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# WATER SCARCITY AND WELL RECHARGE MODEL

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***ABSTRACT***

**Life on earth is linked with water. Early human settlements date back to 5000 BC and people began to settle down near to water resources. This shows the importance of water for human community. In the present condition, about 1.1 billion population face scarcity of water and about 2.7 billion people face the shortage of water at least one month a year. Despite the fact that India has heavy rainfall, many parts of India face scarcity of water. The existing study shows that even though 60 percent of the rainwater can be conserved and utilised, only 20 percent of the rainwater is being utilised. The best method available to conserve rainwater is through harvesting the rainwater. From the study, we found that well recharging model is the most commonly used method of rainwater harvesting. Other methods like artificial storage tanks and rain pits have also been implemented. This project tries to make an impact study on the implementation of rainwater harvesting in Thrissur District of Kerala. The study sample has been chosen from three areas with varied terrain where rainwater harvesting was implemented. The effect of the change in water level was analysed using the tools percentage analysis, paired sample t-test and the statistical tool of one way ANOVA. After conducting the study, it was observed that rainwater harvesting has led to an increase in the water level. It was found that factors like terrain of the area or the type of rainwater harvesting method implemented do not have an effect on the quantum of change in water level after implementation of the system. The results of the study, implies that rainwater harvesting is the best suited method for houses and buildings to solve the problem of water scarcity**

**Keywords: Groundwater, Rainfall, Water, Water Security, Sustainable Development**

## I. Introduction

The Upanishads says that the universe consist of five elements. The earth, water, fire, air and sky. The existence of the universe depends on the balance between all these elements. According to Chadogya Upanishad, water is considered to be the source of joy and the basis for living a healthy life. Again, Manusmriti states the significance of keeping water clean and Padma Purana states that ‘the person who pollutes water of ponds, well or lakes goes to hell’. Therefore the importance of water and water conservation has been stated from the ancient times. It is a universal fact that water is essential for human survival and about 60 percent of the human body is made up of water. Thus water is the basis of life on earth.

Despite the fact that 71 percent of the earth is secured with water, just 2.5 percent is freshwater and in that around 1.5 percent is caught under ice masses and snowfields. Subsequently while assessing; just 0.007 level of earth's water asset is accessible for the utilization of its 7.5 billion populations [10]. It is frequently said that, if there will be a third world war, that would be for water.

Water scarcity maybe seen as a worldwide peril for many reasons. Many researchers have showed that water scarcity will increase drastically over the upcoming years and this will deliver issues for food security, environmental sustainability, and economic development [1] [8]. The city of Cape Town in Brazil is soon to approach day zero, the day when the city's public water system would come to a stop and each person would be entitled for 25 litres of water every day and is to be collected from water collection points [7].

While taking the instance of India, it represents around 4 percent of the world's freshwater asset and is positioned among top 10 water rich nations. At the same time India is also notified as a country with critical water level, as the utilizable freshwater of India (i.e.; 1122 cubic meter) falls below the universal limit (i.e.; 1700 cubic meter). In the present situation, there is a developing need to make an awareness among the natives or occupants about the disturbing circumstance of exhaustion in the quality and amount of water assets and furthermore the significance of water protection and water reusing.

The explanation behind water shortage in India is not only exhaustion of precipitation, yet in addition the improper administration of water. Best strategy to deal with the water is through saving it. The existing studies show that, though 60 percent of rainfall can be harvested, only 20 percent is being utilised now. Rain water can be properly utilised and harvested by using rainwater harvesting system. Rain water harvesting is defined as a method of collecting and storing of rainwater into natural reservoirs or tanks, or the percolation of surface water into underground aquifers. Rainwater harvesting is done through various methods such as surface runoff harvesting: the rainwater that is lost as surface runoff is collected and allowed to be infiltrated in order to recharge the underground aquifers [17]. Rooftop rainwater harvesting: the rainwater that falls in the roof of the building is collected and is stored. There are various methods for storing rooftop rainwater. Those methods are: Artificial storage for direct use, Recharge pits, Recharging groundwater aquifers (Well Recharging). The existing studies shows that the quantum of rainwater harvested can be calculated as $V= a*r*c$, where V is the quantum of rainwater harvested, a is the catchment area, r is the amount of rainfall, and c is the runoff coefficient [16]

## II. Review of literature

Existing study shows that around 66 percent of the global population directly live in states of serious water shortage at least 1 month of the year and half a billion people confront extreme water shortage throughout the entire year [13]. India and China would overpower their renewable freshwater assets by the year 2025. This is caused by increasing local utilization driven basically by unsustainable economic development. India will require in excess of 10 times its current requirement of water by the year 2100 so as to fulfil its needs [3].Variables that influence the accessibility of water are urbanization and population development, precipitation design, uneven distribution of water, contamination of surface water etc. [12]. Rain is the primary source of water. Rivers, lakes and underground water resources are the secondary source of water. Though rain is the primary source, we depend extremely on secondary sources of water. The over exploitation of secondary sources of water leads to unsustainable management of groundwater. Thus, in order to ensure sustainable management of water, rain water harvesting must be adopted [20].

Management of groundwater resource can be done by balancing the demand side needs with the supply availability. The management of supply side measures involves development of groundwater resources and rainwater harvesting. Urgent measures have to be taken on areas where groundwater level is critical [19]. Water scarcity was not a subject addressed in Indian scenario thirty years back. But the quality and quantity of water available has been decreasing. Though the average rainfall in India is higher than the global average, India faces water scarcity as a very little amount of water is percolated and the rest is lost through surface runoff [18].

Groundwater is the most utilised form of water in Kerala. Kerala has many dug wells and the density of dug wells is high in the state. Kerala receives good rainfall. Rainfall received during April 2013 to march 2014 ranges from 1701mm – 4022mm throughout the state. The net groundwater availability is second highest in the District of Thrissur. Out of 17 blocks in Thrissur district, the groundwater utilisation is safe in 12 blocks, Semi-critical in 4 blocks and over-exploited in 1 block. The groundwater utilisation has not reached the critical level in any blocks. In the district of Thrissur, out of 94 habitations affected by the quality of groundwater, 83 have high iron content and the problem of saline intrusion is visible in 11 habitations. The per capita availability of groundwater per day also shows a decreasing trend with the increase in the population [15]. The availability of groundwater is not uniform throughout the state. The earlier methods of extraction of groundwater were much more scientific and had less impact to the groundwater level as compared to the present methods. There is a change in the agricultural pattern too. Paddy fields which had a positive impact on maintaining the groundwater level has been substituted to commercial crops which use more groundwater. Changes in use of groundwater, agricultural pattern, saline water intrusion, unscientific construction of sewage pits have all contributed to the deterioration of the quality and quantity of groundwater. The analysis of decadal water level trend (1996–2005) shows that there is about 0.1 m/year decrease in the groundwater level for pre-monsoon and post-monsoon data respectively. The fresh water lakes in the state are also facing problems due to dumping of waste and extraction of sand. Groundwater in coastal areas faces the problem of saline water intrusion. Extensive use of insecticides and pesticides has also affected the quality of groundwater in the state [4].

## III. Rainwater harvesting

Rainwater harvesting has been adopted in India during early centauries, i.e.; from 3rd BC, and during chola reign [17]. There are mainly 2 methods of harvesting rainwater. They are groundwater recharge and storing in artificial tanks. The process of rainwater harvesting starts with rainwater falling into the catchment area. A coarse mesh is attached in order to block the debris from falling into the rainwater harvesting system. Gutters are attached to the slope to collect the rainwater. It is transported into the plant through pipes called conduits. Filters are attached to the plant so filter the rain water. Either charcoal filter or sand filter is used to filter the water before falling into the system. A first flush model which flushes out the water from first rains are the most commonly used rain water harvesting model [18]. Benefits of rainwater harvesting are less dependence on dams, reduced water bills, decreases soil erosion, inexpensive method, reduces exploitation of groundwater [17]. A study conducted in the rural area of Bangladesh showed that the rainwater harvesting system was implemented using locally available materials. The harvested water could be used throughout the year. It was found that the water stored through rainwater harvesting was safe [2].

In Thrissur District of Kerala, the well recharging model was implemented in households under the guidance of Mazhapolima, an initiative of government of Kerala to increase the water level by harvesting the rainwater. Thrissur District of Kerala was facing water scarcity from months of February to May. In order to overcome the alarming situation of water scarcity, a well recharging system was implemented under the guidance of Mazhapolima in the District. Mazhapolima aims on community based well recharging programme. Keralities extensively use open wells for meeting their water requirements. Mazhapolima implements rain water harvesting through direct well recharging. Water harvested for drinking purpose is filtered by sand filter or nylon filter. Rainwater harvested for non-drinking purpose is harvested without filters, rain pits and surface run-off catch. The project is implemented in 1218 wells in different panchayats in Thrissur with financial support from commercial banks as a part of their CSR programme.

The existing study does not provide a light to the post implementation impact of well recharging programme in the District of Thrissur, Kerala.

## IV. Research Methodology

From the current study, we try to analyse the effectiveness of the well recharging model implemented in the year 2008. The primary data was collected from Vadanappillypanchayat, Chelekkarapanchayat and mucipality area of Thrissur district. The locations within the district were chosen based on varied terrain. A total of 100 samples were collected using the method of simple random sampling. A social survey was conducted among households where the rainwater harvesting system was implemented. The level of water in wells was collected to understand the accurate water level in well post implementation of the project. The method of rainwater harvesting system, the topography of the region was also analysed. The benefits experienced by the households and also the difficulties faced by them were also recorded. The secondary data used in this study was collected from the database of Mazhapolima, an initiative of Thrissur District Administration (Government of Kerala). The effect of the change in water level was analysed using the tool of paired sample t-test and the statistical tool of one way ANOVA was used to check if the change in water level was different across various terrains or various methods of rainwater harvesting.

## V. Hypothesis Formulation

For the current study, we have set 3 hypothesis.

1. There is no significant change in water level after implementation of the rainwater harvesting system.
2. There is no significant difference in change in water level based on the methods of rainwater harvesting.
3. There is no significant difference in change in water level based on the terrain of the area of implementation.

## VI.Data Analysis

A. Change in water level before and after implementation.

Table 1: Level of water in wells

| Water level (meters) | Before (No. of wells) | After (No. of wells) |
|---|---|---|
| 0-2 | 72 | 51 |
| 2-4 | 15 | 28 |
| 4-6 | 10 | 12 |
| 6-8 | 3 | 9 |
| Total | 100 | 100 |

The water level in well was measured before and after the implementation of the system. It was found that before implementation of the system 72 percent of wells had a water level below 2 meters. After implementation of the system, the number of wells with water level below 2 meters has reduced to 51 percent. At the same time water level was between 2-4 metres for 15 percent of wells before implementation of the system and it has increased to 28 percent after implementation of the system. For 10 percent of wells, the water level was between 4-6 meters before implementation of the system and it has now increased to 12 percent after implementation. Water level was between 6-8 meters before implementation of the system for 3 percent of wells and it has increased to 9 percent after implementation of the system.

In order to analyse if there is a significant change in water level before and after implementation of the system, a paired sample t- test was conducted.

Table 2 :Paired Samples Statistics

| Particulars | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Before implementation | 2.160 | 100 | 1.6619 | .1662 |
| | After implementation | 2.835 | 100 | 1.9605 | .1961 |

Table 3 :Paired Samples Correlations

| Particulars | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Before implementation & After implementation | 100 | .805 | .000 |

Ha = There is significant change in the water level after implementation of the rainwater harvesting system.

$H_o$= There is no significant change in water level after implementation of the rainwater harvesting system.

From the analysis using paired sample t test, we found that there is significant change in the water level after implementation of the system (t (99) = -5.787, $p<0.05$, $mean_{(before)}$=2.16, $mean_{(after)}$=2.835). Thus we supported our study hypothesis and inferred that there is significant change in the water level before and after implementation of the system and water level have increased after implementation of the rainwater harvesting system.

The values are shown in table 4 given below:

Table 4: Paired Sample t-test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | Before implementation –After implementation | -0.6750 | 1.1664 | .1166 | -.9064 | -.4436 | -5.787 | 99 | .000 |

B. Method of rainwater harvesting system implemented.

Table 5 : Different methods of rainwater harvesting

| | Positive Change (No. of wells) | Negative Change (No. of wells) | No change (No. of wells) | Total |
|---|---|---|---|---|
| Well recharging | 45 | 17 | 14 | 76 |
| Artificial storage tanks (with overflow) | 16 | 3 | 1 | 20 |
| Rain pits | 3 | | 1 | 4 |
| Total | 64 | 20 | 16 | 100 |

It is observed that about 59 percent of wells where well recharging model was implemented showed a positive result, and 22 percent showed a negative result. There was no change in water level in 19 percent of wells.

80 percent of wells where method of artificial storage tanks (with overflow) was implemented witnessed a positive change and 15 percent witnessed a negative change and 5 percent resulted in no change.

75 percent of wells where rain pits were implemented showed positive change, and 75 percent showed a no change.

For the analysis of second hypothesis, the tool of one way ANOVA was used.

Table 6: :Test of Homogeneity of Variances

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 1.526 | 2 | 97 | .223 |

Ha= The change in water level is different based on the method of rainwater harvesting.

$H_0$= There is no significant difference in change in water level based on the methods of rainwater harvesting.

A one-way ANOVA was conducted to determine if change in water level was different for groups following different methods for rainwater harvesting. There are three methods of rainwater harvesting; well recharging model (n=76), Artificial storage tanks with overflow (n=20) and Recharge pits (n=4). There was a statistically insignificant difference between groups as determined by one-way ANOVA ( $F(2,97)=2.369$, $p>0.05$). Thus it can be inferred that the different methods of rainwater harvesting is insignificant for change in water level. The figures are shown in table 7.

Table 7 : ANOVA ( Independent variable – Method of rainwater harvesting implemented Dependent variable – Change in water level in wells.)

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 6.274 | 2 | 3.137 | 2.369 | .099 |
| Within Groups | 128.414 | 97 | 1.324 | | |
| Total | 134.688 | 99 | | | |

C. Terrain of the area of implementation

Table 8 : Area of implementation of the system

| | Positive change (No. of wells) | Negative change(No. of wells | No change (No. of wells | Total (No. of wells |
|---|---|---|---|---|
| Hilly area | 34 | 14 | 10 | 58 |
| Coastal area | 19 | 1 | 2 | 22 |
| Plain area | 11 | 5 | 4 | 20 |
| Total | 64 | 20 | 16 | 100 |

It can be observed that out of 58 wells observed in hilly area, 34 wells showed a positive change, 14 wells showed a negative change and no change could be measured in 10 wells. Out of 22 wells chosen from coastal area, 19 wells showed a positive change, 1 well showed a negative change and 2 wells showed no change in water level. 20 wells were observed in plain terrain and it was observed that there was a positive change in water level in 11 wells, and 5 wells showed a negative change and 4 wells showed no change in water level.

For the analysis for the third hypothesis, the tool of One way ANOVA was used.

Table 9 :Test of Homogeneity of Variances

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 4.512 | 2 | 97 | .013 |

Ha= The change in water level is different based on terrain of the area of implementation.

$H_0$= There is no significant difference in change in water level based on the terrain of the area of implementation.

A one-way ANOVA was conducted to determine if change in water level was different for groups from varied terrain. There are three terrain selected for the study were; hilly area (n=58), coastal area (n=22) and plain area (n=20). There was a statistically insignificant difference between groups as determined by one-way ANOVA ( $F(2,97=3.047)$, $p>0.05$). Thus it can be inferred that the terrain of the area of rainwater harvesting is insignificant for change in water level. The figures are shown in table 10

Table 10: ANOVA

Independent variable : Terrain of area

Dependent Variable : Change in level of water

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 7.963 | 2 | 3.981 | 3.047 | .052 |
| Within Groups | 126.725 | 97 | 1.306 | | |
| Total | 134.688 | 99 | | | |

## VII. Results and discussion.

The investigation was directed to analyse the effect of rainwater harvesting. Rainwater being the primary source of water must be gathered appropriately keeping in mind the end goal to defeat the issue of shortage of water. Accessibility of clean water will be a threat for the survival of life on earth.

There are numerous strategies for rainwater harvesting. However, the effectiveness of rainwater water harvesting must be analysed to check whether there is a positive effect for rainwater harvesting. The first hypothesis was that there is no significant change in water level before and after the implementation of the system. As indicated by the study, it was watched that before execution of the framework, 72 wells had water level beneath 2 meters. After usage, the quantity of wells with water level beneath 2 meters has reduced to 51. The quantity of wells with water level between 2 meters and 4 meters has increased from 15 wells to 28 wells. Before usage of the framework, 10 wells had water level between 4 meters and 6 meters. After execution, the quantity of wells has expanded to 12. The quantity of wells with water level between 6 meters and 8 meters has increased from 3 meters to 9 meters. Keeping in mind the end goal, to check this hypothesis, the tool of paired sample t-test was utilized. A paired t-test is a statistical tool that is utilized to compare the population means of two samples. The information was gathered specifically from the respondents and this information is valid. From the investigation we found that the null hypothesis can be rejected. In this manner it is discovered that there is a huge change in the water level in wells after usage of the rainwater harvesting. From the gathered information it can be discovered that the change in water level demonstrates a positive change. As indicated by our examination, we can state that rainwater harvesting would bring about an increase in the groundwater level. In the present day circumstance, where the world faces substantial shortage of water assets, water collecting must be executed to control the shortage of water.

The second hypothesis stated that the change in water level is not based on the technique of rainwater harvesting system implemented. There are different techniques for collecting water. Most ordinarily utilized strategies in Kerala are, immediate well recharging model, artificial storage tanks with overflow to wells, and rain pits. Our hypothesis expresses that, the change in groundwater level after execution of the framework is not identified with the strategy for water collecting framework. Out of 76 families where direct well recharging was executed, major share of wells demonstrated a positive change in water level. It was watched that, 20 units had executed artificial storage tanks with overflow into wells for recharging water. Out of those 20 units, 16 units brought about a positive change. Rain pits were implemented in 4 households, and 3 units had a positive effect. Keeping in mind the end goal to statistically demonstrate the hypothesis, One way ANOVA was utilized. From the investigation we found that we don't reject the null hypothesis. It implies that the change in water level does not rely upon the technique for rainwater harvesting framework executed. Hence as per the investigation we can state that regardless of the strategy for water harvesting, the procedure of water collecting would give a positive outcome.

The third hypothesis stated that, the terrain of implementation of rainwater harvesting is immaterial for the quantum of change in water level. For our present investigation, 3 regions were chosen based on varied terrain. The terrain chosen was coastal area, hilly area and plain area. In light of our current study, it was observed that, out of 58 households chosen from hilly areas, 59 percent of wells demonstrated a positive change in water level. 22 households were selected from coastal area, and 86 percent of households resulted in a positive change in water level. 55 percent households identified from plain area also showed a positive change in the water level. To test this hypothesis, statistical tool of one way ANOVA was used. The test was used to examine if the terrain of the area of implementation will have an impact on the quantum of rainwater harvested. After the analysis, we found that the null hypothesis cannot be rejected. It can be inferred that the change in water level is not dependent on the terrain of the area of implementation. Thus we can say that, rainwater harvesting would guarantee a positive outcome in change in water level irrespective of the area of implementation.

## VIII. Conclusion

Water collecting through well recharging model has been powerful arrangement for reaping rainwater which is the primary source of water. From the investigation we have discovered that rainwater harvesting positively affects the water level. The techniques for rainwater harvesting and the landscape of zone of implementation are unimportant for the accomplishment of the framework.

The Government has implemented Rainwater harvesting to be an obligatory arrangement for every new house and structures with floor are of 100 sq.m or more. Be that as it may, the genuine execution of the venture is as yet an inquiry. The Government needs to find a way to guarantee that the framework has been implemented and is appropriately working.

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