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Impact of Land Use Change in Buhana Tehsil on the Environment

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Abstract

This study investigates the environmental impacts of land use change in Buhana Tehsil, Rajasthan, driven primarily by agricultural expansion, urbanization, industrialization, and poor land management practices. Agricultural activities, including monocropping and improper irrigation, have led to soil degradation, erosion, and salinization, while urbanization has resulted in significant deforestation, habitat loss, and microclimate alterations. Industrial growth has exacerbated air, water, and soil pollution, contributing to health risks and ecological imbalances. Water resource depletion, caused by groundwater over-extraction and the diversion of surface water, further strains the region's arid ecosystem. The study highlights the severe consequences of habitat fragmentation and biodiversity loss, as natural areas are converted into agricultural and urban zones, fostering the spread of invasive species. Additionally, land degradation and overgrazing accelerate desertification, undermining soil productivity. These environmental changes have critical socio-economic ramifications, including community displacement, declining agricultural productivity, and worsening public health outcomes. This research underscores the urgent need for sustainable land use practices, including soil and water conservation, green infrastructure development, and biodiversity preservation. Implementing effective policies to mitigate land degradation, conserve water resources, and reduce carbon emissions is essential for ensuring environmental sustainability and enhancing community resilience in Bhuana Tehsil.

Keywords: Environment, ecosystem, over-extraction, ramifications, biodiversity.

1. **Introduction**

Buhana Tehsil, located in the semi-arid Shekhawati region of Rajasthan, has experienced significant land use and land cover (LULC) changes over the past few decades. These changes have been driven by agricultural expansion, urbanization, groundwater overextraction, and climate

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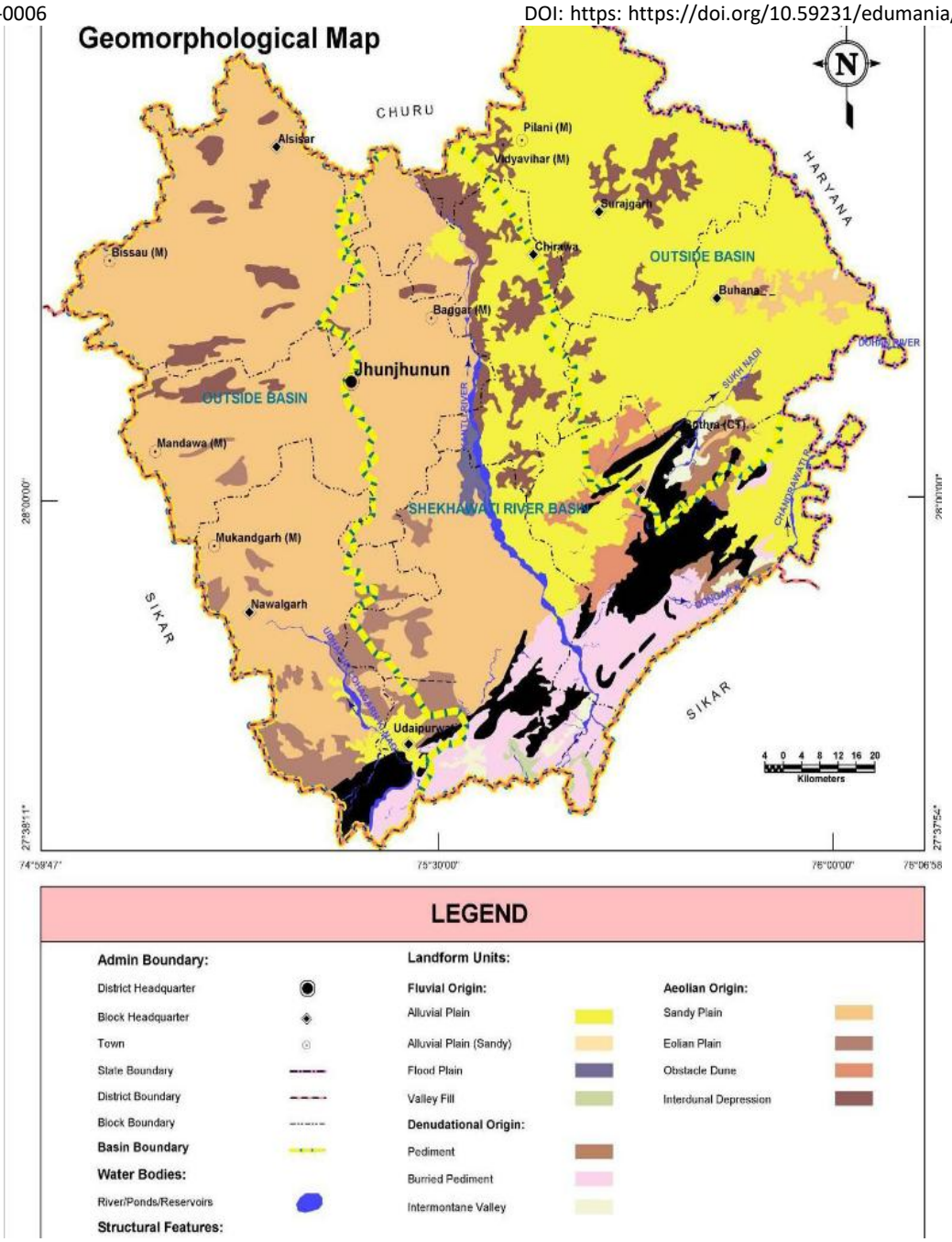

variability. Understanding these transformations is crucial for sustainable land management, water resource planning, and environmental conservation.

2. Geographical and Environmental Context

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Table 1-4: Agro Ecology of Jhunjhunu

Name of Agro-Climatic Zone (ACZ)	Name of Agro-Ecological Situation (AES)	Blocks Covered
Tranzisanal plain of Inland Driange Zone (II-A)	AES-I (Flat medium textured soil with low rainfall and under ground brackish water)	Alsisar
	AES-II (Flat medium to fine textured soil with irrigation)	Jhunjhunu, Chirawa, Buhana, Navalgarh, and Surajgarh
	AES-III (Hilly flat texturedssoil with low rainfall)	Kehri and Udaipurwati

Table 1-5: Monthwise Rainfall, Temperature and humidity in Jhunjhunu district

S.N.	Agro Ecological Zone Type	Block Area (000' Ha)	Normal Annual Rainfall (mm)	Average Monthly Rainfall (mm)	No of Rainy Days
Jhunjhun	Zone 2 A	83092	510.75	42.56	25
Alsisar		81557	643.5	53.62	21
Nawalgarh		68545	663.25	55.27	32
Udaipurwati		84675	542.62	45.22	39
Chirawa		49449	485.25	40.43	29
Surjgarh		80666	485.25	40.43	
Buhana		62180	507.5	42.3	27
Khetari		80779	524.87	43.74	39
TOTAL		**590943**	**545.37**	**45.45**	**30**

Source: SREP Jhunjhunu

Soil Profile

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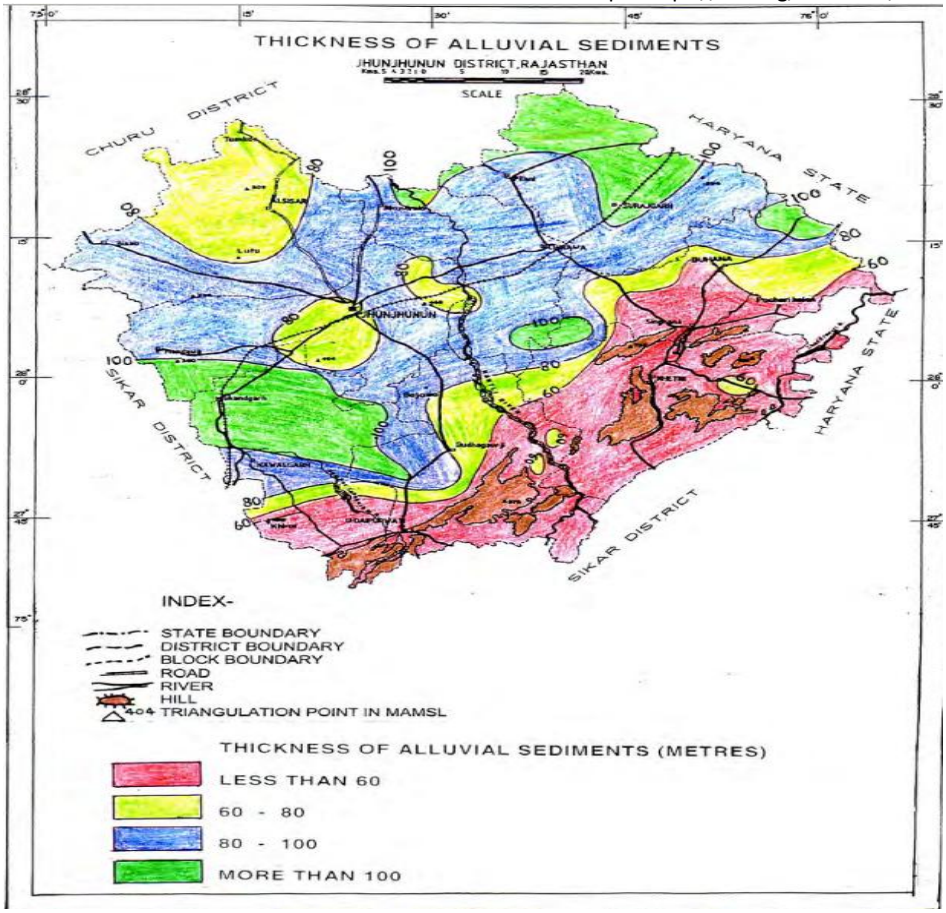

I. **Desert soil** (Covers 2666 sq.km.area forming 44.97% of District) Occurs extensively in the central part of the area covering parts of all the blocks except Surajgarh block.These are yellowish brown, sandy to sandy loam, loose, structure less, well drained with high permeability. They are scanty of vegetation due to severe wind erosion and wind velocity high.

II. **Sand dunes** (Covers 2149 sq.km.area forming 36.25% of Tehsil) Present mostly in northern part of the district covering parts of Alsisar, Buhana, and Chirawa blocks.These are noncalcareous soils, sandy to loamy sand, loose, structureless and well drained.In favourable localities they cultivated

3. Patterns of Land Use Changes

3.1 Historical Land Use Trends

- Pre-1990s: Predominantly rainfed agriculture and natural grasslands.
- 1990–2000: Rapid increase in groundwater-based irrigation.
- 2000–2010: Shift to intensive farming and rise in urban settlements.

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- 2010–Present: Expansion of built-up areas and groundwater salinization.

Table 3. LULC map area statistics in 2001 and 2006 and change statistics of each class with time period.

		2001		2006				
Sl	Land use land cover	1. Area (km²)	2. Percentage of area in LULC	3. Area (km²)	4. Percentage of area in LULC	Change Dynamics (km²)(3–1)	Change pattern of each classes of LULC (in percentage) (4–2)	Status
1	Built-up	112.151	1.893	428.917	7.239	316.766	5.346	+ Increased
2	Mine degraded area	20.256	0.341	24.674	0.416	4.418	0.074	+ Increased
3	Sand affected area	1819.033	30.703	2347.820	39.627	528.786	8.924	+ Increased
4	Agricultural area	2264.395	38.220	1751.961	29.570	−512.433	−8.650	− Decreased
5	Fallow Land	973.941	16.439	829.113	13.994	−144.827	−2.444	− Decreased
6	Water bodies	1.915	0.032	2.651	0.044	0.736	0.012	+ Increased
7	Open forest	69.261	1.169	198.291	3.346	129.030	2.177	+ Increased
8	Dense forest	663.588	11.200	341.261	5.759	−322.326	−5.440	− Decreased
		5924.545	100	5924.693	100	-	-	-

LULC for 2001-2006

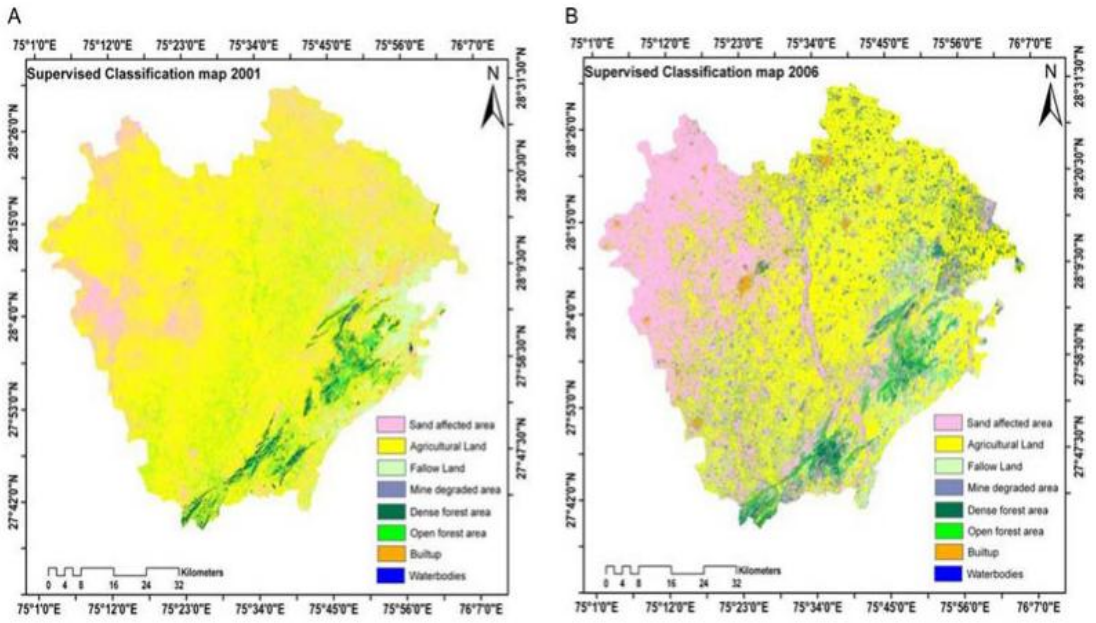

Figure 2. (A) Supervised classification map 2001, (B) Supervised classification map 2006 and Tables 1, 2 and 3.

LULC for 2007-08

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Table 1 Tehsilwise Land Use Statistics of Jhunjhunun district

Mapping unit	Land use category	Jhunjhunun	Chirawa	Nawalgarh	Udaipurwati	Buhana	Khetri	District total
		Area in %	Area in %	Area in %	Area in %	Area in %	Area in %	Area in %
A_{11}	Double cropping with intensity of cultivation > 100%	24.04	72.18	38.68	40.93	55.20	26.05	42.46
A_1	Mono-cropping with intensity of cultivation 80 to 100%	36.04	18.52	51.88	31.00	31.21	34.38	32.54
A_2	Mono-cropping with intensity of cultivation 60 to 80%	26.95	0.48	1.85	2.63	0.21	1.59	8.33
A_3	Mono-cropping with intensity of cultivation 30 to 60%	26.95	0	0	0	0	0.29	0.92
B_1	Sandy waste	0.17	0	0.23	0.49	0	0.17	0.23
B_{1x}	Sandy waste with scrub	0	0	0	0	0.61	0	0.06
B_3	Rocky/stony waste	0.10	0.01	0.06	0.44	0.70	1.06	0.32
B_4	Stony/gravelly waste	0.04	0	0.01	0.94	0.20	2.83	0.56
B_5	Gullied lands	0	0	0	1.69	0	4.55	0.86
F	Notified Forest	0	0.08	1.06	17.85	1.41	25.70	6.36
P	Pasture/grazing land	5.91	5.93	2.94	1.64	6.87	1.29	4.44
S	Settlement/ built up land	3.27	2.63	2.98	1.08	3.21	0.99	2.46
W	Water bodies	0.25	0.17	0.31	1.31	0.37	1.10	0.52
	Total Geog. Area (in ha)	**162244**	**130115**	**68545**	**84675**	**65309**	**80650**	**591538**

LULC for 2014-2015

Table 1-7: Land use pattern in Jhunjhunu district

S.N.	Name of Block	Total geographical Area	Area under Agriculture				AreaIn ha.		
			Gross Croped Area	Net sown Area	Area Sown More Than Once	Cropping Density%	Area under forest	Area under waste land	Area under other use
1	Jhunjhun	83092	80685	56706	23979	142.286	1059	4122	5673
2	Alsisar	81557	70812	59366	11446	119.280	2	4746	5053
3	Nawalgarh	68545	81878	50027	31851	163.667	2195	3117	3682
4	Udaipurwati	84675	84518	49501	35017	170.739	14546	2967	2937
5	Chirawa	49449	69015	38731	30284	178.190	115	833	2297
6	Surjgarh	80666	129085	67307	61778	191.785	27	2891	6299
7	Buhana	62180	81777	49672	32105	164.633	1563	2331	5771
8	Khetari	80779	56757	36530	20227	155.370	20565	1924	3974
	Total	**590943**	**654527**	**407840**	**246687**	**160.486**	**40072**	**22931**	**35686**

Source: District Statistical Handbook 2014-15, Jhunjhunu

3.2 Current Land Use Distribution, 2022

Buhana Tehsil as of 2021-22	Area	Cultivable Wasteland	Degraded Land	Rainfed	Forest Land	Others	Net Sown Area	Gross Cropped Area
	7761	4.01	27.61	5367.3	0	1509.0	5175.882	7954.7743

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4. Categories of Land Use Changes

A. Agricultural Expansion

Increased Net Area Sown (NAS): Agricultural land has expanded significantly, reducing fallow lands and grazing areas.

Shift from Rainfed to Irrigated Agriculture: Farmers are increasingly adopting tube wells and borewells for irrigation, causing groundwater depletion.

Cropping Intensity: With better irrigation, multiple cropping cycles have become common, although they strain water resources.

B. Degradation of Grazing Lands - Traditional grazing lands (Gochar) are declining due to urban encroachments and agricultural expansion. Overgrazing in the remaining pastures has resulted in soil erosion and land degradation.

C. Mining and Industrial Land Use - Mining zones in Khetri, Buhana, and Udaipurwati have converted large tracts of agricultural land into open-pit mining zones. Mining has caused soil contamination, water pollution, and biodiversity loss.

D. Urbanization - Urban and peri-urban areas are rapidly growing, particularly around Buhana city and major towns. Farmlands are being converted into residential colonies, commercial hubs, and industrial parks.

E. Water Resource Challenges - Groundwater depletion is one of the most severe outcomes of land use changes in Buhana. Intensive groundwater extraction for agriculture has resulted in falling water tables and salinity issues.

F. Biodiversity Loss - The conversion of forests and grazing lands into agricultural and mining zones has led to habitat destruction. Native flora and fauna are under threat, and ethnobotanical knowledge is declining.

5. Literature Review: Environmental Concerns in Buhana Tehsil, Rajasthan

Environmental issues in Buhana Tehsil are multifaceted, arising primarily from unsustainable agricultural practices, mining activities, groundwater depletion, biodiversity loss, and poor waste management systems. This literature review summarizes key studies addressing environmental concerns in the Tehsil.

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Authors: T. Juneja, A. Chaudhary

Key Findings: Water quality in rural Buhana is severely affected by high levels of fluoride, nitrates, and heavy metals.Consumption of contaminated water has led to health issues such as fluorosis and gastrointestinal diseases. The study emphasizes the need for water purification interventions and regular monitoring of water sources.

Author: M.K. Sharma 'Bhatt

Key Findings: The environmental landscape of Buhana is deeply impacted by urbanization, agricultural expansion, and deforestation. Over-reliance on groundwater extraction has led to water scarcity and declining water tables. The region faces significant challenges related to land degradation and loss of natural vegetation cover.

Authors: D. Shyoran, V. Kumar

Key Findings: The region supports a wide variety of resident and migratory bird species. Changes in land use patterns, habitat destruction, and pollution have adversely impacted avian diversity. Conservation measures are needed to protect critical bird habitats and migratory corridors.

Authors: A.P. Singh, A. Khakolia, S. Tavanshetti

Key Findings: Groundwater quality in Buhana is compromised due to excessive extraction, industrial pollution, and agricultural runoff. High levels of fluoride and nitrates pose severe health risks to local populations. The study recommends GIS-based groundwater monitoring systems for sustainable management.

Author: A. Jeph

Key Findings: Rapid urbanization and agricultural expansion have led to the loss of native plant species.Traditional ethnobotanical practices are declining due to habitat loss and lack of awareness. Conservation of indigenous plant species is critical for biodiversity preservation.

Authors: D. Shyoran, S. Dubey

Key Findings: Buhana serves as an important stopover for migratory birds. Habitat destruction and increasing pollution have disrupted the natural migratory patterns of several bird species. There is an urgent need for wetland conservation and creation of protected areas.

Authors: M.B. Choudhary, M. Jain, M. Mital

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Key Findings: The Kund system is an indigenous water harvesting method, but its efficiency has declined due to neglect and mismanagement. Modernizing and reviving the Kund system can alleviate the Tehsil's water scarcity problem.

Authors: A. Kumari, Y.K. Gupta

Key Findings: Tube well water samples showed high levels of fluoride, nitrates, and heavy metals. Water contamination poses risks of dental and skeletal fluorosis among residents. Awareness campaigns and installation of water purification units are necessary.

Authors: N. Tanwer, M. Deswal, P. Khyalia, J.S. Laura

Key Findings: Elevated levels of fluoride and nitrates in groundwater affect both human health and crop productivity. Immediate intervention is required to ensure safe drinking water supply and improve groundwater recharge techniques.

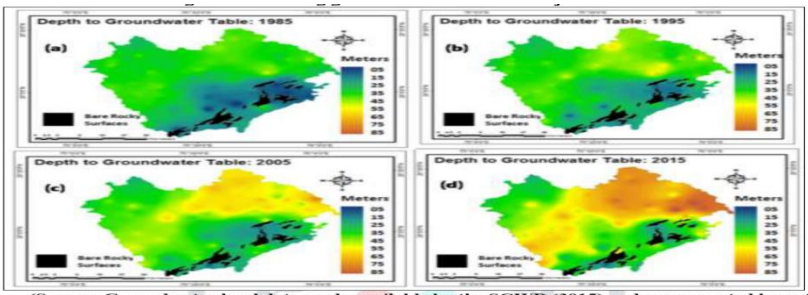
Author: R.B. Singh

Key Findings: The study emphasizes the need for integrated environmental management strategies in the arid desert regions of Buhana. Policy-driven approaches should focus on resource conservation, sustainable agriculture, and waste management.

6. Key Environmental Impacts

6.1 Groundwater Depletion and Salinization in Buhana Tehsil, Rajasthan

Groundwater is the primary source of water for drinking, agriculture, and industrial purposes in Buhana, Rajasthan. However, excessive extraction, unsustainable agricultural practices, and changing rainfall patterns have resulted in severe groundwater depletion and salinization. This analysis explores the causes, consequences, and potential solutions for groundwater-related challenges in Buhana.



(Source: Groundwater level data made available by the SGWD (2015) and maps created by author)

A. Causes of Groundwater Depletion and Salinization

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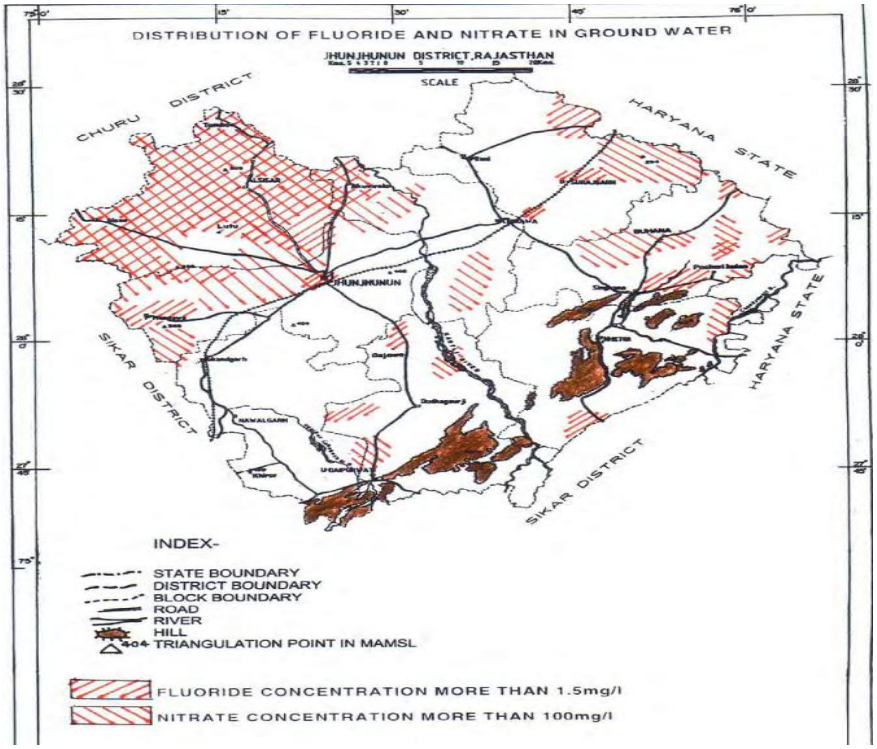
Agricultural Expansion - The region has experienced significant growth in groundwater-irrigated agriculture, which has placed immense pressure on aquifers (Machiwal et al., 2024). The cultivation of water-intensive crops has accelerated groundwater depletion.

Limited Rainfall and Recharge - The semi-arid climate and erratic monsoon patterns have limited the natural recharge of aquifers (Chatterjee et al., 2023). Annual rainfall remains insufficient to replenish deep aquifers. Buhana's geological formations, including hard rock and alluvial deposits, limit groundwater percolation and storage capacity (Chatterjee et al., 2023).

Anthropogenic Contamination - Improper disposal of fertilizers, pesticides, and sewage has contributed to groundwater contamination with nitrates and fluoride (Jandu et al.,2021). High concentrations of nitrate and fluoride were detected in groundwater samples, exceeding permissible limits set by WHO and BIS.



B. Consequences of Groundwater Depletion and Salinization

Aquifers in Buhana are showing rapid depletion trends, with post-monsoon water levels dropping more sharply compared to pre-monsoon periods (Machiwal et al., 2024). Limited recharge has exacerbated water scarcity, especially during the summer months.

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Water Salinization - Increased groundwater extraction has allowed saline water to intrude into freshwater aquifers. Salinity levels are rising, rendering water unsuitable for drinking and agricultural use (Chatterjee et al., 2023).

Health Risks - Elevated levels of nitrates and fluoride have been detected in groundwater, causing health hazards like fluorosis and methemoglobinemia (Jandu et al., 2021). Studies indicate that 86% of samples exceeded nitrate limits, and 54% exceeded fluoride limits, posing significant non-carcinogenic health risks.

Agricultural Challenges - High salinity and reduced groundwater availability have adversely affected crop productivity and soil fertility (Khan et al., 2021). Farmers face increasing financial stress and crop failures.

C. Hydrogeochemical Analysis - Groundwater hydrogeochemistry indicates a weathering of rocks and evaporation as key processes behind salinity. 35 water samples from 35 sampling stations were collected and analysed for physico -chemical parameters (PH,EC Alkalinity, Cl- ,TH, TDS, Ca 2+, Mg 2+,NO3-,F-,SO 42-). The analytical data of various physico Chemical parameters indicates that some parameters like PH,EC,TDS,TSS,Ca2+ ,Mg2+ are found to be in excess than the prescribed limit in some water samples of the study areas. The WQI value indicates that water samples of some sampling stations are quite unfit for drinking purpose because ofhigh value of Ca 2+, Mg 2+, TH etc. suitable suggestions were made to improve the water quality (Anil Kumar Saini and Alka, 2017)

Table 2: Physico-Chemical analysis of ground water for rural area's Buhana

S.N.	Source	PH	EC	Alkalinity	Cl^-	TH	TDS	Ca^{2+}	Mg^{2+}	No_3^-	F^-	So_4^{2-}
1	T.W.	7.7	2.01	316	342	266	1764	124	20	63.4	0.48	64
2	O.W	7.6	2.85	276	365	440	1878	228	60.3	48.4	0.56	65
3	T.W	7.8	2.63	222	146	158	720	62	70	28.8	0.24	17
4	T.W.	7.9	2.74	352	323	370	2031	188	78.3	54.2	1.14	63
5	O.W.	7.4	3.96	230	193	168	946	72	77.9	37.6	0.42	21
6	O.W.	7.3	3.70	234	189	254	1160	122	71.4	94.5	1.02	25
7	T.W.	7.5	1.31	250	270	260	1120	140	61.3	90	1.10	45
8	T.W.	7.9	1.27	260	265	220	1330	160	59.3	55	1.0	30
9	O.W.	8.0	2.08	210	175	200	1400	145	39.4	170	1.4	75
10	T.W.	8.1	1.36	280	300	280	1670	155	45.6	40	0.7	60

Values of EC in the majority of area indicated the need for some short of treatment for the removal of dissolved solid

D. Potential Solutions and Recommendations - Rainwater Harvesting by encouraging rooftop and community-level rainwater harvesting systems. Build recharge wells and check dams to facilitate groundwater replenishment. Efficient Irrigation Techniques like Drip and Sprinkler Irrigation. Crop Diversification by encouraging low-water-intensive crops suited for arid climates.

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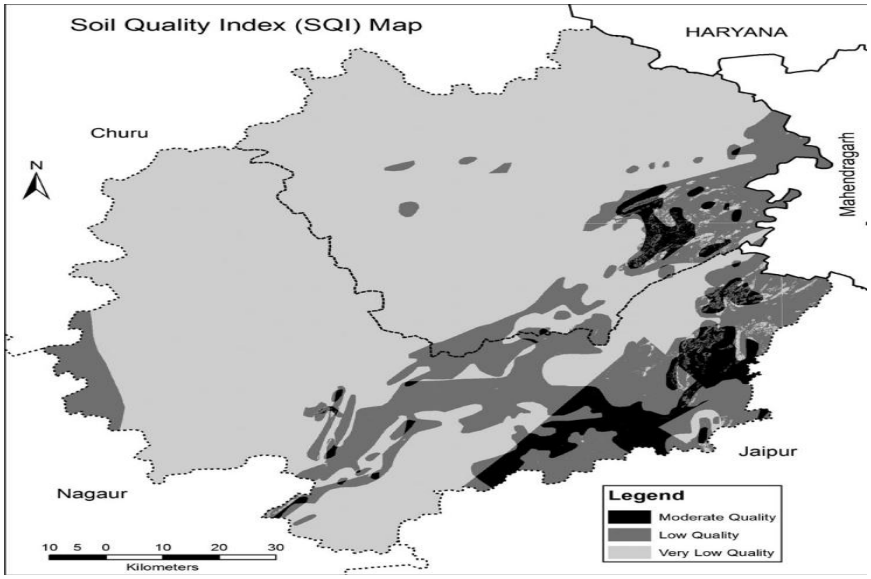
Policy and Governance measures like Groundwater Regulation, enforcing strict monitoring and regulation of groundwater extraction. Subsidy Reforms by Reducing subsidies on electricity for water pumping to discourage overextraction. Water Quality Monitoring by establishing regular groundwater quality monitoring networks to detect salinity, nitrate, and fluoride levels. Providing alternative potable water sources in highly contaminated areas.

6.2 Soil Degradation and Desertification in Buhana Tehsil, Rajasthan

Soil degradation and desertification are critical environmental challenges in the arid and semi-arid regions of Buhana Tehsil, Rajasthan. Unsustainable land-use practices, overgrazing, deforestation, poor water management, and climate change are major contributors to land degradation and desertification. This analysis explores the extent, causes, impacts, and potential solutions to address these environmental challenges.



A. Extent and Patterns of Soil Degradation and Desertification - A significant portion of Buhana and nearby districts is classified as moderately to highly sensitive to desertification (Dutta & Chaudhuri, 2015). Approximately 13% of the area is under high desertification risk, while 45% shows moderate sensitivity. The sand dune ecosystem in Buhana is highly fragile and prone to degradation due to anthropogenic activities and livestock overgrazing (Kumar & Bhandari, 1993). Overgrazing has resulted in a sharp decline in land productivity and increased soil erosion. Wind erosion is a significant driver of soil loss in Buhana, removing topsoil and reducing fertility. Water

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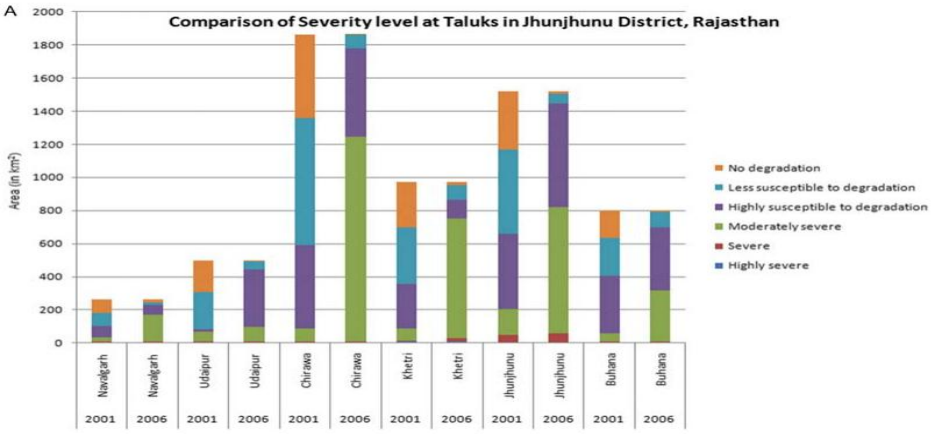
erosion, although less pronounced, contributes to land degradation during monsoons (Sharma et al., 2016).

B. Causes of Soil Degradation and Desertification - Overgrazing is one of the most prominent causes, with livestock density often exceeding the carrying capacity of the land (Kumar & Bhandari, 1993). High grazing pressure during dry seasons exacerbates land degradation. Unsustainable Agricultural Practices like The shift towards intensive farming and monocropping has depleted soil nutrients. Poor irrigation practices have led to secondary salinization, further degrading soil quality (Dutta & Gupta, 2013). Climate Variability in form of Irregular and inadequate rainfall, coupled with rising temperatures, has reduced soil moisture and increased desertification risk (Salunkhe et al., 2018). Forests and grasslands have been cleared for agriculture and urbanization. Loss of vegetation cover has reduced soil stability and increased erosion rates

C. Impacts of Soil Degradation and Desertification - Reduced Agricultural Productivity as soil fertility decline and salinization have significantly reduced crop yields. Farmers face higher input costs to maintain productivity on degraded land (Sharma et al., 2015). Increased Soil Erosion as both wind and water erosion have led to extensive soil loss, reducing the arable area and threatening food security. Water Resources under Stress because Degraded soils have poor water-holding capacity, increasing runoff and reducing groundwater recharge rates (Salunkhe et al., 2018). Habitat destruction due to land degradation has significantly affected local flora and fauna.

A 2001-2006 comparison of Tehsils most prone to sand spread and desertification



D. Strategies for Mitigating Soil Degradation and Desertification- Promoting crop diversification and rotational farming. Implementing soil conservation techniques such as

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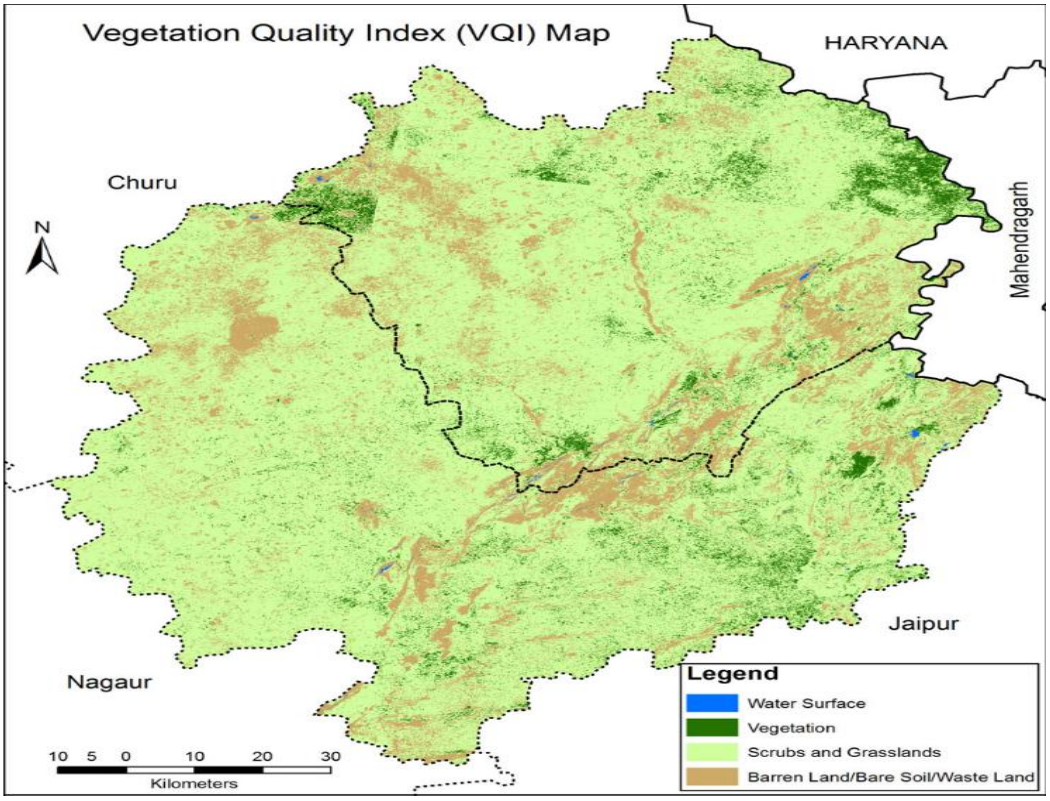
terracing and contour plowing. Vegetation Restoration by undertaking afforestation and reforestation projects aimed at restoring natural grasslands.

6.3 Loss of Vegetation Cover and Biodiversity in Buhana Tehsil, Rajasthan



Buhana Tehsil, located in the semi-arid region of Rajasthan, is facing significant environmental challenges, including loss of vegetation cover and biodiversity. Factors such as unsustainable agricultural practices, overgrazing, deforestation, and land-use changes have contributed to the degradation of natural habitats, affecting flora and fauna diversity in the region.

A. Causes of Vegetation and Biodiversity Loss

Land-Use Changes - Over the last four decades, agricultural expansion and urbanization have led to significant land-use changes, reducing natural vegetation cover (Ram & Chauhan, 2009). Increased groundwater extraction for irrigation has transformed natural habitats into farmlands, impacting native vegetation.

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Overgrazing - Livestock overgrazing, especially in fragile sand dune ecosystems, has caused significant degradation of grasslands and shrub cover (Kumar & Bhandari, 1993). High livestock density exceeds the land's carrying capacity, causing irreversible damage to vegetation.

Deforestation - Unsustainable extraction of forest resources for fuelwood and timber has caused loss of forest patches. Rising demand for agricultural land has contributed to deforestation (Dutta & Chaudhuri, 2015).

Climate Change- Erratic rainfall and prolonged droughts have disrupted natural growth cycles of vegetation, further accelerating habitat degradation (Dutta & Chaudhuri, 2015).

B. Impacts on Biodiversity

Decline in Avian Diversity - A study recorded 101 avian species in Buhana, including globally threatened species. However, habitat fragmentation and vegetation loss are impacting bird populations (Shekhawat & Bhatnagar, 2014). Insectivorous and omnivorous birds, which rely on diverse vegetation and stable ecosystems, are particularly affected.

Loss of Aquatic Biodiversity - The Tehsil's freshwater bodies support 15 aquatic angiosperm species. However, water pollution and reduced vegetation cover around wetlands threaten aquatic plant diversity (Verma, 2014).

Habitat Fragmentation - Conversion of forests and grasslands into agricultural lands has fragmented habitats, isolating animal populations and reducing genetic diversity (Kumar & Bhandari, 1993).

Decline in Flora Diversity - Native plant species adapted to arid conditions are being replaced by invasive species, further degrading the habitat quality (Dutta & Chaudhuri, 2015).

C. Case Studies and Observations

Avian Fauna Study in Buhana - A study documented 101 bird species across 34 families, including two critically endangered species and one endangered species. The guild analysis revealed 41.58% insectivorous birds and 26.73% omnivorous birds, showing dependence on stable vegetation cover (Shekhawat & Bhatnagar, 2014).

D. Mitigation Strategies Restoration of Natural Habitats - Implement afforestation programs using native species. Restore degraded wetlands and sand dune ecosystems. Alternative Grazing Practices like introducing rotational grazing systems to prevent livestock pressure on fragile ecosystems. Adopting soil conservation practices like terracing and mulching. Biodiversity

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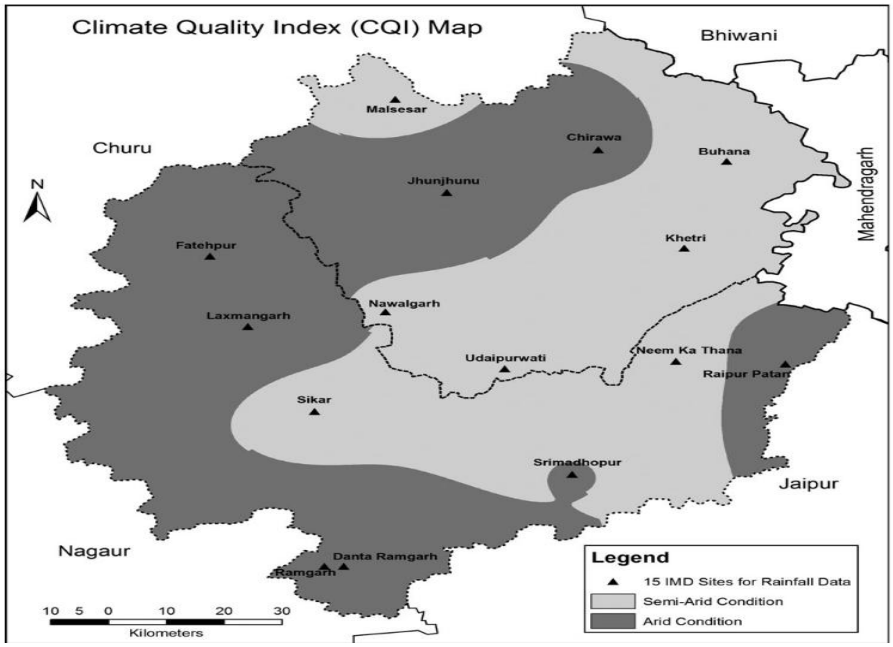
Monitoring and Protection by establishing biodiversity monitoring systems in critical habitats and community involvement.

6.4 Climate Feedback Loops in Buhana Tehsil, Rajasthan

Climate feedback loops in Buhana Tehsil arise from the interconnected impacts of rising temperatures, erratic rainfall patterns, groundwater depletion, and land degradation. These feedback mechanisms amplify the effects of climate change and exacerbate environmental and socio-economic challenges in the region.



Climate Feedback- Reduced Recharge Capacity: Rising temperatures and erratic monsoons decrease groundwater recharge, worsening water scarcity.Higher temperatures lead to increased evaporation from reservoirs and soil surfaces. (Chouhan, 2023). Decreased groundwater availability reduces vegetation cover, leading to increased soil erosion and further limiting groundwater recharge.

Albedo Effect: Loss of vegetation increases surface albedo, reducing local moisture retention and intensifying regional heatwaves. As soil degradation progresses, vegetation becomes harder to restore, perpetuating land degradation and loss of soil fertility.

Temperature Rise and Precipitation Variability Feedback - Rising Local Temperatures: Increasing land surface temperatures have been observed due to reduced vegetation cover and urbanization (Porwal & Choudhary, 2023). Climate models predict erratic rainfall patterns, with

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extreme droughts and heavy rainfall events becoming more frequent (Pradhan et al., 2018). Rising temperatures reduce soil moisture and increase evaporation, which in turn exacerbates heat stress and impacts monsoon circulation.

Agricultural Intensity and Water Resource Feedback - Increased cropping intensity has overexploited groundwater resources and degraded soil quality (Kaur et al., 2021). Excessive irrigation and poor water management have resulted in soil salinization. Soil degradation reduces crop productivity, leading farmers to intensify resource extraction, further degrading soil and water resources.

A. Impacts of Climate Feedback Loops in Buhana

Intensified Droughts - Increasing temperatures and reduced groundwater recharge amplify drought frequency and intensity (Poonia & Choudhary, 2013). The region faces prolonged dry spells, reducing agricultural output and increasing water scarcity. Vegetation loss and soil degradation contribute to accelerated desertification, reducing land productivity. Also sand dune migration and soil erosion worsen desertification risks.

Decline in Agricultural Yields - Reduced water availability and poor soil health have caused significant yield reductions. Farmers are forced to rely on unsustainable practices, perpetuating land degradation. Some other consequences include rural-urban migration. Increased resource competition exacerbates social inequalities and economic distress.

Mitigation can be done via Climate Resilient Infrastructure -Develop early warning systems for droughts and heatwaves. Strengthen rural infrastructure to withstand extreme weather events.

6.5 Hydrological Alterations in Buhana Tehsil, Rajasthan

Buhana Tehsil, located in the semi-arid Shekhawati region of Rajasthan, has witnessed significant hydrological alterations driven by climatic variability, groundwater overextraction, land use changes, and unsustainable water management practices. These alterations have disrupted the natural hydrological cycle, exacerbating water scarcity, groundwater salinization, and ecosystem degradation.

A. Causes of Hydrological Alterations

Climate Change and Rainfall Variability - Climate change has disrupted rainfall patterns, with erratic monsoon cycles and prolonged droughts significantly impacting groundwater recharge

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(Chouhan, 2023). Increased evaporation due to rising temperatures reduces surface water availability and accelerates groundwater loss.

Groundwater Overextraction - Groundwater extraction for agriculture, especially for water-intensive crops, has outpaced natural recharge rates (Chatterjee et al., 2023). Groundwater levels have dropped sharply, particularly in post-monsoon seasons, highlighting the stress on aquifers (Machiwal et al., 2024).

Soil Moisture Decline - Reduced rainfall and increased evaporation have led to significant soil moisture depletion, affecting agricultural productivity and soil health (Khan et al., 2021).

Table 4-7: Water Budget (Volume in MCM)

District	Existing water availability / Usage (MCM)		Total (MCM)	Water Demand (MCM)		Water Gap (MCM)	
	Surface Water	Ground Water		Present	Projected (2020)	Present	Projected (2020)
Alsisar		26.92	26.92	432.82	433.25	405.9	406.33
Buhana		58.68	58.68	689.35	1070.32	630.67	1011.64
Chirawa		64.97	64.97	1261.38	1464.00	1196.41	1399.03
Jhunjhunu		72.11	72.11	799.4	1193.74	727.29	1121.63
Khetri		52.61	52.61	796.39	797.00	743.78	744.39
Nawalgarh		101.85	101.85	537.57	538.46	435.72	436.61
Surajgarh		82.15	82.15	1200.65	1201.06	1118.5	1118.91
Udaipurwati	0.566	107.45	108.01	1110.73	1111.48	1002.72	1003.47
Total	**0.566**	**566.74**	**567.30**	**6828.26**	**7809.32**	**6260.96**	**7242.02**

B. Impacts of Hydrological Alterations

Drinking Water Crisis - High nitrate and fluoride concentrations in groundwater make it unfit for drinking, posing severe health risks (Kumari & Gupta, 2022). Communities face chronic health issues, including fluorosis and nitrate poisoning.

Ecosystem Degradation - Hydrological disruptions have resulted in the drying up of wetlands and the loss of aquatic biodiversity (Verma, 2014). Desertification processes have intensified, reducing vegetation cover and soil stability.

C. Mitigation and Adaptation Strategies

Water Quality Monitoring and Management - Regular monitoring of groundwater quality for contaminants like nitrates and fluorides. Development of affordable water treatment technologies for rural communities. Area is underlained by unsaturated moderate thickness of alluvial which provides sufficient scope of artificially augmentation of the ground water body as alluvial formation has very good storage and transmission capacity in the Tehsil. In the Tehsil, there is rainfall of about 2878.64 mcm considering the area and average annual rainfall. Out of this,

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235.1238 mcm is annual natural recharge as per the ground water estimation as on 31.03.2004. The above data indicate the availability of surplus water which can be used for artificial recharge through the various techniques feasible in alluvial and hard rock terrain.

In alluvial area, following ways of recharge techniques may be adopted.

i) Roof top/paved area rain water harvesting for recharge to ground water in urban and industrial area.

ii) Village water runoff/roof top water harvesting by dug wells/percolation tanks in rural area.

iii) Construction of recharge shafts with gabion structures in nalas.

iv) Recharge by dug well/percolation pit in agriculture farm.

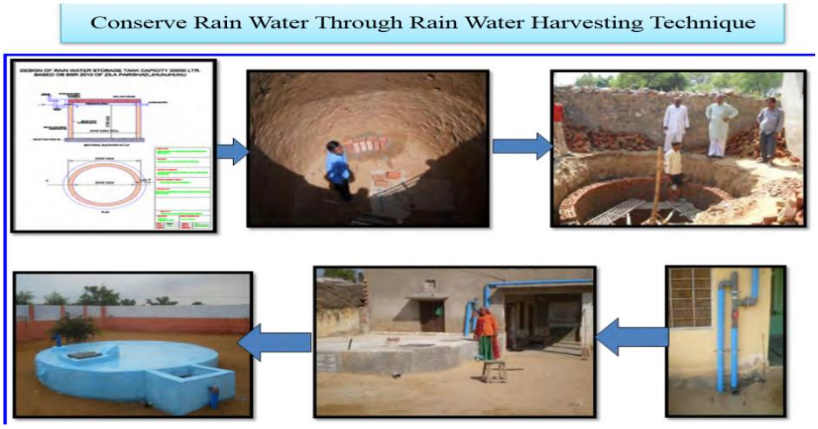
In hard rock terrain nala bunding, anicuts, dug wells, percolation tanks etc. are feasible structures which may be used to recharge the ground water body. Technical guidance is provided to various organizations as and when approached

7. Case Studies on Desertification in Buhana Tehsil, Rajasthan

A. Case Study: Traditional Water Management Systems in Buhana

Background: Buhana faces severe groundwater depletion due to over-extraction for agriculture. Traditional water management systems like johads (earthen dams) and stepwells were historically used to harvest rainwater. NGOs like Tarun Bharat Sangh have worked with local communities to restore johads and stepwells in villages like Chirawa and Mandawa. These structures were desilted and repaired to improve their water-holding capacity.

Outcomes: Groundwater levels in restored areas rose by 2–3 meters. Improved water availability enabled farmers to switch to sustainable crop patterns, such as millet and pulses, which require less water.



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B. Case Study: Afforestation Projects in Beed, Buhana

Background: The Beed forest area in Buhana has experienced significant vegetation loss due to overgrazing and deforestation. Several native plant species, such as Tecomella undulata (Rohida), were nearing extinction. The State Forest Department initiated afforestation drives in collaboration with local communities. Native drought-resistant species were planted across degraded lands. Protection measures, such as fencing and rotational grazing bans, were enforced.

Outcomes: Vegetative cover increased by 20% over five years. Improved soil stabilization reduced wind erosion and sand encroachment.

C. Case Study: Soil Fertility Management in Northeast Buhana

Background: Agricultural lands in northeast Buhana have suffered from declining soil fertility due to monocropping and overuse of chemical fertilizers.Researchers from the ICAR – Central Arid Zone Research Institute conducted a study in partnership with local farmers. Techniques such as crop rotation, organic manure application, and contour plowing were introduced.

Outcomes: Crop yields improved by 15–25%, particularly for drought-tolerant crops like pearl millet. Soil organic matter content increased by 0.5–1%.

D. Case Study: Role of Geo-Informatics in Monitoring Desertification

Background: Monitoring desertification trends in Buhana has been challenging due to the lack of real-time data. Researchers from the Indian Space Research Organization (ISRO) mapped degraded lands using satellite imagery and Geographic Information Systems (GIS). Areas with severe soil erosion and vegetation loss were identified, with a focus on Buhana and Khetri blocks.

Outcomes: The study provided high-resolution maps highlighting critical areas for intervention. Data supported the government's decision to launch targeted afforestation and soil conservation projects.

E. Case Study: Desertification and Livelihood Diversification in Khetri

Background: Farmers in Khetri block faced recurrent crop failures due to desertification. Migration to urban areas became a common coping strategy. The Tehsil Rural Development Agency (DRDA) introduced skill-training programs for weaving, handicrafts, and eco-tourism. Loans and subsidies were provided to set up small-scale businesses.

Outcomes:Over 30% of participating households diversified their income sources within three years. Dependency on agriculture reduced, easing pressure on degraded lands

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F. Case Study: Soil Erosion Control in Chirawa

Background: Chirawa block is prone to wind erosion due to sparse vegetation and loose sandy soils. Farmers adopted contour plowing techniques to slow water runoff and retain soil. Crop residues were used as mulch to cover soil and reduce evaporation.

Outcomes: Soil erosion rates decreased by 35% over five years. Crop productivity increased due to improved soil moisture retention.

G. Case Study: Community-Led Grazing Management

Background: Overgrazing was a major contributor to land degradation in Mandawa. Community groups collaborated to implement rotational grazing schedules. Fodder plantations were introduced on degraded lands to supplement livestock feed.

Outcomes: Vegetation cover on grazing lands improved by 40%. Livestock health improved due to better quality and quantity of fodder.

8. Conclusion

Land use changes in Buhana Tehsil are a complex interplay of agriculture, mining, urbanization, and environmental factors. While these changes have driven economic growth and modernization, they have also led to environmental degradation, water scarcity, and biodiversity loss.

Balancing economic development with environmental sustainability is crucial. Policy measures, community participation, and technological advancements are key tools in achieving sustainable land use management in the Tehsil.

Future Research Directions:

- Dynamic modeling of land use changes using AI and machine learning.
- Long-term monitoring of soil health and groundwater resources.
- Community-led initiatives for sustainable land use.

By adopting integrated strategies and evidence-based policies, Buhana Tehsil can mitigate adverse impacts and pave the way for sustainable development in the arid regions of Rajasthan.

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