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Watershed Concept-Based Development: A Pathway for Environmental Sustainability, Economic Scalability and Social Equity

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Abstract

This article explores the critical role of watersheds as geo-hydrological units, emphasizing their structural, functional, managerial and developmental significance in reducing soil erosion, water harvesting, storage, and biodiversity conservation. These functions are crucial for achieving environmental sustainability, economic scalability, and social equity. The methodology includes observation and phenomenology. The paper highlights the universal blueprint of watersheds, unique characteristics such as the asteroid-impacted Lonar Lake, and the importance of watershed management in preserving ecosystems and promoting sustainable development. The study concludes by advocating for increased research and development initiatives to address challenges such as drought, flood, and climate change, with a focus on technological innovations, stakeholder engagement, and policy development to ensure a sustainable future.

***Keywords**: watershed concept, climate change, sustainable development goal, Lonar lake, Jaigaon village, agriculture, environmental sustainability, economic scalability, social equity*

1. Introduction

The Earth's surface is 71 percent water and 29 percent land. Water is found in the atmosphere, on the surface, and underground. Only 0.001 percent of Earth's water is in the atmosphere, 98.287 percent is on the surface, and 1.712 percent is underground. Most surface and underground water is saline: oceans and sub oceans hold 96.54 percent of Earth's water, 0.93 percent of underground water is saline, and saline lakes contain 0.006 percent. This means 97.476 percent of Earth's water is saline, unsuitable for consumption without treatment. Freshwater makes up 2.524 percent, but much of it is inaccessible: 1.74 percent is in polar caps, glaciers, and permanent ice, 0.022 percent in ground ice and permafrost, 0.0008 percent in wetlands, 0.0001 percent in biological water, and 0.001 percent in the atmosphere. Thus, 1.7639 percent of freshwater is unusable, leaving only 0.7601 percent readily available in soil moisture, rivers, freshwater lakes, and groundwater. This underscores the scarcity and value of freshwater on Earth [1]. The World Water Development Report 2020 by UNESCO highlights that water availability, land degradation, deforestation, and extreme climate challenges significantly threaten watersheds worldwide. Approximately 2.2 billion people lack access to safe drinking water, and 4.2 billion experience severe water scarcity annually. Land degradation affects 3.2 billion people, reducing agricultural productivity and biodiversity. An estimated 7.6 million hectares of forest are lost annually, contributing to habitat destruction and carbon emissions. Climate change exacerbates extreme events like floods, droughts, and storms. Environmental sustainability aims to protect the natural environment and maintain resources for future generations, while financial scalability refers to the capacity of systems to manage increased economic activity efficiently. Social equity ensures fair distribution of resources and opportunities within society. The objectives of the present study include i) Explore watershed roles ii) Investigate significance in reducing erosion, water conservation and supporting biodiversity iii) Highlight unique characteristics like Lonar Lake iv) Emphasize the importance of watershed management v) Demonstrate conservation effectiveness vi) Develop sustainable management strategies vii) Evaluate socio-economic and environmental benefits. viii) Explore technological innovations ix) Emphasize stakeholder engagement x) Address policy and governance challenges xi) Assess ecosystem services' value in planning and policy development. xii) Advocate for research addressing challenges like drought, flood, and climate change.

2. Review of Literature

Garole Pradip, (2024). Localization of sustainable development goals through watershed and allied projects; A case study of Jaigaon Village, Satara District, Maharashtra, India highlights the crucial role of innovative techniques effectively addressed soil erosion and improved water conservation, contributing significantly to the project's success. Watershed impacts, such as a greening effect and reduced soil erosion, were observed, along with increased groundwater levels and water availability, leading to socio-economic improvements like halt completely reliance on water tankers and increased employment opportunities. The survey findings from Jaigaon Village show significant progress in various Sustainable Development Goals, (particularly in "No Poverty," "Zero Hunger," and "Good Health and Well-Being," indicating the effectiveness of implemented interventions and policies. Active community involvement, effective governance, and support from non-governmental organizations and corporate partners have contributed to substantial improvements in poverty, hunger, health, and education [2].

3. Methodology

Observation and phenomenology are employed for this study. Stakeholder engagement and participatory research is emphasized to involve local communities, government agencies, and other stakeholders in the research process. Observation involves systematically watching and recording behaviors and events as they occur naturally, providing rich, contextual data. Phenomenology, on the other hand, delves into individuals' lived experiences through interviews and reflective conversations to uncover their essence. By combining these methods, researchers capture both external actions and internal meanings, offering a comprehensive understanding of the phenomena under study. Finally, interpretation is carried out to analyze and draw meaningful conclusions, providing practical recommendations for sustainable development.

4. Results & Discussion

4.1 Watershed as a Structural Unit of the Earth: A watershed functions as a geo-hydrological unit, also serving as a structural and functional unit of the Earth. Structurally, bounded on all sides by ridgelines except one, it culminates in a common drainage point, possessing just a solitary natural outlet for water discharge. Each watershed comprises three constituents: the ridgeline's natural demarcation, the drainage line's approximate symmetry line, and the convergent juncture known as the outfall point. The region enveloping the ridgeline is divided into three distinct zones: the upper reaches, known as the runoff zone; the middle reaches, known as the recharge zone; and the lower reaches, referred to as the storage zone. This structural blueprint remains consistent across all watersheds and their larger forms, universally, and may also be applicable to all the life-holding celestial bodies.

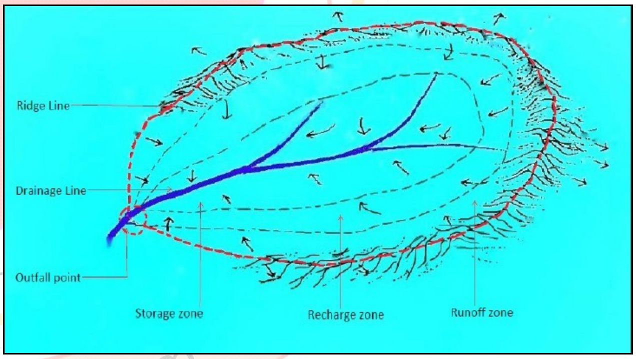

Fig. 1 Constituents and Zones of Watershed

On the basis of the impact of a meteoroid, which has an average diameter of 1831 meters and a depth of 135 meters, Lonar lake (North Latitude 19o55'; East longitude 75o34'), formed some 50,000 years ago and it is encircled by a rim of hills. Lonar Lake's salinity decreases from 300 ppt in 1958 to 100 ppt today, presenting a unique environment [3]. Lonar Lake stands as a closed basin, devoid of any outlet to drain its waters. While Lonar Lake's creation deviates from the typical watershed model, this anomaly underscores the standard natural law. Within its confines, various organisms such as bacteria, archaea, extremophilic haloalkilphiles,

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viruses, viroids, lichens, Monera, Protista, fungi, plantae, and animalia exist, isolated due to natural barriers and heightened salinity. As a result, the genetic material of some lower-level organisms might be pure in form and might be different from that of other organisms.

Fig. 2 Meteoroid impact generated Saline Lonar Lake

Each watershed possesses unique characteristics, including slope, size, geology, soil, land use pattern, climate, rainfall, animal, and human activities. Considering these characteristics are essential in watershed development. Watersheds begin at ridgelines and end where one flow merges into another larger flow of water. The distance between the ridgeline and confluence point is the horizontal distance, while the elevation variance is the vertical distance. Watersheds come in various shapes, adhering to natural boundaries, and their area is not fixed.

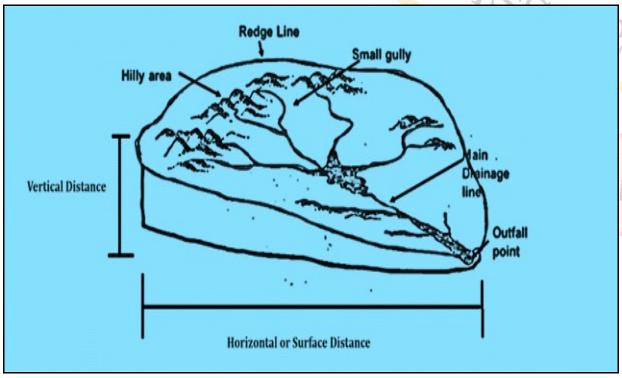

Fig. 3 Horizontal and Vertical distance of Watershed

The roof of every house, the farmland of every farmer, the area of every habitat, as well as the territory of every village, city, and country, belongs to one watershed or another. The smallest watershed is known as a micro-watershed, which converges to form mini watersheds, then sub-watersheds, and eventually river basins and water regions. Water exists in three states: liquid, solid, and gaseous, undergoing transformation rather than creation or destruction. So the Watershed development involves maintaining water in the correct location, time, and proportion. The outer edge of every standing water lies along the contour, minimizing the effect of gravity. Additionally, the researcher posits that earlier oceans contained potable water, while the land had a higher salinity percentage. Due to phenomena like repetitive raining, erosion carried salts to lowlands, making oceans saline over time. The influx of nutrients and oxygen availability in oceans may have fostered the development of life. A comprehensive understanding of these elements is essential for sustainable development and ecosystem management, enabling decision-makers to harness water resources effectively, mitigate environmental impacts, and enhance overall watershed management.

4.2 Watershed as a Functional Unit of Earth: Watersheds serve essential functions in the ecosystem, facilitating the transport and storage of various elements crucial for life. They function as conduits for water, energy, organisms, sediments, and other materials, allowing for the movement and distribution of resources across landscapes. Additionally, watersheds play a vital role in the cycling of key nutrients such as water, carbon, nitrogen, phosphorus, and oxygen. Through processes like chemical transformation and decomposition, watersheds facilitate the transformation and recycling of these nutrients, sustaining ecosystem health and productivity. Moreover, watersheds support ecological succession, promoting the development and evolution of diverse habitats over time. This includes terrestrial forest succession and riparian succession along streams, which contribute to the richness and complexity of watershed ecosystems. Watersheds are vital for agriculture, providing essential physical, chemical, biological, environmental, economic, social, developmental, and technical functions.

4.3 Watershed as a Unit of Management and Development: Effective watershed management requires a comprehensive approach that includes diagnosing issues and implementing treatments like vegetative, engineering, surface, sub-surface, land, and drainage line treatments. Key strategies include rooftop harvesting, in-situ soil and water conservation, runoff management, groundwater management, water use and reuse management. Watersheds, as complex systems of water, land, vegetation, livestock, and people, improve performance in food, fodder, fuel, fruits, fibers, flowers, flesh, fertilizers, flood control, flooded water structures and milk flood. Watershed ecology examines the interplay between biotic and abiotic factors, highlighting the positive correlation between potable water availability and development of specific area. Conservation and restoration are crucial for supporting biodiversity, and mitigating threats like habitat destruction and water pollution. Watersheds are vital units for management, integrating methodologies for sustainable resource use.

5. Conclusion

This study highlights the crucial role of watersheds in ecological and hydrological processes, emphasizing their significance in reducing soil erosion, conserving water, and supporting biodiversity. Unique features like Lonar Lake underscore the diverse characteristics of watersheds and their importance. Effective watershed management is essential for ecosystem preservation and sustainable development, as demonstrated by the successful case study and Survey conducted in Jaigaon Village in Maharashtra, which showcases notable socio-economic and environmental progress. To address challenges such as drought, flood, and climate change, increased research and development initiatives are advocated. Key strategies for sustainable watershed management include evaluating socio-economic and environmental benefits, leveraging technological innovations for implementation, monitoring and conservation, as well as promoting integrated management practices. Stakeholder engagement and collaboration are crucial, as are addressing policy and governance challenges. Integrating the value of ecosystem services provided by watersheds into land use planning and policy development is vital for long-term sustainability and resilience. It provides a pathway to environmental sustainability, economic scalability, and social equity. By fostering discussions among scientists, policymakers, and field workers, we can unlock the potential of watersheds and translate knowledge into impactful policies and practices, leading transformative initiatives for a more sustainable future.

6. References

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