RAIN WATER HARVESTING

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1. INTRODUCTION

Water is essential for life on the planet, water resources have been a decisive factor in the growth and development of human civilization throughout the history. When India gained independence in 1947 its dominant long term objective was to build up its economy. For economic reconstruction and regeneration, agricultural development was to be accorded the highest priority, not only because the food production was to be substantially increased and has to keep pace with the expanding population but also because it was essential to build up the grass roots economy of a country more than 80% of whose people depend on agriculture or agricultural based activities for their livelihood and occupation (Table 1).

India receives an average rainfall of around 1050 mm which is the highest in the world among countries of comparable size, and should be sufficient enough to satisfy its ever increasing demand. But the temporal and spatial distribution of rainfall throughout the country is so erratic that drought and floods occurs frequently and simultaneously. Also the alarming rate of population growth at 2.11 percent has led to increasing pressure on the basic life supporting system. The utilization of water resources in the country has increased over the years.

2. WATER HARVESTING AND ITS NEEDS

Rainfall over India fluctuates widely. The advance of the monsoon into the country takes place in two main branches. The south west monsoon, June to September, is the principal rainy season whenever 75% of the annual rainfall is received all over the country.

There is large variation in rainfall from region to region, season to season and year to year. The normal annual rainfall which is as low as 100 mm in western Rajasthan is over 11000 mm at Cheerapunji in Meghalaya. The spatial unevenness and temporal variation in precipitation has led to complex situation

like the distinctly different monsoon and non-monsoon seasons and the high and low rainfall areas. The problem of large variation in water availability and growing demand leads to water harvesting.

Water harvesting refers to the deliberate collection of rain water from a surface (catchment) and its storage to provide a supply of water. Much of the early history of rainwater harvesting has its origin in Europe. The amount of drinking, cooking and washing water required was provided by collecting the water by rain harvesting and design were incorporated in the houses, for example, roofs and paved courts. The water harvesting in small reservoirs, silt traps, check dams, contour terracing and bordered gardens were important in ancient water harvesting techniques. For agriculture, the water management and water conservation were and being practised as water harvesting techniques.

Table 1: Statistics of irrigation development in India.

Period	Major & Medium Irrigation potential created 10^6 ha.	Minor Irrigation potential created 10^6 ha.
Upto 1951	9.70	12.90
Plan 1(1951-56)	2.49	1.16
Plan 2(1956-61)	2.14	0.73
Plan 3(1961-66)	2.23	2.22
Annual Plan(1966-69)	1.54	1.99
Plan 4 (1969-74)	2.60	4.50
Plan 5(1974-78)	4.12	3.80
Annual Plan(1978-80)	1.79	2.70
Plan 6(1980-85)	3.90	7.40
Plan 7(1985-90)	4.30	8.60

Source: Seventh five year plan (1985-90). Vol. II, Government of India, Planning Commission, New Delhi.

3. RAIN WATER HARVESTING FOR DRINKING WATER

Roof water harvesting is common in areas having high rainfall intensity well distributed in the year e.g. Himalayan areas, Northeastern States, Andaman Nicobar, Lakshadweep Islands, Rajasthan and southern parts of Kerala and Tamil Nadu.

Rain water harvesting is being increasingly followed for meeting the drinking water needs of rural areas particularly during the periods of drought. There are many methods available for harvesting of rain water. The method is site specific. Following steps are commonly followed in rain water harvesting from roofs.

1. Collection of rain water
2. Separation of first rain flush
3. Filtration of rain water
4. Storage of rain water
5. Distribution of water

A system normally used for the separation of first flash and for accumulation of sediment is shown in Fig. 1. Before supplying for human consumption the raw water from the pond should be filtered through a sand filter and kept in a PVC tank connected to a hand pump for withdrawal. In spite of certain limitations rainwater harvesting will be beneficial for providing drinking water to human beings as well as cattle in areas lacking alternative sources.

4. RAIN WATER HARVESTING FOR AGRICULTURE

The rain water harvesting is more so important because the country looses 50-60 percent of rainwater resulting in acute soil moisture deficit. In low rainfall area, it is not sufficient even to meet the crop sowing moisture requirements. Under these circumstances water harvesting techniques are the principal means of water conservation to enhance agricultural production.

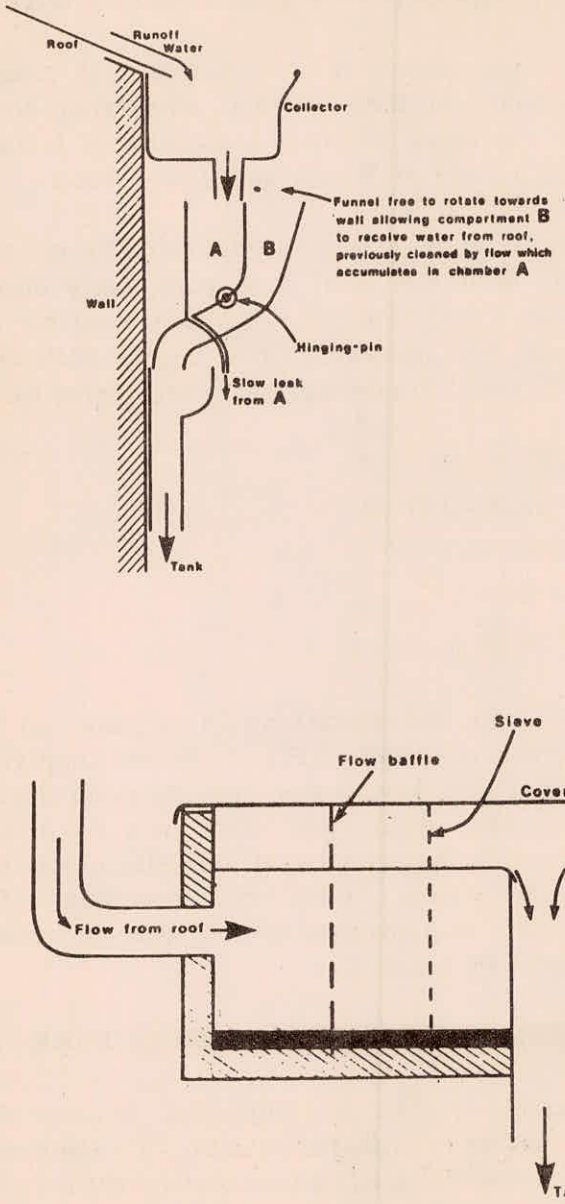
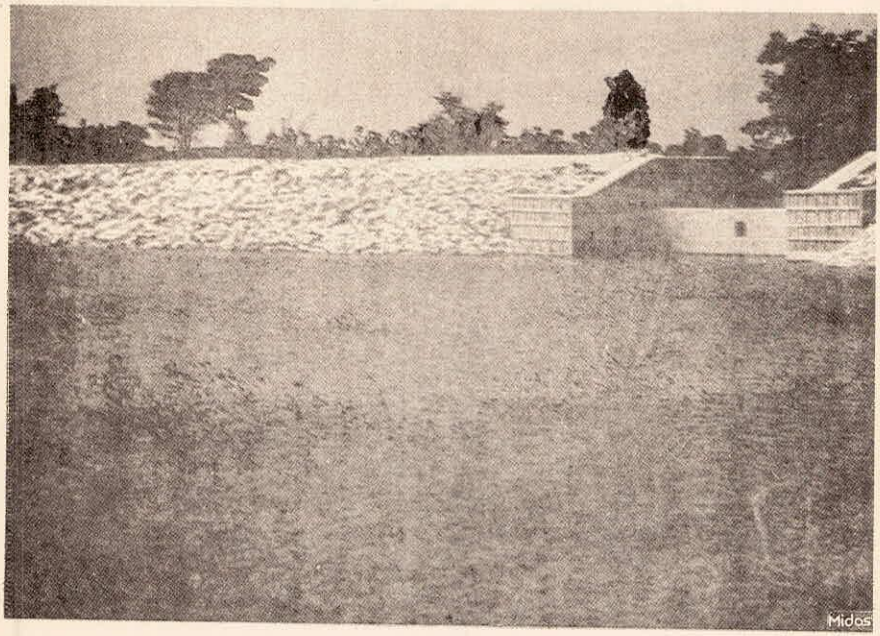


Fig. 1 : Roof water harvesting-A first flash separating and Sediment accumulation system.



SURFACE WATER STORAGE IN WATER HARVESTING

In arid regions where, not much opportunity exists for harvesting and storing of rain water, harvesting is done with the adoption of efficient measure of moisture conservation. Plastic sheet, butyl rubber and metal foil have also been used to cover the soil in water harvesting operations

4.1. Rain water harvesting by ground catchments and microcatchments

Rain water harvesting from ground catchments can be used to supply water for crops, wild life and livestock as well as for domestic use. The various means of increasing the runoff from an area can be classified as follows.

1. Cleaning sloping surface of vegetation and loose material
2. Improving vegetation management by changing ground cover

3. Mechanical treatment, including smoothing and compacting the surface, contour terracing and microwatersheds
4. Reducing soil permeability by the application of chemicals
5. Surface binding treatments to permeate and seal the surface
6. Covering the catchment with a rigid surface
7. Covering the catchment with a flexible surface

The precipitation over an uncultivated catchment is harvested and the runoff is used to cropped micro-watershed. Different method as; (a) Interrow water harvesting system, having micro catchments prepared with a two bottom ridge farming ridges and furrows and (b) modified inter-row water harvesting system having micro-catchments prepared with two opposite runs of single mould broad plough have been recommended.

The inter plot harvesting provide advantages over inter-row harvesting in improving the productivity. In the event of drought during life cycle of kharif, water harvesting becomes extremely useful to provide supplementary irrigation to the crop. In case of no drought, the stored water provide pre-sowing irrigation.

It has been found that the total production by cropping only two third of the field (leaving one third for microcatchments) by adopting the runoff farming is the same as obtained from conventional cropping on a flat surface. The runoff farming offers potential for increasing and stabilizing yield, thereby lowering the risk of crop failure.

4.2. Rainwater harvesting by land treatments

The conservation of moisture, particular in arid and semi arid regions is of most importance. In low rainfall area, the water is not sufficient to meet the crop water requirement. In such areas, there is need to increase the surface runoff in scanty rainfall areas by reducing the infiltration capacity of the soil

through different land treatments, which can be served for agricultural purposes in drought prone area. The various method being adopted for increasing runoff are as follows;

1. Cleaning sloping surface vegetation
2. Vegetation management
3. Reducing soil permeability by chemicals
4. Surface binding treatments

Land cleaning has been in existence as a runoff inducement method for thousands of years due to its simplicity. All the runoff can be utilized by surface cleaning on fairly impervious catchments. The surface treatments such as rock clearing smoothing and compacting are usually done in combination. For smooth catchments, runoff efficiencies ranging from 20-35% have been observed. In India the water yield by cleaning and vegetative management has not been well adopted. While adopting these methods for water yield it should be kept in mind that the water yield should not be erosive.

Vegetation Management can alter the water budget of watershed by modifying the hydrologic processes involved therein. The very concept that different vegetation covers have different evapotranspiration requirement, is used for vegetation management approach. The possible vegetation management strategies include conversion of areas immediately adjacent to stream channels to runoff-enhancing vegetation covers, clearing the forest or shrub cover in uniform or irregular strip cuts, and thinning overstorey densities. All available research works indicate that their is an increase in water yield when forests are converted to grassland. Vegetation management practices have significant potential to increase water yield from watersheds. However, the results reported so far have been mainly of studies conducted in small watersheds which may not be applicable directly to small catchments.

Strip farming is modification of microcatchment farming technique rather than having individual catchments, the farmed area is divided into a series of sloping terraced strips from which water will flow off into the farmed strips on either side.

4.3. Rain water harvesting by percolation tanks, injection wells and subsurface dams

In areas of declining trend of ground water, the artificial recharge of ground water is of great use in water harvesting. Ground water recharge involves augmenting the natural movement surface water into underground formations by some method of construction, by spreading of water, or by artificially changing natural conditions (Fig. 2 and 3). Variety of methods are adopted for it. Few methods are reported below;

1. Water spreading
2. Recharge through pit and wells
3. Induced recharge from surface water bodies

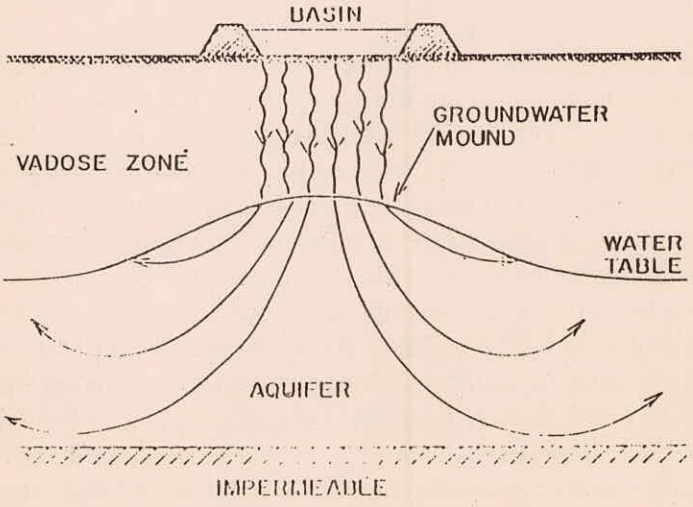


Fig. 2 : Water harvesting by percolation tanks.

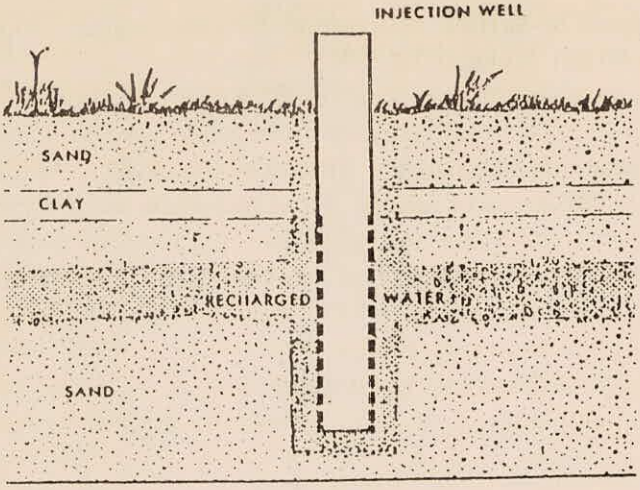


Fig. 3 : Water harvesting by injection wells.

Construction by percolation tanks is a technique useful for arid and semi arid regions in hard rock area. Low rainfall belt in Western India, which received monsoon rains only during the four months in a year, forms a typical area in which percolation tanks are constructed for water conservation. Rainfall in most of this region is between 300-700 mm. Geology, soils and site selection are much more critical for spreading or infiltration recharge system. A successful infiltration recharge system needs following aspects to consider;

1. Surface soil must be sufficiently permeable to maintain high infiltration rate.

2. Vadose zone must be permeable and free from clay layers or other fine materials that could restrict downward flow of water

3. Aquifer must be unconfined, permeable and thick enough to avoid excess amount of ground water mounts

4. There should be sufficient unpolluted surface water supply for percolation tanks

In India, studies on artificial recharge have been taken up in the states of Gujarat, Maharashtra, Andhra Pradesh, Madhya Pradesh, Tamil Nadu and Kerala. The effectiveness of method depends on the site condition and physical characteristics of soil profile. The selection of recharge site involves the consideration of following;

1. Availability of land and topography
2. Hydrological condition
3. Possible source of water for recharge
4. Operational maintenance
5. Economic consideration

The construction of ground water dams is not a new concept. Various small scale ground water damming techniques have been developed and adopted all over the world. The underground dams have following advantages over the surface dam structures.

1. No evaporation from storage takes place
2. No siltation in the reservoir takes place
3. The potential disaster like collapse of dam is not there

The identification of site for construction of dam is most important part and is selected considering the following aspects;

1. Developed in great scarcity area
2. Climatological, topographical and hydrological factors should be carefully considered
3. Technical possibility of dam construction

4.4. Rain water harvesting by mechanical measures

The rain water harvesting particularly in arid and semi-arid regions is of utmost importance. The rainfall distribution is not uniform and most of the rainfall is lost as runoff. In practice the rain water harvesting can be accomplished by such practices as farming practices, level terracing and contouring, mulching and selecting suitable crops. Such practices as contour farming and strip cropping are effective in water holding capacity. Terracing is a good water harvesting practice where the slopes are gentle enough so that the water can spread over a relatively large area. The greater the amount of mulch on the surface the greater the quantity of moisture conserved.

MECHANICAL MEASURES IN RAIN WATER HARVESTING

4.5. Rainwater harvesting by mulch and farming practices

Crop residues as surface mulches for water conservation have big potential. Relatively small amounts of residues may be effective in enhancing the infiltration and

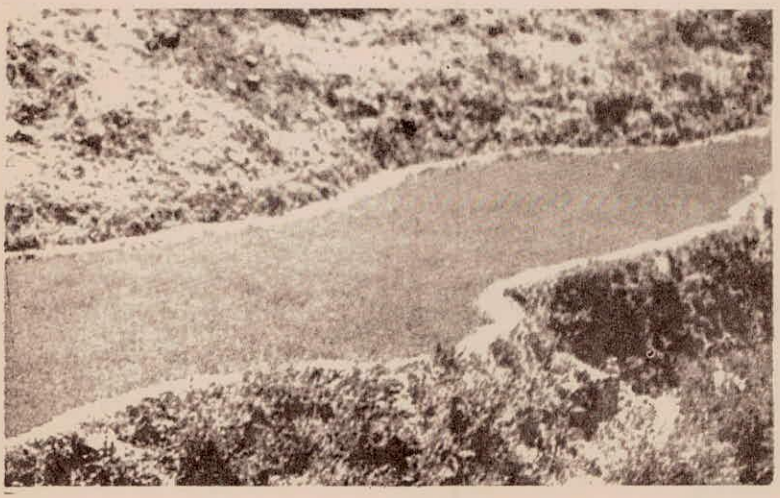
reducing runoff but larger amounts may be required to significantly cut down evaporation loss. Crop residues mulch are most effective in cutting down evaporation during wet season when there is sufficient moisture in soil and their effectiveness gradually decreases with time due to drying of soil unless the thickness of the residue mulch is increased considerably.

Another way of water harvesting is by employing farming practices measures which have great importance in arid and semi arid regions for crop production. In practice there can be accomplished by the following;

1. Contour farming
2. Strip cropping

The three general types of strip cropping are;

1. Contour strip cropping
2. Field strip cropping
3. Buffer strip cropping

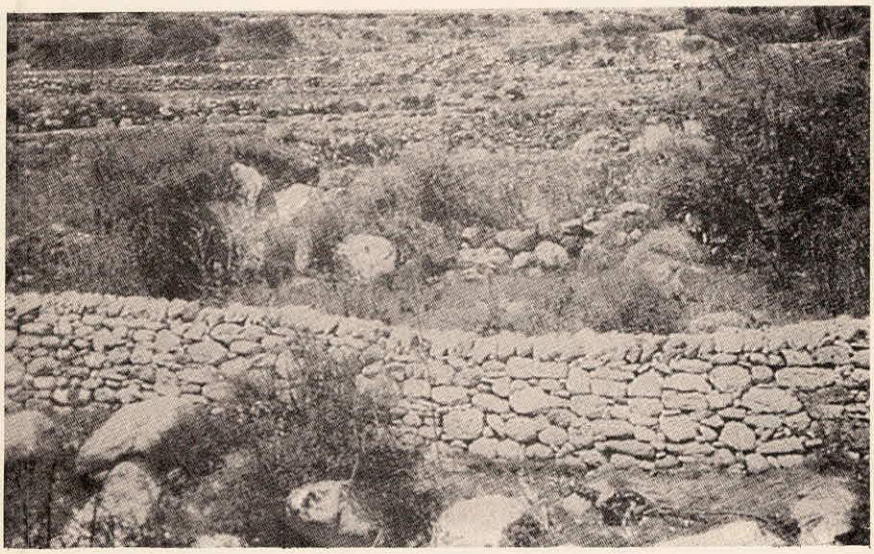


WATER HARVESTING BY CONTOUR FARMING

4.6. Water harvesting by engineering practices

The important types of water harvesting practices are;

1. Silt traps
2. Check dams
3. Bunds and terraces



USE OF SILT TRAP STRUCTURES IN WATER HARVESTING

Silt traps are built of stones across the beds of intermitted streams. The size of silt trap structure varies enormously. In order to asses the adequacy of silt traps one must consider two aspects: first its cost; and second, its effectiveness in harvesting run off. Few silt trap structures are shown in Fig. 4.

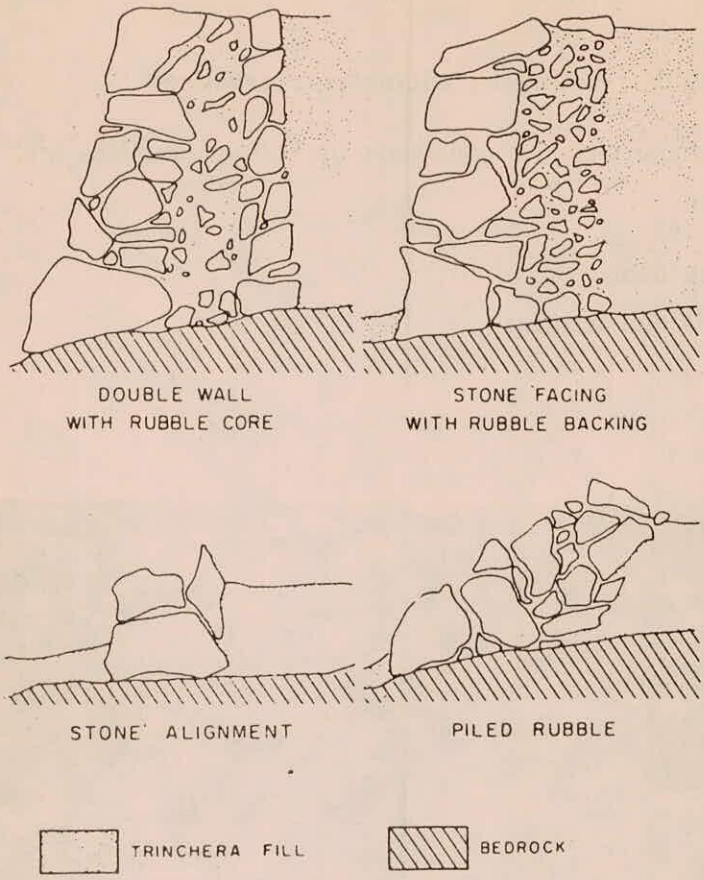


Fig. 4 : Silt trap Structures used for water harvesting

Check dams of varying design constructed for the purpose of stabilizing the grade and harvesting runoff water from large catchments, even under arid conditions. Check dams are made of locally available materials like brush, poles, woven wire; loose rock and plants or slabs. Temporary check dams constructed across the bed of a gully have two uses : (1) to collect enough soil and water to ensure the eventual growth of protective vegetation and (2) to check channel erosion until sufficient stabilizing vegetation can be established. Few temporary check dams are shown in Fig. 5, 6 and 7.

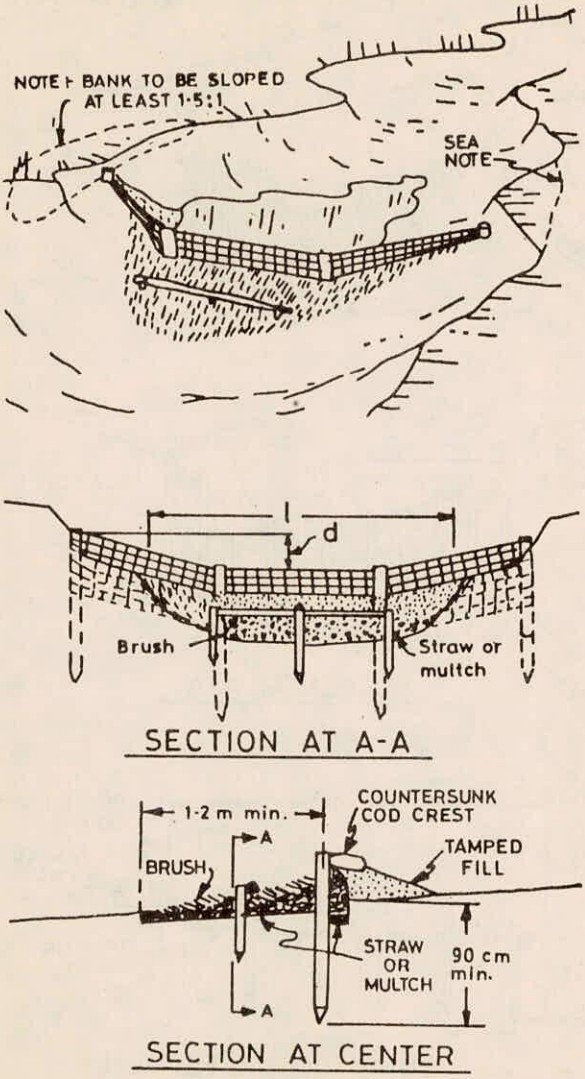


Fig. 5 : A Woven wire dam for water harvesting.

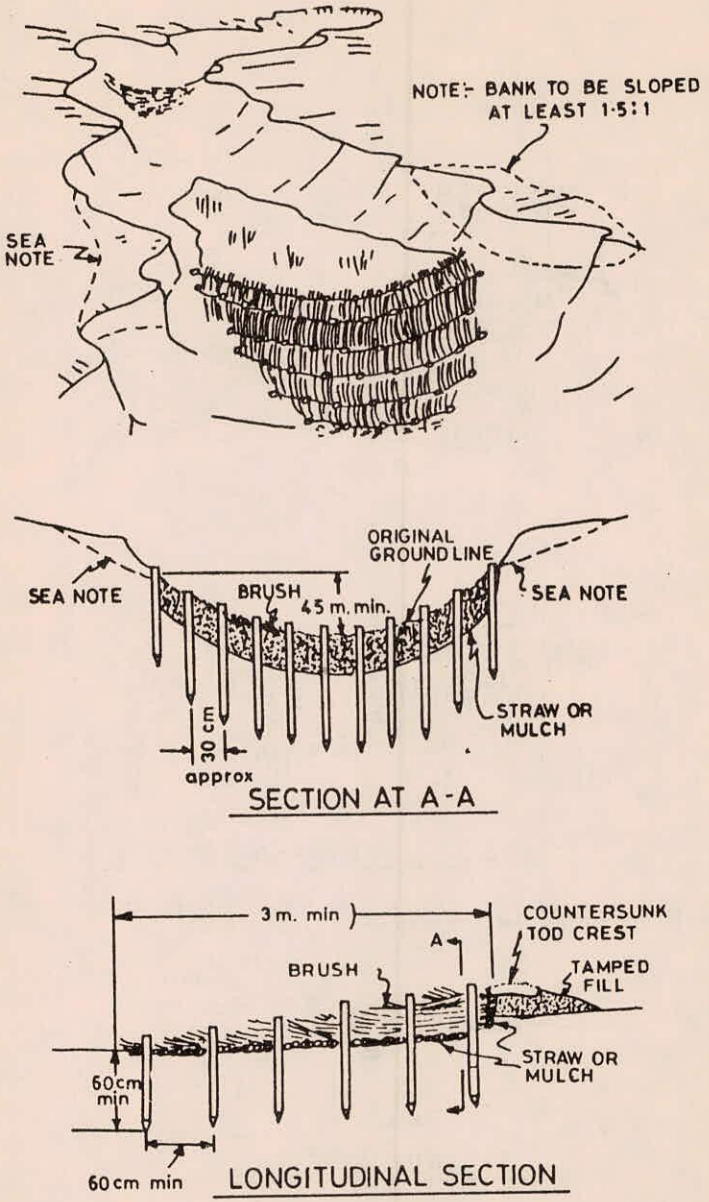
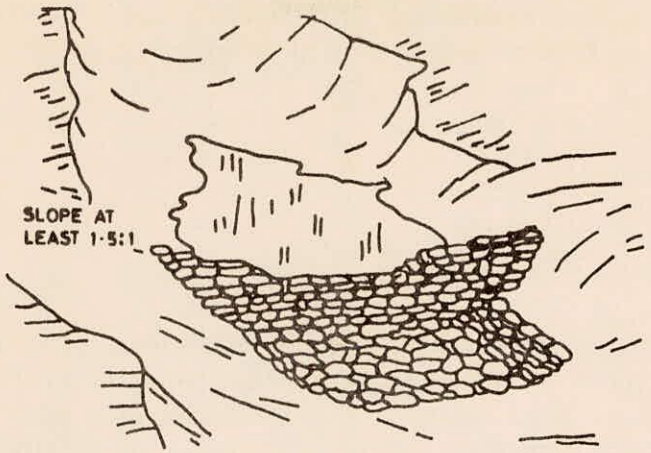
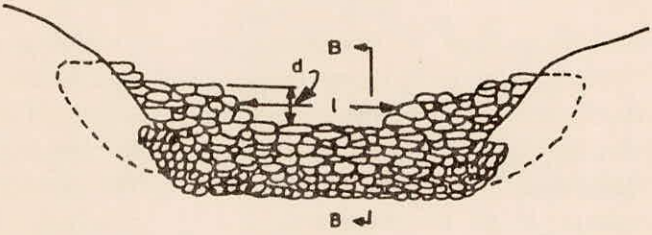
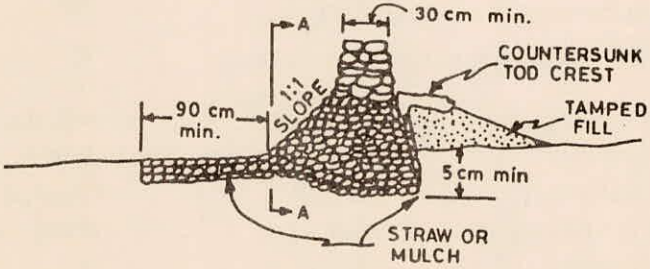


Fig. 6 : A brash dam for water harvesting.





SECTION AT A-A



SECTION AT B-B

Fig. 7 : A loose rock dam for water harvesting.

The life of temporary check dams depends on the quality of the materials and efficiency of construction; but under ordinary conditions, they should last from 3 to 8 years. The following are the check dams normally used in small catchments.

1. Woven-wire dams
2. Brush dams
3. Loose rock dams
4. Plank or slab dams

Bunding is by far the most effective and widely practiced field measure for water harvesting. It is the placing of small earthen dams across local streams to collect the rain water. The reservoirs so formed are called tanks. Tanks are usually shallow and the stored water covers a large area means a relatively large evaporation.

Bench terracing is one of the most popular water harvesting device on sloping and undulating lands. The water either stored in the soil of the cultivated land, or sometimes artificial storage facilities are provided. Most contour terraces are located on slopes of less than 25 percent. The following type of terraces are normally adopted and are shown in Fig. 8.

1. Level bench terrace
2. Inwardly sloping bench terraces
3. Outwardly sloping bench terraces

Condition of soil depth, slope, rainfall, farming practices, etc., have all a direct bearing on terrace design and therefore, very careful consideration should be given to all these factors while designing bench terraces. The design of bench terraces consists of the following;

1. Terrace spacing
2. Terrace grade length
3. Terrace cross section

A few recommended water harvesting structures in different agro climatic zone are reported in Appendix - I. An evaluation criteria for rainwater harvesting at a project site for domestic and agricultural purposes is reported in Appendix - II.

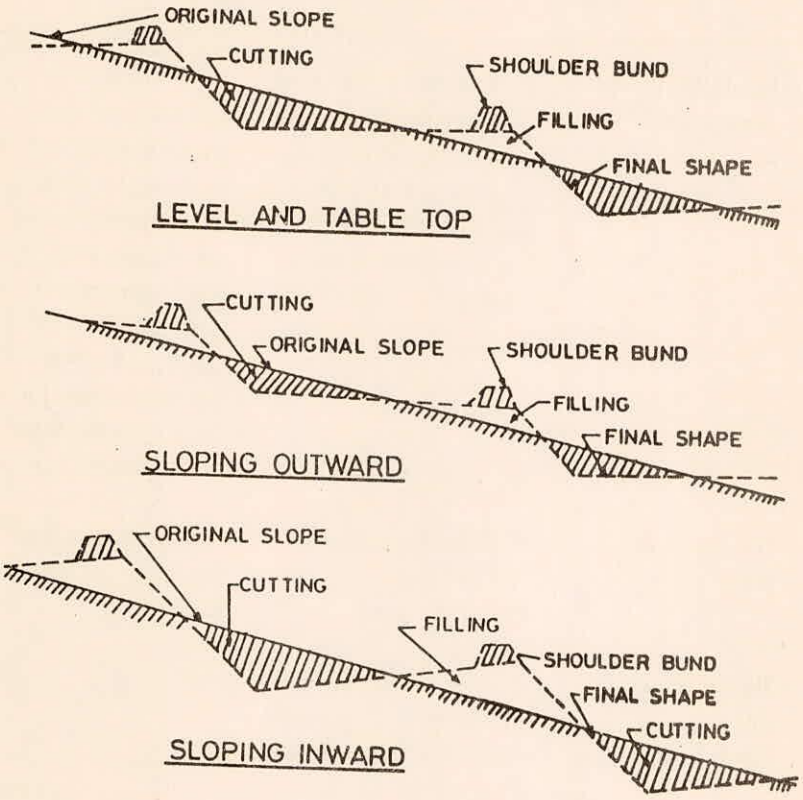


Fig. 8 : Type of bench terraces used for water harvesting.

***Note**: The information/ statistics presented in the brochure have been extracted from the published literature and all authors are hereby acknowledged.*

APPENDIX - I

Table 1: Recommended rainwater harvesting structures in Different Agro-climatic zones.

S.No.	Agro-climatic zone	State of the art	Recommendations
1	2	3	4
1.	Humid North-Western Himalayans	i) Roof water harvesting ii) Diversion of perennial springs and streams in storage structures iii) Village Pond iv) Collection from hill slope	Improvement in roof structures and use of proper material such as corrugated sheets for generating higher run off and with arrangement of foul slush diversion system and proper storage structure for checking water from contamination
2.	Himalayan foot-hills	i) Collections from hill slope ii) Village ponds	Improvement in roof top harvesting system as above
3.	Humid High Rain-fall North Eastern Zone	i) Roof Water Harvesting ii) Diversion of perennial springs and streams in a storage structure (tank)	- do -
4.	Humid Assam Bengal Plains	i) Tank ii) Anicut/check dam iii) Gully plugging	Improved design of tank for minimising evaporation and seepage losses, control of sediment load and water pollution

Contd.

5.	Sub-humid & humid Sutlej Ganga Alluvial zone	i) Pond ii) Check dam iii) Gully plugging iv) Contour bunding	- do -
6.	North-Western Semi-arid & Arid Zone	i) Nadi ii) Tanka iii) Khadin iv) Percolation tank v) Anicut vi) Gully plugging vii) Contour bunding	i) Adoption of improved designing of Nadi and Tanka ii) Sand filled reservoir iii) Subsurface barrier iv) Flat batter tank
7.	Central Semi-arid Vindhyan Zone	i) Pond ii) Check dam iii) Contour bunding iv) Gully plugging v) Subsurface dykes	Same as above
8.	High rainfall High runoff Chotanagpur Plateau	Same as 4	Same as 4
9.	Assured rainfall Deep Black soil Malwa Plateau & Narmada Basin	i) Ponds ii) Check dams iii) Subsurface dams	Improvement of Existing Systems
10.	Variable Rainfall South Central Deccan Plateau Zone	i) Pond ii) Check dam iii) Percolation tank iv) Bandhara v) Gully plugging vi) Subsurface dam vii) Contour bunding	i) Flat batter tank ii) Selection of suitable site and improvement of existing system, better water management
11.	Chhatisgarh Plateau Zone	Same as 10	Same as 10

Contd.

12.	South Eastern Brown/Red Soil Zone	i) Ponds/Tanks ii) Percolation tanks iii) Subsurface dams	Improvement of existing systems
13.	Southern Variable rainfall, Mixed Soil Zone	i) Pond/Tank/Kunta ii) Nadi iii) Check Dam iv) Percolation tank v) Subsurface dam vi) Gully plugging	i) Flat batter tank ii) Selection of suitable site and improvement of existing system for better water management
14.	Southern bi-model Rainfall Zone	i) Ponds/Tanks ii) Percolation Tanks iii) Gully plugging iv) Contour bunding v) Check dams	i) Improvement of existing System
15.	Eastern Coromandal	i) Pond/Tank/Kunta ii) Nadi iii) Check dam iv) Percolation Tank v) Subsurface Dam vi) Gully plugging	i) Adoption of improved design of Nadi and tank ii) Selection of suitable sites and improvement of existing system for better water management
16.	Western Malabar	i) Pond/Tank/Kunta ii) Check dam iii) Percolation Tank iv) Contour bunding v) Bandhara vi) K.T. Weirs vii) Subsurface Dam	i) Improvement in existing system, better water management ii) Construction of structures at suitable sites

Source: Anonymous, 1990. Rainwater harvesting, Deptt. of Rural Development, Ministry of Agriculture, Government of India, New Delhi, May 1990.

APPENDIX - II

Table 1: Evaluation criteria for rainwater harvesting at a project site where the water will be used for domestic purposes.

TECHNOLOGY	EVALUATION CRITERIA									
	Rainfall quantity	Siting and scale	Reliability	Cultural accept-ance	Cost (initial)	Maintenance required and durability	Cost effec-tiveness	Maximizes local input	Health aspects	Overall Score
Interception										
1 Roof										
2 Courtyard										
3 Ground										
Natural										
Prepared										
Selection										
1 Channel or Funnel										
2 Set. Tank										
Storage										
1 Jars										
2 Storage wells (above)										

Contd.

3 Cistern
4 Underground tank

Quality

1 Chemical
2 Nat.pro.
3 Covers
4 Filtration

Retrieval

1 Bucket
2 Hand pumps
3 Endless chain

Source: United Nations Environmental Programme, 1983. Water Resources Series Vol. 5, Stormwater Harvesting in Rural Areas. Tycooly International Publishing Limited, Dublin, Ireland.

Table 2: Evaluation criteria for rain and stormwater harvesting at a project site for agricultural use.

TECHNOLOGY	EVALUATION CRITERIA												
	Effective rainfall	Siting and scale	Reliable harvests	Cultural acceptability	Cost (initial)	Maintenance	Cost effectiveness	Maximizes local inputs: 1.labour 2.materials	Conservation measures	Associated erosion problems	Associated health problems	Water quality	Overall score
1 Contour Farming													
Type 1 (Terracing)													
Type 2 (deep furrows)													
Type 3 (other)													
2. **Silt Traps**													
Type 1 (simple)													
Type 2 (warping)													
Type 3 (other)													
3 **Check Dams**													
Type 1 (natural)													
Type 2 (prep.)													
Type 3 (haffirs)													
4 **Floodwater** Farming													

Contd.

	Farming
	Type 1
	Type 2
	Type 3 (other)
5	Micro-catchments
6	Dew harvesting
7	Other

Source: United Nations Environmental Programme, 1983. Water Resources Series Vol. 5, Stormwater Harvesting in Rural Areas. Tycooly International Publishing Limited, Dublin, Ireland.

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