SITE SELECTION FACTORS FOR RAIN WATER HARVESTING IN URBAN AREA

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Abstract

Rapidly increasing urbanization in last 10 years has increased deforestation, causing Climatic Changes resulting in monsoon deficit. All these factors are leading to drastic reduction in rainwater percolation, depleting groundwater table further. Urban areas in India consisting of large and medium sized cities face the twin problems of flood during monsoon and shortage of fresh water during summer. The day by day depleting ground water level is alarming. Rain water harvesting (RWH) is one of the major techniques used in different styles to resolve this issue. Hence, various methodologies have been developed to find a suitable site for RWH. Some of the factors that affect the collection of underground water include land use, slope of land, runoff potential, soil type, rainfall, drainage line etc. Past Rainwater harvesting models had certain limitations like; the recharge point of any area could not be shifted nearby if any obstruction occurs on the selected point, Secondly, quantity of water collection at a selected point cannot be estimated using these methods. Also, factors affecting the quality of water like contamination are not taken into consideration. Areas consisting of Industries or Hospitals have not been noticed. Their waste water will be heavily loaded with harmful bacteria compared to residential areas. Therefore the filter quality has to be double checked. 2 As per this review, major work needs to be carried out to develop a technique that is more measurable, feasible and flawless.

Keywords: Rain water harvesting; runoff potential; factors affecting

1. Introduction

Groundwater table in urban areas is depleting day by day due to reduction of open spaces leaving very minimal area unpaved for infiltration of water. To avoid groundwater depletion as well as flood in urban area it is essential to implement rainwater harvesting (RWH) in different parts according to hydro-geological conditions. Rainwater harvesting is the collection and storage of rainwater for reuse on sites rather than allowing it to runoff. It can be collected from roofs, roads, open spaces etc. and redirected to deep pit, well, shaft or boreholes. Many parameters affect RWH such as slope, soil, density, roads, used land, drainage density etc. This paper discusses the study of such parameters and their models to make practical RWH model for implementation in urban areas

2. State of development

2.1 Integrated Water Resource Management

Wietske Medema, Brian S. McIntosh, and Paul J. Jeffrey2008 critically reviews the claims made for Integrated Water Resources Management (IWRM) and Adaptive Management(AM). The success of IWRM and AM is mixed. To achieve this, they have reviewed the main issues that challenge the implementation of both frameworks. More specifically, they have analyzed the various definitions and descriptions of IWRM and AM. The findings suggest that similar issues have affected the lack of success that practitioners have experienced throughout the implementation process for both frameworks. These findings are discussed in the context of the broader

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societal challenge of effective translation of research into practice, science into policy and ambition into achievement.

According to **J.E. de Steiguer, Jennifer Duberstein, Vicente Lopes 2003** Integrated Watershed Management (IWM) has emerged worldwide as the preferred model for watershed planning. IWM uses the watershed as the basic geographic planning unit while integrating social, economic, ecological and policy concerns with science to develop the best plan. Stakeholder input is key to successful IWM. However, stakeholder participation can present problems when the public is uncertain or unclear about the IWM planning criteria. The Analytic Hierarchy Process is a decision method for assisting IWM because it treats planning criteria and criteria weighting in an open and explicit manner. **Muhammad Mizanur Rahaman & Olli Varis 2005** addresses the prospects of IWRM in resolving the current water crisis. It also identifies seven crucial challenges for implementing IWRM

2.2 Rainwater harvesting

VincenzaNotaroa, Lorena Liuzzoa, Gabriele Frenia 2016 have focused on RWH system installed to supply water for toilet flushing purpose with reference to a single-family house in a residential area of Sicily (Southern Italy). Historical water consumption data were analyzed to obtain a flushing water demand pattern. A water balance simulation of the rainwater storage tank was performed and the yield-after spillage algorithm was used to define the tank release rule. The model's performance was evaluated using data from more than 100 different sites located throughout the Sicilian territory. Results showed that RWH systems have performed good when catchment area is 200-300 m2 where in 85% water saving efficiency is achieved.

Slovakia D. Kaposztasovaa, Z. Vranayovaa, G. Markovic , P.Purcz (2014) have focused on Contemporary sustainable potable water management. Mostly people use potable water for flushing toilets, irrigation or washing vehicles. The appropriate solution is to substitute potable water with rainwater for some purposes and this water source is considered sustainable. This paper presents risk assessment using risk analysis of the rainwater harvesting (RWH) system, also does not deal with the rain water harvesting system in details but presents the semi quantitative approach of the evaluation methodology verified by analytical hierarchy process.

The main objective of **AmmarAdham, MichelRiksen, Mohamed Ouessar , CoenRitsem (2016)** was to determine the best method for selection of suitable RWH sites in Arid and semi-arid regions (ASARs) by assembling an inventory of the main methods (Steiguer et al., n.d.)and criteria. They categorized and compared four main methodologies of site selection. The most important criteria for the selection of suitable sites for RWH are 1) slope 2) land used /covered 3) soil type 4) rainfall 5) distance to settlement/streams 6) cost. They have categorized the method/tools that have been applied to identify suitable sites in ASARs are .1) GIS/RS, 2) Hydrological Modelling with GIS/RS , 3) multi- criteria analysis integrated(MCA) with HM and GIS/RS , 4) MCA integrated with a GIS Water balance simulations of rainwater tanks were carried out by **A. Campisanoa,, D. Di Libertoa, C. Modicaa, S. Reitanob., 2014** to explore the potential benefits of tank-based rainwater harvesting systems to reduce runoff flow peaks at the household scale in urban area.

Ammar Adham , Michel Riksen , Mohamed Ouessar and Coen J. Ritsema(2016) proposed a scientifically-based, generally applicable methodology to better evaluate the performance of existing RWH techniques in semi- arid regions. It integrates engineering, biophysical and socio-economic criteria using the Analytical Hierarchy Process (AHP) supported by the Geographic Information System (GIS). The study revealed that site characteristics play more important role in the overall suitability than other criteria. This integrated methodology, which is highly flexible, saves time and costs, is easy to adapt to different regions and can support designers and decision makers aiming to improve the performance of existing and new RWH sites.

Abdel Rahman Al-shabeeb (2016) aimed to select the optimum sites for water harvesting in the Azraq basin of Jordan through the use of GIS techniques. The Azraq basin is characterized by flash floods that involve large quantities of runoff. The selection criteria in this research were based on six parameters. Five experts were then asked to evaluate the importance of each criterion. The consistency ratio between the expert's opinions was evaluated using the pair wise comparison method and a final weight was computed for each criterion. This research can be

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used to assist in the efficient planning of the water resources management to ensure a sustainable development of the water in Jordan and in other areas suffering from water shortages.

According to GUO Fengtai & MAO Xiaochao(2012) water resources in northern cities of China are in short supply, while rainwater resources are under utilized which actually can resolve the problem of water shortage if utilized properly. This paper gives an example of Handan city and analyzed potential, economic benefits of city after rainwater utilization. They discussed on two projects; pattern 1st: Road rain water collection and 2ndroof rainwater collection. After analysis, it was observed that these two patterns solved the water shortage problem and reduced the load of rainwater pipe network which is economical.

Shufen Chen, Heli Wang1, Wenzhe Yang, Dingxuan Zhang (Chen, Wang, Yang, & Zhang, 2012) shows that the rainwater can save the energy in direct and indirect ways. Direct energy is achieved through climate, long-distance water transportation and sewage treatment and indirect energy is saved by water and pipe and reduction of pipe laying, pumping operation, urban flooding and nonpoint source pollution. According to **Guru**

Balamurugan , KarthikSeshan, SomnathBera (2017) the sites were selected on the basis of depth of groundwater level, source of spring well locations and gradient from natural spring to selected recharge wells. 86 spring wells had been located in the study area, of which 60 wells were considered for success rate and remaining 26 wells were considered for prediction rate in frequency ratio (FR) model. They determined the probability of groundwater potential areas on the basis of relationship between dependent variable, spring wells and independent variable, groundwater influencing factor FR= [(W/TW)/(CP/TP)] Where, FR is frequency ratio of the class of factor, W is a number of pixels of spring well locations for each class of thematic maps; TW is a number of total pixels of spring well in the study area. CP is a number of pixels in each thematic class and TP is a total number of pixels in the study area. In the FR model, FR value of each class in a thematic layer was considered as weight of that particular class in thematic parameters to determine groundwater potentiality.

I.P.Senanayake*, D.M.D.O.K. Dissanayake, B.B. Mayadunna, W.L. Weerasekera(2016) , observed that GIS approach was used to delineate potential artificial recharge sites in Ambalantota area within Hambantota. Influential thematic layers such as rainfall, lineament, slope, drainage, land use/land cover, lithology, geomorphology and soil characteristics were integrated by using a weighted linear combination method. Study can be improved by increasing the accuracy and spatial resolution of the data. The methodology employed in this study can be generalized for the entire Hambantota District by using appropriate parameters, ranks and weights. Further, it can be extended into other areas of the dry zone of the country to identify potential groundwater recharging zones with suitable modifications. The field verifications are useful in identifying the most suitable artificial recharge structures to replenish groundwater in the study area based on existing terrain conditions, land use/land cover and drainage system. Hence, it will provide clear guidelines to the decision makers in implementing proper groundwater management endeavors.

Emily C. Edwards a,Thomas Harter a, Graham E. Fogg a, Barbara Washburn b, HamadHamad (2016) have shown that drywells can be an effective means to increase recharge to aquifers; however, the contamination of groundwater caused by polluted water that flows in full speed can have a strong possibility of spreading the contaminated bacteria in the nearby dry wells. This has prevented more widespread use of drywells as a recharge mechanism. Numerous studies have shown that groundwater and drinking water contamination from drywells can be avoided if drywells are used in appropriate locations and properly maintained. The effectiveness of drywells for aquifer recharge depends on the hydro geological setting and land use surrounding a site, as well as influent storm water quantity and quality.

An integrated approach for assessing the characteristics of groundwater recharge using GIS technique was proposed for the Hualian River watershed, eastern **Taiwan Hsin-Fu Yeh ,Youg-Sin Cheng, Hung-I. Lin, Cheng-Haw Lee (2016).** This study produced a groundwater recharge potential map of the mountainous basin. This study was important for sustainable use of the groundwater resource thereby enhancing groundwater recharge by proper management. The results indicate that application of

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GIS techniques help for groundwater exploration in narrowing down the target areas for conducting detailed hydrogeological surveys on the ground. The results indicate that the most effective groundwater recharge potential zone is located in the Huatung Valley. In this region, the gravelly stratum and the concentration of drainage also helps the stream flow to recharge the groundwater system. Additionally, the concentration of drainage also indicates the ability of stream flow to recharge the groundwater system. This study establishes the interrelationships between the groundwater recharge potential factors and the groundwater recharge potential scores from the general hydrology characteristics of Taiwan. The maps obtained by this method can be used by government and water policy decision makers as a preliminary reference in selecting suitable sites for groundwater resources management, e.g., drilling new boreholes.

Mohd. Saleem & Gauhar Mahmood (2017) , studied different techniques of RWH along with its impact, various methods of recharge, use of RS, GIS and models in artificial recharge were reviewed. It helped to learn the past RWH implementation experiences around the world and the different way that are likely to provide the most quantitative estimates of recharge. From the various literatures, it has been identified that various researchers handled different objectives with different methodologies and identified that all the works done are at initial levels. So there is a need to handle the other issues of ground water recharging by applying the rain water harvesting techniques which is a major challenge these days.

Patrick Bitterman a, Eric Tate a, Kimberly J. Van Meter b, Nandita B. Basu (2016), presents conceptual framework and proposed indicator set for measuring water security in the context of rainwater harvesting tanks. The primary benefits of tanks and threats to their functionality are profiled as a precursor to construction of a causal network of water security. The causal network identifies the key components, causal linkages and outcomes of water security processes and is used to derive a suite of indicators that reflect the multiple economic and socio-ecological uses of tanks. Authors recommendations are useful for future research and data collection to operationalize the indicators to support planning and assessing the effectiveness of tank rehabilitation.

Uri Nachshona et al. 2016, reviewed the history of rain water harvesting and discuss the impact of rain water harvesting in modern urban environments on the hydrological system. There are two types of rain water harvesting methods like; storing of the harvested water in reservoirs and direct infiltration of the harvested water into the aquifer are being discussed and compared. Quantitative examples from Tel-Aviv, Israel are given and indicate that rain water harvesting may play an important role in the local and regional hydrological cycle and that direct infiltration of the harvested water into the aquifer is preferable for heavily populated cities.

Sagar Kolekar, Simran Chauhan1, Hitesh Raavi1, Divya Gupta1, VivekChauhan(2017) have highlighted the importance of parameters like land use, slope, soil map, drainage networks etc. The efficiency and accuracy of SCS- Curve number method is also expressed where two main factors i.e landuse and soil maps are combined to identify potential water harvesting sites

2.3 Water imanagement

According to **Joong Gwang Lee and James P. Heaney (2004)** an imperviousness is an important indicator of the impact of urbanization on storm water systems. A hydrologic analysis was performed to evaluate long-term impacts from an apartment area in Miami. The result shows that the directly connected impervious area DCIA, which covers 44% of the catchment, contributes 72% of the total runoff volume during 52 years. Few studies have actually measured the DCIA with a high level of accuracy for residential areas that constitute the largest proportion of urban land.

M. Zeleákováa,, G. Markovi, D. Kaposztásová, Z. Vranayová(2014), contribute to the theme of reuse of rainwater for buildings captured from its rooftops. The paper describes comprehensive rainwater management approaches and contains an overview of the source control techniques ultimately aiming to design these systems as an alternative source of water.

Md. Arfanuzzaman, A. AtiqRahman (2017), suggests an integrated SWDM approach, which incorporates optimum pricing, ground and surface water regulation, water conservation, sustainable water consumption and less water foot print to ease groundwater depletion. In order to attain sustainability in water demand management

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(WDM) the study recommends certain criteria under economic, social and environmental segment to administer the increasing water demand of growing population and conserve the fresh water resources of the world's mega cities for social–ecological resilience building. The layout effects and optimization of runoff storage and filtration facilities are crucial to the efficiency and management of the cost of runoff control, but related research is still lacking. Area **Wei Xing a,b, Peng Li a, Shang-bing Cao c, Li-li Gan a, Feng-lin Liu a, Jian-e Zuo a, (2016),** studied scenarios with different layouts that simulated using the storm water management model (SWMM), to investigate the layout effects on control efficiency with different precipitations. Based on weighting analysis, an integrated ranking index was obtained and used to determine the optimal layout scenarios considering different rainfall events

3. Summary

Based on various methods developed and literature survey, our main purpose is to find effective method for identification of suitable rainwater harvesting site in urban area. The success of rainwater harvesting system depends upon the parameters used in design according to the type of site. The biophysical criteria are soil type, rainfall, slope, land used/cover is a major parameters in any RWH system. Out of this criteria soil type is not major role in case of dense urban area and one more parameter is required intensity of rainfall. Because heavy rainfall occur for short duration then it will cause maximum runoff and mostly cities land cover is maximum so it will cause more runoff. Remote sensing and GIS is the best tool for identification of RWH sites. It is valuable tool for site selection in any remote as well as in urban area. To increase its more usefulness it is necessary that to refine the model and to include other pertinent ancillary data like social economic factors

4. Conclusion

As we can see, all the researchers have invested their valuable time is assessing the significance of Rain water harvesting in their own ways. But so many researchers clearly mention that their own models have some practical constrain. Increase in population leads to modification of land use land cover, which results in reduction of ground water levels. So according to modification of land use our RWH models shall be flexible and convenient for any practical changes. From the above literature review, it is observed that the rain water harvesting models have worked on the identification of suitable site for recharge of aquifer through rain water harvesting using hydro geological data. The RWH model can be made flexible, convenient and useful if additional points mentioned below are considered:

1. Immobile nature of recharge point should be considered while making the model for future changes.
2. The underground world of water is not stable and keeps changing from one recharge point to another depending on the structure of that particular land. Hence it is very difficult to monitor the quality of water collected in any specific recharge point. This can play as one of the major drawback as we are concentrating on reuse of waste water to save the overall water resources.
3. Area wise contamination of water was not considered; such as chemical industry, medical industry etc. which can exert some chemical / waste. This can further be mixed with other recharge points and contaminate them too during rainfall

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