended. colloidal and dissolved solids). In arid and semi-arid areas water resources are so scarce that there is often a major conflict between urban (domestic and industrial) and agricultural demands for water. This conflict can usually only be resolved by the agricultural use of wastewater: the cities must use the fresh water first, urban wastewater after proper treatment-used for crop irrigation. If such a sequence of water resource utilization is not followed, both urban andagricultural development may be seriously constrained with consequent adverse effects onnational economic development [6].Public Parks play vital role in development of any cities. Everyday thousands of people turns to parks to relax and for recreational activities. It is very important for municipal authorities to main these park and keep them clean and green for most days of the year. So plenty of water should be allotted every day to meet its evaporation demand. Thus it makes huge pressure on authority to supply potable water every day for irrigation. Hence study is made to find sustainable techniques for irrigation and to reduce dependency on potable water for irrigation

2 MATERIALS AND METHODS

2.1 Study area description

Makkah city is located in the south-west part of Saudi Arabia, about 80 Km east of the Red Sea (Figure.1). It extends from 39^o 35' E to 40^o 02' E, and from 21o 09' N to 21o 37' N. The area of the metropolitan region (the study area) equals 1593 square kilometers approximately [7]. The topography of Makkah is complex in nature, and several mountainous areas exist inside its metropolitan extent. The Holy City is 277 meters (909 feet) above sea level. Thelocation of Holy Makkah has been shown in Figure 1.

The annual rain over Makkah city, for a period extends from 1966 to 2009, varies from 3.8 mm to 318.5 mm, and with an average of rainfall equals 101.2 mm [8]. Holy Makkah city is surrounded by hill and much development is in the valley. Any occurrence of flash floods converts this valley into river thus imposing threat to life and property.Although annual rainfall is very less in Makkah but high rainfall in short period is very common. Location of study area has been shown in Figure 2.

2.2 Estimation of softscape area:

The Aziziyah Park consists of mainly long palm trees, and grass as lawn area. The aerial image of Aziziya Park has been taken from Google earth and imported to AutoCAD 2013 for geometry calculation. The site visits were conducted to verify the landscape present in the park. The soft cape areas have been shown in Table 1.The distribution of softscape area has been shown in Figure 3.

Figure 1: Location of Holy Makkah**(**Dawod, G., and Koshak, N. (2011)[8]

Table 1: Softscapes in Aziziya Park

Area description	Area (m^2)/nos
Lawn	24741
Palms	98

Figure 2: Location of study area

3. WATER SAVING TECHNIQUES TO BE IMPLEMENTED IN RESEARCH

3.1 Usinglocal and drought-resistant plants

The local, drought-resistant plants species suited to Makkah's scorching heathave been selected for Aziziya Park. The California fanpalm, trees, deer grass/lawn a use low to medium water for its growth and appearance and also has low maintenance requirements.

3.2 Using grey water (TSE) (Treated sewage effluent)

Grey-water is domestically-produced, primary and secondary treated waste water that contains no sewage or any harmful ingredients.It is proposed that remaining water demand will be fulfilled using TSE water. TSE water is supposed to be tapped directly from municipal TSE supply line.

3.3 Implementation of Landscape Coefficient (K_L) method: for reducing potable water demand

Landscape coefficient technique gives advantage of using some water reducing factor based on plant types and its ability to resist sun, draught, wind and other factors. The proposed plant for Aziziya Park is draught resistant and can withstand scorching 8 hours sun. The predicted value of $K_L$has been shown in Table 4. Following formula can be used to estimatethelandscape evapotranspiration by implementing $K_L$factor.

$$(ET)_L = K_L \times ET_0$$

Landscape Evapotranspiration = Landscape Coefficient x Reference Evapotranspiration

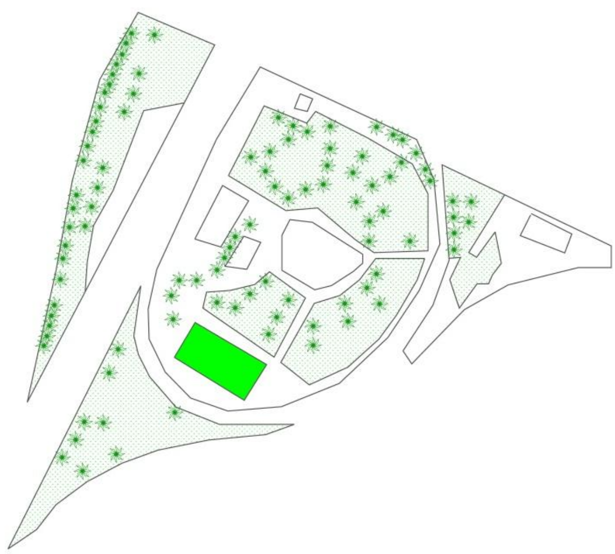

Figure 3: Distribution of softscape area

Where:

$KL = k_s \times k_d \times k_{mc}$

Landscape Coefficient = species factor x density factor x micro-climate factor

By applying the K_L method in estimating thelandscape plantings water requirements of the Aziziyah Park, itwas ensured that water will be enough but no more to main the plants' health, appearance and growth.

3.4 Irrigation by Latest water efficient technologies

The proposed irrigation system is to be fully automatic, an equipped it with a smart control system (Figure 4) that will connect command valves, flow weather station and soil moisture sensors. The controller and remote control devices allow the punctual supply of irrigation water to the landscaped areas. The irrigation design divides the landscaped area intoirrigation zones, based on plant types, water-usage category, and wind and sun exposure. These zones were controlled by separate valves delivering the necessary water amount. The valves, all remote-controlled, can control one irrigation zone at a time. The control system calculates the water requirement on daily basis based on the weather condition and automatically reduces the water to supply.Thus savings ofabout 50 percent and more can be achieved if planned carefully.

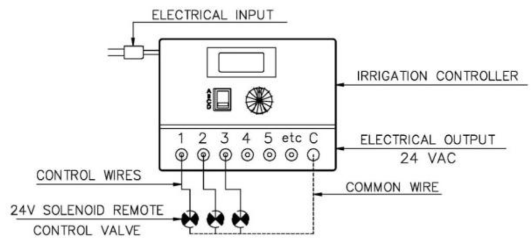

Figure 4: Typical wiring diagram for irrigation control system

3.5 Automatic Drip and Sprinkler System

The designproposes highlydrip and sprinkler irrigation systems that supply water slowly and directly to the plant up to root depth. Drip system is used for palm tree in the form of bubbler. Sprinkler system is proposed for lawn area in the form of rotor. Highly efficient and well maintained system can reduce water usage by almost 50%.

Adopting these designs and technologies helpsto save substantial amounts of water over conventional irrigation systems.

4 DATA COLLECTION

4.1 Meteorological data

The meteorological data has been collected with courtesy from Jeddah Regional Climate Center

South West Asiaweb site. The climate data from 1985 to 2010 was obtained (Table 2). The net evapotranspiration value was calculated as 12 mm/day for the Makkah region. The efficiency of the drip and sprinkler system has been taken as 80%. The gross irrigation value becomes 15 mm/day.

Table2: Rainfall data (1985 to 2005)

No of months	Monthly			24 Hours		
	M	Extreme	YY	Extreme	YY	DD
1	20.8	66.7	1992	65.2	2005	22
2	3	44.8	2010	43	2010	13
3	5.5	35.8	1998	34.1	1998	6
4	10.3	89.2	1989	71.1	1989	9
5	1.2	17.2	2010	17	2010	23
6	0	0	--	0	--	--
7	1.4	25.2	1995	24.6	1995	23
8	5	46.2	1992	35	1998	29
9	5.4	35.7	2006	27	2006	5
10	14.5	84.9	2006	55	2004	3
11	22.6	155.2	1996	53.7	2000	16
12	21.1	76.6	1989	63	1985	18

4.2 Estimation of storm water runoff:

The rational method has been used to calculate the runoff volume produced by rainfall. The coefficient of discharge value has been shown in Table 3.

$$Q = CiA$$

Where,
Q = Runoff in m^3/sec
C = Coefficient of runoff
I = runoff value in mm/hr.
A = hydrological catchment area in (hectare)

Table3: Average coefficient of runoff 'C'

Area description	Area (m^2)	C
Lawn	24741	0.35
Sand area	4721	0.5
Building structures	13477	0.95
Football turf	1268	0.95
Average		0.6875

4.2 Reduction of daily water requirement using K_L technique:

The concept of land scape coefficient has been taken into account to calculate the irrigation water requirement for Aziziya Park. The draught resistant plants have been chosen so that it requires less amount of water. The obtained results show that K_L technique reduces the daily irrigation water requirement almost 60% which is very effective. The design calculation has been shown in Table 4.

4.3 Principal of sizing storm water tank and daily available stromwater:

It can be concluded from available rainfall data that rainfall in Makkah generally occurs in the month from September to February which is coolest weather in Makkah. To avoid uncertainty and make irrigation system most efficient, we have calculated daily water available for irrigation on the basis of monthly rainfall. Although to capture the torrential rainfall which frequently occurs in Makkah, we considered rainfall of 150 mm/hr. at 50 year return period for sizing of storm tank. Required size of storage tank will be 7000 cubic meter. Locations of tanks have been shown in Figure 2. The calculation results have been shown in Table 5.

Table 4: Water reduction using K_L

Conventional	Area / nos	water (m^3/day)	Draught resistant	K_L	water (m^3/day)
Palm	24741	378.85	California Fan Palm	0.43	162.90
Lawn	98	15.0	Deer Grass	0.14	2.10
Water required without K_L		394	Water required with K_L		165

5. MODELING&PROGRAMMING OF DAILY WATERING :

It should be noted that demand and supply of irrigation water will not be constant throughout the year. The most fluctuating quantity of water will be rainwater. Our main aim should be to use maximum rainwater as possible. In case of rain water is not able to meet demand, TSE will be used to fulfill remaining demand. No potable water will be used to irrigate the water. Following steps/ guidelines should be followed for irrigation.

1. Weather station will measure the meteorological parameters such as temperature, wind, sunlight, humidity, dew, rainfall and will automatically adjust the daily irrigation demand in m^3/day

Table5: Estimation of monthly/daily runoff depth

Days in a month	Average monthly rainfall depth	Ave. C	Average month. runoff depth	Runoff volume m^3/month	Runoff volume m^3/day
31-Jan	20.80	0.6875	14.30	632.16	20.39
28-Feb	3.00	0.6875	2.06	91.18	3.26
31-Mar	5.50	0.6875	3.78	167.16	5.39
30-Apr	10.30	0.6875	7.08	313.04	10.43
31-May	1.20	0.6875	0.83	36.47	1.18
30-Jun	0.00	0.6875	0.00	0.00	0.00
31-Jul	1.40	0.6875	0.96	42.55	1.37
31-Aug	5.00	0.6875	3.44	151.96	4.90
30-Sep	5.40	0.6875	3.71	164.12	5.47
31-Oct	14.50	0.6875	9.97	440.69	14.22
30-Nov	22.60	0.6875	15.54	686.87	22.90
31-Dec	21.10	0.6875	14.51	641.28	20.69

2. The irrigation will be commenced with the available water (daily allotted) in the rain water tank.
3. TSE water will be used only when rain water is not able to meet demand which isthroughout the year in Aziziya Park(Khataten Garden).
4. Irrigation should be done in midnight when there is no exposure of sunlight to avoid evaporation.
5. In case of high velocity wind, scheduling for sprinkler irrigation must be changed.

CONCLUSIONS:

Adopting these designs and technologies helped to save substantial amounts of water over conventional systems. The final calculation proved that the design eliminatespotable water use and reduces pressure on water authority. The reduction in total water applications together with the no-potable water use strategy helped to maintain sustainable environment. If authority can trap and store all the rainwater in Aziziya area then no TSE water will be required to water the public park. This study and its theory can use all over the world to irrigate the public parks without heavily relying on potable water. However storing, treating and using TSE/rainwater requires careful planning and periodical maintenance.

REFRENCES:

1. Credit, S.(2007)."Water Global Equity Research". Retrieved October 27, 2008, from http://www.ewatertek.ca/PDF/Credit%20Suisse.
2. ClarkE. H.(2007)."Water prices rising worldwide". Earth Policy Institute. Retrieved October 27, http://www.earthpolicy.org.
3. Hicks, B. (2008). "A cost-benefit analysis of rainwater harvesting at commercial

facilities in Arlington County, Virginia". Duke University. http://dukespace.lib.duke.edu:8080/dspace/bitstream/10161/512/1/MP_wdh11_a_200805.pdf

4. LaBranche, A., Wack, H. O., Crawford, D., Crawford, E., & Brand, C. (2007). "Virginia rainwater harvesting manual". Retrieved October 27, 2008, from http://www.cabellbrandcenter.org/Virginia%20Rainwater%20Harvesting%20Manual.pdf
5. Mechell, J. (2008). "Rainwater harvesting: Rain gardens". Texas A&M University, Publication No. L-5482.http://dot.ci.tucson.az.us/stormwater/downloads/2006WaterHarvesting.pdf
6. Braatz S., and Kandiah A. "Use of Municipal Waste Water for Forest and Tree Irrigation" Forestry Officer in the Forestry Resources Division of FAO.
7. Dawod, G., Mirza, M., and Al-Ghamdi, K. (2011), "A GIS-based approach for estimating flash flood hazards in Makkah metropolitan area, Saudi Arabia". Journal of Geographical Information System, 3(3), pp 217-223.
8. Dawod, G., and Koshak, N. (2011), "Developing GIS-Based Unit Hydrographs for Flood Management in Makkah Metropolitan Area, Saudi Arabia", Journal of Geographic Information System, 3(2), pp 153-159.

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