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Sustainable Watershed Management in Dryland Areas

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Watershed management is an integrated approach for conserving and efficiently utilizing land, water, soil and biological resources within a defined drainage area. It is particularly important in dryland areas, where water scarcity, soil erosion, drought, desertification and land degradation constrain agricultural productivity. The major objective of watershed management is to improve the sustainable food, fodder, fuel, fruits, fibre and other agricultural resources production while simultaneously maintaining ecosystem stability. It emphasizes the judicious use of land according to its natural capacity and maintaining adequate vegetative cover to minimize degradation. In-situ moisture conservation and rainwater harvesting are important strategies for reducing runoff, improving infiltration and ensuring water availability during dry periods. Soil and land conservation measures including bunding, bench terracing, gully control, vegetative barriers, afforestation and agrostological measures help minimize soil erosion and conserve moisture. Intercropping, crop rotation and alternative land-use systems enhance productivity per unit area, time and resources. Watershed management also contributes to groundwater recharge, flood control, drought mitigation and reduction of siltation in reservoirs. Integrated crop, livestock, tree and labour systems can improve long-term income and livelihood security in dryland regions. In India, watershed development programmes such as IWDP and NWDPR have supported integrated management of rainfed and degraded areas. In Gujarat, the Gujarat State Watershed Management Agency plays an important role in implementing watershed development programmes through institutional and community participation. Overall, watershed management provides a sustainable framework for improving agricultural productivity, conserving natural resources and strengthening the resilience of dryland ecosystems and rural livelihoods.

Keywords: Contour bunds, Soil conservation, Watershed, Watershed Management

Introduction

Watershed management is an integrated approach for the sustainable development and conservation of land, water and biological resources within a defined drainage area. A watershed represents a geographical unit in which rainfall and surface runoff are naturally collected and conveyed towards a common outlet such as a river or other water body. Dryland areas are particularly vulnerable to water scarcity, soil erosion, land degradation, drought and declining agricultural productivity. Erratic rainfall, high runoff, inadequate soil moisture retention and recurrent droughts further intensify the constraints to agricultural production in these regions. In addition, overgrazing, deforestation, improper land use, shifting cultivation and excessive exploitation of natural resources contribute to the degradation of watershed ecosystems. Therefore, efficient management of rainwater, soil and vegetation is essential for improving the resilience and productivity of dryland farming systems. Watershed management seeks to conserve natural resources while enhancing the sustainable production of food, fodder, fuel, fruits, fibres, fish and milk. A major objective is

to utilize land according to its inherent capability and maintain adequate vegetative cover to protect soil from degradation. Conservation of rainfall at the point where it falls is particularly important in dryland agriculture for improving soil moisture availability. Excess runoff can be safely diverted and stored in suitable structures such as farm ponds for use during periods of water scarcity. Such interventions improve groundwater recharge, reduce runoff losses and enhance the availability of water for agricultural and other productive activities (Hadded *et al.*, 2026). Soil and moisture conservation measures are also important for reducing erosion and maintaining soil fertility in fragile dryland environments. Hydrological practices aim to reduce runoff velocity, increase the contact time of water with soil and enhance infiltration into the soil profile. In-situ moisture conservation techniques such as ridges and furrows, tied ridging, dead furrows, compartmental bunding and broad-bed systems help retain rainfall within agricultural fields. Land management practices including bunding, terracing, trenching, gully control and vegetative barriers further minimize soil and water losses. Bunding along natural contours helps control erosion, while compartmental bunding is particularly useful for maximizing rainfall capture under semi-arid and desert conditions. Bench terracing reduces slope length and consequently decreases the erosive force of flowing water on sloping lands. Gully control structures such as brush check dams, rock dams and concrete check dams help regulate the velocity of runoff and minimize channel erosion. Vegetative barriers, afforestation and agrostological measures provide additional protection by reducing runoff and intercepting the impact of rainfall on soil. Crop management is another important component of watershed development, involving appropriate selection of crops and varieties according to local soil and climatic conditions. Proper sowing time, nutrient management, weed control and irrigation practices can improve crop productivity and water-use efficiency under moisture-limited conditions. The integration of bio-inputs such as mycorrhizae and rhizobium can support vegetation establishment in degraded and arid environments and improve tolerance to water stress. Intercropping and crop sequences can increase productivity per unit area, time and water while improving the efficient utilization of available resources. Alternative land-use systems can also bring marginal lands into productive use and reduce pressure on vulnerable natural resources. In India, watershed development programmes have played an important role in promoting integrated management of rainfed and degraded lands. The Integrated Watershed Development Project was initiated in 1989 to address wasteland development, followed by the National Watershed Development Programme for Rainfed Areas during 1990–91. In Gujarat, the Gujarat State Watershed Management Agency functions as the state-level nodal agency for implementing watershed development programmes, now associated with PMKSY-WDC. Thus, watershed management provides a holistic framework for conserving soil and water, restoring degraded ecosystems and improving agricultural productivity in dryland regions. Its successful implementation can strengthen livelihood security, enhance resilience to drought and floods, generate employment and promote long-term ecological and economic sustainability. Consequently, integrated watershed management is an important strategy for sustainable agricultural development and efficient natural resource management in dryland areas.

Watershed

A watershed is an area of land and water that is separated by a boundary, where all the rainwater and runoff flows into a single outlet, such as a river or other body of water.

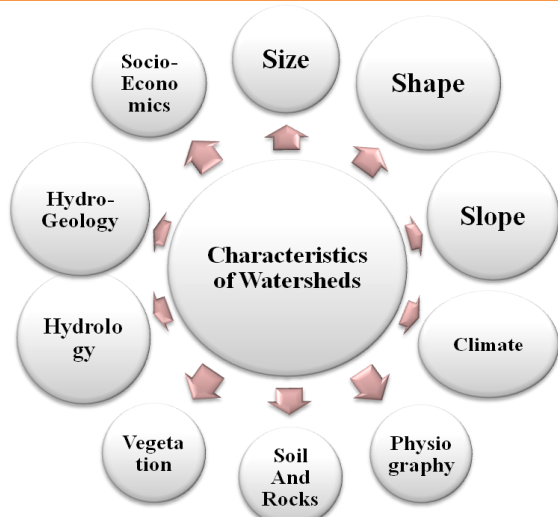
It is also referred to as a catchment area or a drainage basin.

Why Watershed Management?

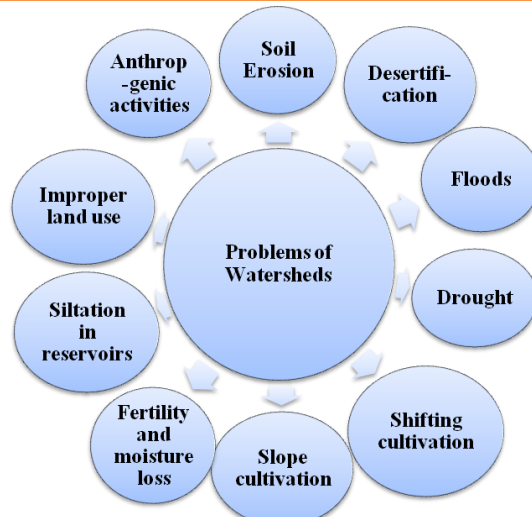
- To increase the sustainable production of food, fodder, fuel, fruits, fibers, fish, and milk.
- To prevent the overuse of natural resources by controlling excessive activities like overgrazing.
- To make farm operations and follow-up programs more efficient by ensuring easy access to different locations within the watershed. (Anonymous)
- To store water at suitable locations for various uses.

- To protect wild animals and native plant species in specific areas.
- To prevent floods and reduce the risk of droughts.
- To ensure the safety of the ecosystem.
- To promote economic stability.
- To create employment opportunities.
- To recharge groundwater.
- To prevent soil erosion and reduce silt accumulation in multi-purpose reservoirs.
- To provide recreational opportunities.

Characteristics of Watersheds: A watershed has specific boundaries and includes various landforms and water bodies.



Problems of Watersheds: Watersheds can face challenges such as overuse of resources, soil erosion, water scarcity, and environmental degradation.

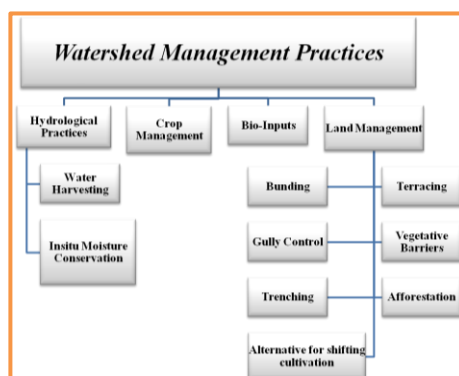


Principles of Watershed Management:

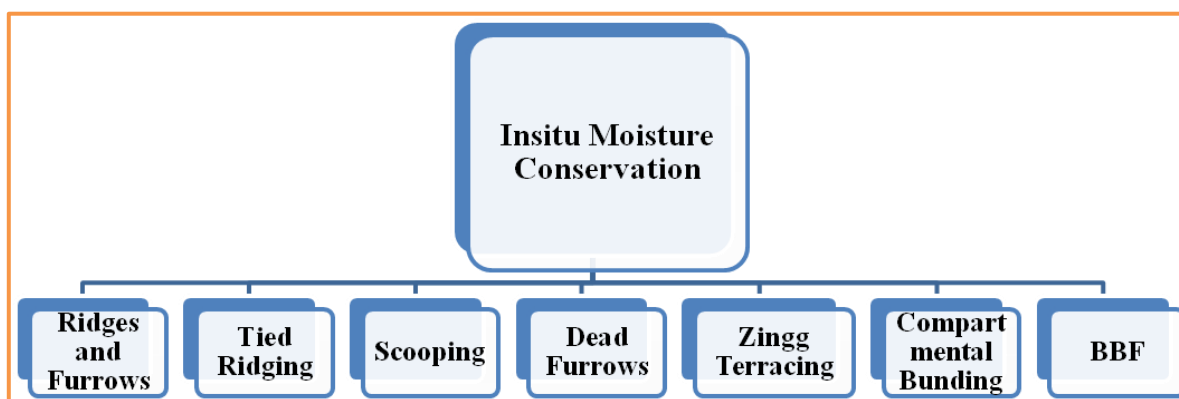
- Using land in a way that matches its natural capacity.
- Providing adequate plant cover to protect the soil.
- Conserving as much rainwater as possible where it falls, especially in farmland and public areas.
- Managing excess water by directing it safely to storage ponds for later use.
- Preventing gully formation and controlling erosion by installing barriers at suitable intervals.
- Maximizing productivity per unit of area, time, and resources.
- Increasing crop yield and land efficiency through intercropping and crop sequences.
- Using marginal lands by adopting alternative land use practices.
- Ensuring the sustainability of ecosystems that benefit humans, animals, plants, land, and water.
- Maximizing long-term income from integrated crop, livestock, tree, and labor systems.

Components of Watershed Management/ Practices

1. **Hydrological Practices/In-situ Moisture Conservation and Water Harvesting:** The main goal of hydrological practices is to reduce runoff, increase the contact time of water with the soil, and thereby enhance water infiltration into the ground.
2. **Crop Management:** This involves selecting the right crops and varieties based on local climate and soil conditions, along with proper timing of sowing, fertilizer use, weed control, and irrigation.



3. **Bio-Inputs:** Applying bio-inputs such as mycorrhizae, rhizobium, and organic chemicals like Bactrin, Natrin, and Phospin helps accelerate vegetation growth in degraded areas, especially in arid and industrial regions.



These inputs help improve plant resistance to water stress and chemical imbalances.

4. Land Management/Soil Conservation

- **Bunding:** Constructing bunds along the natural contours of the land helps control erosion effectively. This method is commonly used in well-drained red soils in areas with low rainfall. There are three types of bunding: graded bunding, inter-bunding, and compartmental bunding. Graded bunding uses a 0.2% slope to manage overland flow. Inter-bunding leaves gaps between beds to help retain more rainfall. Compartmental bunding divides the land perpendicular to the contours to maximize rainfall capture in semi-arid and desert conditions.
- **Bench Terracing:** Converting steep land into level platforms along the slope reduces erosion by shortening the slope length. Bench terraces can be level, sloped in or out, and are typically used on slopes between 16% and 33%.
- **Gully Control:** Temporary barriers like brush check dams, rock dams, and permanent structures such as chute spillways and concrete check dams are used to reduce channel erosion by controlling water flow speed.
- **Vegetative Barriers:** Planting rows of crops along contours helps slow down runoff and control erosion.
- **Afforestation:** Planting trees and shrubs helps intercept rain, reducing the impact of raindrops on the soil.
- **Agrostological Measures:** Using grasses to stabilize waterways, contour bunds, and the sides of bench terraces helps control erosion and protect against wind.

Programmes for Watershed Development in India

- The Integrated Watershed Development Project (IWDP) was initiated by the National Wasteland Development Board (NWDB) in 1989.
- The National Watershed Development Programme for Rainfed Areas (NWDPA) was launched in 1990-91 under the Ministry of Agriculture. It is implemented in 25 states and 2 union territories, based on the principles of integrated watershed management and sustainable farming. (Anon., 2009)
- The financial pattern of the NWDPA follows the pattern of the Ministry of Panchayati Raj (MMA), with a 90:10 split between Central and State Governments.
- However, in North Eastern states, it is entirely funded by the Central Government.

Programmes for Watershed Development in Gujarat (Commissionerate of Rural Development, Government of Gujarat)

The Gujarat State Watershed Management Agency (GSWMA) has been established to function as a State Level Nodal Agency (SLNA) for implementing the Integrated Watershed Management Programme, now known as PMKSY-WDC, in the state.

GSWMA is a non-profit organization run by a Governing Body that includes the Principal Secretary/Secretary of the Rural Development Department as the Chairperson, alongside senior officials from the Government of Gujarat.

The management of GSWMA includes: the CEO, a group of professional specialists in various fields such as Finance, SMC, GIS, MIS, Capacity Building, Monitoring and Evaluation, along with other Administrative personnel.

GSWMA is situated in the state capital Gandhinagar within Dr. Jivraj Mehta Bhawan. District Watershed Development Units (DWDUs) have been established in every district to implement the PMKSY-WDC at the district level.

- District Tier (DWDU): Each district of Gujarat has a DWDU. The DWDU is a branch of the GSWMA and does not function as a standalone entity.
- Project Level (PIA): The relevant DWDUs might recommend PIAs for executing IWMP in their districts. The GSWMA will make the decision on this matter. The PIAs may include any institution or organization as indicated in the watershed guidelines.
- Local Community: At the village level for executing the project, a Village Watershed Committee (VWC) is formed, consisting of a President, a secretary and/or an accountant, along with a minimum of 8-10 additional members representing different class and caste groups, as well as women. This committee must be registered according to the Society Registration Act of 1860.

Conclusion

Watershed management is an essential approach for sustainable development of dryland areas, where water scarcity, soil erosion, drought and land degradation are major constraints. Effective management of rainwater and soil moisture can improve water availability, soil productivity and agricultural sustainability. Practices such as water harvesting, in-situ moisture conservation, bunding, terracing, gully control, vegetative barriers and afforestation help minimize runoff and soil erosion. Appropriate crop management and the use of bio-inputs further support vegetation establishment and productivity in degraded lands. Integrated crop, livestock, tree and other land-use systems can enhance resource-use efficiency and provide long-term economic benefits. Successful watershed development also requires active participation of local communities and coordinated institutional support. Thus, integrated watershed management can contribute significantly to drought resilience, natural resource conservation, ecosystem protection and sustainable livelihoods in dryland regions.

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