INTRODUCTION

- The rain-fed agriculture contributes 58 per cent to world's food basket from 80 per cent agriculture lands (Raju *et al.* 2008).
- As a consequence of global population increase, water for food production is becoming an increasingly scarce resource, and the situation is further aggravated by climate change.
- The rainfed areas are the hotspots of poverty, malnutrition, food insecurity, prone to severe land degradation, water security and poor social and institutional infrastructure (Rockstorm *et al.* 2007).
- Watershed management is one such effective tool which addresses all these problems.

WATERSHED ?

- Geographic area through which water flows across the land and drains into a common body of water, whether a stream, river, lake or ocean.
- All the land on the earth is part of one or other watershed.
- Watershed is thus the land and water area (Geohydrological unit), which contributes runoff to a common point.

Conceptual Watershed Cross Section

WATERSHED ATLAS OF INDIA (ON 1:1 MILLION SCALE)

Water Resource Regions (WRR) wise Distribution of Different Basins

Basin Legend

- 1A- Sutlej
- 1B- Beas
- 1C- Ravi
- 1D- Chenab
- 1E- Jhelum
- 1F- Indus
- 1G- Ephemeral
- 2A- Lower Ganga
- 2B- Upper Ganga
- 2C- Upper Ganga
- 2D- Chambal
- 3A- Right Bank Brahmaputra upto Lohit confluence
- 3B- Left Bank of Brahmaputra
- 3C- Brahmaputra Tributaries Flowing into Bangladesh (Kalni,Surma)
- 3D- Eastern Parts of Manipur & Mizoram Draining into Chidwin(Burma)
- 4A- Cape Comorin to Cauvery
- 4B- Cauvery
- 4C- Cauvery to Krishna
- 4D- Krishna
- 4E- Godavari
- 4F- Godavari to Mahanadi
- 4G- Mahanadi
- 4H- Mahanadi to Ganges Basin
- 4I- Andaman and Nicobar Islands
- 5A- Southern Western Ghats
- 5B- Northern Western Ghats
- 5C- Tapti
- 5D- Narmada
- 5E- Mahi
- 5F- Sabarmati
- 5G- Southern Kathiawar
- 5H- Gulf of Kutch
- 5I- Lakshadweep
- 6A- Great Rann of Kutch & Luni
- 6B- Ephemeral(Barmer to Jaisalmer,Nagaur,Sikar)
- 6C- Ephemeral(Jaisalmer,Nagaur,Sikar)
- 6D- Ghaghar and old Saraswati

WATERSHED MANAGEMENT ?

- Watershed management basically refers to efficient management and conservation of surface and ground water resources and other natural (land, water, plant and animals) and human resources within the watershed.
- Watershed management emphasises on scientific soil and water conservation in order to increase biomass production.
- The process of creating and implementing plans, programs and projects to sustain and enhance watershed functions that affect the plant, animal and human communities within a watershed boundary.

Why Watershed Development ?

- Watershed Development as a means for increasing agricultural production in rainfed, semi-arid areas.
- There is nearly 85 million hectares of land as rainfed area in the country.
- These areas were bypassed by the Green Revolution and so experienced little or no growth in agricultural production for several decades.
- By capturing the water resources and improving the management of soil and vegetation, Watershed Development aims to create conditions conducive to higher agricultural productivity while conserving natural resources.

Objectives of watershed management

1. To control damaging runoff and degradation and thereby conservation of soil and water.
2. To manage and utilize the runoff water for useful purpose.
3. To protect, conserve and improve the land of watershed for more efficient and sustained production.
4. To protect and enhance the water resource originating in the watershed.
5. To check soil erosion and to reduce the effect of sediment yield on the watershed.

6. To rehabilitate the deteriorating lands.
7. To moderate the floods peaks at down stream areas.
8. To increase infiltration of rainwater.
9. To encourage restoration of ecological balance.
10. To enhance the ground water recharge, wherever applicable.
11. Promote the economic development of the village community.
12. To improve the socio-economic condition of the resource poor and disadvantaged sections of watershed community.

Factors affecting watershed management

a) Watershed characters

i) Size and shape
ii) Topography
iii) Soils
iv) Relief

b) Climatic characteristic

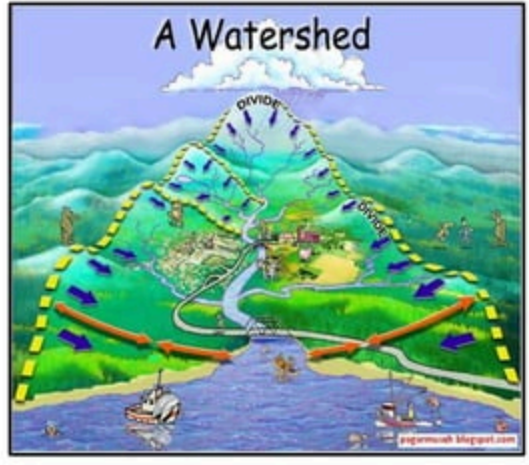
i. Precipitation
ii. Amount and intensity of rainfall

d) Land use pattern

i. Vegetative cover
ii. Density

e) Social status of inhability

f) Water resource and their capabilities.



TYPES OF WATERSHED

- Watersheds is classified depending upon the size, drainage, shape and land use pattern.

1. Macro watershed (> 50,000 Hect)
2. Sub-watershed (10,000 to 50,000 Hect)
3. Milli-watershed (1000 to10000 Hect)
4. Micro watershed (100 to 1000 Hect)
5. Mini watershed (1-100 Hect)

- For easy management generally 500 ha is taken as a watershed unit.

Activities in watershed (control measures)

A. Agronomical measures

1. **Strip cropping:** growing of few rows of erosion resisting crops and erosion permitting crops in alternate strips on contour with the objective of breaking long strips to prevent soil loss and runoff.

2. Contour cultivation:

- Involves all cultural practices such as ploughing, sowing, intercultivation etc. across the slope reduce the soil and water loss.
- Ploughing across the slope , each ridge and plough furrow and each row of the crop act as obstruction to the run off. Thus reduced soil and water loss.

3. Mulching:

- Protect the soil from direct impact of raindrop and reducing the sediment carried with runoff.
- A minimum plant residue cover of 30% is necessary to keep runoff and soil loss within acceptable limits.

4. Conservation tillage:

- low intensity tillage favours consolidation of soil and imparts erosion resistance.
- Practice of minimum tillage and zero tillage along with mulching are ideal for soil and water conservation.

5. Cropping systems:

- Prevent monocropping of erosion permitting crops.
- Intercropping or crop rotation with erosion resistant crops.
- Legumes (cowpea, green gram, horse gram, black gram) are effective for soil conservation due to their smothering effect.

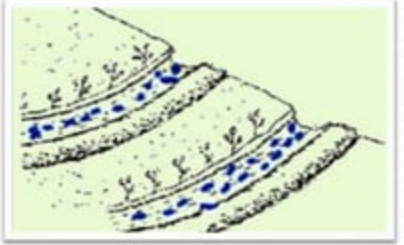
2. Engineering measures (Structural practices)

1. Contour bunds

- construction of bunds on contour to impound runoff water behind them so that it gets infiltrated into soil.
- Recommended for areas receiving less than 600 mm rainfall and slope up to 6% in agricultural lands.

2. Graded bunds or channel terraces

- Rainfall more tan 600 mm, where excess rain water has to be removed safely out of the field to avoid water stagnation.
- Water flows in graded channels constructed on upstream side of bunds.



3. Bench terracing

- consists of transforming relatively steep land into series of level strips.
- Field is made into series of benches by excavating soil from upper part and filling in the lower part of terrace.
- Normally practiced in 16-33 % slope range.

4. Construction of check dams

- A check dam is a small, sometimes temporary, dam constructed across a drainage ditch or waterway to counteract erosion by reducing water flow velocity.
- In turn, this obstruction induces infiltration rather than eroding the channel.

5. Construction of farm ponds

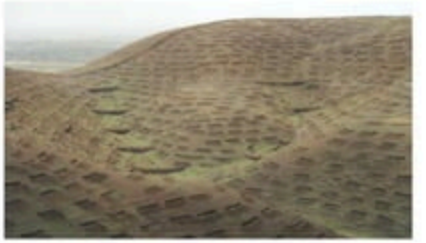
- A farm pond is a large hole dug out in the earth, usually square or rectangular in shape, which harvests rainwater and stores it for future use.
- It has an inlet to regulate inflow and an outlet to discharge excess water.
- Ideal size of farm pond 10m X 10m X 3m.
- Water from the farm pond is conveyed to the fields manually, by pumping, or by both methods.

6. Percolation pond:

- A percolation pond is a small water harvesting structure, constructed across a natural stream or water course to harvest and impound the runoff from the catchments for a longer time.
- To facilitate vertical and lateral percolation of impounded water into the soil substrata, thereby recharging groundwater storage in the zone of influence of the pond.

7. Contour trenches

- Contour trenching is an agricultural technique to allow for water, and soil conservation, and to increase agricultural production.



8. Micro catchments for sloping lands

- Micro catchments are simply ditches that concentrate surface runoff, thus reducing runoff and increasing infiltration to the.

RAIN WATER HARVESTING AND ARTIFICIAL RECHARGE TO GROUND WATER

- Rain Water Harvesting (RWH) - process of collecting, conveying & storing water from rainfall in an area – for beneficial use.
- The storage of rain water on surface is a traditional technique and structures used were underground tanks, ponds, check dams, Reservoirs etc.
- Recharge to ground water is a new concept of rain water harvesting and the structures generally used are pits, trenches, dug wells, Recharge wells and Recharge shafts.

RAIN WATER HARVESTING

- RWH - yield copious amounts of water. For an average rainfall of 1,000mm, approximately four million litres of rainwater can be collected in a year in an acre of land (4,047 m^2), post-evaporation.
- As RWH - neither energy-intensive nor labour-intensive.
- It can be a cost-effective alternative to other water-accruing methods.
- With the water table falling rapidly, RWH is the most reliable solution for augmenting groundwater level to attain self-sufficiency.

- **Pits** :- Recharge pits are constructed for recharging the shallow aquifer. These are constructed 1 to 2 m, wide and to 3 m. deep which are back filled with boulders, gravels, coarse sand.
- **Trenches**:- Trench may be 0.5 to 1 m. wide, 1 to 1.5m. deep and 10 to 20 m. long depending up availability of water. These are back filled with filter. materials.
- **Dug wells**:- Existing dug wells may be utilised as recharge structure and water should pass through filter media before putting into dug well.

- **Recharge wells** :- Recharge wells of 100 to 300 mm. diameter are generally constructed for recharging the deeper aquifers and water is passed through filter media to avoid choking of recharge wells.

- **Recharge Shafts** :- For recharging the shallow aquifer which are located below clayey surface, recharge shafts of 0.5 to 3 m. diameter and 10 to 15 m. deep are constructed and back filled with boulders, gravels & coarse sand.

INTEGRATED WATERSHED MANAGEMENT

- Involves integration of technologies within the natural boundaries of a drainage area for optimum development of land, water, and plant resources to meet the basic needs of people and animals in a sustainable manner.
- This approach aims to improve the standard of living of common people by increasing his earning capacity by offering all facilities required for optimum production (Singh, 2000).
- It suggests to adopt land and water conservation practices, water harvesting in ponds and recharging of groundwater for increasing water resources potential and stress on crop diversification, use of improved variety of seeds, integrated nutrient management and integrated pest management practices, etc.

WATERSHED DEVELOPMENT PROGRAMMES

- Watershed development originally managed by national wasteland development board under Ministry of Environment and forest.
- It is now placed under Ministry of Rural Development and Department of Land Resources.
- The main objective of these programmes is development of waste lands in non-forest areas, checking of land degradation, putting such waste land into sustainable use and increasing bio mass, availability of fuel wood, fodder and restoration ecology etc.
- Thus concept of watershed development is a integrated nurture with multi disciplinary activities in the area.

At present, there are six major projects/programmes in watershed development programme namely,

1. National Watershed Development Project for Rainfed Areas (NWDPRA)
2. Watershed Development in Shifting Cultivation Areas (WDSCA)
3. Drought Prone Areas Programme (DPAP)
4. Desert Development Programme (DDP)
5. Integrated Wasteland Development Project (IWDP)
6. Employment Assurance Scheme (EAS)

Table 1. Runoff volume and coefficient, sediment concentration, soil loss and sediment yield in treated and control sub-watersheds

Variable	sub watershed	Mean value	Mean standard error
Runoff volume (L	Treated	34.78	1.05
	Control	41.25	1.18
Runoff coefficient (%)	Treated	3.52	0.18
	Control	3.75	0.21
Sediment concentration (g/ L)	Treated	0.65	0.05
	Control	0.78	0.06
Soil loss (g)	Treated	24.15	2.02
	Control	31.93	2.67
Sediment yield (t ha-1)	Treated	0.011	0.001
	Control	0.014	0.001

Khamsan, Iran

Darvishan *et al.* (2016)

Table 2. Differences in variables reported by the interviewees in six tribal villages, three with and three without implementation of integrated watershed management programme in Thane district, Maharashtra, India.

Variable		IWMV (N=142) Number (%)	NWMV (N=144) Number (%)
Water availability			
Prolonged scarcity of water	Yes	20 (14)	126 (88)
	No	**122 (86)**	18 (12)
Average distance of water source <1000 m during scarcity period	Yes	**123 (87)**	103 (71)
	No	19 (13)	41 (29)
Hygiene and sanitation			
Bathing place	Home	85 (60)	59 (41)
	River	57 (40)	85 (59)
Practice of defaecation	Toilet	79 (56)	22 (15)
	Open air	63 (44)	122 (85)
others			
Migration	Yes	86 (61)	104 (72)
	No	56 (39)	40 (28)
		(N=90)	**(N=87)**
Discontinuation of girl-child education	No discontinuation	80 (89)	63 (72)
	Discontinuation	10 (11)	24 (28)

Thane, Maharashtra

Nerkar *et al.* (2015)