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Study of Effectiveness of Rainwater Harvesting Structures on Bhavani Sub-basin, TamilNadu,India

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Abstract—Water scarcity has become one of the main problems in India. It is estimated that by 2020, India will become a water-stressed nation. Surface water sources get reduced and we partially depend upon ground water for various needs. This sub-surface water needs artificial recharge. One such simple method is the construction of check dam.

The motive of under taking this project is to estimate the quantity of ground water level recharged before and after construction of the check dam. In this present work, an attempt has been made to investigate the characteristics of the ground water collected after the commissioning of check dam and analyzed the effects of check dam in the five selected study area. To identify the exact level of recharge in each study area, we have compared the rainfall data with groundwater level, year wise from 1996 to 2012.We have also checked the water quality after the construction of check dam. Further we also estimated the storage of water recharged into ground by precipitation method.Ground water recharging has increased after the construction the check dam.And the efficiency of the check dams at Pattakaranur,Pandian Nagar,Njandupuram,Sokkattampalli and Neelampathy is 61.99%, 84.86%, 42.56%, 61.6% and 92.50% respectively.

Index Terms—check dam, ground water level, rainfall data, study area, precipitation method, artificial recharge, water stressed,rain water harvesting.

1 Introduction

WATER scarcity has become one of the main problems in India. Nearly 50% of villages still don't have any source of protected drinking water.Surface water sources gets deficit so we depend upon ground water, But due to population increases catchment area of rainfall has been decreased.

Encroachment of catchment areas is one of the reasons for ground water deficit. So we prefer macro-level recharge (check dams) in streams and micro level recharge in buildings (small-recharge pits). Harvesting rainwater can re- duce the use of drinking water for landscape irrigation. It is also an effective water conservation tool and proves more beneficial when coupled with the use of native, low-water-use and desert-adapted plants. Additionally, rainwater is available free of charge and puts no added strain on the municipal sup- ply or private well. The technique of rainwater harvesting in- volves catching the rain from localized catchment surfaces such as roof of a house, plain and sloping ground surface etc. The rainwater that falls on this catchment is diverted into dugout ponds, vessels or underground tanks to store for long periods. Construction of small barriers across small streams to check and store the running water is also an example of small catchment water harvesting. Broadly, rain water can be har- vested for two purposes.

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1. Stored for ready use in containers above ground or below ground.
2. Charged into the ground for withdrawal later (ground water recharging).

One method of effective water harvesting is the intro- duction of a check dam. Check dams are small scale, low cost-structures. They are built across a small stream to prevent rain water from flowing away, they check the velocity of water, reduce the erosive force of water, store water in stream cours- es, increase groundwater recharge, and increase soil moisture conditions , thus increasing the post monsoonal flow often by months. This harvested water provides direct irrigation for the surrounding areas, through direct lift and ground water per- colation.

Check dams are a micro-level treatment and charac- teristics are site specific. As they are shallow structures accu- mulating a body of water over a large area, water logging does not take place. Since water storage in a check dam increases percolation into the soil, it can serve to recharge nearby dug- wells, this can further relieve some of the problems of water deficiency by providing additional sources of drinking, wash- ing and cooking water as well as additional water for irriga- tion.

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Sometimes there is criticism over the drying up of check dams or the check dams not holding water all year round. But even if a particular dam only holds water for 2-3 months after the monsoon, such storage helps greatly in recharging the adjacent ground water, and prolonging crop growth. To analyze the effect of rainwater harvesting structures in Bhavani sub basin, we have selected five locations viz: Nanjundapuram, PN Palayam Panchayat,Pattakaranur, Marudur Panchayat, Pandian Nagar, Vaddakalur Panchayat, Neelampathy, Tholampalayam Panchayat, Sokkatampalli, Pogalur Panchayath.

The objective of this project:-

1. Collection of rainfall and water level data.
2. Characterisation of the water collected after the commissioning of all the Check Dams.
3. Estimation of capacity of all the Check Dams.
4. Ascertaining the quantity of ground water recharged.

2. STUDY AREA

2.1 Neelampathy

Geographically Neelampathy village is located at (N11^{0}09′06.896″E76^{0}49′52.622″) and 3 kms far from Thollampalayam near Down Hill of Kurudumalai. The private open well has been taken as Observatory well. It has been located 80m near A.R.S in the agriculture farm (N11^{0}09′09.671″ E76^{0}49′51.326″).

2.2 Pattakkaranur

Pattakkaranur has been located in Marudur (N11^{0}12′53.115″ E76^{0}53′25.740″) on the way to Vellinkadu from Karamadai. ″). The Check Dam has been located at Pattakkaranur. The private open well has been taken as Observatory well. It has been located 75m near A.R.S in the agriculture farm (N11^{0}12′54.375″ E76^{0}53′28.078″).

2.3 Pandian Nagar

Pandian Nagar has been located at Vadakkalur(N11^{0}15′31.828″ E77^{0}05′05.627″).The Check Dam has been located at Pandian Nagar. The private open well has been taken as Observatory well. It has been located 50m near A.R.S in the agriculture farm (N11^{0}15′32.530″ E77^{0}05′05.104″).

2.4 Sokkattampalli

Sokkattampalli village has been located at Pogalur(N11^{0}15′42.730″E77^{0}02′51.930″)in Annur toMettupalayam State Highway. The Check Dam has been located at Sokkattampalli on the way to Vadakkalur from Pogalur. The private open well has been taken as Observatory well near the Check Dam at the distance of 80m from the left of A.R.S (N11^{0}15′42.150″ E77^{0}02′51.017).

2.5 Nanjundapuram

The check dam and the observatory well have been situated at Kanuvai and it is 1km far from Kanuvai higher secondary school road; near the bridge, the apt place is called Nanjundapuram in PN PALAYAM. The co-ordinates of this village (N11^{0}04′18.720″ E76^{0}54′02.948″). The private open well has been taken as Observatory well which is located near the Check Dam at the distance of 150m from A.R.S (N11^{0}04′14.925″ E76^{0}54′02.881″).

2.6 Hydrology Of Bhavani Sub-Basin:

The yearly average rainfall in Sub-Basin is in the range of 650 - 850 mm. This is comparatively equal to the India's average rainfall of 800 mm. However, this rainfall occurs in short spells of a few weeks - on an average throughout the year. The characteristics of rainfall demands not only to conserve large quantity of rainwater during these few weeks but also to store wherever it rains in catchment areas like mountains, preferably for storing as ground water. Failure results in flooding of low lying areas and wastage, by means of run-off into the sea during rainy season and water scarcity during summer months. Also, due to the fast rate of urbanization, the nearby city has become a concrete jungle and it is very difficult to find open surfaces which would enhance the recharge of ground water. Even the open space left is paved with concrete or bitumen which does not allow the natural recharge of ground water. This highlights the need to implement for recharging the ground water aquifers as well as for direct storage and use of rain water.

3 MATERIALS AND METHODOLOGY

3.1 QUANTITY OF WATER HARVESTED

The total amount of water that is received in the form of rainfall over an area is called the rain water catchment / endowment of that area. Out of this, the amount that can be effectively harvested is called the water harvesting potential. The collection efficiency accounts for the fact that all the rain water falling over an area cannot be effectively harvested.

3.2 Materials:

Artificial recharge is one of the many techniques used to manage water resources and is being promoted as a significant solution to water scarcity in many nations. Aquifers (groundwater) can be recharged in two basic ways - naturally and artificially. In natural recharge, the rainwater or surface water get percolated into shallow and deep aquifer by itself through uncovered soil surfaces and fissures on the rock mass. Artificial recharge to the aquifer is the process of draining the rain water or surface water into the aquifer by constructing simple civil structures.

The methodology here relates only onthe artificial recharge of groundwateraquifer by introducing check dam, considering RWH is a promising solutionthat helps to qualitatively improvecontaminated groundwater aquifers byreducing concentration of pollutantsby dilution.

To collect the qualitative and quantitative data, regarding the overall effect of the check dam, Public Work Department (PWD) and Tamilnadu water and drainage board (TWAD) were the main source. The data collected from the PWD will form the main basis for the report. The information gathered from all the TWAD board was enough to form some qualitative and quantitative conclusions on the effectiveness of check dams.

3.3 Test Locations:

Out of the 5 test locations, details of the Neelampathy is given and discussed here.The other 4 locations are briefly discussed

3.3.1: Neelampathy

3.3.1.1: Geometry Of Check Dam

Length of the check dam : 6m
Height of the check dam : 1.2m
Maximum length of the water :200m
Width of the stream : 10m
Effective height of the check dam : 0.75m
Volume of water stored : 200x10x0.75 =1500m^3

Table 1: Yearly average Rainfall and Ground Water Level

S.no	Year	Yearly Average Rainfall(mm)	Yearly Avg G.W.L(m)
1	1996	67.34	13.28
2	1997	79.57	11.89
3	1998	63.92	9.2
4	1999	82.26	10.04
5	2000	66	9.22
6	2001	11.67	11.96
7	2002	20.59	13.4
8	2003	38.45	13.8
9	2004	32.52	8
10	2005	73.29	7.5
11	2006	63.75	8.88
12	2007	26.90	10
13	2008	24.75	14
14	2009	25.2	13

3.3.1.2 InfluenceOf Check Dam- social study

We have chosen the village called Neelampathy at Tholampalayam in Karamadai union for the social study purpose. This village consists of 301 Houses and 340 Ration cards. The total population of this village 600, among 600 there are 350 adults and 250 children. The main occupation of the village is agriculture and all villagers depend on irrigation only for the source of income. The water resource for the village is only from well and bore wells. Regarding this data, the researchers gathered information from the local persons about the bore wells, Rainwater Harvesting structures, Water level and Water quality data. Accordingly, before the construction of check dam two open well and panchyat well are used by the villagers for their uses. Even private bore wells were also not established. Though the level of water decreasing slowly, the people have to take from those open wells, later that too have dried and well water also contaminated.

So for the welfare for the people TWAD had constructed check dam in the village and also bore well near check dam for drinking purpose. From this bore well they have pumped this water to the overhead tank and from that overhead tank people use water for the basic needs. They have bored up to the depth of 802′ and water level from ground is 5′.Ten thousand liters of water being filled within five hours of time in the overhead tank. For this they use 14HP motor is used to fill the water.

It is also found out from the investigations that rain water harvesting was not followed by village people, but they initial-

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ly practiced due to the compulsion of the government. Later they didn't follow and maintained properly. So we tried to give awareness about the rain water harvesting and their needs.

The researchers collected information from the agriculture owner about the well, bore well and water recharging conditions. For the six acres of land, one well and bore well is being used for agriculture purpose. The size of the well is 20'in length and 18' in breadth. The depth of water in well is 7m from the ground level and this level will be getting recharged next day with same level of capacity. For pumping the use 5HP motor used. Nowadays they can take water for 3 hours only per day because of power shortage.

During the month of November and December rainy season, the velocity of water in streams is usually very high. Due to this crop have been got damaged and loss heavy incurred to the farmers. To control the force of water, the depth of streams should increase. For this process a grant of rupees 4-5 lakhs is expected from the government to increase the stream depth.

Table 2: Water Quality

Sample Details		Location
S. no	**Physical Examination**	**Neelampathy Village**
1.	Appearance	Clear
2.	Colour	Colorless
3.	Odur	None
4.	Turbidity Nt Units	2
5.	Total Dissolved Solids Mg/L	805
6.	Electrical Conductivity Micro Mho/cm	1151
Chemical Examination		
7.	pH	7.61
8.	pH Alkalinity As $Caco_3$	0
9.	Total Alkalinity As $Caco_3$	290
10.	Total Hardness As $Caco_3$	410
11.	Calicum As Ca	108
12.	Magnesium As Mg	32
13.	Sodium As Na	72
14.	Potassium As K	7
15.	Iron As Fe	0.12
16.	Manganese	0
17.	Free Ammonia As Nh_3	0.03
18.	Nitrite As No_2	0.02
19.	Nitrate As No_3	24
20.	Choride As Cl	130
21.	Fluoride As F	0.6
22.	Sulphate As So_3	65
23.	Phosphate As Po_4	0.02
24.	Tidys Test 4hrs As O_2	-
25.	Residual Chlorine	-

Table 3: Groundwater LevelAfter Construction:

S. No	Year	Yearly Average Rainfall(mm)	Yearly Average G.W.L (m)
1	2010	33.5	10.04
2	2011	53	3.2
3	2012	48.95	0.5

Estimation Of Storage Of Total Water Recharged: By Precipitation Method:

Max Flood Discharge = 0.01157 x I x A

Where I = rainfall in mm for 24 hrs

A= Catchment area in Sq.Km

In 2010,

Max Flood Discharge = 0.01157 x I x A

=0.01157 x 33.5 x 1.5

=0.58 m^3/day

= 2088 m^3/year

In 2011,

Max Flood Discharge = 0.01157 x 53 x 1.5

=0.91 m^3/day

= 3301 m^3/year

In 2012,

Max Flood Discharge = 0.01157 x 48.95 x 1.5

=0.85 m^3/day

= 3058 m^3/year

Hence total quantity of rain water recharged into the ground after construction of the check dam is 8447m^3.

Test Location 2: Pattakkaranur

Images of check dam, GWL and average rainfall data,water quality is shown below for this study area.

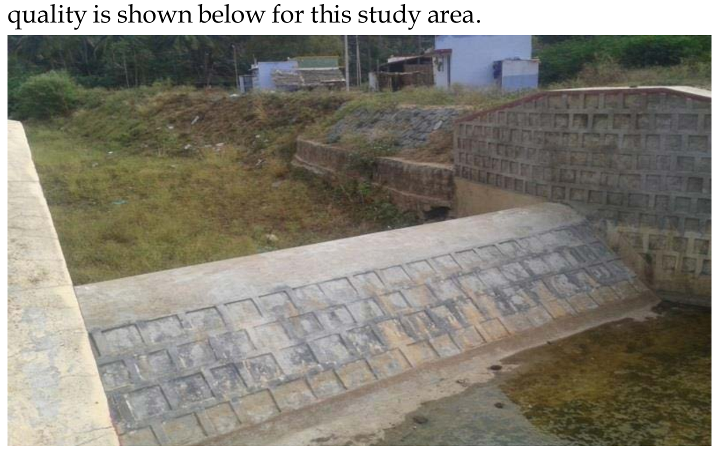

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Table 4: Ground Water Level And Average Rainfall Before Construction

S.No	Year	Yearly Average Rainfall(mm)	Yearly Average G.W.L (m)
1	1996	67.34	11.98
2	1997	79.57	7.72
3	1998	63.92	5.84
4	1999	82.26	7.31
5	2000	66	6.7
6	2001	11.67	12.25
7	2002	20.59	10.17
8	2003	38.45	14.74
9	2004	32.52	11.99
10	2005	73.29	6.48
11	2006	63.75	7.65
12	2007	26.90	8.92
13	2008	24.75	10.84

Table 5: Water Quality

SAMPLE DETAILS		LOCATION
S.no	Physical Examination	Pattakaranur Village
1.	Appeareance	Clear
2.	Colour	Colorless
3.	Odur	None
4.	Turbidity NT units	4
5.	Total dissolved solids Mg/L	1652
6.	Electrical conductivity Mho/Cm	2360
Chemical Examination		
7.	pH	7.65
8.	pH alkalinity as CaCo3	0
9.	Total alkalinity as $CaCo_3$	460
10.	Total hardness as $CaCo_3$	670
11.	Calicum as Ca	176
12.	Magnesium as Mg	53
13.	Sodium as Na	208
14.	Potassium as K	22
15.	Iron as Fe	0.24
16.	Manganese	0
17.	Free ammonia as NH_3	0.06
18.	Nitrite as NO_2	0.02
19.	Nitrate as NO_3	41
20.	Choride as Cl	410
21.	Fluoride as F	0.8
22.	Sulphate as SO_3	92
23.	Phosphate as PO_4	0.04
24.	Tidys test 4hrs as O_2	-
25.	Residual chlorine	-

Table 6: Ground Water Level And Average Rainfall After Construction

S.no	Year	Yearly Average Rainfall(mm)	Yearly Average G.W.L(m)
1	2010	33.5	16.46
2	2011	53	7.11
3	2012	48.95	6.1

Test Location 3: Pandian Nagar

Images of check dam, GWL and average rainfall data,water quality is shown below for this study area.

Table 7: Ground Water Level And Average Rainfall Before Construction

S.no	Year	Yearly Average Rainfall(mm)	Yearly Average G.W.L(m)
1	1996	23.88	21.54
2	1997	33.84	19.09
3	1998	26.02	16.08
4	1999	39.09	15.19
5	2000	54.17	17.8
6	2001	59.65	19.61
7	2002	26.48	19.77
8	2003	47.48	16.91
9	2004	41.7	19.14

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10	2005	47.33	17.26
11	2006	37.16	16.5
12	2007	42.35	18.95
13	2008	42.37	18.48
147	2009	24.69	20.1

Table 8: Water Quality

Sample Details		Location
S.no	**Physical Examination**	**Pandian Nagar Village**
1.	Appeareance	Clear
2.	Colour	Colorless
3.	Odur	None
4.	Turbidity Nt Units	5
5.	Total Dissolved Solids Mg/L	1792
6.	Electrical Conductivity Micro Mho/Cm	2560
Chemical Examination		
7.	pH	7.68
8.	pH Alkalinity As $Caco_3$	0
9.	Total Alkalinity As $CACO_3$	470
10.	Total Hardness As $CACO_3$	690
11.	Calicum As Ca	184
12.	Magnesium As Mg	55
13.	Sodium As Na	254
14.	Potassium As K	27
15.	Iron As Fe	0.36
16.	Manganese	0
17.	Free Ammonia As Nh_3	0.06
18.	Nitrite As No_2	0.04
19.	Nitrate As No_3	42
20.	Choride As Cl	420
21.	Fluoride As F	1.0
22.	Sulphate As So_3	162
23.	Phosphate As Po_4	0.02
24.	Tidys Test 4hrs As O_2	-
25.	Residual Chlorine	-

Table 8: Ground Water Level And Average Rainfall After Construction

S.no	Year	Yearly Average Rainfall(mm)	Yearly Average G.W.L (m)
1	2010	37.55	17.84
2	2011	49.2	13.21
3	2012	35.50833	3.05

Test Location 4: Sokkattampalli

Images of check dam, GWL and average rainfall data,water quality is shown below for this study area.

Table 9: Ground Water Level And Average Rainfall Before Construction

S.No	Year	Yearly Average Rainfall (mm)	Yearly Average G.W.L (m)
1	1996	23.88	17.49
2	1997	33.84	12.95
3	1998	26.02	9.49
4	1999	39.09	11.21
5	2000	54.17	11.50
6	2001	59.65	14.42
7	2002	26.48	15.06
8	2003	47.48	0.00
9	2004	41.7	15.50
10	2005	47.33	12.22
11	2006	37.16	12.08
12	2007	42.35	12.89
13	2008	42.37	13.22
14	2009	24.69	14.37

Table 10: Water Quality

Sample Details		Location
S.no	Physical Examination	Sokkattampaali Village
1.	Appeareance	Clear
2.	Colour	Colorless
3.	Odur	None
4.	Turbidity NT units	4
5.	Total dissolved solids Mg/L	1575
6.	Electrical conductivity Mho/Cm	2250
	Chemical Examination	
7.	pH	7.64
8.	pH alkalinity as $CaCo_3$	0
9.	Total alkalinity as $CaCo_3$	420
10.	Total hardness as $CaCo_3$	630
11.	Calicum as Ca	168
12.	Magnesium as Mg	50
13.	Sodium as Na	210
14.	Potassium as K	22
15.	Iron as Fe	0.12
16.	Manganese	0
17.	Free ammonia as NH_3	0.03
18.	Nitrite as NO_2	0.02
19.	Nitrate as NO_3	41
20.	Choride as Cl	400
21.	Fluoride as F	0.8
22.	Sulphate as SO_3	84
23.	Phosphate as PO_4	0.04
24.	Tidys test 4hrs as O_2	-
25.	Residual chlorine	-

Table 12: Ground Water Level And Average Rainfall After Construction:

S.no	Year	Yearly Average Rainfall(mm)	Yearly Average G.W.L (m)
1	2010	37.55	13.90
2	2011	49.2	10.01
3	2012	35.50	8.1

Test Location 5: Pappanaickenpalayam

Images of check dam, GWL and average rainfall data, water quality is shown below for this study area.

Table 13: Ground Water Level And Average Rainfall Before Construction

S.no	Year	Yearly Average Rainfall(mm)	Yearly Average G.W.L(m)
1	1996	85.94	20.02
2	1997	78.83	15.73
3	1998	69.33	10.43
4	1999	66.41	10.44
5	2000	73.08	10.46
6	2001	54.72	13.67
7	2002	0.5	14.6
8	2003	0	20.52
9	2004	17.27	22.45
10	2005	74.53	18.12
11	2006	75.9	17.33
12	2007	42.03	17.11
13	2008	56.42	19.3
14	2009	62.41667	22.84

Table 14: Water Quality

Sample Details		Location
S.no	**Physical Examination**	**Nanjudapuram Village**
1.	Appeareance	Clear
2.	Colour	Colorless
3.	Odur	None
4.	Turbidity NT units	3
5.	Total dissolved solids Mg/L	987
6.	Electrical conductivity Mho/L	1411
	Chemical Examination	
7.	pH	7.69
8.	pH alkalinity as $CaCo_3$	0
9.	Total alkalinity as $CaCo_3$	270
10.	Total hardness as $CaCo_3$	430
11.	Calicum as Ca	124
12.	Magnesium as Mg	37
13.	Sodium as Na	98
14.	Potassium as K	10
15.	Iron as Fe	0.12
16.	Manganese	0
17.	Free ammonia as NH_3	0.03
18.	Nitrite as NO_2	0.02
19.	Nitrate as NO_3	39
20.	Choride as Cl	210
21.	Fluoride as F	0.8
22.	Sulphate as SO_3	97
23.	Phosphate as PO_4	0.04
24.	Tidys test 4hrs as O_2	-
25.	Residual chlorine	-

Table 15: Ground Water Level And Average Rainfall After Construction

S.no	Year	Yearly Average Rainfall(mm)	Yearly Average G.W.L(m)
1	2010	78.09	24.08
2	2011	85	23.11
3	2012	30.70	8.76

4. Result and Discussion:

From the water quality analysis of all the test location suggested it has been clearly seen, that it cannot be used for drinking purpose due to presences of excess Total Dissolved Solids and Turbidity. Upon analyzing the pH value and the chemical examination of ground water shows standard values that can be suggested for irrigation purposes.

By comparing the water level data with yearly rainfall for the test location it has been seen that, the efficiency of ground water recharging has been increased after the construction the Check Dam. The results are given below,

Efficiency Of Test Locations:-

STUDY AREA	EFFECTIVENESS IN %
NEELAMPATHY	96.50
PATTAKARANUR	61.99
PANDIYAN NAGAR	84.86
SOKKATAMPALLI	42.56
PAPPANAICKENPALAYAM	61.60

By comparing the effectiveness of A.R.S in the above test locations, the researcher found that the most effective A.R.S structure is Neelampathy.

5. Conclusion:

From the study we have concluded that the ground water level recharging have been improved after the construction of the Artificial recharge structures (i.e.) check dam in the path of stream in different test location. We also found some dramatic change in the ground water level of certain test location that we got upto 92% when compared to before the construction of check dam. But in certain test location we got only 40% in the ground water due to the hard stratum. To improve these areas we can adopt recharging bore wells in the upstream side of the check dam. This recharging of bore well is done by filling the bore holes with pebbles which acts as Artificial Recharge Structures.

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