



# WATERSHED MANAGEMENT

Module 2 – (L7) Sustainable Watershed Approach  
& Watershed Management Practices

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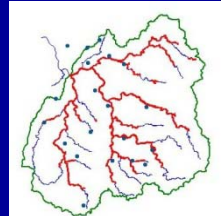
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Lecture No - 7

Watershed Management in Arid  
Regions & Strategic Planning

## L7– Watershed Management in Arid Regions & Strategic Planning

- **Topics Covered**
- Watershed Management Practices in Arid and Semi-arid Regions, strategies, Case study
- **Keywords:** Watershed management practices, Strategies, Arid region, Semi-arid region.



## Arid & Semi-arid Regions

- Drylands cover more than 60% of the earth's surface.
- Arid zones - described as a part of the drylands, & have most severe climatic conditions.
- Major distinguishing feature -the arid zone has low rainfall ( $< 500\text{mm}$  or Aridity Index  $< 0.20$ ) with more than 50% inter-annual variability.
- This makes - difference in terms of nature of ecosystem, socio-economic environment & challenges for sustainability.
- High wind and solar regimes further increase the effect of rainfall variability.

## Arid & Semi-arid Regions..

- Whole complexities makes a fragile ecosystem in which small disturbances may cause great loss to the sustainability, which are sometimes irreversible.
- Hot arid zones of the world are economically and environmentally disadvantaged, with unique problems.
- Ecosystems of these zones are highly fragile with large risks that cause.
- Severe impediments to development programs. Of the total land area in the world, arid zones cover 18.8%.
- These arid zones are diverse in terms of climate, soils, vegetation, animals, and the lifestyles and activities of the people.

## Arid & Semi-arid Regions...

- Little but variability in rainfall & presence of distinctive periods of drought are characteristics of arid tropics.
- Often, terms **drought & aridity** are used incorrectly.
- A drought is a departure from average or normal conditions - shortage of water adversely impacts on functioning of ecosystems, & people,
- Aridity - average conditions of limited rainfall & water supplies, not to the departures there from.

Extent of the arid zone in different continents of the world

Continent	Area (10 <sup>6</sup> hectares)	Percent of total
Africa	1175.5	46.1
Asia	903.0	35.5
Australia	303.0	11.9
Europe	11.0	0.4
North America	84.6	3.3
South America	70.2	2.8
<b>Total</b>	<b>2547.3</b>	<b>100.0</b>

## Arid & Semi-arid Regions - India

- Hot arid regions of India- covering an area of 31.70 mill. Ha, involving seven states: Rajasthan, Gujarat, Punjab, Haryana, AP, Karnataka, & Maharashtra.
- 11.8% of the country is under hot arid environment.
- Arid regions of Rajasthan, Gujarat, Punjab, & Haryana - constitute Thar Desert, - accounts for 89.6% of total hot arid regions of India.

. Distribution of arid regions in different states of India.

State(s)	Area (10 <sup>6</sup> hectares)	Percent of total
Rajasthan	19.61	61.0
Gujarat	06.22	19.6
Punjab and Haryana	02.73	09.0
Andhra Pradesh	02.15	07.0
Karnataka	00.86	03.0
Maharashtra	00.13	0.4
<b>Total</b>	<b>31.70</b>	<b>100</b>



Drought problem

## Issues in Arid & Semi-arid Regions

- In Arid & semi-arid regions: Desertification, land degradation & drought affect more than 2 billion people - situation might worsen due to climate change.
- 2.6 billion people (44%) are affected by desertification
- Population growth - 18.5 % in dryland areas in 1990s
- GDP in dryland areas is 50% lower than in non-dryland areas
- Natural regeneration of vegetation cover & soils in arid areas takes 5-10 times longer than in favorable areas with greater and more regular rainfall.

## Issues in Arid & Semi-arid Regions..

- Main agricultural land use types in dryland areas: cropland, irrigated land, and rangeland.
- Different land degradation problems occur depending on the type of land use.
- 55% of the gross value of food is produced under rainfed agriculture.
- Cropland in dry rainfed areas is used primarily by smallholder farmers to cultivate field and cash crops.



## Challenges in Arid & Semi-arid Regions

- Infertile soil
- Lack of water for irrigation
- Expansion of cultivated fields and diminishing of natural vegetation cover
- Insufficient amounts of organic material and nutrients
- Burning of organic material (harvest residue, brush fires)
- Soil erosion (wind and water)
- Free grazing, no clear land use rights
- Deforestation
- Poverty, Socio economic problems.

## Watershed Management **in Arid Regions**

- Integrated Watershed Management (IWM) provides - framework to integrate natural resource management with community livelihoods in a sustainable way.
- Addresses issues of degradation of natural resources, soil erosion, landslides, floods, frequent droughts and desertification, low agricultural productivity, poor water quantity and quality and poor access to land and related resources from an **IWM** perspective.

## Watershed Management in Arid Regions

- Mapping of SLM practices
- On-site and off-site interactions –eg: Dust storms originate on threaten people & livelihoods close by but far away.
- Highland-lowland interactions: People in arid areas are dependent on ecosystem services provided by highland areas. Eg. highlands - give water to surrounding lowlands.
- Regional interactions and rural-urban linkages
- Participation and community involvement:
- Planning for sustainable land management:
- Multi-functional use: helps to reduce risk through diversification, to promote synergies that produce added economic, ecological or social value, & to preserve & strengthen ecosystem services.

## Sustainable Land Management in Arid Regions

- SLM helps to:
- Increase food security, primarily for smallholder farmers
- Provide local energy
- Provide local fresh & clean water
- Mitigate soil degradation
- Increase soil moisture - soil development & functions
- Enhance primary production and nutrient cycling
- Preserve biodiversity at the farm level through agro forestry, intercropping, fallow, and preservation of locally adapted seed

## SLM in Arid Regions

- Preserve soil moisture (for plant production)
- Increase primary production
- Regulate river, lake and groundwater levels
- Regulate water discharge from highland to lowland areas, reducing Floods and increasing low flows
- Integration of crop production and livestock production - core of multi-functional land use.

## Multi-functional Land Use

- Production of food and cash crops is a priority.
- Irrigated land: Dryland areas with high potential for groundwater & surface water are used to cultivate crops, fruits & vegetables.
- Rangeland: Livestock production is the priority. Livestock management reduces risks, while rotation of grazing land ensures that vegetation cover is preserved.
- Dryland areas react with particular sensitivity to disturbances in the water and biomass cycles. Regulating and supportive functions are seriously affected by inappropriate management of the soil and the vegetation cover.

## Dry Land Management

- **Dryland areas** react with particular sensitivity to disturbances in the water and biomass cycles.
- Regulating & supportive functions – seriously affected by inappropriate management of soil and vegetation cover.
- **Biomass cycle:** Soil organic matter influence on multiple soil functions such as soil biodiversity, fertility, carbon storage, regulation of surface water flows & improved water quality.
- **Water cycle:** Reduction of soil cover (plants, litter & mulch) and of soil organic matter - starting point in vicious degradation spiral due to drastic disturbance of water cycle.
- **SLM practices** for better soil cover- improve biomass & water cycles, key to improve soil fertility & water availability.
- **No-tillage** with controlled traffic, Furrow-enhanced runoff harvesting, Rotational Grazing.

## WM Plans - Arid Regions

- Development of *in-situ* rainwater harvesting techniques - require less labor and maintenance
- Development of plant-based water absorbing/retaining materials
- Initiatives for widespread adoption of rainwater conservation techniques
- Improvement in traditional water harvesting systems
- Development of simple windbreak establishment techniques.
- *Exploring the potential of arid zone agro forestry as a tool for solving environmental problems.*
  - *Organic farming in virgin arid lands.*
  - *Eco-tourism.*



## WM Practices- Arid Regions

- **Run-off Farming:** system of growing crops on harvested & stored water in the farm - by earthen dam or a bund across the gentle slope of the farmland - Shallow, gravelly and rocky uplands for grazing - harvesting runoff water; Major components: water collecting area, contour bands (channels), moisture storage basins, impounding mechanism (bands, spillways & sluice) & a zone of cultivator's settlements.
- **Silvi-pasture:** used in areas rainfall below 200 mm/yr & food production is very difficult; On the other hand there are some grass species, e.g. *Cenchrus ciliaris*, *Lasiurus indicus* etc., well adapted to such climate and make natural rangelands. Tree species like *Prosopis cineraria* and *Zizyphus numularia* come up in these rangelands & make a silvipastoral system. Animals- cows, goats & sheep are part of this farming system.
  - Good example of sustainable management.

## WM Practices in Arid Regions

- **Agri-silviculture:** popular system in areas of rainfall 200-400 mm/yr. People protect naturally germinated seedlings of useful trees like *P. cineraria*, *Z. numularia*, *Tecomela undulata*, etc., come up in crop fields. Mixed cropping of pearl millet, moth bean, cluster bean and sesame is carried out under these trees. These trees do not compete with the crops but complimentary in terms of improving microenvironment.
- **Agri-Horticulture:** Based on experiments in research farms & farmer's fields, a new agri-horticulture system of jujube (*Ziziphus mauritiana*) inter-cropped with arid legumes e.g. clusterbean /mothbean /greengram developed for areas receiving rainfall of more than 250 mm. Agri-horticulture system found to give better & earlier production, year-round work and resilience to erratic rainfall.

## WM Practices in Arid Regions

- **Lay farming:** on one piece of land a rotation of grasses for 4-6 years, followed by food grain crops like pearl millet or legumes for 2-3 years & then land is left fallow for 2-3 years. Whole farm is divided into parts in such a way that every year all three practices, *i.e.* grass production, crop production and fallow, are available in one or another part.
- **Wind breaks/shelterbelts:** Wind erosion, high thermal regime & hot desiccating winds - serious problems, - affect the establishment, growth & yield of crops in arid areas. Mixture of trees & shrubs planted across the wind direction help in reducing wind speed.

## Watershed Management Techniques in Arid and Semi-arid Regions



- **Engineering or Structural Technologies**
- **Side Hill Ditches or Similar Diversion Structures**—typically separating higher, non-arable land from cultivated land below.
- **Contour Bunding or Ridges**—Built along the contour as part of the crop field layout from either stones or soil.
- **Grassed Waterways**—Carry away run-off that has been channeled by contour structures to a central down slope drain.
- **Terraces**—Radical conversion of sloped land into a series of graded steps approximating flat conditions.
- **Small-Scale Terracing**—Discontinuous use of terracing, usually small platforms on which to plant fruit trees.
- **Micro-Basins**—Pits or half-moon structures built in a pattern across the slope to trap rainfall, usually in drier areas.
- **Gully Plugs**—Barriers built perpendicular to slope across drainage ways to slow water run-off & contain transported soils & silt.

## Watershed Management Techniques in Arid Regions

- **Vegetative Treatment Measures**
- **Strip Cropping or Contour Farming** - Orienting ploughing & tilling along contour to avoid run-off & erosion.
- **Living Barriers**—Planted along the contour to trap or filter run-off and retain soil, such as contour hedgerows or grass strips.
- **Leguminous Cover Crops**—Fix nitrogen, raise organic matter content, and protect the soil, such as green manure or mulch.
- **Zero Low Tillage**—Crop residues left on site after harvest, while the next crop is dibbled into the soil with a minimum of disturbance.
- **Adjustments to Agronomic Practices** - Improved plant spacing & appropriate crop rotation, including inter-cropping.
- **Compost Application** - Improve the organic matter content of the soil, its tilth, and its ability to infiltrate rainfall.
- **Agro forestry Practices** - Addition of a tree crop to the farming system for conservation.

## Watershed Management & Strategic Planning

- Overall goal is alleviation of poverty & upgrading of living standards by means of sustainable development of water & water resources and conservation of the environment.
- The overall goal incorporates the three following main **mission goals**:
  1. **Manage**, develop and protect water and related resources to meet needs of current and future generations.
  2. **Operate**, maintain and rehabilitate facilities safely, reliably efficiently to protect the public investment.
  3. **Enhance** the organizational effectiveness of the water resources coordination system, & promote capacity-building.

## Strategic Planning - WM

- Identify priority watersheds
- Priority for watershed with critical conditions
- Population
- Storage reservoir, water intake or diversion dams
- Make best of available resources
- Control of soil erosion – Priority
- Agriculture productivity
- Optimization techniques
- People participation
- Poverty alleviation



## Watershed Management Strategies

- Set objectives – WM Plans
- Strategies to implement
- Implementation by individuals, Government, Group, NGO etc.
- **Preventive strategies:** -preserving existing sustainable land use practices: Establish & sustain preventive measures including land use practices - results in long term, sustainable resource development and productivity without causing land degradation
- **Restorative strategies:** - to overcome identified problems or to restore conditions in a watershed to a desirable level



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## Watershed Strategies

Problem	Possible Alternative solutions	Watershed Management objectives
Deficient water supply	<ul style="list-style-type: none"> <li>a) Reservoir Storage and transfer</li> <li>b) Water harvesting</li> <li>c) Reduce evapotranspiration</li> <li>d) Cloud seeding</li> <li>e) Pump from aquifer</li> </ul>	<ul style="list-style-type: none"> <li>➤ Reduce sedimentation</li> <li>➤ Localized collection and storage</li> <li>➤ Deep root to shallow rooted</li> <li>➤ More rainfall</li> <li>➤ Recharge</li> </ul>
Flooding	<ul style="list-style-type: none"> <li>a) Reservoir storage</li> <li>b) Construct levees channelization</li> <li>c) Re-vegetate</li> </ul>	<ul style="list-style-type: none"> <li>➤ Minimize sediment delivery</li> <li>➤ Minimize sedimentation</li> <li>➤ Plant more vegetation</li> </ul>
Energy Storage	<ul style="list-style-type: none"> <li>a) Utilize wood for fuel</li> <li>b) Hydropower</li> </ul>	<ul style="list-style-type: none"> <li>➤ Plant more trees</li> <li>➤ Reduce sedimentation</li> </ul>
Food Shortage	<ul style="list-style-type: none"> <li>a) Develop agro forestry</li> <li>b) Increase cultivation</li> <li>c) More live stock</li> <li>d) Import food</li> </ul>	<ul style="list-style-type: none"> <li>➤ More productivity, better crop</li> <li>➤ Restructure land</li> <li>➤ More grazing land</li> <li>➤ More economic dev.</li> </ul>

## Watershed Strategies

Erosion/ Sedimentation	a)Erosion control structure b)Contour terracing c)Revegetate	➤ Better structures ➤ Re-vegetate, stable slopes
Poor quality drinking water	a)Supply from wells and pumps b)Treat water supplied	➤ Protect groundwater from contamination ➤ Filter through wet land
Polluted streams	a)Control pollutants	➤ Buffer strips, vegetative cover etc.
Reduced fishery production	a)Treat waste water	➤ Use forest, wet lands etc.

## Typical WM Strategies

- Based on rainfall, temperature, soil, topography, cropping and farming systems and water resources
- **Examples for India:** Western – Himalayan Region
  - J&K, HP, U.P. Hills - Steep hilly land, mountains
    - **Thrust:** Water Conservation & use; Land use planning, crop diversification etc.
- Eastern Himalayan Region
  - Sikkim, Darjeeling, Arunachal, Meghalaya, Assam
    - High rainfall, high forest, soil erosion
  - Thrust:** Soil and water conservation, improvement of farming systems
- Lower Gangetic Plains – west Bengal
  - Frequent floods, poor water management
  - Thrust:** Irrigation development, crop productivity, improvement, livestock

## Typical WM Strategies...

- Eastern Plateau and Hills: Madhya Pradesh and Orissa
  - High rainfall, Soil erosion

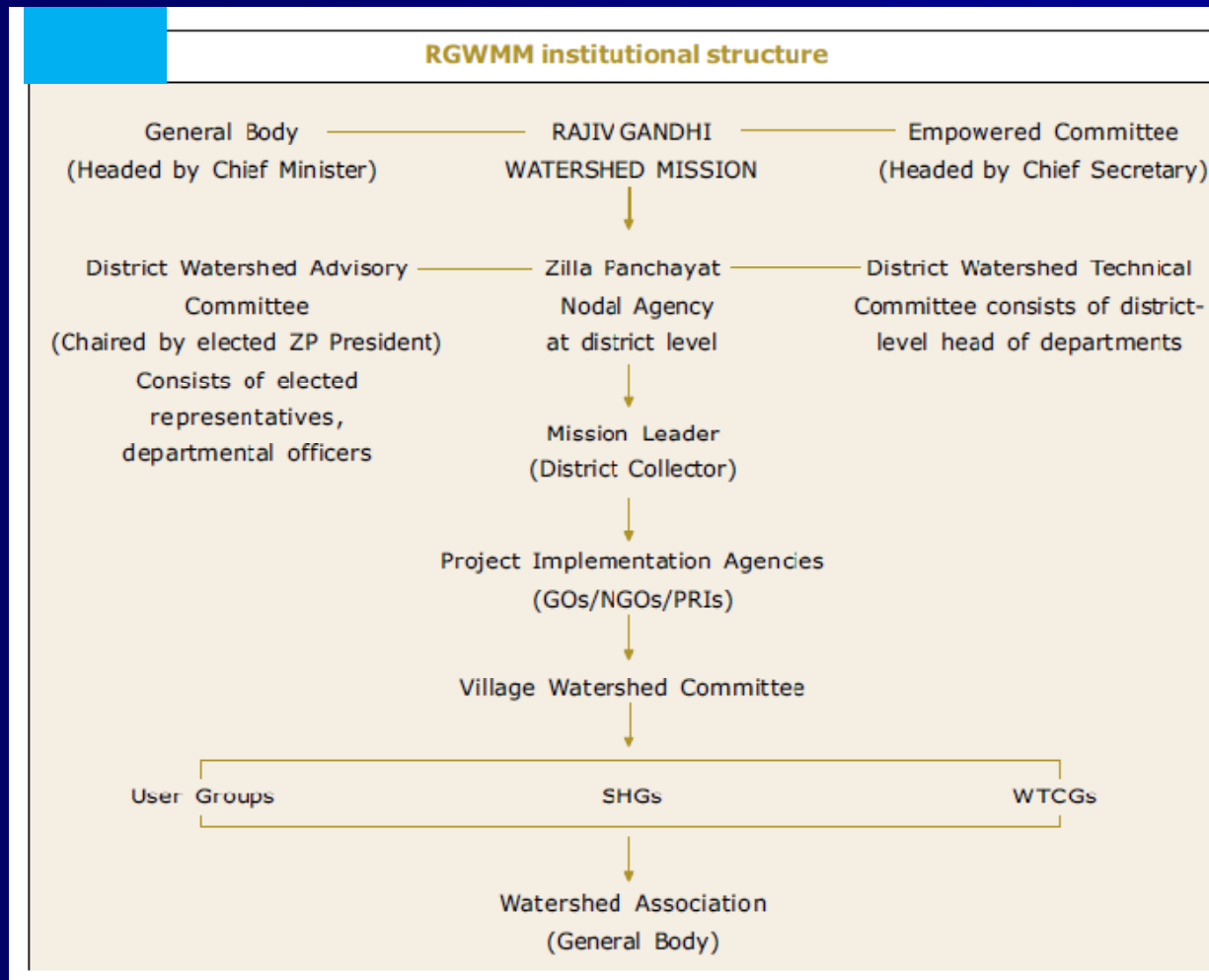
**Thrust:** Water conservation, irrigation development, soil correction etc.
- South Plateau and Hills: Andhra Pradesh, Karnataka and Tamilnadu - Rainfed farming

**Thrust:** Irrigation development, crop management

- Gujarat Plains and Hills
  - Arid zone, less rainfall, less irrigation

**Thrust:** Water conservation, dry land farms, water management, wasteland development
- Western Dry Region
  - Rajasthan
    - Deserts, sandy, less rainfall, high evaporation

# Typical Watershed Management Strategy – MP, India



## Case Study: Desert Rainwater Harvesting Initiative

- Need for the **Desert Rainwater Harvesting Initiative**: aimed at alleviating poverty & providing reliable water supply to some of remote populations in rural Rajasthan - grips of severe drought for the last few years.
- Project utilize traditional Rainwater Harvesting techniques - **sustainable model** drought affected areas.
- Rajasthan -desert state in India with 10% of area, but with 1% of water resources. Scarce and fragile water resources in this semi-arid environment are under threat from frequent droughts, increasing groundwater salinity & falling water tables.

<http://www.yogaindailylife.org/initiatives/rainwater-harvesting>

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## Case study: **Desert Rainwater Harvesting Initiative**

- Grass roots project aimed at alleviating poverty and providing a reliable water supply
- Outcome of Initiative- formation of global partnerships & establishment of a centre to promote Rainwater Harvesting for desert and semi-arid regions.
- **Rainwater Harvesting Solution**
- Created in response to increasing water crisis facing India's remote rural communities in Rajasthan & from requests from villages.
- Initiative aims - year round supply of fresh water for rural communities in drought affected areas - Lead Partner has a long standing presence and ongoing working relationship with local villages.
- Village Water Action Planning - Community Based Water Management

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<http://www.yogaindailylife.org/initiatives/rainwater-harvesting>



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## Case study: **Desert Rainwater Harvesting Initiative**

- NGO -International Sri Deep Madhavananda Ashram Fellowship - launched this initiative. It utilizes traditional Rainwater Harvesting techniques in conjunction with community based watershed management plans to provide a sustainable model to be used in drought affected areas
- Village Water Action Planning - **Community Based Water Management**
- Huge success – could change the face of many villages
- Many villages became self sufficient in water & food.



<http://www.yogaindailylife.org/initiatives/rainwater-harvesting>

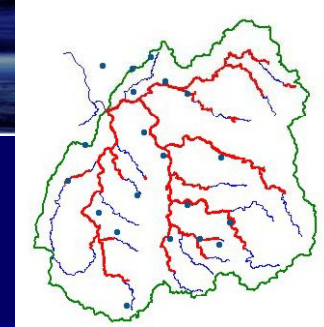
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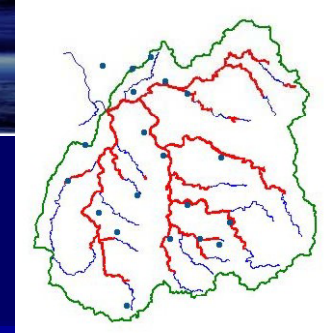
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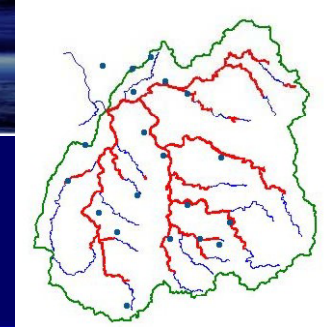
## Tutorials - Question!..?.

- **Illustrate the typical Watershed Management Strategies in different Agro climatic regions of India.**
- Identify the agro climatic region.
- Identify states
- Discuss the thrust areas
- Discuss possible watershed management plans.



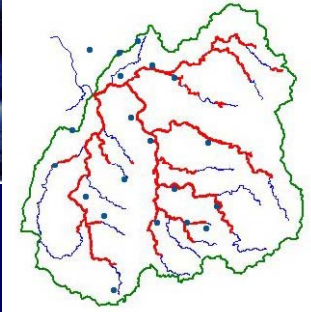
## Self Evaluation - Questions!.

- What are the land & water related problems in arid regions?.
- What are the major challenges related to watershed management in arid regions?.
- Discuss dryland management in arid regions.
- Illustrate watershed management strategies for various problems.



## Assignment- Questions?.

- Differentiate between drought & aridity.
- Illustrate soil erosion processes.
- What are the important issues in arid regions?.
- What are different types of water erosion?.  
Discuss each type?.
- What is the scope of Integrated Watershed Management in Arid Regions?.
- Discuss the importance of strategic planning in watershed management.



## Unsolved Problem!

- For an arid region of average annual rainfall of less than 250mm, prepare Watershed Management plan for Integrated Sustainable Development?.
- Identify the problems.
- Find out different options of sustainable land management.
  - Improving Water availability
  - Improving agricultural production
  - Reduce soil/ wind erosion & suggest scientific methods for soil conservation

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# THANK YOU

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