IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Groundwater Conservation Through Staggered Trenches And Dugout Ponds: A Case Study In Muddanur Village, Muddanur Mandal, YSR Kadapa District, A.P.

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Abstract

Groundwater depletion has emerged as a critical challenge in the semi-arid regions of Andhra Pradesh, particularly in the Rayalaseema region. **Muddanur** Gram Panchayat (GP), located in Muddanur mandal of YSR Kadapa district, faces irregular rainfall, high runoff, and declining water tables. This paper explores the application of staggered trenches and dugout ponds as community-based water conservation structures in . Staggered Muddanur trenches on hill slopes reduce runoff and enhance infiltration, while dugout ponds in valley bottoms collect rainwater and recharge groundwater. Integrating these measures at the micro-watershed scale can improve water security, support agriculture, and strengthen climate resilience in the GP.

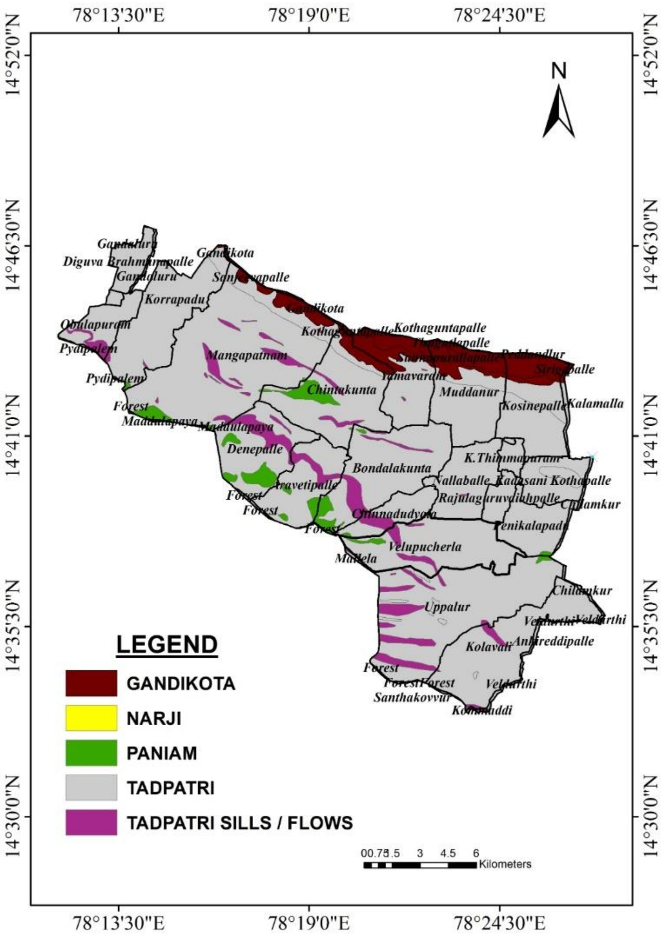
Introduction

Groundwater provides nearly 60% of irrigation and most domestic water supply in Kadapa district. However, rainfall variability (~718 mm annual average) and hard-rock geology have led to poor natural recharge and declining well yields. Muddanur GP, comprising agricultural fields interspersed with low hillocks, exemplifies these challenges. Farmers depend largely on borewells, but falling water tables threaten sustainability. To address this, rainwater harvesting through staggered trenches and dugout ponds offers a practical solution.

The geology of Muddanur Gram Panchayat (Muddanur mandal, YSR Kadapa district) is dominated by hard rock formations of the Cuddapah Basin, mainly quartzites and shales of the Papaghni Group, with patches of limestone of the Chitravati Group and underlying granite-gneiss basement. These rocks have very low primary porosity, and groundwater occurs only in weathered zones, joints, and fractures, forming shallow to moderately deep aquifers. The uplands are covered by thin red loamy soils derived from quartzite and shale, while the valley portions have black cotton soils developed over shales and limestones. This geological setup results in limited natural groundwater storage, making the area highly dependent on artificial recharge structures such as staggered trenches on uplands and dugout ponds in valley bottoms to enhance infiltration and sustain groundwater resources.

Key Words: Staggered Trenches, Dugout Pond, Aquifer, Infiltration

Study area



The study was carried out in Muddanur Gram Panchayat, Muddanur mandal, YSR Kadapa district, with a focus on groundwater recharge using staggered trenches and dugout ponds. The methodology included geological–hydrological survey, site selection, structural design, and evaluation.

Geological and Hydrological Survey

Field investigations revealed that the area is underlain by quartzites and shales of the Cuddapah Basin, with shallow red loamy soils on ridges and black cotton soils in valley bottoms. Such hard rock terrains are characterized by low primary porosity, but groundwater occurs mainly through fractures and weathered zones (Muralidharan & Athavale, 1998). Seasonal fluctuations of water levels in open wells were recorded to establish baseline hydrological conditions.

Site Selection

Staggered trenches were planned on upland quartzite ridges to intercept surface runoff. A representative site was selected near 14.64079049°N, 78.34634711°E, where slope-induced runoff is high.

Dugout ponds were located in valley depressions where runoff naturally accumulates. A key pond site was constructed at 14.64364099°N, 78.35074856°E, in black cotton soil zones favorable for recharge (CGWB, 2019).

Structural Design

Staggered trenches were constructed along contour lines in alternating fashion to reduce runoff velocity and promote infiltration. Dimensions ranged between 3–5 m length, 0.6–0.9 m width, and 0.5–0.7 m depth, adjusted according to slope gradient (Reddy & Syme, 2004).

Dugout ponds were excavated in depressions, with average dimensions of 20–30 m length, 15–20 m width, and 2–3 m depth. Excavated soils were compacted into bunds to enhance storage capacity.

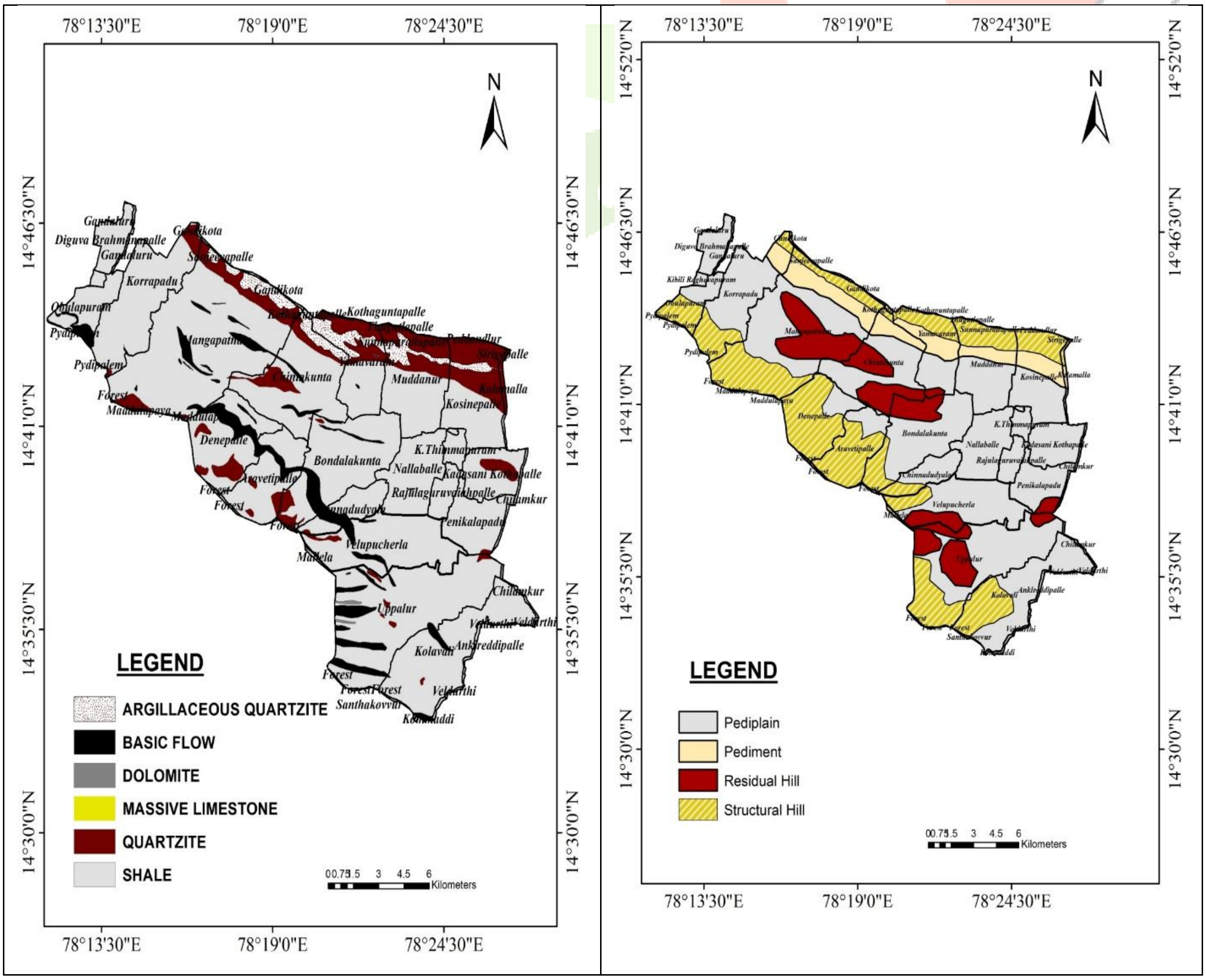
Monitoring and Evaluation

Post-implementation monitoring included:

1. **Groundwater levels** – measured pre- and post-monsoon in open wells.
2. **Soil moisture** – retention capacity analysis in cropped fields near structures.
3. **Community feedback** – farmers' perceptions of water availability and agricultural productivity.

This methodology, supported by earlier hydrological studies in hard rock regions of India (Muralidharan & Athavale, 1998; CGWB, 2019; Reddy & Syme, 2004), ensured that the **local geology of Muddanur GP** guided the design and placement of water harvesting structures.

Geological and Geomorphological map of study area



Staggered Trenches in Muddanur GP

In the upland parts of the GP, red soils on gentle slopes generate quick runoff during monsoon showers. Staggered trenches can be laid along the contours of these hillocks.

- **Design:** Trenches of 0.5–1.0 m depth, 0.3–0.6 m width, and 2–3 m length, dug in staggered rows with 20–30 m spacing.
- **Function:**
  - Slow down rainwater rushing down the slope.
  - Allow water to percolate into the subsoil, replenishing shallow aquifers.
  - Reduce soil erosion and protect cropped fields at the base of slopes.

This practice directly supports **soil and water conservation** in the GP's hilly terrain, reducing pressure on wells.

Dugout Ponds in Muddanur GP

At the valley bottoms and low-lying parts of the GP, surface runoff accumulates during rains but quickly drains away. Dugout ponds can be excavated in these natural depressions.

- **Design:** Ponds 2–4 m deep with gentle 1:2 to 1:3 side slopes, capacity 10,000–12,000 m^3 each, depending on catchment.
- **Function:**
  - Store rainwater for livestock and supplementary irrigation.
  - Recharge nearby wells by seepage.
  - Act as drought-proofing structures for the GP.

These ponds also create micro-environments supporting trees and vegetation.

Integrated Watershed Approach

When staggered trenches on the upper slopes are combined with dugout ponds in the valley bottoms, a complete watershed system emerges. In Muddanur GP:

1. Upper slopes – trenches reduce runoff velocity.
2. Mid-slopes – water infiltrates into soil, increasing moisture for crops.
3. Valley bottoms – ponds capture the excess runoff and recharge aquifers.

This integration ensures both soil conservation and groundwater sustainability.

Benefits Observed and Expected in Muddanur GP

1. Groundwater recharge – gradual rise in water levels in open wells and borewells.
2. Reduced soil erosion – less silt deposition in fields.
3. Improved water availability – more protective irrigations possible in groundnut, sunflower, and horticultural crops.

4. Community participation – Panchayat-led initiatives encourage collective maintenance of structures.
5. Resilience to droughts – farmers secure at least one crop cycle even in weak monsoon years.

Conclusion

Muddanur GP, situated in the semi-arid Rayalaseema region, faces the dual challenge of water scarcity and rainfall variability. Adoption of staggered trenches on uplands and dugout ponds in low-lying zones provides a low-cost, effective strategy for conserving rainwater and recharging groundwater. By embedding these structures into local watershed programmes, Muddanur can achieve sustainable groundwater management, improve agricultural productivity, and strengthen climate resilience for its rural community.

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