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Assessing the effectiveness of rainwater harvesting structures in an urban environment

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ABSTRACT

Proper implementation of rainwater harvesting (RWH) fulfills long term water requirements and its effectiveness has a direct impact on groundwater recharge. This comprehensive study on effectiveness of RWH system within Chennai City, Tamil Nadu, India is done by interconnection with the aquifer, adequacy and recharging capacity into the aquifer. For this purpose, a questionnaire is formulated to collect the details of implemented RWH structures. Analysis of the responses from the individual households is carried and used to develop the spatial distributed map. The interconnection of RWH with the aquifer shows that fully penetrated exist about 35.8%, and remaining systems needs improvement. Adequacy of RWH exist revels that major portion of RWH system (about 70.4%) are constructed with proper recharging area. The inundation criteria about 52.8% of RWH structures recharge entire rainwater to the aquifer and scope for improvement is possible in many areas. The combined spatial distribution map shows that very good condition of implemented RWH system, exist for about 1/3rd of structures, 1/4th of them are in poor state and remaining fall in good category. Hence, improvement in RWH system must be carried at several parts of the study area to enhance the groundwater quantity and quality.

Keywords: Rainwater harvesting; Performance evaluation of RWH; Urban aquifer; Geographic Information System

1. Introduction

Rain is the prime source for all water bodies, and which can be used directly or indirectly to fulfill various water requirements. The rainwater must be properly collected and stored either in surface or subsurface and ignoring this will automatically leads to water crisis. The un-conserved portion of rainfall drained without benefiting the place of occurrence of it and finally joins the stream/sea. Rainwater harvesting (RWH) is a method of conservation of rainwater at the place where it falls [1]. The collected rainwater can be stored either in surface and/or underground tanks or in subsurface aquifer. The stored water can be used for irrigation and landscaping also other than potable and non-potable purposes. Treating of collected rainwater is required mainly for potable uses and without any treatment it can be used for non-potable requirements [2].

RWH can fulfill both short term water shortages by direct supply and long-term deficit by augmentation of groundwater aquifers, which will lead to a sustainable development. The ever-increasing water demand can be met either fully or partially by storing the rainfall through proper RWH technique [3]. In semi-arid region RWH is very much useful to conserve the local runoff [4]. The water productivity increases at the production system level by implementing the RWH system [5]. Rainwater harvesting

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increases water holding capacity of soil, which results in reduction of degradation of soil and thereby crop damage also decreased. The continuous availability of water due to RWH reduces the susceptible adverse effect of dry spell periods on the crops [6,7].

Only 8% of rainfall is contributing towards groundwater recharge, whereas the remaining flows as surface runoff to the nearby stream/river and finally reaching the sea. Increase in rainfall recharge will result in rise of water storage in subsurface aquifers which lead to improved groundwater potential. The conservation of rainfall can be easily done by various methods. When enough area is available, then surface spreading technique is commonly adopted. Apart from this, other methods such as construction of check dams, development of percolation tank, provision of contour and nalla bunds, gully pulg and facilitating sub surface recharges are also adopted in rural areas. Generally, these small structures are constructed to collect runoff either to supplement irrigation or groundwater recharge, which is quite common in India [8] and in Africa [9] which is mostly possible in rural areas. Urban area consists of more impervious area, and hence, the rain falling on these areas results in increase in both quantity and peak of runoff within a short time. Impervious surface is more in Metro cities in the form of buildings, roadways, etc., makes the design of RWH must be done within a smaller area with improved storage and recharging characteristics. Rainfall occurring on the building roofs, paved and unpaved portion of urban area can be stored in underground sumps and/or groundwater aquifers. This individual household water conservation cannot be done only by Government. Public participation on this will lead to successful and effective implementation.

RWH is made as compulsory for all new buildings in 18 states of India. Tamil Nadu state also enforced this in such a way that the water supply and sewerage connections will be provided only after installing the RWH systems [10]. Karnataka State Government proposed to give up to 10% rebate on the water bill if they are practicing RWH [11]. Over a period, this would help to solve about 40%–45% of water related problems in urban areas. In Delhi state also, Government had made RWH systems compulsory in all the buildings with an area of 100 m^2 and above. But in Mumbai state, Government has slightly varied the plot area of 300 m^2 and above to install RWH. Same way in Indore city, area for consideration to install for RWH is 250 m^2 or more and rebate of 6% on property tax has been offered as an incentive for implementing RWH.

Generally, continuous tapping of groundwater and reduction in natural recharge leads to fall of water table lower than unsustainable levels. Implementation of RWH will be the only option solve this problem and bring sustainable groundwater development in these areas. The site-specific conditions, such as topographic, hydro-meteorologic and hydro-geologic, should be incorporated while designing of RWH structures. Understanding this, Government of Tamil Nadu passed legislation to carryout recharging of shallow aquifers in 2003 for provision of rainwater harvesting structures through vigorous campaigns. All these structures are constructed with lesser adaptation of scientific and site-specific norms required for the design of RWH and no proper design details are available for the implemented structures.

Interviews and questionnaire survey are useful in identifying the adoption level and benefits of RWH ponds by the households [12] and the inferences can be obtained by using Microsoft Excel as a tool. From the results it is evident that the failure in adoption level of RWH ponds is mainly due to the lack of training regarding its use and role to the users. Hence, if adequate training is given prior to the implementation of RWH structures will leads to improvement in adoption level.

The evaluation tool should consist of integration of engineering, biophysical and socio-economic criteria while testing the performance of already implemented RWH structures [13,14]. Combination of Geographic Information System (GIS) and Analytical Hierarchy Process (AHP) is one such tool and much helpful in terms of integration various parameters in the evaluation of implemented RWH system [15,16].

The impact of RWH systems on groundwater recharge depends mainly on the attribute parameters such as effectiveness of the RWH structures and the response behaviour of the aquifer. In RWH system-based studies, generally, major focus will be towards identification of suitable site and technique for the RWH structures and minor in terms of evaluation of already implemented RWH system [17]. But the later fulfills a significant portion in catering the needs of groundwater development and management in an urban context. Hence, the main aim of this study is to investigate the efficiency of implemented RWH in an urban context in terms of parameters adopted for the structure, which play an important role to assess the possible recharge that occurred in a particular area towards improving groundwater potential in mitigating water crisis.

Chennai City, the oldest of the presidential cities in India is selected for the study (Fig. 1). The geographical area is about 75.45 km^2 covering 12 sub watersheds. Combination of rapid urbanization and industrialization along with raise in population increases the water demand of the Chennai City to a higher level. Groundwater resource becomes the first choice for the fulfillment of city water supply requirements at the micro level due to the absence of perennial rivers and reservoirs. The human intervention with waterbodies in terms of waste filling and slum encroachments leads to disappearing of lakes/wetlands and other natural depressions in many parts of the city [18]. Some studies reveals that the flood risk in Chennai is majorly caused by land-use issues such as encroachment occurred at the rivers/streams, reduction/loss of natural areas and water bodies, uncontrolled multiplication of built-up areas, etc. [19]. Further, with reduced natural recharge, most of the rainwater is flowing to the sea which leads to less possibility for groundwater increase.

The main aim of this comprehensive study is to assess the effectiveness of implemented RWH. For this purpose, RWH system is checked under three criteria's: (i) interconnection of RWH with aquifer, (ii) adequacy of RWH system and (iii) recharging capacity of RWH system. All these parameters are considered during the design and implementation of RWH system, which remains unchanged. Additionally, this study does not deal with improvement in groundwater potential, and hence, ground situation remains unchanged. This study is conducted for the implemented RWH structures

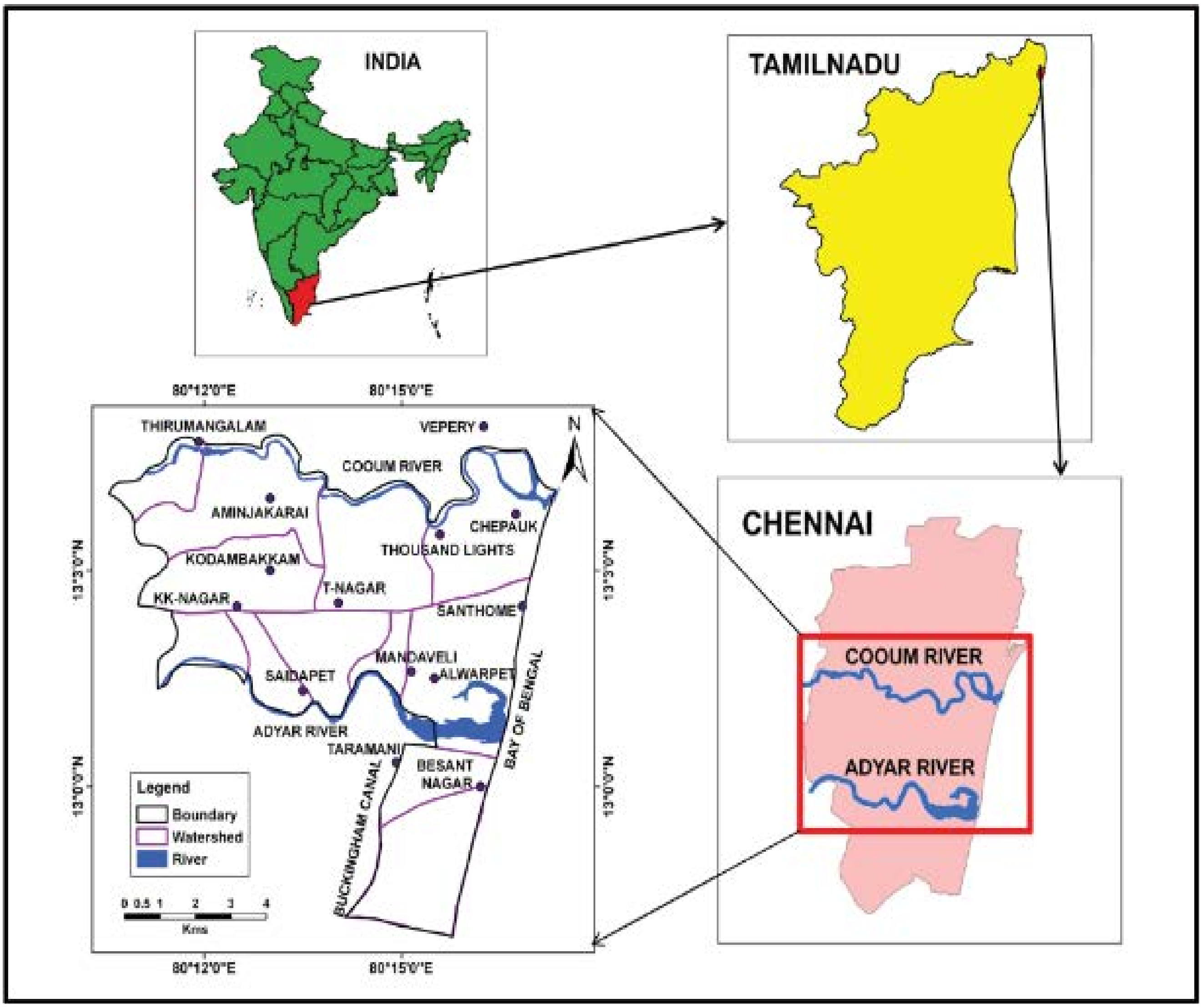

Fig. 1. Index map of the study area.

during 2009–2010, that is, 6-y after the enforcement from the Tamil Nadu government to implement the RWH in all locations. Since the parameters for this study do not change over period, the study can be conducted at any time after completion on RWH structures at the field.

2. Methodology to evaluate implemented RWH structures

This study requires the area of roof top, dimension and type of RWH implemented, type of soil and aquifer parameters and intensity of rainfall. If the water bearing formation (aquifer) is available at deeper strata, then RWH should be designed to reach that depth to facilitate effective groundwater recharge. Otherwise, the rainfall excess will not continuously be moving down but only stagnation takes place causing inundation. Hence, firstly inter connection of RWH structure with the aquifer is investigated based on depth to aquifer and total depth of RWH implemented. The first one, depth to aquifer, is obtained as secondary data from various departments and as primary data by conducting electrical resistivity survey at various locations of the study area. If the depth to aquifer is lesser than total depth of RWH implemented, then it is termed as "penetrated". At the same time, if both depths are almost similar then it is designated as "Partially Penetrated". Whenever the former one (depth to aquifer) is lesser than that of the latter (total depth of RWH), then it is termed as "Not Penetrated".

Secondly, the adequacy of RWH is checked by comparing the recharge rate required and the soil conductivity. The soil conductivity is calculated from both horizontal and vertical permeability. Required recharge rate is estimated from the roof/open space runoff volume. Assessment of roof/open space runoff volume is carried by soil conservation services curve number (SCS CN) technique [20–22].

The depth of rainfall excess is multiplied with the area of roof/open space will give the runoff volume generated from that space. Recharge rate (K_R) required for individual structure is calculated by dividing the volume of runoff with 1-h stagnation time and area of recharge. Both inner surface area and bed area are summed for calculating the recharge area available in that RWH structure.

$$K_R = \frac{R}{T_s S_A}$$

where K_R – required recharge rate (mm/h), R – runoff volume (mm^3), T_S – stagnation time (h), S_A – surface area available for recharge in an RWH structure (mm^2).

If the recharge rate required is less than the hydraulic conductivity of the soil in the site, then the structure has well adequate recharge. If it is equal and lesser than the hydraulic conductivity, then it is classified as adequate and inadequate, respectively.

Thirdly, the capacity of RWH system is verified by comparing the intensity of rainfall to the hydraulic conductivity. Using the intensity duration (ID) graph, the maximum rainfall intensity for 1-h lag time is obtained which is applied for comparison. This comparison of rainfall intensity and hydraulic conductivity gives the details about transmitting capacity of RWH structure and soil. Further application of this information gives inundation details. If rainfall intensity is lesser or equal to hydraulic conductivity, then full recharging takes place and otherwise, the area will be inundated. The results of all the above three criteria are combined to know the overall status of implemented RWH structures in augmenting the groundwater recharge at a specific site.

The detailed methodology for investigation of RWH system developed for this study is presented in Fig. 2.

2.1. Data collection and analysis

2.1.1. Secondary data

Toposheet from Survey of India, City map from Chennai Metropolitan Development Authority, rainfall data from Indian Meteorological Department (IMD) and Department of Economics and Statistics and Bore Hole Lithology from State Ground and Surface Water Resources Data Centre and Central Ground Water Board.

2.1.2. Questionnaire survey (primary data)

Details of implemented RWH system is obtained from the respondents using specifically designed questionnaire both in English and vernacular language - Tamil. The questionnaire contains three major parts: (i) General information regarding the residents' personal details, area of the premises, soil details and awareness about RWH systems, (ii) Information about the water availability, water usage, quality of water and the sufficiency of the available water at their premises, and (iii) Details of the RWH systems like type, features and their opinion. These details are further analyzed to meet technical requirements of the study. Questionnaire Survey is conducted using Participatory Urban Appraisal (PUA) concept by discussing with individual households and totally 159 samples are collected out for this study.

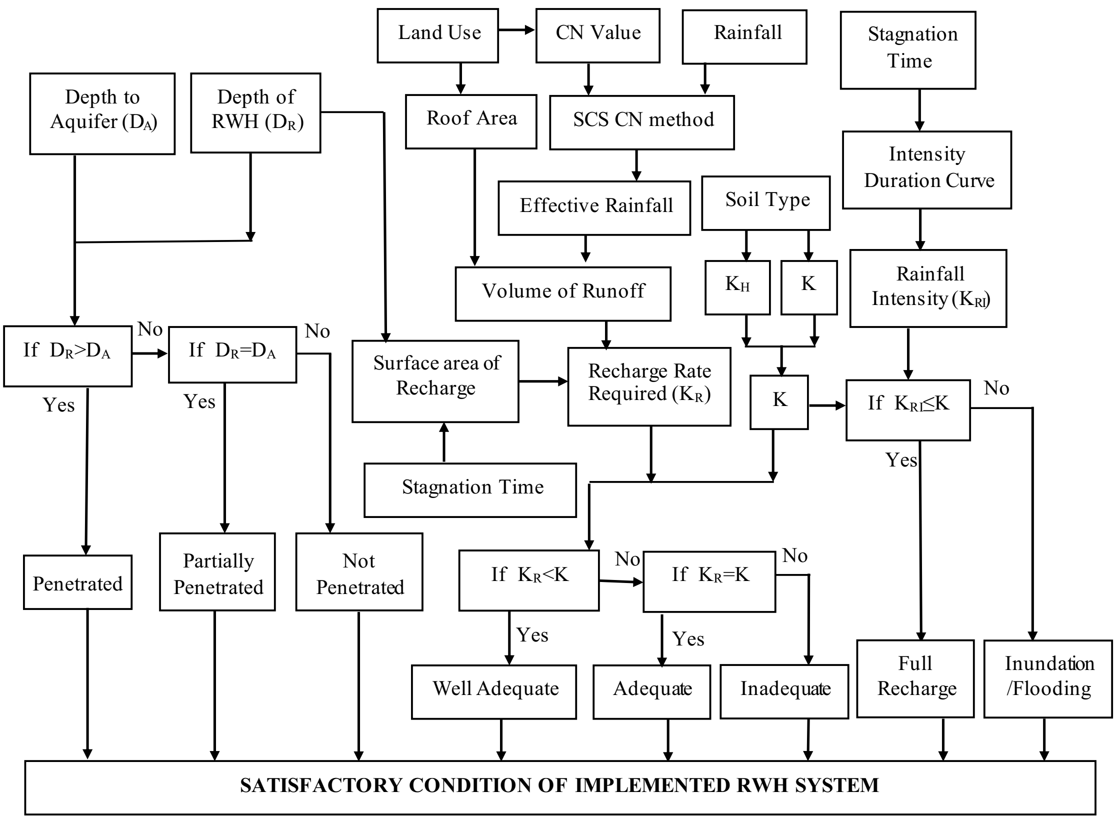

Fig. 2. Flow chart for evaluation of satisfactory condition of implemented rainwater harvesting structures.

2.2. Questionnaire analysis

The information collected in the questionnaire from respondents (residents in the study area) is coded. Scaling techniques are used for measuring the data. The responses sought from the respondents are qualitative in nature. The merit of this technique is that with the use of scaled answer/responses, qualitative information gets recorded in a quantifiable and measurable form.

The respondents are asked whether they are aware of RWH structures for improving groundwater recharge. Most of the people are aware of structures like sump, source well through filter bed and recharge well, but only 50%–60% of respondents are aware of percolation pit and recharge well cum bore pit.

The respondents are also asked about the cost of implementation, period of implementation, designer details and the type of the RWH structures. Implementation of RWH structures is carried out from the year 2001 but major works are done during the year 2003. They have spent Rs. 2,000 to Rs. 4,000 on an average. About 62% of the RWH structures are designed and constructed by the local plumbers. Most of the structures are accounting for roof top RWH but not for open space water harvesting.

Regarding the implementation of RWH structures, 68.57% of respondents have implemented source well through filter, 10% recharge well and 20.09% percolation pit but only 1.33% recharge well cum bore pit. Data required for investigation of implemented RWH such as type, size and depth of RWH and roof area are derived from questionnaire.

3. Results of evaluation of implemented RWH structures

3.1. Interconnection of RWH structures with the aquifer

To check interconnection with aquifer depth of RWH structure is extracted from questionnaire survey and depth to aquifer is obtained from litho-log is collected from CGWB. From the analysis, out of 159 samples the status of wells in terms of penetration of aquifer, 57 well are identified as fully penetrated, 68 wells partially penetrated and remaining 34 wells comes under not penetrated category. From the survey results, most of the wells are partially penetrating the aquifer over the entire study area. Along the coastal area most of the wells are fully penetrated due to presence of aquifer near to the ground surface. Whereas at the interior locations, more wells are partially penetrated due to higher depth to aquifer. If the depth to aquifer increases the chance of fully penetration decreases due to higher initial cost of the RWH structures. Details of the results of few samples are presented in Table 1.

The result of each well is used to map the spatial representation of interconnection of RWH with the aquifer with the help of ArcGIS (Fig. 3). Map of implemented RWH in respect of connection to aquifer indicates that no special emphasis for appropriate design either by people or by monitoring departments in all the areas. At the same time a slight improvement in interconnection of RWH with aquifer exist in coastal areas and this may be due the presence of sandy layer at the shallow depth. From the interconnection map, about 35.8% of area falls under penetrated and 42.8% in partially penetrated wells. Remaining 21.4% area covered by not penetrated category of wells.

3.2. Adequacy of RWH structures

The size of RWH structure must be designed based on the depth of rainfall/volume of runoff arising from an individual plot, so that the recharging area provided should be adequate to absorb it. To check the adequacy of implemented RWH system, first of all, the rainfall excess must be calculated. The rainfall occurred during post implementation of RWH structures should be considered, that is, rainfall during the year 2005 is adopted for the calculation of rainfall excess using SCS CN method. Recharge rate (k_R) required for individual structure is calculated by dividing the volume of runoff with 1-h stagnation time and area of recharge of the RWH structure (inner area). Adequacy of implemented RWH system is checked by comparing the recharge rate required and soil conductivity.

The questionnaire survey result shows that both well adequate and inadequate category of wells to facilitate the movement of runoff generated from the rainfall is equally distributed over the study area (46 and 47 wells). Remaining majority of wells (66 wells) is adequate to discharge the runoff into the aquifer. Hence, most of the area is facilitated with good recharging capacity in terms of penetration into the aquifer. Status of adequacy for few samples wells is shown in Table 2. The spatial distribution spread

Table 1
Interconnection of rainwater harvesting with the aquifer

Sample No.	Location	Depth of RWH structure (m)	Depth to aquifer (m)	Nature of interconnection
2	Besant Nagar	3.3	0.00	Penetrated
21	Thiruvanmiyur	2.2	2.10	Partially penetrated
31	Adyar	2.0	3.96	Not penetrated
40	T. Nagar	4.0	3.00	Penetrated
77	Saidapet	3.3	3.00	Partially penetrated
68	West Mambalam	2.0	3.00	Not penetrated
85	Koyambedu	5.5	4.80	Penetrated
94	Virugambakkam	4.8	4.80	Penetrated
96	Chinmaya Nagar	2.0	4.80	Not penetrated

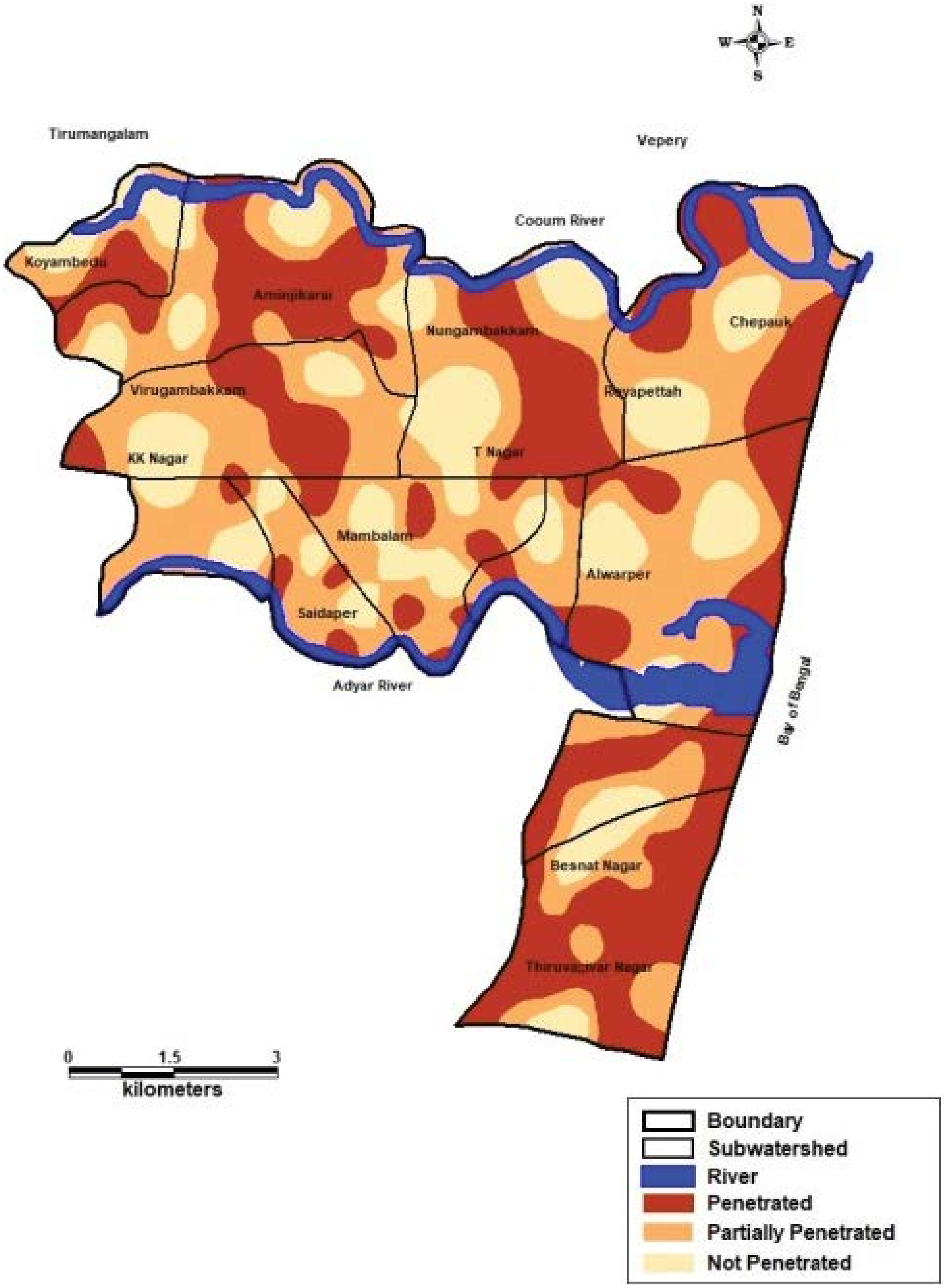

Fig. 3. Map of interconnection of rainwater harvesting with the aquifer.

of adequacy of RWH structures is mapped using ArcGIS and shown in Fig. 4. The spatial distribution map also reveals that the adequacy of RWH is well distributed over the entire study area and needs further improvement in the densely populated areas.

3.3. Recharging capacity of RWH structures

Investigation of recharging capacity of RWH structure starts with collection of data on rainfall intensity and hydraulic conductivity of soil. Recorded rainfall data of 15 min duration for the year 2003 from Nungambakkam Meteorological Station is collected and used to draw the intensity duration curve for different storm events. Based on this maximum rainfall intensity of 72 mm/h occurs for 8-h storm duration with 1-h stagnation time is considered for this study.

If this rainfall intensity is less than or equal to hydraulic conductivity of soil, then full recharge is possible. Otherwise, flooding/inundation of site occur due to overflow of water. About 84 wells (52.8%) are capable of to recharge the runoff generated from the desired rainfall intensity and remaining 75 wells (47.2%) unable to do it so, which results in increased inundation in those areas. The recharging

Table 2
Adequacy of rainwater harvesting structures

Sample No.	Location	Roof/open space area (m^2)	Volume of runoff (m^3)	Recharge area (m^2)	Required recharge rate (m/d)	Soil conductivity (m/d)	Status of adequacy
2	Besant Nagar	121.70	5.230	20.72	6.048	17.280	Well adequate
21	Thiruvanmiyur	80.00	3.440	8.80	8.640	8.640	Adequate
31	Adyar	225.00	9.675	6.28	37.152	8.640	Inadequate
40	T. Nagar	69.70	3.000	9.00	7.776	7.776	Adequate
77	Saidapet	83.61	3.590	10.88	7.776	7.776	Adequate
68	West Mambalam	232.25	9.980	6.28	38.016	7.776	Inadequate
85	Koyambedu	223.00	9.590	17.27	12.960	0.864	Inadequate
94	Virugambakkam	93.00	3.990	15.00	6.048	0.864	Inadequate
96	Chinmaya Nagar	70.00	2.990	6.30	11.232	0.864	Inadequate

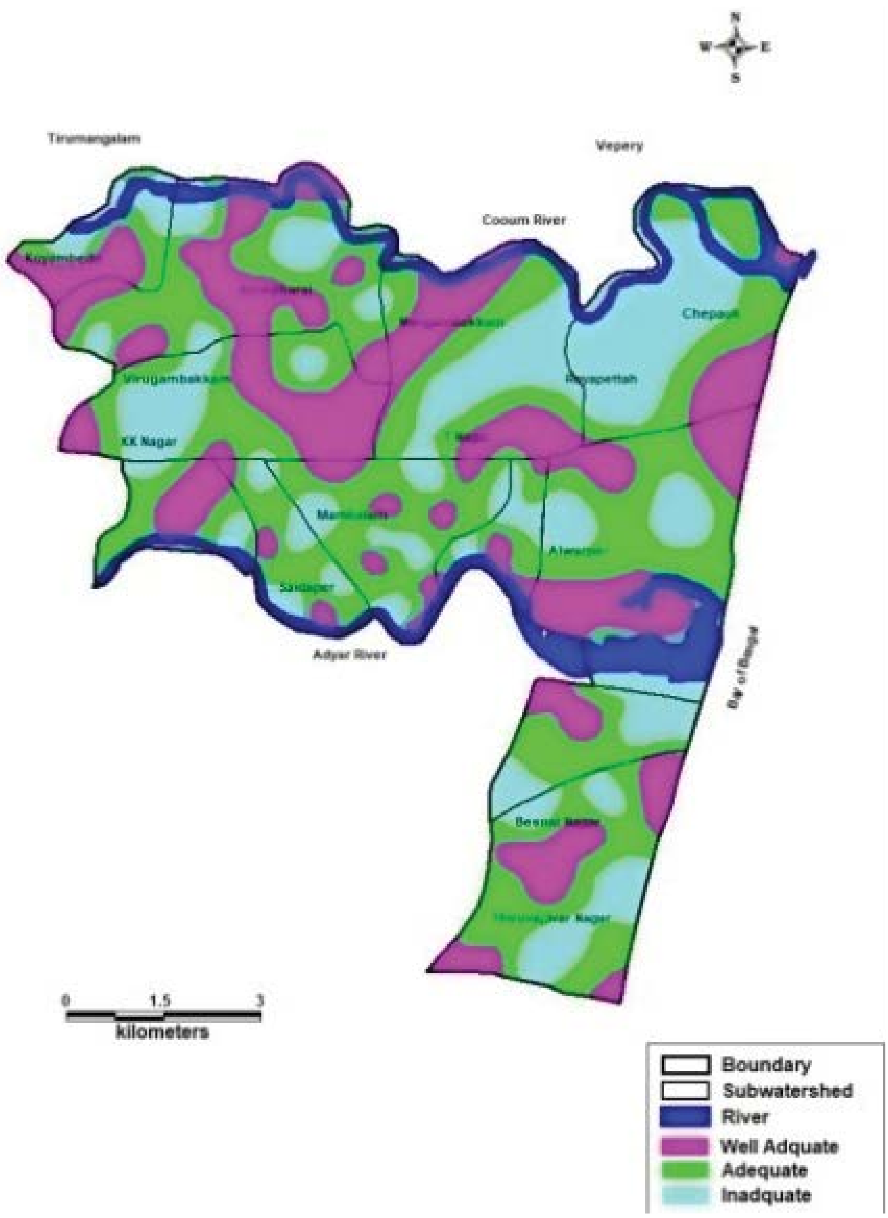

Fig. 4. Map of adequacy of rainwater harvesting structures.

Table 3
Recharging capacity of rainwater harvesting structures

Sample No.	Location	Intensity of rainfall (m/d)	Hydraulic conductivity (m/d)	Recharging capacity of RWH structure
2	Besant Nagar	1.73	17.280	Full recharge
21	Thiruvanmiyur	1.73	8.640	Full recharge
31	Adyar	1.73	8.640	Full recharge
40	T. Nagar	1.73	7.776	Full recharge
77	Saidapet	1.73	7.776	Full recharge
68	West Mambalam	1.73	7.776	Full recharge
85	Koyambedu	1.73	0.864	Inundation
94	Virugambakkam	1.73	0.864	Inundation
96	Chinmaya Nagar	1.73	0.864	Inundation

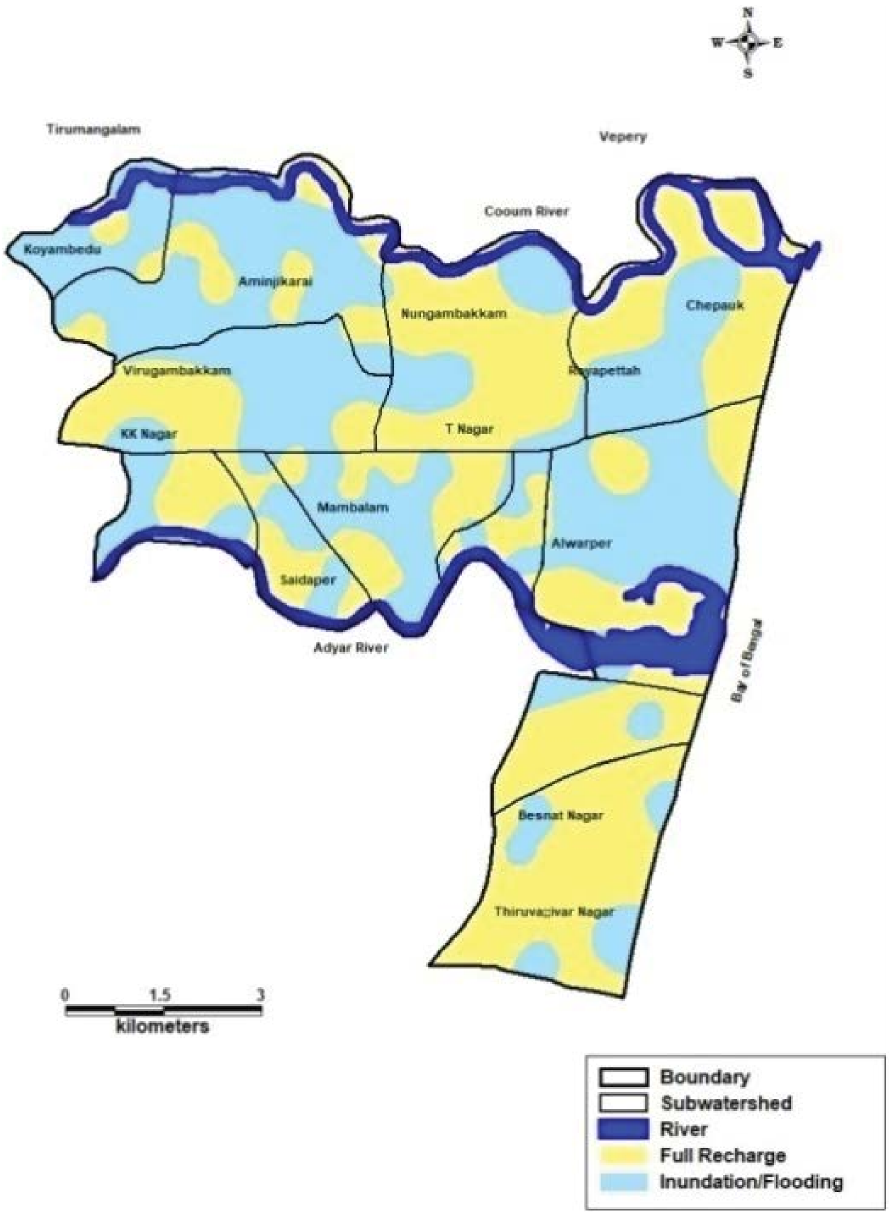

Fig. 5. Map of recharging capacity of rainwater harvesting structures.

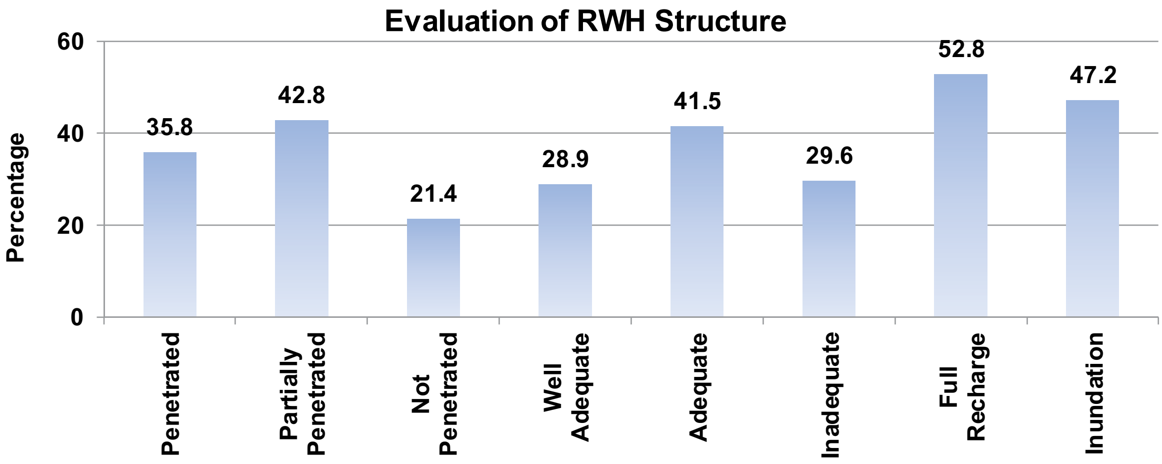

Fig. 6. Graphical representation of evaluation of rainwater harvesting structures.

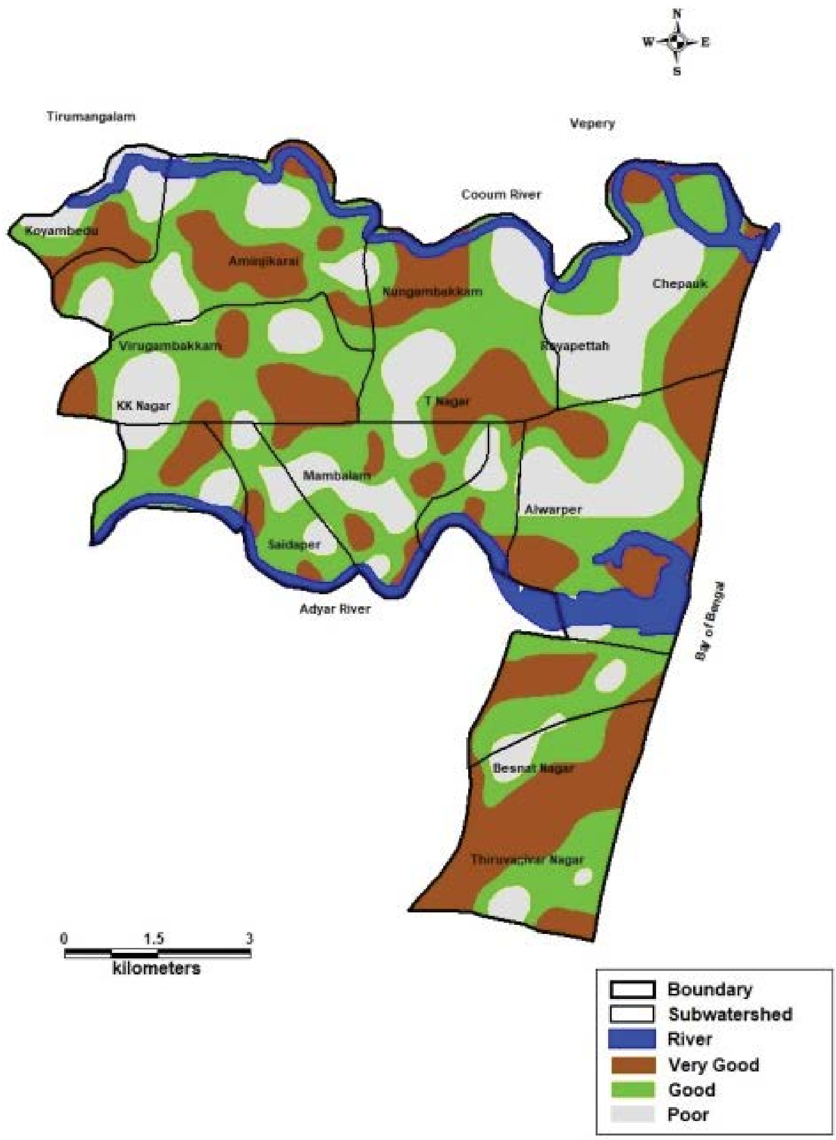

Fig. 7. Spatial distribution of satisfactory condition of implemented rainwater harvesting structures.

capacity of few RWH over three type of watershed is shown in Table 3. The ArcGIS map developed to know the spatial sharing of recharging capacity of RWH structure over the entire study area (Fig. 5) exposes the need of improvement in RWH structures in terms of interconnection with aquifer at the interior part of the study area than that of the coastal region, more particularly for the area which has higher depth to aquifer values.

3.4. Combined status of implemented RWH structures

After analyzing all the samples, percentage of distribution of criteria is plotted and shown in Fig. 6. The interconnection of RWH structure with aquifer in the study area, 35.8% are penetrated, 42.8% are partially penetrated and 21.4% of structures are not penetrated into the aquifer. With regard to adequacy of RWH system, 28.9% of structures are well adequate, 41.5% are adequate and 29.6% are inadequate to recharge the entire amount of runoff generated from the rainfall to the aquifer. In terms of recharging capacity in the study area, 52.8% of structures are capable for full recharging and 47.2% are not capable of recharging fully leading to flooding/inundation in that area. Hence, these implemented RWH structures must be enhanced in order to increase the groundwater recharge during the rainy days.

Overlaying of the individual maps obtained from the interconnection, adequacy and recharge capacity of RWH systems is done with the capabilities of Geographic Information System (GIS) to reclassify the study area for satisfactory condition of implemented RWH structures into very good, good and poor categories. The final output shows the spatial distribution map (Fig. 7) of satisfactory conditions of implemented RWH system within the study area. Very good condition of RWH exists in about 31% area followed by 43.8% of good and 25.2% are poor. Hence, the RWH systems must be improved in many parts of study area to increase both quantity and quality of the groundwater resource.

4. Conclusion

Rainwater harvesting becomes very much important in fulfilling the water requirement, more particularly in an urbanized context, and hence, it must be designed and implemented to obtain maximum benefit out it. The status of implemented RWH systems in an urban area is assessed on the basis of three parameters such as interconnection with the aquifer, adequacy of the system and its recharging capacity for the Chennai City, an important metropolitan. Based on the analyses, the interconnection of RWH with the aquifer shows that fully penetrated exist about 35.8%, and hence, remaining systems must be improved to get full benefit. At the same time adequacy of RWH exist for about 70.4% of systems revels that implemented RWH systems are constructed with proper recharging area. About 52.8% of wells do not create inundation and entire water will get recharged; but the scope improvement in RWH systems is possible in many areas which will improve quantity and quality of groundwater potential. The results are combined to develop the spatial distribution map using GIS overlay analysis which show that 31% of the RWH structures implemented are very good (satisfying all three criteria), 43.8% are good and 25.2% are poor conditions. Hence, the enhancement of existing RWH systems, at many parts of the study area, is needed to increase the groundwater potential both in terms of quantity and quality. This shows lot of scope and potential towards improve the RWH structures over the entire study area to rejuvenate and augment the groundwater resources.

Acknowledgement

"On reasonable request the raw data of questionnaire results can be provided" keeping it compatible with the law on protection of personal data.

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Questionnaire – rainwater harvesting system

Study area

I. General information

1. Name:

2. No. of persons in the family :

3. Area of premises :

Total land area : Roof area :
Permeable un-built area : Impermeable un-built area:

4. Soil details at different depths : a) b) c)

5. Awareness:

i) Are you aware of rainwater harvesting? ☐ Yes ☐ No
ii) Do you know the purpose of rainwater harvesting? ☐ Yes ☐ No
iii) Are you aware of the following structures of rainwater harvesting?

☐ Sump ☐ Source well ☐ Recharge well ☐ Percolation pit
☐ Recharge well cum bore pit

iv) Are you aware of the impact of rainwater harvesting? ☐ Yes ☐ No

6. Willingness:

i) Will you allow for conducting a study to measure the impact of rainwater harvesting?

☐ Yes ☐ No

II. Water resources engineering

1. What is the total quantity of water usage (in pots):

Capacity of overhead tank:

2. Is water available at your premises? ☐ Yes ☐ No

a) If yes, what is the source of water ☐ Open well ☐ Bore well
b) Specify the details of the water source at your premises:

Sl. No.	Type	Diameter	Depth	Mode of pumping	Duration of pumping	Power of pump	Type of pump
1	Open well						
2	Bore well						

3. Depth of water table from ground level:

4. Depth of well:

5. How is the quality of water available at the premises?

Current status: Previous status:

6. For what purpose do you use the water available at the premises?

S. No.	Type	Drinking	Cooking	Bathing	Washing	Gardening
1	Open well					
2	Bore well					

7. State the sufficiency of the water available at the premises:

☐ Completely sufficient ☐ Moderately sufficient ☐ Insufficient

8. Do you avail water from outside sources? ☐ Yes ☐ No

If yes, specify the source, frequency and the quantity of supply.

S. No.	Source	Type	Usage		Purpose of usage				Frequency & quantity (in pots)		
			Yes	No	Drinking	Cooking	Bathing	Washing	Daily	Alternate days	Once in a week
1	Metro water	Directly through sump									
		Hand Pump at premises									
		Hand pump at end of street									
		Tankers									
2	Private tanker water	Price	Usage		Purpose of usage				Frequency		
			Yes	No	Drinking	Cooking	Bathing	Washing	Daily	Alternate days	Once in a week

III. Rainwater harvesting

1. Has the rainwater harvesting been done? ☐ Yes ☐ No

If Yes,
i) Time of implementation :
ii) Cost of implementation :
iii) Designed by :
iv) Specify the form of rainwater harvesting :

S. No.	Type	Yes	No	Storage facility			
				Open well	Sump	Open well thro' sump	Recharge to the ground
1	Roof top runoff						
2	Open space runoff						

2. Do you use the same structure for open space runoff harvesting? ☐ Yes ☐ No

3. State the details of structure used for rainwater harvesting:

a) Sump:

i) Capacity of the sump:

b) Filter:

i) Any filter available in the structure? ☐ Yes ☐ No
ii) Depth of filter:
iii) Filter type: ☐ Gravel ☐ Pebble ☐ Sand ☐ Wire mesh ☐ Combination
iv) Location of the filter: ☐ End of roof pipe ☐ Near to storage structure

c) Recharge structure to ground:

i) Type of recharge: ☐ Source well ☐ Recharge well
☐ Percolation pit ☐ Recharge well cum bore pit
ii) Features of the recharge structures:

S. No	Features	Roof top runoff				Open space runoff			
		Source well	Recharge well	Percolation pit	Recharge well & bore pit	Source well	Recharge well	Percolation pit	Recharge well & bore pit
1	Diameter								
2	Depth								
3	Filling								
4	Filter type								

4. Maintenance of the rainwater harvesting structures:

i) Do you maintain the structure? ☐ Yes ☐ No
ii) If yes, how do you maintain? ☐ Cleaning ☐ Desilting
iii) Have you faced any problems with the existing structure? ☐ Yes ☐ No
iv) If yes, state the problem faced. ☐ Clogging ☐ Over-flowing