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Roof-Top Harvesting Of Rainwater: An Answer to Present Day Water Crisis of India (With Special Reference to West Bengal)

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Abstract: *he present paper wants to convey the message that, for maintaining good health and to avoid water-borne diseases (which are the cruelest killer of thousands of people every year) it is necessary to establish the rights to access safe water resource for every human being. Keeping in mind, the grave water-crisis of the present day world to meet the requirement of modern civilization, rainwater harvesting can be the only solution. Government of India shows a crude calculation as a design for rainwater storage tank. This crude design is not practical at all and also not economically feasible. So the present paper tries to suggest a feasible design for rainwater storage tank.*

Key words: *Crisis, Design, Precaution, Scarcity, Stress.*

I. Introduction

Today development means, not only mere economic growth, but also, enlarging people's choices and expansion of human capabilities; and poverty means that opportunities and choices most basic to human development are denied to lead a long, healthy creative life and to enjoy a decent standard of living, freedom, dignity, self respect and the respect of others. One of the major criteria of poverty is deprivation of basic material requirements like food. Supply of food depends on good harvests, which is also depended mainly on guaranteed supply of adequate rain or irrigation water. In addition, for maintaining good health and to avoid water-borne diseases (which are the cruelest killer of thousands of people every year) it is necessary to establish the rights to access safe water resource for every human being. Keeping in mind, the grave water-crisis of the present day world to meet the requirement of modern civilization, rainwater harvesting can be the only solution. [2] In the first section of the paper ancient practices to preserve water in different parts of the world are referred. In the second section nature of water crisis has been analyzed. In the third section advantages, problem and precaution of roof-top rainwater harvesting system have been depicted. In this section author has suggested economically feasible design of storage tank. In the last section, case of State of West Bengal has been analyzed.

II. Ancient Practice

With the first human settlement about 6000 years ago, began on two-fold struggle with water, on the one hand people had to protect themselves against floods, on the other, they had to ensure safe water supply for domestic use and irrigation. As a consequence, hydro-technical installations were among the earliest technological achievements of human kind.

- The oldest known cisterns were discovered in – Palestine and Greece.
- These cisterns were used to collect rainwater from roofs, from paved squares and some times also from water bearing sub-soil strata.
- The earliest cisterns were made of rocks. Masonry cisterns developed at a later date. From about 2000 BC did mortar begin to be used for sealing these cisterns.

Some ancient water harvesting system in India

1.	Rajasthan	-	khadins, tanks, nadis
2.	Maharashtra	-	bandharas and tals
3.	Himachal Pradesh	-	kuhls
4.	Kandi belt of Jammu	-	ponds
5.	Tamil Nadu	-	eris
6.	Kerala	-	surangams
7.	Karnataka	-	kattas

- Traditional systems used low cost, user friendly techniques.
- They were easily kept in good operational condition by local communities.
- Traditional community-based structures contribute to social cohesion and self reliance.
- This encouraged economic independence and optimization of local resources at micro-level.

India as a whole has a millennial tradition of rain-water harvesting and West Bengal is no exception. These traditions have developed over centuries in an ecologically sound manner. These were decentralized systems, where the urban and rural communities played an active role in water management.
Traditional water harvesting system declined, when the British took control of India. The Govt. took over the role of the main provider of water and replaced traditional decentralized systems with centralized ones.
After the British left, the Indian Bureaucracy took over the self appointed role of supplying water. This marked the end of a glorious tradition. More over now, there is a growth of a heavy and un-sustainable dependence of surface and groundwater sources and a gross neglect of the primary source of water—rain. (Saha, 2003) [4]

III. Definition Of Rainwater Harvesting

Rainwater is the first form and also the purest form of water, which can be collected, stored and utilized in the time of need. This three-way process, i.e. collection, storage and utilization of first form of water in a proper way is called rainwater harvesting.

IV. Nature Of Scarcity Of Water

Some points one should remember:

a) 71% of the earth-surface is covered by water.
b) Water in spite of being a renewable resource has only limited reserves.
c) Total water resource of the world is estimated to be 1.5 billion cubic km
d) 3% of this water resource is 'Sweet Water'.
e) 0.37% of this water resource is usable for human civilization.
f) In order to meet the requirements of development – water resource management is needed.
g) Today 120 crores persons can not avail pure drinking water.
h) 240 crores people do not have proper sanitary facility.
i) Each year 50 lakh men & women and 6000 children die due to non-availability of pure drinking water and sanitary facility.
j) Now-a days each year the number of death due to water related causes is just 10 times higher that the total no. of death in the 2nd world War.

4.1 Reasons behind water scarcity

Readers of this work can quickly look through the following information.

1. India experiences uneven availability of water resource, e.g.

Region	Per capita availability in cubic metre
Brahmaputra Valley	18417
Kanyakumari	411
Western part of Yamuna Valley	740
Gandak valley	3379

2. India's annual rainfall: 1170 mm or about 4000cubic kilometre. 80 percent of it
a) fall during three months of rainy season.
3. During rainy season all the rain falls in about 200 hours, and half of it, in 20-30 hours.
4. Consequently the run-off is high.
5. More or less 20% of the river run-off is stored at dam-sites. The rest of it flows away.
6. Increase in paved surfaces and rampant reduction of vegetative cover have facilitated the run-off, thus depleting the earth's groundwater aquifers.

Demands are much less as compared to the availability of water in India; shortages occur mainly due to lack of conservation and regeneration. [3]

4.2 Water crisis and scarcity indicators:

Following discussion will help the readers to understand the nature of crisis in India.

Per capita availability of renewable fresh water in a region	Level of stress
< 1700 km^3	Water stress
<1000 km^3	Water scarcity
< 500 km^3	Absolute scarcity

Concept propounded by Main Falkenmark on the basis that 100 litres a day (36.5m^3 a year) is roughly the minimum per capita requirement for basic household needs and to maintain good health. Government of India claims that India has 2464 m^3 of water per capita per year. Despite this fact some parts of India face severe scarcity of water. Ironically, Cherrapunji which receives about 11,000 mm of rainfall annually, suffers from acute shortage of drinking water

Water resource in India

1. Total Surface water resources = 1880 km^3
2. Total usable groundwater resources = 418 km^3
3. Total usable surface water resources = 690 km^3
4. Total usable water resource (2+3) = 1108 km^3

Source : Central water commission

Estimated Annual Demand for Water in India in Cubic Kilometer

CATEGORY	1985		2000		2025	
	SURFACE WATER	GROUND WATER	SURFACE WATER	GROUND WATER	SURFACE WATER	GROUND WATER
IRRIGATION	320	150	420	210	510	260
OTHERS	40	30	80	40	190	90
1) DOMESTIC	16.7		28.7		40	
2) LIVE STOCK	10		30		120	
3) THERMAL POWER	2.7		3.3		4	
4) MISCELLANEOUS	40.6		58		116	
TOTAL	540		750		1050	

Source : The Citizen's Fifth Report Part - II

Considering the increasing water crisis of the present day world – Rainwater harvesting can be the only solution.

V. Advantages Of Roof-Top Rainwater Harvesting

This is an ideal solution of water problem where there is inadequate ground water supply or surface resources are either lacking or insignificant.

5.1 General good impacts on both physical and socio-economic impacts:

1) To utilise the rainfall runoff, which is going to sewer or storm drains.
2) Rainwater is bacteriologically pure, free from organic matter and soft in nature.
3) It will help in reducing the flood hazard.
4) To improve the quality of existing ground water through dilution.
5) Rainwater may be harnessed at place of need and may be utilised at Time of need.
6) The structures required for harvesting the rainwater are simple, Economical and eco-friendly

5.2 Positive impacts on women especially the girl children:

Throughout third world women and girls are the main providers of household water supply and sanitation, and also have the primary responsibility for maintaining a clean home environment. The lack of access to safe water and sanitation facilities therefore affects women and girls most acutely.

Problems from no access to safe water at home:

5.2.1. Death from Diarrhoea: Major portion of population has to practise

- Open defecation.
- Poor water and sanitation,
- Unsafe hygiene practices

These are the main causes of diarrhoea, one of the main child killers in the world. 15 million children under the age of five die each year because of diseases caused by drinking water. Each year more than 250,000 children under the age of five die from diarrhoeal diseases.

5.2.2. Less Attendance in school:

Surveys from 45 developing countries show that in almost two-thirds of households without a drinking water source on the premises, it is girl-children who collect water. This considerably reduces their time for other activities such as playing and school attendance.

5.2.3. Victim of Violence:

Without access to latrines, girls become 'prisoners of daylight', daring to relieve themselves only under the cover of darkness. Night-time trips to fields or roadsides, however, can put them at risk of physical attack and other violence. Possible remedies by providing safe water at home is through Rooftop Rain Water harvesting. [7]

5.3 Positive impact on Urban Water Supply

Demand for water is growing in most cities as every urban citizen requires almost double the amount of water that a rural citizen requires. Moreover, India is rapidly urbanising. Urban population in India has grown almost five times in five decades from 1951 (62.44 million) to 2001 (286.08). Not long ago, most of our cities were self sufficient in meeting their water needs from the extensive urban water bodies to supply water to citizens. Today these water bodies have completely disappeared. Municipalities have been stretched to their limits to find water for the growing urban populations. Groundwater is being extracted by the government as well as the private parties. In this situation the eco-friendly answer will be the Roof-top Rainwater Harvesting. [9]

5.4 Positive impact on meeting the Rural Requirement of Water

The mission of the Government relating to drinking water supply during post-independence was largely dedicated towards the urban centres, while the rural areas remained neglected. The National Water Policy (2002) declared that ensuring the supply of drinking water should be the first priority of the Government. No village in India receives such scanty rain that the thirst of people cannot be met. So here also rain water harvesting can be the right answer to rural water crisis. [8]

VI. Problems & Precautions

Problems: Problems are as follows:

If harvested water is polluted : -

1. Direct consumption will have immediate impact on health
2. Polluted water recharged into ground water would cause long-term problems of aquifer pollution.

Precautions :

At the Catchment level :

- Keeping the catchment clean
- Using net to trap debris at the catchment itself
- Paving the catchment with ceramic/stone tiles or other such non-erosive materials.

At the conduit level

- Provision of first-flush to drain run-off from initial spell of rain

Before Recharging

- Allowing for sedimentation of the rainwater
- Filtering the water

VII. Design For A Rainwater Storage Tank

Let it be supposed, the system has to be designed to meeting drinking water requirement of a five member family in a building with a roof top area of 100 Sq. Mt. in Purulia district of West Bengal in India. The daily requirement of water per head per day for drinking and cooking is 7 litres (as per WHO standard). Including waste we can say it is 10 litres per head per day. So total requirement of the family is: 10 litres × 5 = 50 litres per day.

Area of the catchment (A) = 100 sq. m..

Height of rainfall in Purulia (R) = 1364 m.

(Height of rainfall means annual total rainfall)

Volume of rainfall (in litres)/100 sq. m Flat terrace:

(area of terrace × height of rainfall) = 100 × 1.364 = 136.4 cubic metre

= 136400 litres

(1 cubic metre of water means 1000 litres of water)

Volume of effectively harvested rainwater (in litres) = 81840 litres.

(Assuming that 60% of the total rainfall is effectively harvested)

(Assuming, monsoon extending over 4 months or 120 days)

The dry period = 365-120 = 245 days

Drinking and cooking water requirement for the family (dry season) = 245 × 5 × 10 litres
= 12,250 litres
As a safety factor, the tank should be built 20% larger than required, I.e. 14,700 litres storage tank can meet the basic drinking water requirement of a 5-member family for the dry period.
Source: Rainwater harvesting and water conservation, Department of Environment, Govt. of West Bengal; West Bengal Pollution Control Board [4]

VIII. Implementation-Problem Arising From This Official Guidelines

A storage tank of capacity of approximately 15000 litre means three 5000 litre tanks should be installed beside one household. One 5000-litre tank means a tank with diameter of 2 m. and height of 3.5 m. with concrete basement. It means that the tank will be as high as one storied building. Now the consequences will be the following –

1. There will be acute space problem to install three such big tanks for every household in a dense locality.
2. A double layered food grade PVC tank costs rupees 7 / litre. With concrete basement, conduit and masonry charges, the proposed system will cost at least three lakh rupees, which will be very high for a common Indian.
3. In a present status of population density and living condition every common Indian household does not have 100 square metre of roof top or courtyard.

8.1 Ways to overcome such problem :

If people want to reduce the size of the tank, they should try to identify a shorter span of meteorological deficit period. If tanks smaller than 15000 litre capacity can meet the yearly requirement of a family, the installation cost for the common people will be bearable. If the system becomes cost-effective, it will gradually gain popularity.

8.2 An alternative design for water harvesting tank :

Daily requirement of a 5-member family = (5×10) litres =50 litres (assumed that water requirement / capita / day for drinking and cooking =10 litres)
Therefore monthly requirement of the family = (50×30) litres =1500 litres

Case of Purulia

Months	Available water per sq.m. catchment in litre #	Effective availability i.e. 60% of the total available water in litre.	Water available in 50 sq. m. Catchments.	Monthly surplus or deficit in litre.
January	12.1	7.26	363	-1137
February	20.0	12	600	-900
March	22.2	13.32	666	-834
April	30.6	18.36	918	-582
May	59.0	35.4	1770	+270
June	252.9	151.74	7587	+6087
July	298.5	179.1	8955	+7455
August	290.9	174.54	8727	+7227
September	233.8	140.28	7014	+5514
October	70.0	42	2100	+600
November	19.3	11.58	579	-921
December	12.6	7.56	378	-1122

Calculated according to the normal monthly rainfall.

Total water deficit = (1122 + 921 + 1137 + 900 + 834 + 582) litres = 5496 litres
If the tank is built with 20% excess capacity then the size will be approximately 6600 litres.
So in this method, we can see that 6600 litre-tank can meet the yearly requirement of a 5-member family in Purulia. By this process calculated annual deficit in different districts of West Bengal will be like this—

a. Darjeeling - 4000 litres
b. Jalpaiguri - 4440 litres
c. Koch Bihar - 5340 litres
d. Uttar Dinajpur - 5775 litres
e. Dakshin Dinajpur - 6006 litres
f. Malda - 6168 litres [1]

Different states in India have already made the water harvesting system mandatory in the Municipal building rules. One example has been cited below.

IX. Tamil Nadu Acts And Ordinances No. 4 Of 2003

After section 257 the following section shall be inserted –

257-A Provision of Rain Water Harvesting Structure

1. In every building owned or occupied by the Govt. ---- Rainwater harvesting structure shall be provided by the Govt.
2. Every owner or occupier of a building shall provide rainwater harvesting structure
3. Where the rainwater harvesting structure is not provided as required, the executive authority may, after giving notice provide rainwater harvesting structure and recover the cost – in the same manner as property tax.
4. Where the owner or occupier of the building fails to provide the rainwater harvesting structure in the building before the date as may be prescribed, the water supply connection provided to such building shall be disconnected till rainwater harvesting structure is provided.

21st July, 2003, P.S. Rammohan Rao, Governor of Tamil Nadu [5]

X. Why It Is Necessary In West Bengal

- Inspite of good rainfall, districts like Purulia, Bankura, Birbhum are draught prone region due to terrain condition.
- Ground water of eight to nine districts of Gangetic West Bengal is seriously contaminated with arsenic.
- In some districts in western part groundwater is contaminated with fluoride.
- In the northern hilly tracts, severe crisis of water is experienced every year despite very heavy rainfall.
- In the south people are suffering due to salinity of water.
- In the urban area level of ground water is diminishing at a very high rate.

So all over West Bengal people's easy access to adequate safe water is denied.

XI. Problem Of Implementation

- Rainwater harvesting is an accepted fresh water augmentation technology, yet has to be designed and implemented in the proper way.
- Districts of West Bengal have unique characteristics of their own in relation to relief, drainage, micro-climate variation, nature of urbanization and nature of requirements.
- Most of the discussions deal with this subject in theoretical approach, so proper way which can be implemented practically, is not resolved.
- Detailed study of rainfall variation and rate of evaporation of each district in different parts of year is necessary

In addition Government's initiative to aware and educate people about 'the necessary of being self sustained in water supply' – is very much essential, unless and until common people became aware about the harm of over-consumption and wasting of water and the benefit of wise use of freshwater, situation would not be better.

XII. West Bengal's Present Scenario

Housing complex having 100 or more than 100 flats and any built up area more than equal to 60,000 Sq. Ft. – should collect N.O.C from Pollution Control Board. Condition for getting N.O.C is to build up own rainwater harvesting system.

Dept. of Environment gave the proposal, that rainwater harvesting system should be included in Municipal Building Rules as a compulsory item. As a result Rainwater Harvesting facilities are now compulsory in new housing projects having more than100 flats or with a super built area more than 60,000sq.ft. in the State.

New Rainwater Harvesting demonstration projects have been set up at Bidhannagar Govt. College, Bidhannagar Poura Bhawan and WBPCB Regional Office at Siliguri.

Ongoing roof top rain water harvesting projects are in 83 schools (15 in Darjeeling, 17 in Birbhum, 17 in Bankura, 21 in Purulia, 5 in Murshidabad, 5 in Nadia, 3 in Kolkata) and Government Buildings in Kolkata and districts.

The executing agencies are The Institute of Environmental Studies and Wetland Management (IESWM) and NGOs like Action for FOOD Production (AFPRO), Centre For Ground Water Studies, Institute for Motivating Self Employment (IMSE) and Paschim Banga Vigyan Mancha (PBVM). The West Bengal Pollution Control Board acts as main coordinating agency in the State to implement rainwater harvesting projects at various places.

Draft policy guidelines for conservation of water by rainwater harvesting is under process. Framing of Municipal bylaws for mandatory rainwater harvesting is under process.

12.1 State Govt.'s present policy

1) Schools should have their own water harvest system.

Objective:

a) To provide safe drinking water to students (Double layered food grade PVC tank with sand filter and either zero bacteria filter or chlorination)
b) To provide sanitation to girl students (cement tank)
c) Awareness generation in people.
d) Rainwater collected from different catchment can be stored in a pond.
e) To prevent seepage loss poly lining is done.
f) After passing the water through a horizontal roughing filter, it can be used for drinking purpose.

2) Pond lining scheme

a) Rainwater collected from different catchment can be stored in a pond.
b) To prevent seepage loss poly lining is done.
c) After passing the water through a horizontal roughing filter, it can be used for drinking purpose.

3) Recharging of groundwater scheme:

This system has been launched at the soil survey office at Patuli

XIII. Effect Of Water Harvesting On Society

- Every village in India can meet its own water needs.
- Good combination of water harvesting and groundwater recharge, can increase and stabilize the productivity of the rainfed land.
- Increased and assured water availability means increased and stable agricultural production and improved animal husbandry – both of which together form the fulcrum of the rural economy.
- Community based rainwater harvesting helps to generate a community spirit within the village and build up what economists call the 'Social Capital'.

XIV. Conclusion

14.1 Advantages of the article

Rainwater harvesting is a technology which is extremely flexible and adaptable to a wide variety of settings, it is used in the richest and poorest societies on the planet, and in the wettest and driest regions of the world. [6] The present paper explains this unique system in different angles and approaches.

14.2 Limitations of the article

Every part of India e.g. Districts of West Bengal have unique characteristics of their own in relation to relief, drainage, micro-climatic variation, nature of urbanization and nature of requirements. Hence a detailed study of rainfall variation and rate of evaporation (if possible study of variation of daily data) of each district in different parts of year is necessary. The present article has no scope to analyze such data.

14.3 Possible applications of the article

The design of the storage tank for harvested rainwater, suggested in the present paper can be implemented in reality.

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