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ESTIMATION OF RAINWATER HARVESTING POTENTIAL AND ITS UTILITY IN THE EDUCATIONAL INSTITUTES OF LAHORE USING GIS TECHNIQUES

RUMANA SIDDIQUI* , SAIMA SIDDIQUI**, KANWAL JAVID***, MUHAMMAD AMEER NAWAZ AKRAM****

*Department of Geography, Queen Mary College, Lahore, Pakistan

**Department of Geography University of the Punjab, Lahore, Pakistan

****Department of Geography, Lahore College for Women University Lahore

****Sheikh Iqbal Akhtar & Co. (SIAC), Gujrat, Pakistan

Corresponding author's e-mail: rumanasiddiqui5@gmail.com

ABSTRACT

Lahore, the city of colleges is going to face severe water scarcity by 2025. To find some other reliable water resources is the need of time. Water table of Lahore is depleting with an alarming rate of 3 feet annually. The main reason is undue extraction of ground water which is greater than the recharging rate. In this scenario, ground water is not able to fulfill the future demand of water. The purpose of the research is to address the water scarcity issues and solution in educational institutions of Lahore city because educational institutions are the hub of our future generation. The idea and practice to conserve water for future is necessary to cultivate the importance of sustainable water resources, in the brains of young generation. To conserve water through rainwater harvesting (RWH) is a reliable choice to semi-arid area with an average rainfall more than 600 millimeters. Therefore, by using GIS techniques rainwater harvesting potential (has been estimated from the roofs institution, which is 691000m^3 per annum. This huge amount of water, before going into sewage, can be used wisely in RWH system. Data base and tools of ArcMap10.5 have made its presentation possible and vibrant. RWH is the best technique to prevent the water crisis in Lahore city. Introducing rainwater harvesting system as a solution to water conservation, in the educational institutions will be a thought-provoking idea. Utility of rainwater can turn Lahore a water wise city of Pakistan.

KEYWORDS: Water conservation, Rainwater Harvesting system, water management, water table, rainwater-harvesting potential

INTRODUCTION

Rainwater harvesting (RWH) is an adaptation to climate change due to urbanization. It improves the livelihood of urban dwellers and conserves water for anthropological consumption of our future generations. Conserve water is essential to encounter present and upcoming water crisis in Lahore city due to frightening decline of water table at the degree of 0.9144m/ year or 3 feet per year (Kanwal et al. 2015).

Rainwater harvesting (RWH) is the trustworthy solution of the environmental complications global water crisis created by urbanization and undue water extraction from Lahore aquifer. Rainwater harvesting is the method to conserve water in many parts of the world (Li and Gong 2002;

Yuan et al. 2003). Yet, RWH can be defined as capturing and storing seasonal excess runoff and diverting it for domestic and cultivation usages (Bhatti and Nasu 2010). It is simple method of conserving rainwater for future drinkable and non- drinkable utilization. In RWH rainwater can be obtained and stored by ordinary methods from any available catchment surface like rooftops, roads, open spaces (Apana 1997, 1999; Fewkes, 1999; Jones and Hunt 2010).

Water is an important element to sustain life on the planet earth. By 2025, majority of world inhabitants will be affected by global water crisis. Therefore, sustainable water management is the need of the time (World Water Vision 2000). Rainwater harvesting (RWH) by simple scientific calculations become necessity in present situation of water. RWH is an easy choice for unchecked urbanization and rising demand for water use at present. RWH is the concept which has been proved feasible and practical all over the world to conserve fresh water and use it for pot able non-potable purposes. It can also be proved useful in Lahore city and replenish the depleting water table of Lahore which is decline rapidly table: I.

Table 1: The declining rate of water table in Lahore

Period	Average Rate of Water Table Decline in Lahore	
	ft/year	m/year
1967-1973	1.804	0.55
1973-1980	1.969	0.60
1980-2000	2.133	0.65
2007-2011	2.6	0.792
2011-2013	3	0.9144

Source: Kanwal et al., 2015

Lahore is the major educational centre in Pakistan, the literacy rate of Lahore is 74%. Lahore is famous for educational institutes (Pakistan Statistical Year book 2007). Thousands of students have been migrated to this city for educational purposes annually. Thus, increased the population in Lahore city, which is semi-arid area of the Punjab.

An institutional environment plays crucial role in learning processes of the students. Water is basic need of human life. For instance, provision of potable and non-potable water is included in basic needs. Any kind of deficiency in the basic needs would made students uncomfortable and they do not concentrate on their studies.

MATERIAL AND MEATHODS

The presented research work is conducted in the selected institution of Lahore district. Lahore, the second largest city by inhabitants in Pakistan and is located between $31^0 15^{/} - 31^0 45^{/}$ N latitude and $74^0 01^{/} - 74^0 39^{/}$ E longitude.

It is covering total area of 1772 km^2 which is still growing. India is lying at eastern border, while Lahore is bounded by Sheikhupura district from the Northern and Western sides and by Kasur District on the South. Lahore is the 2nd largest urban hub with left bank of Ravi river (Pakistan Statistical Year book 2007; Siddiqui & Siddiqui 2018). The Queen Mary College is taken as case study to estimate RWHP, which is situated at the heart of Lahore.

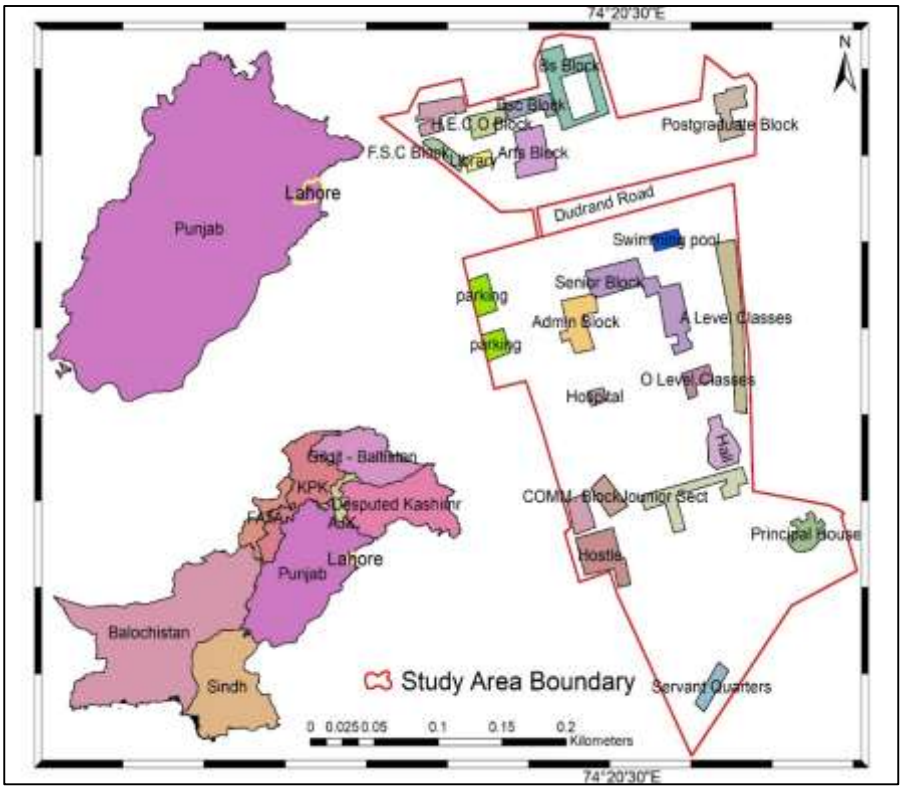

Fig. 1 Map Showing Study Area Queen Mary College, Lahore

Over a period of one hundred years , Queen Mary College, Lahore, has aquired a certain charisma. It was established in 1908, during the reign of king George V was named after his spouse named Queen Mary. It is an unique and different college from the other women colleges of Pakistan because its sevices are for all the ages of women. It is a special institution where education is imparted from grade 1 to the Postgraduate level. Once it was know as a garden college its trees and grounds were watered by Lahore cannal. With passage of time the surrounding open land turned into expanding housing colonies. Likewise, open spaces of the college area also has benn converting into buildup areas. Increasing number of students need more class rooms, consequently land for infiltration has been converted into

built up areas. There are 7,106 students altogether in different college sections in the year 2018. The teaching faculty is 244, while non teaching and minal staff is 65 and 100 respectively (QMC 2018). Now, being situated at the center of the populous city, Queen Mary College has to face the difficult challenges of the 21st century. One of the formidable challenge is to face water scarcit. Because, the declining of water table level is at the fastest rate at the center of Lahore.

Case study approach is used in present work. Queen Mary College, an educational institution has been purposefully chosen, for the reason that it is famous and unique educational institution in a fully developed residential area and can be used as a model institution for water wise building. The current consumption and requirement of drinking and non- drinking water can be calculated. Being employee of the same institution, it has been easy to conduct field survey. To introduced rainwater harvesting system is merely depends on the amount of captured rainwater, which is called rainwater harvesting (RWH) potential. Estimated RWH potential is amount of harvestable rainwater. Harvestable rainwater can be calculated from the Rooftop Catchment Method (Gould & Nissan 2005).

Formula: RWHP = Average rainfall per annum × Catchment area × Cr (equation no.1)

where; Cr = Runoff coefficient

CATCHMENT AREA

To estimate RWHP the area of rooftops is needed to calculate. Because rooftops are the runoff catchment area from where rainwater can be collected therefore in order, to find out area, all the rooftops of Queen Mary College are digitized and calculated by using ArcMap 10.5. Primary data is used satellite image of quick bird. Area of the roof has been calculating after completing the digitization and area maps are generated latter on.

AVERAGE RAINFALL PER ANNUM

Total volume of the rainfall and rainwater which could be caught is a decisive element for the adaptation of rainwater harvesting in an area. It is also important to find the estimated amount of captured rainwater to finalize the RWH system at a selected place. For planning, sound RWH system in an institution of Lahore city, the annual rainfall data has been collected for the thirty years (1988-2017). The said data from Lahore Metrological Department (LMD) was proved an authentic source to check the rainfall trending in Lahore (PMD &WASA, 2018).

RUNOFF COEFFICIENT (Cr)

The ratio rate between rainfall and runoff values is called runoff coefficient is dimension less ratio. It is a combined effect of catchment and losses of

rainwater because all the rainwater runoff could never be stored. Because, some of the amount of rainfall water could be lost by the retentive effect of surface. There are also the chances of lost this fresh water by processes of evaporation. The rate of lost rainwater is dependent on the surface of constructed material. Gould & Nissan (2005) has calculated Cr by:

Cr = amount of run off from the given surface / total amount of rainfall on the given surface (equation no. 2)

The rooftops of college are made up of bricks. Conferring the tableII the rate of runoff coefficient is as 0.6 for the said roof made of bricks. The rate equal to 0.6 directs that there is 40 % loss fresh rainwater from catchment zone.

Table II: Runoff coefficient factors for several type catchments

Type of Catchment	Coefficients
Bricks	0.8 – 0.9
Sheets of corrugated metal	0.7 – 0.9
Concrete	0.6 – 0.8
Pavement of brick	0.5 – 0.6
Untreated ground catchments	0.0 – 0.3
Soil on slops less than 10% Rocky natural catchments	0.2 – 0.5

Source: Pacey & Cullis (1989).

RESULTS AND DISCUSSION

The calculated study area is 82098 square meters. For accomplishing the resultant area measurement, all the rooftops of college buildings were digitized. Which later on, is followed by calculate estimated amount of rainwater harvesting potential (RWHP) in GIS system with addition of query as a field. Rainwater harvesting potential map is generated broadly figure 2. The estimated rainwater potential from roof surface of said institution has shown by five classes in the map. It is revealed that the estimated potential is directly proportional to the surface area of rainfall. The entire estimated potential for RWH is 5740753cubic meters. When the mean annual rain in study area was for 0.61682 mm in 2017. Calculated amount of rainwater potential is an enormous amount of fresh water. It explained by the thematic map generated by GIS.

Table2: Calculated rainwater harvesting potential volume (cubic meters and litres) by using mean annual rainfall data of 2017

Description	Rainwater harvesting potential in volume	Surface area of catchment (rooftops)

	In cubic meters	In liters	In square meters
Rooftops of buildings	5740753	5740753000	15221

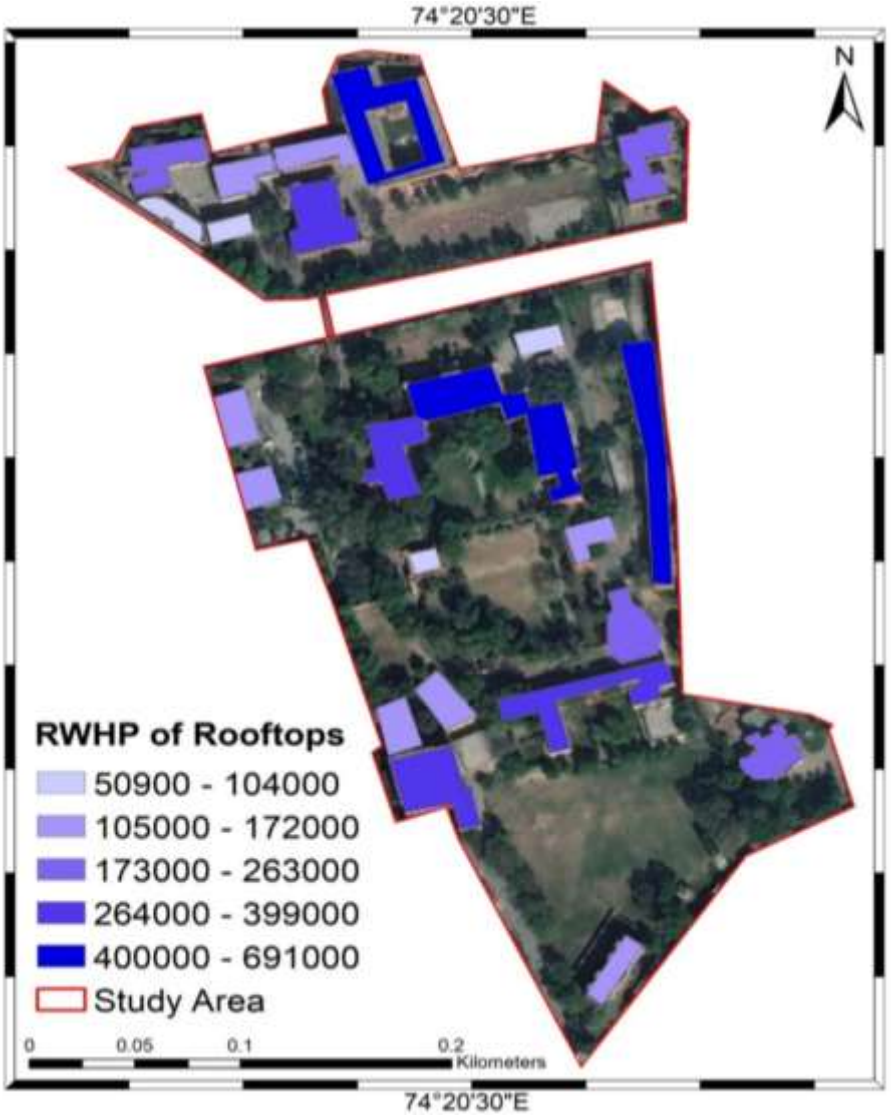

Fig.2 Showing rainwater-harvesting potential on the rooftops of Queen Mary College Lahore, Pakistan

RAINWATER HARVESTING SYSTEM UTILITY IN AN INSTITUTION

Rainwater belongs to everyone. It is sustainable and environmental friendly method of conserving water.

- Harvested rainwater could be used for potable needs after filtration or directly use for non- potable needs like cleaning and washing floors of institutions.

- Introduce rainwater harvesting system in an institution will be an act of awareness campaign for students. They will also think to conserve water.
- Harvested rainwater can be used to watering plants.
- It could also be used to recharge aquifer through recharger pit.
- To control dengue, RWH system in an institution is also used as a preventive measure in rainy season (WHO 1999).
- Harvested runoff water could be used in air coolers of institutional offices in summer season to conserve water for other purposes.
- This is an easy mode of providing non-drinkable water at institutions, to fulfill the demand of water use for washrooms and cleaning.
- Consuming harvested rainwater is extremely simple like the daily use of taps for water.
- The burden on the WASSA supply system could be lowered by introducing RWH system in semi-arid areas.
- It can save more than 50% main or central supply water usage. Reduce water bills.
- The charges for the maintenance of installed RWH system is low that is why it is in practicing in mountainous area of Pakistan.

CONCLUSION

A single step to conserve water is the step to secure our future. The RWH system utilities and advantages belong to everyone. It is sustainable and environmental friendly method of conserving water. Lahore is appropriate for RWH with 600 mm average monsoon rainfall (Siddiqui et al. 2018). The huge amount of harvested rainwater in 2017 sturdily supports the idea of installation of rainwater harvesting system to meet the present demand of water use in fast growing urban areas. It also encounters the future challenges of Lahore at institutional level. RWH system is a new water supply system to use in urban area like Lahore, Pakistan. It is a paradigm shift to bring sociocultural change to conserve water for future generation and a step towards a water wise city. This social change can be inculcated in the minds of students by introducing the RWH system in their own institutions. Hence, there is a need of some strategic plan to develop RWH system at institute level.

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