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A Cornerstone to Sustainable Development in the Evaluation of the State of the Ground Water Supply and Its Recharge through Rainwater Harvesting for the NCR and Surrounding Areas: A Case Study

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Abstract: Increasing population and rapid urbanization in NCR region has high dependency on ground water to meet the daily needs. River Yamuna is the prime source of surface water in monsoon season only. Usage of ground water for domestic, agricultural, and industrial purposes has put tremendous pressure on groundwater aquifers where water tables are depleted daily. NCR region gets enough rainfall to meet the ground water need however the volume of extraction of ground water is high as compare with its natural recharge. Hence Rainwater harvesting is the effective method that can be adopted to increase the volume of ground water recharge. Urban and rural areas can adopt different methods of rainwater harvesting based on the requirements. In parallel with that, rejuvenation of surface water bodies using increased storage of its tank capacity is also another approach of increasing water table using rainwater. The cost of installation of rainwater has reduced due to advancement in technology. Hence, by identifying the water deficient areas and prioritizing them for implementation of Rainwater harvesting system, as a mandatory provision for all can help recharge drying aquifer more. The importance of rainwater harvesting system, the available ground water resources of Delhi NCR, the rainfall pattern of the said area for last few decades, conventional- or traditional rainwater harvesting patterns, technological components of harvesting patterns, modern harvesting systems and their relevance etc. are briefly summarized in this paper.

Keywords: Ground water, Rainwater Harvesting (RWH), Aquifers, Water table, National Capital Region (NCR)

Introduction

India has witnessed with increase in ground water usage in last few decades. It results in haphazard exploitation of ground water resources for daily usage. Ground water is the best and important source of water for drinking purposes in rural India. As per a report published by the Central ground water board (2011) 70% of water used for domestic purposes in rural areas as well as 50% of the water for urban and industrial areas came from ground water. Modernization of water pumping equipment and uncontrolled exploitation has depleted the ground water across various parts of the country. This adversely impacts ground water quality too. Areas having the best rainfall and availability of surface water sources such as rivers are blessed with the natural process of recharging ground water. However, water table is depleting faster in areas having less rainfall or dense urban areas where availability of open, unpaved surface area is less for percolation. Hence to balance the best availability of ground water, artificial recharge through rainwater is being practiced.

Rainwater harvesting is being practiced in India since long in irrigation activities. In the last few decades Rainwater harvesting was focused primarily for drinking water purposes where meeting the increasing demand was targeted through low cost RWH installation projects. Nowadays it is being practiced for drinking water purposes and irrigation activity across the world. It includes low-cost installation of RWH system in individual households to installation of sub surface dikes for improvement of ground water level for entire community. Approach of community as well as government policy is getting inclined for large projects of water harvesting where budget allocation has also increased considerably. Study suggests that quality of ground water has improved by harvesting rainwater. It also dilutes the content of other chemicals in ground water in some areas which makes water unfit for use such as nitrates, fluorides etc.

As per a report published by Delhi Jal board (2020), 935 million Gallon of potable water per day is being produced, out of which 850 million gallon per day is produced from surface water source while85 million gallon per day from ground water sources. Delhi NCR gets enough rainfall to recharge the depleted ground water pockets as well as it has tremendous potential to meet the growing need of groundwater for domestic usage.

1. Rainfall in NCR Region

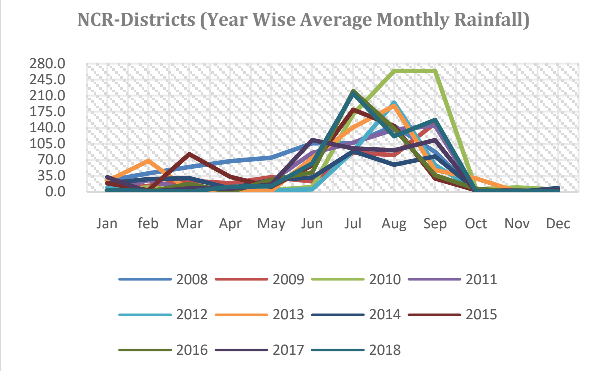
National Capital Region of India includes NCT (National Capital Territory of Delhi) comprises of 1483 SQKMs [1], 13 District of Haryana comprises of 25327 SQKMs, eight district of Uttar Pradesh comprises of 14826 SQKMs and two districts of Rajasthan comprises of 13447 SQKMs. Along with NCT of Delhi all other districts in NCR region belongs to neighboring states have witnessed rapid urbanization and industrialization in past decades. Change in land use pattern and increasing population of immigrants has added increased demand of water for domestic and industrial usage. As per 2011 census the cumulative total population of all 34 districts (including Muzaffarnagar, Jind, Karnal, Shamli, was not part of NCR in 2011) along the NCR was 60.7 million which has forecasted to increase up to 68 million by end of year 2020.Fresh and safe water availability and its supply became a major challenge across the region. In absence of perennial river, Yamuna is the prime source of water which carries major volume of water in monsoon season only. Hence to meet the water demand for irrigation, domestic and industrial usage, ground water is exploited across the NCR. Ground water in these areas is always under stress as the only source for its recharge is rainfall along with other sources such as canals and surface water bodies. Monsson season in NCR region is limited to 3 - 4 months every year, this results in lack of continuous source of water in water bodies throughout the year. It results in dying water bodies which adversely impact ground water recharge.

Table-1: various districts across Haryana, UP, Delhi and Rajasthan lie under NCR Region

S.NO	State	Name of the Districts	Count of Districts	Area (in sq kms)	Population (census,2011)
1	Haryana	Faridabad, Gurgaon, Mewat, Rohtak, Sonepat, Rewari, Jhajjhar, Panipat, Palwal, Bhiwani (including Charkhi Dadri), Mahendragarh, Jind and Karnal	13	25,327	16427524
2	UP	Meerut, Ghaziabad, Gautam Budh Nagar, Bulandshahr, Baghpat, Hapur,Shamli and Muzaffarnagar	8	14,826	21332206
3	Rajasthan	Alwar and Bharatpur	2	13,447	6222641
4	Delhi	Whole of NCT Delhi.	11	1,483	16787941
		Total	**34**	**55083**	**60770312**

For analysis of rainfall data, District wise yearly rainfall statistics available on the website of India Metrological department was extracted. Data is available in tabular format [2] on the web browser as customized rainfall information system (CRIS) and open to access by all. The value of rainfall data is in millimeters which are arithmetic average of Rainfall of stations under the district. Month wise yearly data was extracted for all districts lying under National Capital Region (NCR) from 2008 till 2018 for analysis. Average Monthly rainfall of 10 years was plotted for NCR including all districts as a whole and separately for districts lies in neighboring states. In NCT of Delhi, the rainfall has maximum occurrence from July-September, on peak in August. The average monthly rainfall in the Monsson season is 161mm. 2010 saw heavy rainfall in NCT of Delhi, with average rainfall in mm being 336.6 mm in August and 361.3 mm in September.

13 Districts from neighboring district Haryana lie under National Capital region. Rainfall in these districts is comparatively less than NCT of Delhi. In Monsson Season (July-September) the average monthly rainfall is 105 mm. August Month witnessed with heavy rainfall among the three months in monsoon. Among the 8 districts from Uttar Pradesh (lie under NCR) the rainfall pattern is slightly different. Monsson begins in the month of June and ends in September. The maximum rainfall occurs in July. 2 Districts from state Rajasthan lie under NCR. The rainfall pattern is like that of NCT of Delhi. Monsoon Starts from Late June till September. The maximum rainfall occurs in September.



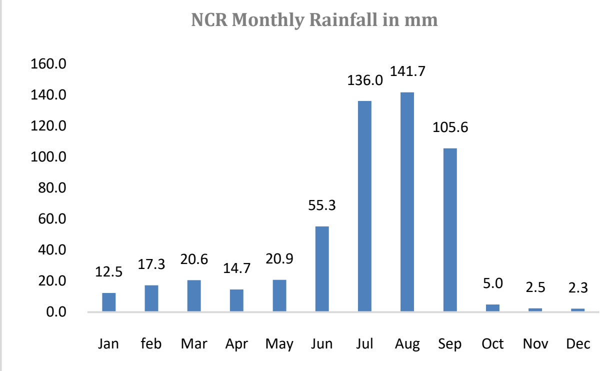
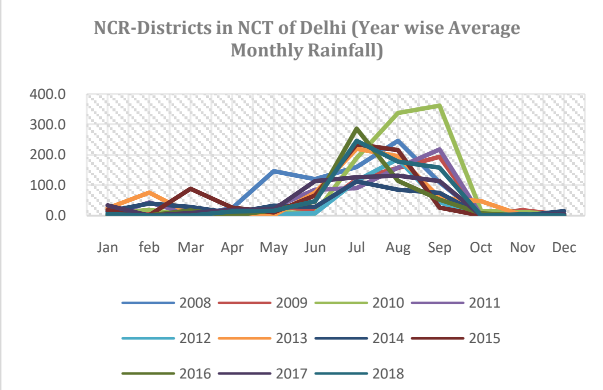


Fig.1 NCR, Year wise Monthly average Rainfall

Fig.2 NCR Monthly average rainfall(2008-2018)



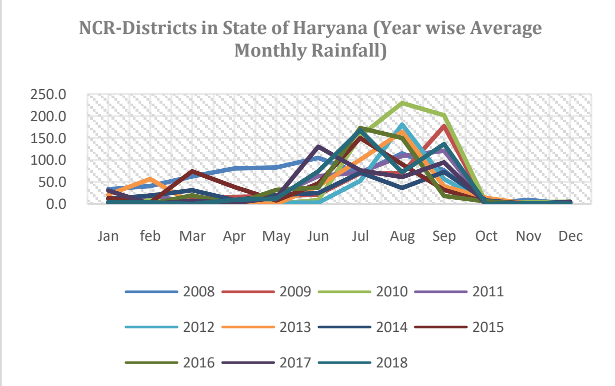
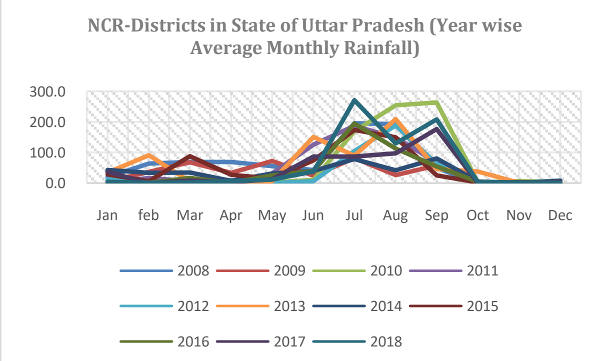


Fig.3 NCR-Districts in NCT of Delhi

Fig.4 NCR-Districts in State of Haryana



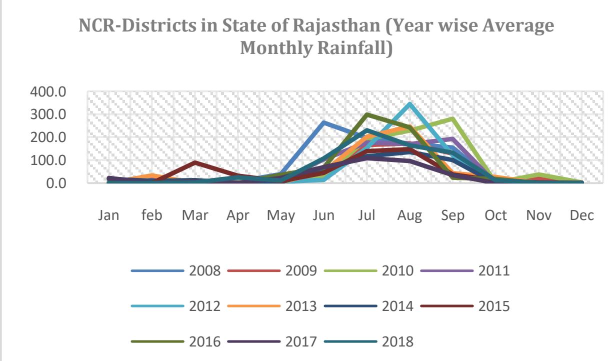


Fig.5 NCR-Districts in State of Uttar Pradesh

Fig.6 NCR-Districts in State of Rajasthan

2. Ground Water usage and recharge in NCR Region

Water requirement in India has increased many folds in last few decades for domestic, agriculture as well as other purposes. As per central ground water board, 85% of the rural drinking water supply as well as 60% of the total area under irrigation has dependency on ground water to meet their demand.

For analyzing the groundwater usage and its natural recharge, data in xls format was downloaded from www.data.gov.in [3] for the year 2013 and 2017. Statistical data includes district wise dynamic ground water resources for all districts across the various states and Union territories of India. Considering the limitation of our study area up to the NCR region, statistical data was consolidated for all 34 districts across the NCR region which belongs to NCT of Delhi, UP, Rajasthan and Haryana (Table-1).

Dependency on extracted ground water for domestic and industrial use has increased in the last decade in all the 34 districts across NCR region (fig.7). In NCT of Delhi it has increased from 65% (2013) to 69% (2017). In 8 districts of UP lie under NCR region, from 7% (2013) to 10% (2017). In thirteen districts of Haryana lie under NCR region, from 3% (2013) to 8% (2017). In two districts of Rajasthan from 10% (2013) to 11% (2017). Overall, in the year 2013, of the total ground water extraction, 7% was used for domestic and Industrial purposes whereas 93% was used for Irrigation purposes. In 2017, of the total ground water extraction, 11% was used for Domestic and industrial purposes whereas 87% was used for irrigation purposes. The overall proportion of ground water usage in NCR region for domestic and industrial purposes has increased from 7% (2013) to 11% (2017) and for agricultural purposes decreased from 93% (2013) to 87% (2017). This indicates the increasing population and rapid urbanization has resulted in an increase of demand for domestic and industrial purposes and a decrease of demand in agriculture due to change in land use pattern across the NCR region.

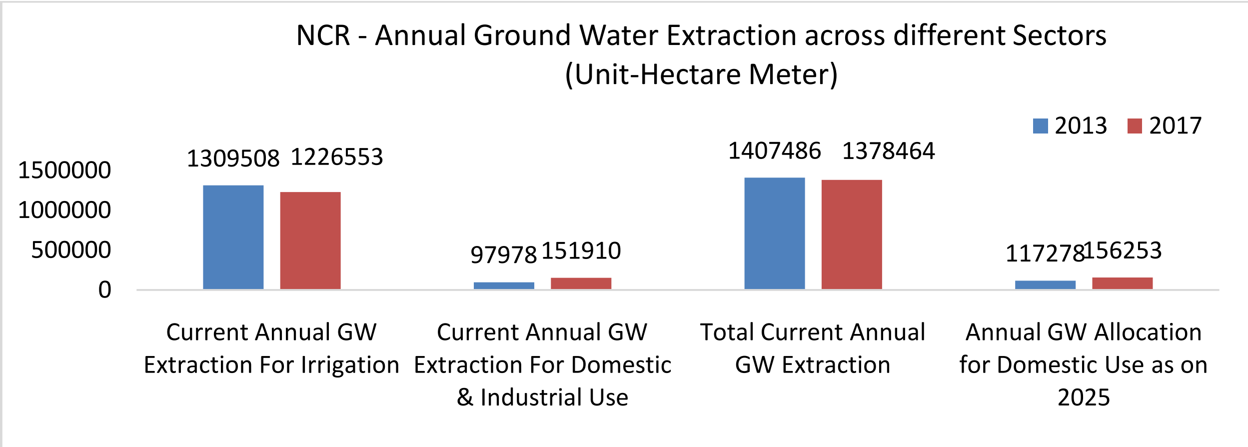


Fig.7 Annual ground water extraction and its usage across various sector in NCR Region

Ground water recharges depending on rainfall, the prime source of water to replenish the decreasing ground water table. Analysis of data suggest (fig. 8) that, out of total ground water recharge, rainfall contributes towards 46% in year 2013 while42% in year 2017. Recharge from other sources (canals, irrigated fields, surface water bodies) was 54% in 2013 while 51% in 2017.

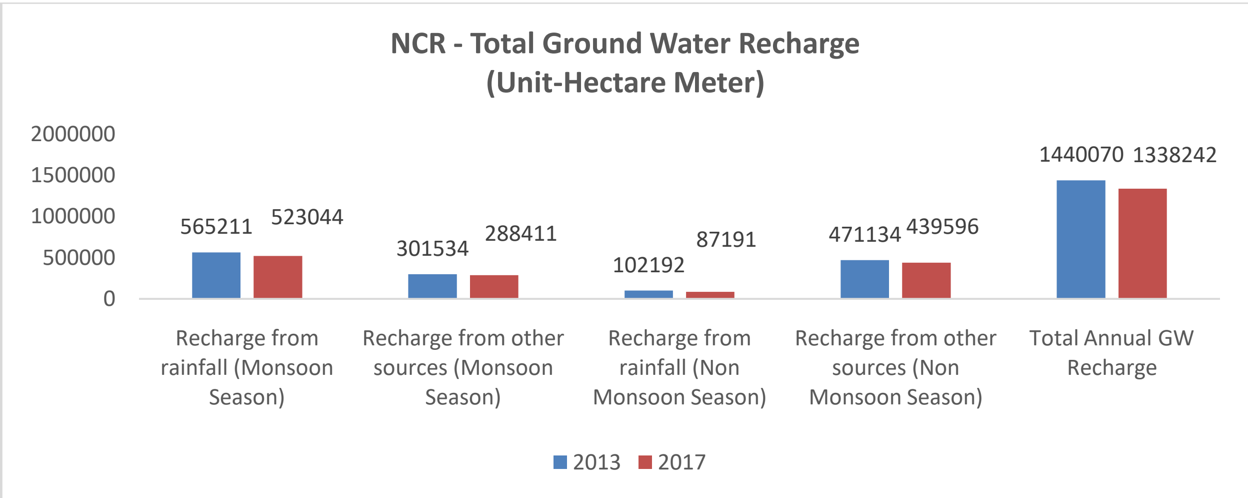


Fig.8: Total ground water recharge in NCR Region

Of the total ground water recharged 91% turned up to extractable ground water resources (fig.9) in 2013 while it was 85% in the year 2017.

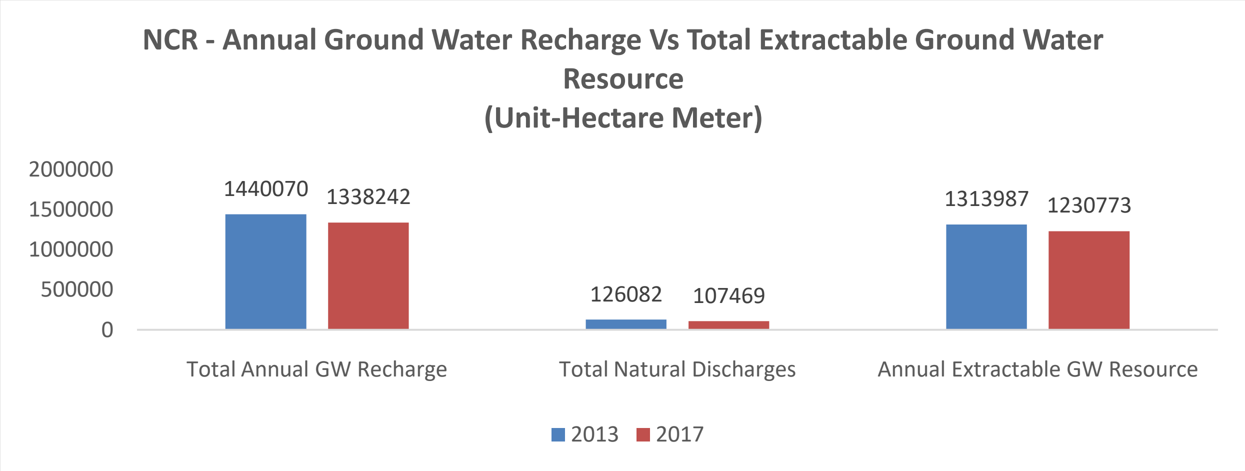


Fig.9: Total ground water recharge and extractable water availability in NCR Region

3. Rainfall Vs Ground Water recharge in NCR

Analysis of Rainfall data suggests that the Monsson season begins in NCR region from late June till September. Whereas analysis of ground water recharge data suggests that the maximum ground water recharge is done during monsoon season. In 2017, rainfall was less than 2013 (Table-2), reducing the total volume of ground water recharged as mentioned in Table-3.

Table-2 Rainfall in mm for NCR region (data consolidated for 34 districts; Unit is in millimeter)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	24	68	3	4	2	74	141	188	47	29	1	2
2017	32	0	8	7	16	113	95	90	113	0	0	4

Table-3 Ground water recharge during monsoon and non-monsoon season in NCR (data consolidated for 34 districts; Unit is in Hectare meter))

Year	Recharge from rainfall (Monsoon Season)	Recharge from other sources (Monsoon Season)	Recharge from rainfall (Non-Monsoon Season)	Recharge from other sources (Non-Monsoon Season)	Total Annual GW Recharge	Total Natural Discharges	Annual Extractable GW Resource
2013	565211	301534	102192	471134	1440071	126082	1313987
2017	523044	288411	87191	439596	1338242	107469	1230773

Table-4 Ground water recharge Vs Ground water consumptions (data consolidated for 34 districts; Unit is in Hectare meter))

Year	Total Annual GW Recharge	Total Natural Discharges	Annual Extractable GW Resource	Current Annual GW Extraction for Irrigation	Current Annual GW Extraction for Domestic & Industrial Use	Total Current Annual GW Extraction
2013	1440071	126082	1313987	1309508	97978	1407486
2017	1338242	107469	1230773	1226553	151910	1378464

NCR regions get enough rainfall to meet the requirement of ground water demand and recharge. Analysis suggests that the volume of annual GW extraction has increased 7% in the year 2013 to 12% in the year 2017 from available annual extractable GW resources (Table-4). The marginal gap in recharge versus extraction can be minimized or reduced by implementing rainwater harvesting techniques across the NCR region.

4. Rainwater Harvesting: Definition, Need and Advantages

Areas devoid of perennial sources of surface water such as rivers have high dependency on rainwater for storage, usage after treatment and ground water recharge. India is seeing higher average annual rainfall however rainfall pattern is not uniform across the country and its distribution is highly uneven [4]. This results in severe water scarcity in various areas with higher land mass and less rainfall and high rainfall in an area with low land masses. The natural ways of ground water recharge are very slow and do not meet the deficit with reference to the volume of ground water being exploited due to advancement in technology. Hence to meet the increasing demand for domestic and industrial purposes effective artificial water harvesting technique is very much needed. It is a technique for tapping, collection and storage of rainwater [5] at surface or underground before its losses due to surface runoff or evaporation. Depending on requirement, rainwater collection can be done using rooftop and surface runoff catchment to store in artificial tank or reservoir for further usage or for recharge of ground water. Rainwater harvesting is being practiced widespread to meet the increasing demand. It enhances the water table at specific location where water table has dipped due to over exploitation.

India is a culturally rich country where the significance of water has mentioned in day-to-day life as well as in mythological practices. To obtain spiritual and physical cleanliness water is being used in all rituals in Hinduism. Use of water using concept of sustainable development was well explained in Vedas and Upanishad which suggests preserving water for future generation. Ancient temples were found near rivers, coasts or in mountains near water bodies. Water harvesting system or storage tank was part of all temples. These were known with different names based on their regional importance. The most common manmade or natural water body used to store water for drinking purposes is talab, it is also known as Pokhara in eastern part of India. The purpose of the Talab [6] is to regulate the flow of water and reduce the risk of flooding. There are other water harvesting structures that can be seen near ancient temples or historical monuments such as Jhalara, Bawari, Kund, Bawoli.

5. Methods and Techniques for harvesting rainwater

There is various method of rainwater harvesting that is being practiced in India based on its requirement across the different geographical areas [7].

5.1. Rural Areas

Water harvesting in rural part of India is practiced for drinking as well as irrigation purposes. Hence based on type of terrain and abundance of rainfall [8] different techniques of water harvesting are used. Some of the common methods of water harvesting in rural areas are as below.

5.1.1. Gully Plug

During Rainy season water flows across the slopes and carry topsoil along with. Hence to reduce the flow of water a plug or bandh like structure using stones or boulders is placed at a different interval along the course of water [9]. The plug structure is made up of loose boulders hence on steep slope this method of harvesting is not used. Gully plugs reduce [10] the flow of water (surface runoff) and hence between two plugs the time of water stay is increased. This allows the percolation of water across the soil and increases the volume of ground water recharged. This also helps in soil conservation and increases oil moisture. This is a labor oriented low-cost water harvesting method used across mall slopes.

5.1.2. Gabion Structure

This method is used along the small streams which overflow during the rainy season. Boulders tightened with wired mesh are being placed as a check dam along the stream to reduce the flow water. The structure is 0.5 meters in height [11] and placed at a regular interval as per requirement. Excess water overflows along these structures and thus keeps a certain volume to maximum time between two structures. This increases the time of water percolation to recharge the ground water.

5.1.3. Check Dams/Cement Plugs/Nala Bunds

In degraded areas where natural or agricultural vegetation was lost or not capable of holding topsoil's, the check dams are opted as water harvesting technique. This can be grouped into two types, one as temporary such as gully plug and gabion structure and permanent made up of cement to last many decades and resist massive flood [12] events in the area. This structure is opted considering the topography and intensity of rainfall. Check dams are also called cement plugs as the structure in this technique is made up of stones or concrete masonry using cement to hold high flow of water. This technique is also preferred upstream along a catchment to avoid destruction of the downstream structure if any.

5.1.4. Percolation Tank

This is the most common method and widely accepted water harvesting technique, where a series of artificial water bodies is created for water storage. The tank's purpose is to increase the ground water recharge through percolation along soil. These structures [13] are preferred where the strata support the water infiltration along them or else in low infiltration strata water will evaporate and the purpose of ground water recharge will not be met. Hence Percolation tank is prepared in area with fractured and weathered rock for enhanced ground water recharge.

5.1.5. Recharge Shaft

This is the fastest method of ground water recharge where benefit can be analyzed in short span of time after its installation. In this method, the ground water aquifer is recharged directly, so no time needed for water percolation or loss of water due to evaporation has no impact. This method [14] has an advantage over other techniques as it does not require a large land area. The diameter of the shaft is 2 meters and dug to the level of ground water aquifer. A vertical recharge shaft is being used for deep penetration along the ground till it reaches the aquifer. There are two types of Recharge Shaft, one is without Injection well and another is with Injection well. Without injection well is suited with depth up to 15 meters. Injection well is made up of 100- 150 mm (about 5.91 in) diameter pipe-like structure built at the bottom of the shaft vertical shaft. It pierces to the aquifer and can be 5 to 10 meters below the water table.

5.1.6. Dug Well

Wells are used for domestic and irrigation purposes in rural areas. Digging of wells using manual method is still in practice across the different part of India. In water scarcity areas dug wells are dried during non-monsoon season. These dug wells can be used to store rainwater during the rainy season. This is the easiest method [15] of water harvesting. In this method along with existing wells, new wells can also be dug across various locations and flow of surface runoff water or water collected from roof top can be put into the same after first filtration. Filtration includes passing rooftop water or runoff water through the filtration bed such as gravel and sand. The quality of surface runoff water can be checked to ensure that the water is not getting polluted due to local external sources.

5.1.7. Ground Water Dams or Sub-surface Dikes

This is the method of increasing ground water table for an area by creating an artificial dam across the natural flow of water through underground stream, aquifer. The name itself suggests the dam across ground water or construction of dikes in sub surface area. These dams are usually prepared along terrain having gentle slope. Dykes' construction is a trench like structure which is dug up to the level of bed rock or other stable layer like clay. It is usually 2 to 3-meter-wide and filled with concrete and sand. This structure is then covered with an impervious layer such as a thick sheet of PVC (Poly vinyl chloride). Construction [16] is done in downstream area which restricts the flow of sub surface water and increases the water table of upstream area. The major advantage of this technique is no loss of water happens due to evaporation. It also has an added advantage of safe water harvesting as all processes are done on sub surface. There is no contact with external components or contaminants which may pollute the water during harvesting. Once constructed the structure is filled or covered with impervious layer hence the chances of submergence of land or collapsing of dam structure is negligible.

6. Urban Areas

Rapid urbanization has reduced the open surface area for natural percolation of rainwater for ground water recharge. It is a wastage of pure form of water if not stored for further use or ground water recharged and drained completely [17]. Hence considering the scarcity of water and to meet the increasing demand, rainwater harvesting can be an essential and mandatory need for every building structure in urban area. There are different methods of rainwater harvesting in urban areas which involve installation of harvesting structure and periodic maintenance for its successful operation. Some of the common method of water harvesting in urban areas are as below;

6.1. Recharge Pit

This is a common method of harvesting rainwater in urban areas where water is collected through rooftop and then it passes through a recharge pit to percolate further to recharge the underneath aquifer. In Delhi government has made a mandatory requirement for installation of rainwater harvesting system for building having roof area of more than 100 square meters. For small roof top recharge pit is a suitable harvesting technique that can be installed with low cost. A recharge pit can be of varied sizes, usually it is a 2-3-meter-wide and 3-5-meter-deep structure. The inlet of the recharge pit relates to rooftop through a pipe. During rain, water collected on rooftop flows through pipe to recharge pit which percolate further to recharge the ground water. For initial cleaning or filtration of rainwater, the pit is filled with layers or boulders, gravels, and coarse sand on top. During periodic maintenance before monsoon onset, the sand layers can be changed to increase water percolation across the pit.

6.2. Recharge Trench

This method is similar to recharging pits, however used for rooftops having size more than 200 – 300 square meters in size. In this technique a trench like structure is constructed instead of a pit to accommodate large volumes of water during monsoons. The trench is a concrete structure of 1 meter wide, 5 -10 meter in length and 2 – 3 meter in depth. The dimension of the recharge trench can vary based on estimation of volume of water on roof surface area during monsoon season. For initial cleaning or filtration, the trench is filled with thick layer of boulders, gravels, and coarse sand. It also requires a periodic cleaning before monsoon like recharge trench.

7. Importance of Rainwater Harvesting

Delhi NCR region has high dependency on neighboring states to meet the demand of water for domestic usage. Rainwater harvesting [18] can supply an alternate approach across various pockets in Delhi NCR where water supply is inadequate. Rain is the purest form of water which is free from organic pollutants,and it is bacteriologically pure. It helps to increase the ground water table and helps in improving the ground water quality [19] in areas where ground water is identified as saline. Installation of rainwater harvesting system is simple, cost efficient and eco friendly. RWH can bring the following long-term benefits to society.

- Helps in buffering the volume of water in ground water reservoir
- Improve the ground water quality
- Dilute the already available chemicals in ground water which makes it unfit for use such as nitrates, fluorides etic
- Society can be self-sustaining by water conservation
- Reduced cost of water usage compared to other sources

8. Policy towards Rainwater Harvesting and challenges

In last two-decade, Government has taken adequate measure for installation of Rainwater harvesting by policy measure and by its implementation on large scale. However, it is always better to get buffered ground water reserve rather than facing deficit in the coming future. State government across NCR region has policy based on their local hydrological conditions.

NCT of Delhi: Government has implemented policy of mandatory RWH [20] system for all buildings having roof top size more than 100 square meters. This has added with a subsidy of 10% on monthly water bill if the RWH system is approved by the Delhi Jal Board. Likewise, there is a penalty of 50% of the total water bill if a plot has a measuring area of 100 sqm or more and does not install the RWH system. In addition to the subsidy the government is providing up to 50% of the total cost or up to 50,000 INR as financial help for installation of RWH systems. Technical assistance for designing and installation is being provided by the Delhi Jal board.

Haryana: Likewise, in the state of Haryana, government [21] has made mandatory provision to install rainwater harvesting system in the building having roof top size more than 100 square meters. This rule is effective in the area that lies under Haryana Urban development Authority.

Rajasthan: in Rajasthan, RWH is mandatory for all buildings in urban regions covering plot areas of over 500 square meters.

Uttar Pradesh: In the state of Uttar Pradesh, 'Policy for Sustainable Ground Water Management in Uttar Pradesh' that was issued by a Government Order No 280/60-1-2013-7 WP-2004, TCIII dated 18 February2013 and published in Uttar Pradesh Extraordinary Gazette, 2013. The policy aims to implement the rainwater and recharge programs in an integrated manner and to effectively minimize the existing level of ground-water withdrawals through efficient water use and techniques. There is separate provision for installation of RWH as mandatory requirement based on the hydrological conditions. In terms of Rainwater harvesting, this policy document needs to be synchronized with a law for effective implementation of the policy wish list.

States across NCR region or across India is following different rules for a common goal of improving water table by Rainwater harvesting. Rules are specific for Urban area and for specific size of building structure. This results in a non-common approach of adopting rainwater harvesting where people's participation is limited to the local level. Water is essential for all living beings and hence public participation is very much needed for its sustainable usage and conservation. Hence the policy measure of Rainwater harvesting must include participation of all sectors such as rural, urban, industrial, Agricultural. Following measure can be taken for effective planning and management of RWH;

- Identification of areas where ground water is scare and depleting fast
- Mass awareness among local people about the scare water resources, depleting ground water and benefit of Rainwater Harvesting
- Prioritization of problematic areas with mandatory installation of RWH system in all buildings
- Plan for RWH through roof top as well as surface runoff
- Subsidy scheme can be implemented in problematic area for installation of RWH
- Temporal analysis of Ground water table of the area for both volume as well as quality to be done to understand the changes in ground water table pre and post implementation of rainwater harvesting system of that area
- Monitoring of RWH system in private buildings can be assigned to local civic bodies
- Mass awareness and required technical support by government in preventive maintenance of RWH system before monsoon
- Slum area can be given opportunity to adopt surface water bodies for management of rainwater
- As per census 2011, approx. 10.63% of the Delhi population is living in slums. There are other slum areas in Delhi where installation of RWH system is not feasible due to the less size of roof top. In such areas, rejuvenation of exiting surface water bodies and creation of new water bodies can be done. These water bodies than can be linked with the nearby large water harvesting system (School, college, government buildings) to feed water during monsoon season

9. Conclusion and Recommendation

Changing climatic condition globally, increase of population, rapid urbanization has increased the demand of water. Sustainable usage of available freshwater resources can help in making a natural balance between its availability and exploitation. Mass awareness about rainwater harvesting and supporting policy guidelines from government can enable its installation and practice in domestic, agricultural, and industrial usage. Rainwater can be used for various purposes in urban environments. Its potable usage can be done in daily domestic usage other than drinking. For drinking purposes, the required treatment is required such as filtration, disinfection. Other than domestic purposes it can be used for gardening, irrigation, and other miscellaneous activity. Irrigation using rainwater can reduce the burden on ground water. Rainwater is purest form of water and hence irrigation using the same can create a pollution free environment. Rainwater harvesting is gaining the attention of people in urban areas in Delhi NCR as a favorable practice of water conservation. Governments across various states bring policy towards the implementation of RWH. As a policy, if RWH is mandatory for all, then the people below the poverty line or unable to install the system due to financial issues can be taken care of separately. Hence the policy implementation can be effective if government can bring socio economic factor while deciding subsidy or incentives. Policy must also include the post implementation strategies so that it can have long term benefits. If subsidy is given during installation of RWH, a separate incentive scheme can also strengthen the yearly maintenance of RWH system during post-implement phase.

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