SKU JOURNAL OF ENGINEERING RESEARCH Vol-3 Issue-3
(NATIONAL PEER REVIEWED E-RESEARCH JOURNAL)
(July – September 2026)
E-ISSN 3048-930X

Watershed Management and Sustainable Water Resource Development in Chhatarpur District, Madhya Pradesh

[1]Aditya Lakhera
[2]Chetan Mishra
Assistant Professor
Department of Civil Engineering
Shri Krishna University, Chhatarpur (M.P.)

ABSTRACT

Watershed management is an integrated approach to conserving soil and water resources through the scientific management of land, drainage networks, vegetation, and surface runoff. Chhatarpur district of Madhya Pradesh lies in the Bundelkhand region, where rainfall variability, seasonal water scarcity, groundwater dependence, and land degradation create important challenges for sustainable development. This review examines watershed management practices and their potential contribution to sustainable water resource development in the district. The paper reviews regional hydrogeological conditions, rainfall-related challenges, soil and water conservation techniques, groundwater recharge structures, and participatory watershed development approaches. It also discusses the role of contour bunding, check dams, percolation tanks, farm ponds, vegetative measures, and integrated watershed planning in reducing runoff and improving water availability. Official groundwater assessments and published studies are used to identify regional conditions and research needs.

The review indicates that watershed interventions should be selected according to local geology, slope, soil characteristics, drainage patterns, groundwater conditions, and community requirements. A combination of engineering structures, vegetation-based conservation, demand-side water management, and long-term monitoring can support more sustainable water resource development. The paper proposes a location-specific framework for Chhatarpur district and identifies priorities for future research, planning, and implementation.

KEYWORDS

Watershed management, Chhatarpur, Bundelkhand, groundwater recharge, rainwater harvesting, soil conservation, water resource development, sustainable agriculture.

1. INTRODUCTION

Water is an essential natural resource for human survival, agricultural production, industrial development, and ecological stability. The increasing demand for water, irregular rainfall, land degradation, and

over dependence on groundwater have made sustainable water resource management a major challenge in many parts of India. Watershed management is an important approach for addressing these challenges through the integrated development and conservation of land and water resources. A watershed is a geographical area in which rainfall and surface runoff drain toward a common outlet, such as a stream, river, lake, or reservoir. Watershed management involves the planned use of soil, water, vegetation, and other natural resources within this drainage area. Its main purpose is to reduce soil erosion, conserve rainwater, improve groundwater recharge, increase vegetation cover, and support sustainable livelihoods.

Chhatarpur district is situated in the Bundelkhand region of Madhya Pradesh. The region experiences considerable seasonal variation in water availability, and rural communities depend on rainfall, groundwater, tanks, ponds, and other surface water sources for domestic and agricultural purposes. The district's varied geological formations and groundwater conditions require locally appropriate approaches to water conservation. The Central Ground Water Board (CGWB) has prepared an aquifer mapping report for Chhatarpur district covering its eight assessment blocks, providing a technical basis for understanding aquifer characteristics and planning groundwater management.

1.1 Background of the Study

The Bundelkhand region is characterized by variable rainfall, periods of water stress, and substantial dependence on seasonal water resources. In such conditions, rainwater may be lost through surface runoff when its movement is not adequately managed. At the same time, excessive extraction of groundwater can reduce the reliability of water supplies during dry periods.

The development of watershed-based conservation measures can help improve the retention, infiltration, and productive use of rainfall. Such measures may include:

- Construction and rehabilitation of check dams and small water-retention structures.
- Contour bunding and field-based soil conservation.
- Development of farm ponds and percolation tanks.
- Restoration of traditional ponds and drainage channels.
- Vegetative barriers and afforestation in suitable locations.
- Groundwater recharge and monitoring.
- Community-based planning and maintenance.

The effectiveness of these measures depends on site conditions and their integration within the entire watershed.

1.2 Need for the Study

The need for the present review arises from the importance of sustainable water management in a region where water availability is strongly influenced by rainfall and groundwater conditions.

The major reasons for undertaking this study are:

1. To understand watershed management requirements in Chhatarpur district.
2. To examine the relationship between rainfall, surface runoff, groundwater recharge, and agricultural water availability.
3. To review engineering techniques used for soil and water conservation.
4. To identify the suitability and limitations of different watershed interventions.
5. To propose an integrated framework for sustainable water resource development.
6. To identify research gaps relevant to civil engineering and regional water planning.

1.3 Aim and Objectives

Aim

To review watershed management techniques and develop a location-specific framework for sustainable water resource development in Chhatarpur district, Madhya Pradesh.

Objectives

- To review the geographical, climatic, and hydrogeological characteristics relevant to watershed management.
- To examine existing approaches to rainwater conservation and groundwater recharge.
- To evaluate the potential role of civil engineering structures in reducing runoff and soil erosion.
- To discuss integrated watershed planning for agricultural and domestic water requirements.
- To identify technical, institutional, and environmental challenges.
- To recommend future research and monitoring strategies for sustainable watershed development.

2. STUDY AREA: CHHATARPUR DISTRICT, MADHYA PRADESH





2.1 Geographical Setting

Chhatarpur district is located in the northern part of Madhya Pradesh and forms part of the Bundelkhand geographical region. Its landscape includes agricultural fields, rocky uplands, settlements, seasonal drainage channels, and areas with varying soil depth and vegetation cover. These characteristics influence the movement of rainfall across the land surface. The amount of runoff generated within a watershed depends on rainfall intensity, slope, soil permeability, vegetation, land use, and the condition of

the drainage network. The district's natural drainage systems provide opportunities for watershed-based water conservation, provided that structures are planned according to catchment characteristics and downstream requirements.

2.2 Geological and Hydrogeological Characteristics

The district has a diverse geological setting. The District Environment Plan identifies formations including Bundelkhand Granite, Bijawar limestone, Vindhyan sandstone and shale, basaltic lava flows, and alluvium.

Madhya Pradesh Pollution Control Board

The geological characteristics influence groundwater occurrence, storage, movement, and recharge. In hard-rock areas, groundwater availability may be controlled by weathered zones, fractures, joints, and other secondary porosity features. In sedimentary formations, groundwater conditions may differ according to the permeability and thickness of the formations. Consequently, groundwater recharge structures should not be located solely on the basis of visible surface runoff. Geological and hydrogeological investigations are required to determine whether a proposed location can effectively store or transmit recharge water.

2.3 Groundwater Resource Conditions

The District Environment Plan reports a historical groundwater resource assessment based on 2013 data. It identifies three blocks as safe and five as semi-critical under that assessment. The reported district-wide stage of groundwater development was 62.92%. Madhya Pradesh Pollution Control Board

These figures are historical and should not be interpreted as the current groundwater status. A later groundwater resource assessment for 2022, reproduced in the available material, indicates that groundwater development conditions and block classifications changed in subsequent assessments.

2.4 Rainfall and Water Availability

Rainfall is a major source of replenishment for surface water and groundwater resources in the district. However, total annual rainfall alone does not determine water availability. The timing, intensity, duration, and spatial distribution of rainfall also influence runoff, infiltration, and storage. High-intensity rainfall can generate substantial runoff, particularly where soil infiltration is limited or land surfaces are compacted. Conversely, low-intensity rainfall may contribute more effectively to infiltration under suitable soil and land-cover conditions. A published study by Sahu, Sahu, and Jain examines Chhatarpur rainfall records from 1950 to 2020 and discusses statistical rainfall analysis and its implications for groundwater recharge. Bulletin of Pure and Applied Sciences-Geology For watershed planning, rainfall data should be examined alongside groundwater levels, soil characteristics, land use, and stream flow measurements.

3. REVIEW OF LITERATURE

The literature on watershed management in Bundelkhand and Chhatarpur provides information on groundwater conditions,

rainfall variability, artificial recharge, and community-based water conservation. This section reviews selected studies and identifies their relevance to sustainable water resource development.

3.1 Aquifer Mapping and Groundwater Management

Mathur and Paramasivam (2018) prepared the Aquifer Mapping Report: Chhatarpur District, Madhya Pradesh under the Central Ground Water Board. The report covers groundwater-related characteristics across the district's eight blocks and includes information on aquifer characteristics, geology, rainfall, drainage, water levels, and groundwater resources.

3.2 Rainfall Analysis and Groundwater Recharge

Sahu, Sahu, and Jain (2021; published online in 2025 according to the journal page) examined rainfall data for Chhatarpur district over the period 1950–2020. The study discusses statistical parameters, regression analysis, rainfall trends, and their relationship with groundwater recharge. It recommends rainwater harvesting and artificial recharge as measures for addressing water supply challenges.

3.3 Hydrogeology of the Bhadar River Basin

Kulkarni (2008) documented hydrogeological observations in the Bhadar river basin in Nowgong block, Chhatarpur district. The work was associated with groundwater management and community capacity-building activities.

3.4 Groundwater Quality in the Banne Watershed

A study on groundwater quality in the area around Banne watershed in Chhatarpur examined water suitability for drinking and irrigation. The research discussed rainfall variability, groundwater dependence, and water-quality concerns, including nitrate and fluoride.

3.5 Groundwater Management Interventions in Bundelkhand

A 2021 study published in the Journal of Hydrology: Regional Studies investigated groundwater management interventions in degraded landscapes of Bundelkhand. It reported improvements in groundwater resilience and agricultural activity associated with rainwater-harvesting interventions in the studied community-scale watershed.

3.6 Government Guidelines for Artificial Recharge

The Central Ground Water Board identifies rural rainwater-harvesting options such as contour bunds, gully plugs, gabion structures, percolation tanks, check dams, recharge shafts, dugwell recharge, and subsurface dykes. It emphasizes that artificial recharge requires appropriate site selection and technical design.

4. RESEARCH METHODOLOGY

4.1 Research Design

The present study adopts a descriptive and analytical review methodology. It synthesizes information from published research, government groundwater reports, technical guidelines, and regional watershed studies. The review focuses on

the relationship between watershed characteristics, water conservation measures, groundwater recharge, and sustainable development. No new field measurements, laboratory tests, or original hydrological simulations are claimed in this paper. The proposed framework is intended to guide future field-based research and engineering planning.

4.2 Sources of Information

The review uses the following categories of information:

1. Central Ground Water Board reports and technical publications.
2. Madhya Pradesh Pollution Control Board district environmental information.
3. Published research on rainfall analysis in Chhatarpur.
4. Hydrogeological studies from the Bhadar basin and surrounding areas.
5. Research on groundwater management interventions in Bundelkhand.
6. Technical literature on soil and water conservation and artificial recharge.

5. MAJOR WATERSHED MANAGEMENT CHALLENGES IN CHHATARPUR

5.1 Rainfall Variability and Seasonal Water Scarcity

Rainfall variability can cause fluctuations in water availability. Periods of intense rainfall may generate rapid runoff, while prolonged dry periods can reduce the availability of water for agriculture and domestic needs. A watershed development programme must therefore account for both flood-related runoff and dry-season water requirements.

5.2 Groundwater Dependence

Groundwater is an important resource for irrigation and domestic water supply. Excessive dependence on groundwater without adequate recharge and demand management can increase the vulnerability of communities during dry periods. The district's groundwater assessments demonstrate the importance of evaluating resource conditions at the block level rather than relying exclusively on district-wide averages.

5.3 Soil Erosion and Land Degradation

Runoff flowing across exposed or poorly protected land can detach and transport soil particles. This process may reduce soil fertility, damage agricultural fields, and increase sedimentation in downstream water bodies.

6. WATERSHED MANAGEMENT TECHNIQUES FOR CHHATARPUR DISTRICT

Contour Bunding



Contour bunding involves constructing small embankments approximately along contour lines to reduce the speed of

surface runoff and retain water within agricultural fields.

Engineering principle

Contour bunds interrupt the natural flow of runoff down a slope. By reducing flow velocity, they can encourage infiltration and reduce soil erosion.

Potential applications

- Agricultural fields on suitable gentle slopes.
- Areas with sufficient soil depth for bund construction.
- Locations where runoff can be safely retained or released.

LIMITATIONS

Contour bunds require proper alignment, stable construction, and provision for safe overflow. They may be unsuitable on certain steep slopes or where waterlogging could damage crops.

Check Dams and Nala Bunds



Check dams are small barriers constructed across suitable drainage channels to slow runoff and temporarily store water.

Functions

- Reduce the velocity of flowing water.
- Store runoff for local use.
- Encourage infiltration where subsurface conditions permit.
- Reduce downstream sediment movement when properly designed.
- Support groundwater recharge in suitable locations.

Design considerations

The design of a check dam should consider catchment area, design rainfall, peak discharge, sediment load, foundation conditions, spillway capacity, and downstream safety. A check dam should not be assumed to recharge groundwater merely because water is stored behind it. The amount of recharge depends on the underlying geology and hydraulic conditions.

Percolation Tanks



Percolation tanks are shallow water-storage structures designed primarily to promote infiltration into suitable subsurface formations.

Main benefits

- Increase the time available for infiltration.
- Support groundwater recharge where permeable formations are present.

- Reduce a portion of rapid runoff.
- Provide localized ecological and agricultural benefits.

Site suitability

Potential sites should be investigated for soil permeability, geological formations, catchment characteristics, and groundwater conditions.

Sediment control is important because excessive deposition may reduce infiltration capacity.

Farm Ponds



Farm ponds are small storage structures used to collect runoff for agricultural and other approved local uses. They can support supplementary irrigation, livestock water requirements, and short-term water storage. However, farm ponds may experience significant water loss through evaporation and seepage.

Their design should include appropriate storage capacity, embankment stability, inlet protection, and safe overflow arrangements. Farm ponds should be integrated with efficient irrigation systems to avoid unnecessary water consumption.

Gully Plugs and Gabion Structures



Gully plugs and gabion structures are used in small drainage channels to reduce runoff velocity and control erosion. Gabion structures generally consist of stone-filled wire mesh units. They can be suitable for certain small channels where their stability, foundation conditions, and hydraulic capacity are verified.

These structures may help:

- Reduce gully erosion.
- Retain sediment.
- Slow runoff.
- Support local channel stabilization.

They require regular inspection because wire damage, foundation scour, and excessive sediment accumulation can reduce performance.

Vegetative Measures and Afforestation

Vegetative measures complement engineering structures by protecting soil surfaces and improving watershed stability.

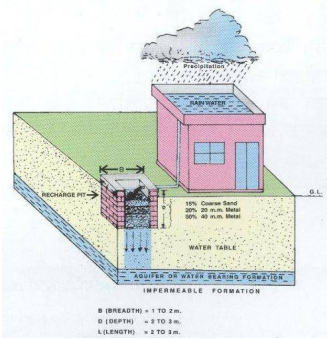
Examples include:

- Grass strips and vegetative barriers.
- Tree planting in suitable degraded areas.
- Protection of natural vegetation.
- Agroforestry and farm-boundary planting.

- Restoration of riparian vegetation where appropriate.

Vegetation can reduce soil detachment, improve surface roughness, and contribute to soil structure development. However, plant species should be selected carefully to avoid excessive water consumption or competition with crops.

Rooftop Rainwater Harvesting



Rooftop rainwater harvesting can supplement water conservation in houses, schools, colleges, offices, and public buildings. The system generally includes a roof catchment, gutters, downpipes, a first-flush arrangement, filtration, and a storage or recharge facility. CGWB identifies recharge pits, trenches, shafts, and wells among the available urban rainwater-harvesting approaches.

CONCLUSION

Watershed management is an important approach for sustainable water resource development in Chhatarpur district, Madhya Pradesh. The region's rainfall variability, groundwater dependence, and diverse geological formations require integrated and location-specific water management strategies.

The literature reviewed in this paper demonstrates the importance of aquifer mapping, rainfall analysis, hydrogeological investigations, and water conservation planning. Engineering techniques such as contour bunding, check dams, percolation tanks, farm ponds, gully plugs, and rooftop rainwater harvesting can contribute to water conservation when appropriately designed and maintained.

However, no individual structure can ensure sustainable water availability across the entire district. Effective watershed management requires the integration of engineering interventions with soil conservation, vegetation restoration, groundwater monitoring, efficient water use, and community participation.

The review identifies important research needs in recharge quantification, GIS-based watershed prioritization, sedimentation, water quality, climate-resilient design, and long-term project evaluation. Addressing these gaps through field investigations and interdisciplinary research can support better watershed planning in Chhatarpur. In conclusion, a scientifically planned, community-supported, and continuously monitored watershed management

framework can contribute to improved water security, agricultural resilience, soil conservation, and sustainable regional development in Chhatarpur district.

REFERENCES

1. Mathur, L. K., & Paramasivam, K. (2018). Aquifer Mapping Report: Chhatarpur District, Madhya Pradesh. Central Ground Water Board, Ministry of Water Resources, Government of India. Official publication.
2. Sahu, O. P., Sahu, P., & Jain, P. K. (2021). Rainfall Data Analysis and Environmental Impacts Study of Chhatarpur District, Central India. Bulletin of Pure and Applied Sciences—Geology, 40F(2). Journal article.
3. Madhya Pradesh Pollution Control Board. (2021). District Environment Plan: Chhatarpur. Government of Madhya Pradesh. District Environment Plan (PDF) .
4. Kulkarni, H. (2008). Observations Regarding the Hydrogeology of the Bhadar River Basin, Nowgong Block, Chhatarpur District, Madhya Pradesh. Advanced Center for Water Resources Development and Management. Research report.
5. Central Ground Water Board. (2003). Rain Water Harvesting Techniques to Augment Ground Water. Government of India. Technical publicatio .
6. Central Ground Water Board. FAQ: Groundwater Recharge and Rainwater Harvesting. Ministry of Jal Shakti, Government of India. Official technical guidance .
7. Building Resilient Agricultural System through Groundwater Management Interventions in Degraded Landscapes of Bundelkhand Region, Central India. (2021). Journal of Hydrology: Regional Studies, 37, 100929. Research article .
8. Assessment of Water Quality for Drinking and Irrigation Use in Area Around Banne Watershed of Chhatarpur District, Madhya Pradesh, India. Research paper .
9. Government of India, Central Ground Water Board. Dynamic Ground Water Resources of India—2022. Madhya Pradesh assessment information. Assessment material .
10. Government of India. (2024). Lok Sabha: National Aquifer Mapping and Artificial Recharge Initiatives. Parliamentary document