Journal of Advances and Scholarly Researches in Allied Education

Vol. VII, Issue No. XIV, April-2014, ISSN 2230-7540

IMPACT OF RAINWATER HARVESTING ON CATCHMENT HYDROLOGY

AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

www.ignited.in

Journal of Advances and Scholarly Researches in Allied Education
Vol. VII, Issue No. XIV, April-2014, ISSN 2230-7540

Impact of Rainwater Harvesting on Catchment Hydrology

Sapna Yadav[1]* Sukh Dev[2]

[1] Research Scholar, Calorx Teachers' University, Ahmedabad

[2] Associate Professor, Calorx Teachers' University, Ahmedabad

Abstract – Shortage of water for industrial and commercial use and even for drinking purpose is a concern throughout the world, especially in developing countries. The current decline in groundwater availability in India necessitates the formulation of sustainable groundwater management plan through proper assessment of the available resources. Rainwater harvesting (RWH) for groundwater recharge is seen as one of the solutions to solve the groundwater problem. This is reflected in an increase in watershed development programs, in which RWH is an important structural component. Understanding the net effect of these development programs is crucial to ensure that net effect on groundwater is positive both locally and within a watershed. The appropriate design and evaluation of a RWH system is necessary to improve system performance and the stability of the water supply. This review article is focused on a literature survey of the design of RWH and its aquifer modeling and application of remote sensing and geographic information system to artificial recharge.

----------X----------

INTRODUCATION

RWH is the process of collecting and storing rain for later productive use. It has gained tremendous interest among academicians, institutions, professionals and non-professionals in the past few years since it is a low cost solution to water crisis. RWH as one of the artificial recharge techniques is a useful tool in water management as it directly benefits the society by solving the water problem of present and future generation. Different techniques of RWH are found throughout the Middle East, Africa and South Asia. In India, one of the main purposes of RWH is storing runoff to recharge shallow groundwater aquifers using small-scale structures. Various literatures highlight RWH as an efficient cost-effective method of replenishing aquifers. Extensive literature is available on RWH with respect to various methods, its impacts on groundwater quantity and quality and its modeling. Numerous literatures were collected and critically reviewed on RWH related aspects and only those in consonance with the set objectives are presented. Basic issues such as recharge estimation, application of RS and GIS in artificial recharge studies and groundwater modeling are covered initially. Specific aspects of this thesis such as RWH implementation and its impact studies are presented after the basic issues.

To collect and store rainwater for future various uses, rainwater harvesting (RWH) is a beneficial technique. It is a beneficial technique due to a low-cost solution to water crisis among the community, academic, accomplished, system, incompetent and accomplished in the past few years. Underground water is recharged by artificial recharge techniques (RWH). For solving the water problem of present and future generation, rainwater harvesting is a useful tool in water management. Storing runoff to recharge shallow aquifers using miniature structures is achieved by (RWH) in India. To restore aquifers by (RWH), various literature are highlighted. Various methods, its impacts on groundwater quantity and quality and its modeling are available on (RWH). Initially, various issues such as the application of remote sensing (RS) and geographic information system (GIS) in artificial recharge studies, recharge evaluation and groundwater modeling are covered. Basic issues such as (RWH) implementation and its impact are carried out in this review paper

Estimation of groundwater recharge

Revive is characterized as the vertical progression of water joining the water table, adding to the groundwater stockpiling. Revive is ordinarily communicated as the volume per unit time, for example, m3/day. Precipitation revive, return stream from the surface and groundwater water system, leakage from tanks and lakes and drainage from trenches are different components of energize. For proficient administration of the groundwater asset, the investigation of the characteristic energize is vital .To survey the revive quantitatively, numerous writings have accomplished. Korkmaz (2013) assessed the groundwater revive from water level and precipitation

information. During the time of 1975–1984, the normal yearly energize was discovered 180 mm. The normal yearly precipitation was discovered 33% .

Chiew et al. (2012) anticipated the joined surface and groundwater demonstrating strategies for groundwater revive. The potentiometric head and streamflow information were estimated by this model. They disclosed the model to the Campaspe River Basin in North-Central Victoria, and the outcomes established that this displaying access can assess sufficiently the spatial and transient dissemination of neighborhood energize rates coming about because of precipitation and water system water. They inspected that the incorporated model was better than those anticipated when the groundwater and surface models were utilized independently. Osterkamp et al. (1995) investigated the groundwater energize assessment in dry and semiarid territories by models from Abu Dhabi.

In South Africa, Bredenkamp et al. (1995) clarified the emotional springs by taking the total precipitation flight (CRD) strategy. They inspected the relocation of precipitation from the mean precipitation of the first run through is worried about the regular ground-level change. On the off chance that the movement is positive, at that point the water level will increment and tight clamp versa (Xu and van Tonder 2001). Giambelluca et al. (1996) considered the vulnerability in revive evaluation and effect on groundwater defenselessness gauges for Pearl Harbor Basin, O'ahu, Hawai'i, USA. They researched the energize vulnerabilities for rural land under pineapple or sugarcane development by taking a mix of first-request sensation investigation and vagueness examination. By taking unconventionality, the energize was discovered 58% for pineapple and 49% for sugarcane (Giambelluca et al. 1996).

Finch (1998) assessed the direct groundwater energize by taking straightforward water balance model. They talked about shifting the vegetation overhang boundaries for the timberland notwithstanding differing the dirt dampness model (Finch 1998). Amitha (2000) assessed regular ground revive by utilizing different strategies, for example, zero stream plane strategy, soil water balance technique, opposite demonstrating strategy and one-dimensional soil water stream model (Kumar 1997), groundwater-level variance technique, isotope and solute profile procedures, compound water change strategy and groundwater balance strategy. Kichurl (2001) assessed the groundwater energize rate for cracked hard rock spring, Chojeong territory, South Korea. Six distinct strategies were taken to assess groundwater revive rate including Soil Conservation Service-Curve Number Method (SCS-CN) plan, multi-direct relapse investigation and spring demonstrating procedures. The scientists recommended that SCS-CN and flood recipe are more reasonable for the top unconfined spring, which had different water powered conductivity including lower cracked hard rock development; the revive rates accomplished from those diagnostic models are twice that esteem from spring model (Kichurl 2001). For assessment of energize, changed aggregate precipitation flight (CRD) technique was utilized. Xu and Van Tonder (2001) assessed the periodicities and the patterns in the precipitation, which was not analyzed in Bredenkamp recipe. Energize Estimation Model in Excel (REME) was advanced in this investigation (Xu and van 2001). Moon et al. (2004) assessed groundwater energize in South Korea by taking the factual examination of water table vacillation and hydrographs. Groundwater hydrographs were ordered into five regular gatherings by taking water table perception information from the National Groundwater Monitoring Network in Korea. To assess groundwater energize, an adjusted water table variance (WTF) technique was created between the comparing precipitation reports and total WTF (Moon et al. 2004).

Baalousha (2005) reviewed estimation of groundwater resuscitate in the Gaza Strip, Palestine by taking the CRD procedure. To restrict the root mean squared misstep (RMSE), the CRD strategy was finished between the acknowledged groundwater head and assessed head. The results compared with the outcomes of other stimulate evaluation procedures from the composition. It was suggested that the results gained by this methodology are amazingly close to the delayed consequences of various systems (Baalousha 2005). Sun (2005) evaluated groundwater resuscitate appraisal in Montagu region of the western Klein Karoo, South Africa by water balance procedure. To consider long stretch ordinary empower, flood model and exploratory evapotranspiration were thought of. The drawn out ordinary resuscitate was a component of the site conditions, for instance, soil, environment, area and geology. The positive evapotranspiration, empower and direct flood were estimated by using long stretch physical and climatic data from the various precipitations time period check stations (Sun 2005).

Chand et al. (2005) considered neutron soddenness test for groundwater invigorate in Hayatnagar scaled down watershed, India. Eight objections of Hayatnagar scaled down watershed at ordinary timeframes were gotten for the earth soddenness decency (Sandhu et al. 2000). It was found that the overall volume of water (resuscitate) vacillates from 0.22 to 0.37 m. The storativity varies from 6.9 to 10.6% as a result of rise in water level. Adelana et al. (2005) found groundwater restore in part of the Sokoto bowl, Nigeria, by using hydrochemical, exploratory and basic hydrological strategies. For appraisal of resuscitate in a huge segment of the bowl, the chloride mass leveling methodology was commonly noteworthy (Adelana and MacDonald 2008). Lorenz and Delin (2007) surveyed common groundwater empower by regional backslide resuscitate (RRR) model. To survey the resuscitate from, surface water squander bowls, precipitation, ordinary bowl and unequivocal yield (SY) (RRR) model was used. The invigorate assessed by the RRR methodology was moreover the most insignificant (0–5 cm/year) (Lorenz and Delin 2007).

Delin et al. (2007) surveyed the groundwater resuscitate in Minnesota, USA, using three commonplace scale moves close (water table changes (WTF), unsaturated-zone water adjustment and age dating of groundwater). It was contemplated that the WTF system was the most easy and calmest to apply for restore assessment (Delin et al. 2007). Rasoulzadeh and Moosavi (2007) reviewed groundwater empower in the proximity of Tashk Lake by using CRD procedure. Groundwater restore evaluation procedure (GRET) was used to decrease the differentiation between the perceived water table and copied statures. For high volume of groundwater motivation in the assessment zone, the normal restore isn't sufficient (Rasoulzadeh and Moosavi 2007).

Bingguo et al. (2008) analyzed groundwater revive in Hebei Plain, China by tritium and bromide tracers. Tritium and bromide following was utilized for energize coefficient and ordinary revive rates. It was discovered that this strategy is helpful for the profound water table (Bingguo et al. 2008). Sibanda et al. (2009) corresponded the groundwater revive assessment techniques for the semiarid Nyamandhlovu territory, Zimbabwe by utilizing chloride mass equalization strategy. The stream net assessments and demonstrating techniques gave improved appraisals to airborne revive than the elective strategies. In view of groundwater demonstrating, a last revive (from precipitation) was assessed to be 15–20 mm/year (Love et al. 2010).

For energize assessment dependent on a water balance approach, Government of India has bound a lot of rules through a Groundwater Resource Estimation Committee (GWREC 2009). Various qualities are to be taking from siphoning test examination. Groundwater stockpiling increment could be assessed by utilizing the variety in explicit yield, groundwater level and territory of impact (Kumar 2009). Adnan (2010) decided groundwater revive displaying utilizing WetSpass model for Gaza strip, Palestine. For assessment of long haul normal spatial examples of outright evapotranspiration, surface spillover and groundwater revive, the WetSpass model was created (Adnan 2010). Izuka et al. (2010) deciphered groundwater energize on tropical islands by basic conditions. Conditions were utilized for energize gauges from soil interruption, and penetration, and going before soil water spending concentrates in Hawai, USA (Izuka et al. 2010).

Chandra et al. (2011) assessed spatiotemporal revive dissemination in translucent rocks of Bairasagara watershed and Maheshwaram watershed of India by lithologically compelled precipitation (LCR) strategy. Three info boundaries, i.e., vadose zone thickness, soil resistivity and precipitation were utilized in lithologically obliged precipitation (LCR) strategy. It was assessed in the investigation that the LCR is a summed up, quick strategy and financially savvy additionally to assess regular revive incompletely and transiently from precipitation in hard rock area and develop a helpful time arrangement of characteristic energize in the read watershed for predicting contemplates (Chandra et al. 2011).

Srinivas et al. (2011) decided the phase of groundwater improvement in Kurmapalli Vagu Basin in Deccan Plateau by practicing distant detecting and geological data framework strategies related to average techniques. Groundwater energize from channels, precipitation, minor water system tanks recuperation stream of water system and water the board structures were assessed. The general groundwater revive and yearly utilizable groundwater assets from various sources were estimated. The groundwater equalization of the bowl accomplished 1.95 MCM. The phase of groundwater advancement accomplished to 80.6% which falls in the semi-basic class (Pradeep Kumar and Srinivas 2012). Mondal et al. (2011) delimited planned groundwater revive zones in a hard rock zone from Southern India by RS and GIS procedures. They accomplished the approval of assessed energize values utilizing the altered water table change (WTF) technique (Mondal et al. 2011).

From the different writing considers, it is perceived that one must comprehend water assets the board that how much water is reviving the groundwater springs. Along these lines, the GWREC (2009) approach is received for this investigation.

Application of remote sensing and GIS for artificial recharge

GIS and RS are proficient devices for incorporating metropolitan arranging and groundwater energize considers. Satellite information are exceptionally helpful in controlling the event and development of groundwater like geomorphology, basic, land use/land spread, soil and highlights. RS and GIS are helpful apparatuses in counterfeit energize displaying (Mondal 2012). Ramasamy and Anbazhagan (1997) distinguished reasonable destinations for fake revive in Ayyar sub-bowl in Cauvery River, India by gathering the information of water-level variety, omphalic, topography and subsurface geography. Positive destinations for different fake revive structures were separated (Ramasamy and Anbazhagan 2014).

Saraf and Choudhury (1998) characterized the groundwater investigation and distinguishing proof of counterfeit revive destinations in hard rock landscape in the Sironj zone of Vidhisha District, India by the possibilities of incorporated RS and GIS. The investigation shows repository incited counterfeit energize downstream of surface water repositories. Groundwater energize in a hard rock district through revive bowls or repositories was chosen by legitimate locales (Saraf and Choudhury 2007). Kshirish et al. (2002) characterized the boundaries like seepage, surface shape, propensity and groundwater profundity by utilizing RS and GIS for Rengareddy

District, Andhra Pradesh. An away from of the revive zones was finished up by this investigation (Kannan 2007).

Shankar and Mohan (2005) considered the site-explicit counterfeit revive techniques in the Deccan Volcanic Province of India by the GIS-based hydrogeomorphic approach. The hydrogeomorphological attributes separated from the IRS-1C LISS-III (Indian Remote Sensing-1C Linear Imaging Self Scanner-III) were received for GIS examination. Check dams and permeation lakes structures were suggested for fake revive (Shankar and Mohan 2005). De Winnaar et al. (2007) considered the potential overflow gathering destinations in the Thukela River Basin, South Africa by GIS procedure. Likely spillover gathering destinations were recognized by GIS (Anderssona et al. 2011). Mbilinyi et al. (2007) considered the likely locales for water reaping in Tanzania by GIS-based choice emotionally supportive network (DSS). Guides of precipitation, soil surface, slant, soil profundity and seepage and land use information were gathered by DSS (Below et al. 2007).

Ghayoumian et al. (2007) decided most appropriate locales for fake groundwater revive in a beach front spring in Southern Iran by GIS procedure. Penetration rate, limited layers for slant, nature of alluvial dregs, profundity to groundwater and land use were inspected for finished and incorporated into a GIS domain (Xiaojun 2009). Lin et al. (2009) decided groundwater energize and release assessment by PRO-GRADE GIS toolboxs. The mass parity strategy, for example, water table, pressure driven conductivity and ground height information was utilized for GRADE GIS (Lin et al. 2009). Maggirwar and Umrikar (2009) built up the chance of fake energize in overdeveloped little watersheds by RS–GIS procedure. Town map, waste guide, geomorphology, soil guide and land utilized were ready for bound springs (Maggirwar and Umrikar 2009).

Sukumar and Sankar (2010) portrayed the potential zones for counterfeit energize in Theni region, Tamilnadu by utilizing GIS strategy. Moderate, high and least positive zones were ready for fake energize. Soil profundity, penetrability, waste power, soil surface and water holding limit maps were ready for various kept layers (Nagaraju et al. 2010). Peiyue et al. (2011) analyzed the fake revive locales in Sivaganga District, Tamilnadu by utilizing the RS and GIS methods. Different kept guides, for example, seepage, lineament, waste thickness, lineament thickness, land use, geomorphology, land spread and Landsat satellite information were readied. For refreshing the bound guides, the standardized distinction vegetation list (NDVI) strategies were ready for all coordinated and limited guides (Peiyue et al. 2011).

Chowdhury et al. (2010) portrayed the RS, GIS and multi-measures dynamic (MCDM) strategies for groundwater revive zones and to recognize the fake energize destinations in West Medinipur locale, West Bengal. Customary and IRS-1D symbolism information were ready for kept layers. In view of the accessible field data, check dams were proposed for fake energize structures (Chenini 2010). RS and GIS are an exceptionally valuable procedure for groundwater revive examines. To characterize the potential groundwater revive zones, counterfeit groundwater energize must be actualized.

Groundwater modeling

Evaluating groundwater revive is imperative to gauge RWH impacts and is additionally important for supportable groundwater asset the executives in semi-dry and parched territories. Be that as it may, energize is one of the most troublesome parts of the water parity to gauge, since it should be estimated beneath the noticeable surface and is exceptionally factor. A large number of the accessible revive assessment strategies have their own restrictions. Revive can be assessed utilizing physical estimations through tracer methods, chloride mass parity, lysimetry, water balance, and so on at the nearby scale for an individual structure. Water balance approach is a basic technique for the assessment of groundwater potential and energize. Most field strategies are costly, tedious or don't convey the ideal precision. Furthermore, high transient and spatial inconstancy of precipitation, soil and spring water driven properties imply that long time arrangement ofhistoric information are required. Information is restricted in semi-bone-dry/bone-dry areas especially in creating nations where populaces are scanty and financial assets are restricted. Groundwater displaying may offer a method of evaluating the revive at a bigger catchment scale, yet model info and exactness will decide the handiness of the conclusive outcomes. Visual MODFLOW, a 3-dimensional limited distinction groundwater model (Harbaugh and Mc Donald 1996) is utilized to recreate the hydrogeologic system in a locale. Spatial examination of groundwater revive relies upon a few factors and needs a computationally steady control of georeferenced data at various scales. As groundwater is dynamic and interdisciplinary in nature, an incorporated methodology of Remote Sensing (RS) and Geographic Information System (GIS) procedures are helpful in different groundwater the board considers. Uses of RS and GIS in groundwater the executives have been accounted for by various scientists (Ghayoumian et al 2007; Ramasamy and Anbazhagan 1997; Ravi Shankar and Mohan 2005).

To foresee revive of groundwater, the down to earth the executives of groundwater is important. For assessing stream and revive in groundwater frameworks, the deterministic, doled out boundary, PC reenactment models a well-known device. Conditions, constants or coefficients of physical properties in the conditions and amplitudes of the state are performed by numerical models (Delleur 2003). Protection of mass, vitality and energy depends on numerical groundwater models. To decide the need of counterfeit energize, a numerical model can be utilized as a plan apparatus. Numerous analysts around the globe have

endeavored to do groundwater revive demonstrating. Bekesi and McConchie (2003) utilized Monte Carlo method for Manawatu district of New Zealand for groundwater revive displaying. In this investigation, a local precipitation energize model was created. For the essential inconstancy of soils, randomized soil dampness boundaries were utilized. Great understanding between the displayed and genuine groundwater levels was gotten (Ekesi and McConchie 2000).

Gnanasundar and Elango (2000) did the groundwater stream displaying of a negligible spring close to Chennai city, India utilizing MODFLOW. The model was estimated under consistent and transient conditions. The auxiliary appropriation of groundwater head and well hydrograph was separated from the memorable information. They accomplished that fast urbanization would prompt further bringing down of the water table at not many areas along the Northern shoreline of the spring framework. They likewise demonstrated that their model is sensitive in any event, for 5% decrease in revive (Gnanasundar and Elango 2011). Gogu et al. (2001) performed groundwater displaying of Belgium for the Walloon area by utilizing the GIS-based hydrogeological information base. Distinctive hydrogeological attributes of five stream pool were picked in the information base. A "free coupling" gadget was assessed between the groundwater mathematical model interface Groundwater Modeling System (GMS) and the basic information base arrangement. Put away information in the data set of hydrogeological information can be utilized effectively for auxiliary questions and following time inside various groundwater mathematical models (Wojda et al. 2006).

Pliakas et al. (2005) inspected the groundwater revive of Bedin Xanthi plain, Greece by reactivating an old stream. MODFLOW was utilized to duplicate the spring arrangement of the investigation region (Katpal et al. 2013). Fayez and Tamer (2006) analyzed groundwater stream for Mujib spring of Jordan by utilizing MODFLOW method. The effect of the stream framework under different anxieties was analyzed, and MODFLOW model was utilized to construct a groundwater stream procedure. The consistent state of the underlying head shape lines was estimated by MODFLOW model. The effect of the drawdown of an all around was analyzed and utilized this information to adjust the impermanent model. To foresee spring framework reaction under various condition different situations were guaging (Abdulla and Al-Assad 2006). Shammas and Jacks (2007) decided the development of the freshwater/saltwater interface by utilizing the codes MODFLOW and MT3DMS for solute transport. The assurance of the groundwater in Salalah plain spring in Oman from further interruption by a fake revive with recycled water along the Salalah waterfront rural strip was suggested (Jacks 2007).

Rejani et al. (2008) assessed the proficient groundwater the executives in Balasore Coastal Basin, India by Visual MODFLOW method. It was discovered that the energize from precipitation, stream drainage and inflow than to flat and vertical pressure driven conductivities and clear stockpiling is exceptionally simple in the Balasore spring framework (Praveen et al. 2010). Zume and Tarhule (2008) utilized MODFLOW procedure for the effects of groundwater siphoning on stream–spring elements in semiarid Oklahoma, USA. Siphoning prompted changes in base stream, stream absolute bundle and stream spillage were assessed by MODFLOW to gauge stream exhaustion in the Beaver-North Canadian waterway framework (Zume and Tarhule 2008)

OBJECTIVES OF THE STUDY

1. To evaluate the design of implemented RWH structures.

2. To prepare recharge response zonation mapping using cross correlation technique.

3. To study the impact of RWH on improvement in groundwater potential.

CONCLUSIONS

Various strategies of RWH alongside its effect, different techniques for revive, utilization of RS, GIS and models in counterfeit energize were audited. It assisted with learning the past RWH usage encounters far and wide and the diverse way that are probably going to give the most quantitative appraisals of revive. From the different writing, it has been distinguished that different scientists took care of various goals with various strategies and recognized that all the works done are at the underlying levels, so there is a need to deal with the various issues of groundwater energizing by applying the water collecting methods which are significant difficulties nowadays.

REFERENCES

1. Abdulla F, Al-Assad T (2006) Modeling of groundwater flow for Mujib aquifer, Jordan. J Earth Syst Sci 115(3): pp. 289–297

2. Adelana S, MacDonald A (eds) (2008) Applied groundwater studies in Africa. CRC Press/Balkema, London, UK

3. Adelana S, Olasehinde P, Vrbka P (2005). Identification of groundwater recharge conditions in crystalline basement rock aquifers of the southwestern Nigeria. International symposium on mixed and augmented reality, 5th international symposium

4. Adnan M (2010). Antimicrobial potential of alkaloids and flavonoids extracted from

tamarix aphylla leaves against common human pathogenic bacteria. Afr J Tradit Complement Altern Med 12(2): pp. 27–31

5. Amitha K (2000). Estimation of natural ground water recharge, lake 2000: national conference. Indian Institute of Science, Bangalore, Nov 27–29

6. Anderssona JCM, Zehnder AJB, Rockström J, Yanga H (2011). Potential impacts of water harvesting and ecological sanitation on crop yield, evaporation and river flow regimes in the Thukela River basin. S Afr Agric Water Manag 98: pp. 1113–1124

7. Baalousha H (2005). Using CRD method for quantification of groundwater recharge in the Gaza Strip. Palest Environ Geol 49: pp. 634–635

8. Bekesi G, McConchie J (2003). Empirical assessment of the influence of the unsaturated zone on aquifer vulnerability, Manawatu Region, New Zealand. Groundwater 38(2): pp. 193–199

9. Below T, Artner A, Siebert R, Sieber S (2007). Micro-level practices to adapt to climate change for African small-scale farmers. A review of selected Literature. IFPRI discussion paper 00953. Environment and Production Technology Division, International Food Policy Research Institute

10. Chiew FHS, McMahon TA, O'Neill IC (1992) Estimating groundwater recharge using an integrated surface and groundwater modelling approach. J Hydrol 131: pp. 151–186

Corresponding Author

Sapna Yadav*

Research Scholar, Calorx Teachers' University, Ahmedabad