A Comprehensive Review of Traditional and Modern Soil and Water Conservation Practices

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Abstract:- Traditional practices of soil and water conservation have long been employed in various regions of India to combat soil erosion, preserve water resources, and sustain agricultural productivity. This paper explores a diverse range of traditional techniques and structures used for soil and water conservation in different parts of the country. From Ladakh's compact reservoirs and Himachal Pradesh's kuls and khatris to Nagaland's bamboo drip irrigation and Rajasthan's johads and bundela tanks, these traditional practices demonstrate indigenous wisdom and innovation in harnessing natural resources. However, modern soil and water conservation practices have also emerged to address contemporary challenges. Mechanical measures, such as check dams and temporary structures, are utilized to slow down runoff, prevent erosion, and store water. Permanent gully control structures, including drop spillways and chute spillways, are implemented to manage water flow in areas prone to gully erosion. Agronomical measures, such as contour cropping, mulching, and furrow irrigation, aim to preserve soil integrity and minimize erosion.By examining both traditional and modern practices, this paper highlights the importance of integrating indigenous knowledge with contemporary techniques to achieve sustainable soil and water conservation. Understanding and preserving these traditional practices can contribute to the development of effective and context-specific conservation strategies for the future.

***Keywords**:- Water conservation; traditional practices; rainwater harvesting; soil conservation; modern practices; artificial recharge.*

I. INTRODUCTION

Soil and water conservation practises are critical to preserving the delicate balance of ecosystems, supporting agricultural output, and assuring the supply of safe drinking water. Over time, communities all over the world have evolved both traditional and modern approaches to soil and water conservation, taking into consideration concerns such as climate change and the pursuit of sustainable development goals.

Rainwater harvesting is an ancient practise that has endured over the years of time. Rainwater harvesting is the collection and storage of rainwater for a variety of applications such as irrigation, residential consumption, and replenishment of groundwater reserves. This age-old practise was used by ancient civilizations across several continents, demonstrating the wisdom of using natural water supplies to suit human requirements while minimising environmental damage (Amos et al., 2016). Groundwater reservoirs represent another significant means of storing freshwater and present distinct requirements for sustainable utilization. It is crucial to establish a comprehensive monitoring system to continuously assess the depletion and salinization of these reserves due to current practices of extracting water for agricultural irrigation and urban supply. Achieving water-supply stability and preserving ecosystems through sustainable utilization of groundwater necessitates integrated management approaches that combine these resources with surface water. By capitalizing on their complementary hydrological attributes, conjunctive management can optimize water availability and enhance conservation efforts (Foster et al., 2011).

In recent times, the urgent global challenge of climate change has heightened the importance of soil and water conservation practices. As the Earth's climate continues to undergo significant changes, such as altered precipitation patterns and increased frequency of extreme weather events, traditional practices alone may not suffice.The rise in global temperatures witnessed in recent decades has consistently resulted in transformations across various aspects of the hydrological cycle and hydrological systems. These transformations encompass alterations in precipitation patterns, including changes in intensity and the occurrence of extremes. Additionally, the melting of snow and ice has become widespread, while atmospheric water vapor content has increased. Evaporation rates have also risen, and there have been notable shifts in soil moisture levels and runoff dynamics (Huntington, 2006). Hence, modern approaches to soil and water conservation have emerged, incorporating innovative technologies and scientific knowledge to address the evolving environmental conditions.

Additionally, the advancement of sustainable development goals has given soil and water conservation practises an additional layer of relevance. The Sustainable Development Goals (SDGs) of the United Nations seek to promote economic growth, social mobility, and ecological resilience. Several SDGs, including objectives for sanitation and water quality, climate action, and sustainable production and consumption, are closely tied to soil and water conservation (UN General Assembly, 2015). By using both traditional and contemporary conservation practises, society may help to attain these aims while also protecting the earth for future generations.

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In this discussion, we will explore the interplay between traditional and modern practices of soil and water conservation, with a particular focus on rainwater harvesting, climate change, and the pursuit of sustainable development goals. By understanding the strengths and limitations of different approaches, we can develop comprehensive strategies that promote the long-term health of our ecosystems, enhance food security, and ensure the sustainable management of water resources.

II. TRADITIONAL PRACTICES

➢ *Zing:*

Water collection systems observed in Ladakh consist of compact reservoirs designed to capture the melted water from glaciers. These reservoirs are connected through a network of conduits that channel the water from the glaciers into the tanks. Throughout the day, as the glaciers gradually melt, the channels slowly fill up with a gentle stream of water, which transforms into a flowing current by the afternoon. As evening approaches, the collected water settles in the tanks and is reserved for utilization the following day. To ensure fair distribution, a water authority known as the Churpun oversees the equitable allocation of water resources.

Fig. 1: Zings

➢ *Kul:*

Kuls, the water conduits discovered in steep mountainous regions, serve as vital channels transporting water from glaciers to the villages of the Spiti Valley in Himachal Pradesh. In areas where the terrain is muddy, protective measures are taken to line the kuls with rocks, preventing blockages and ensuring smooth water flow. Similarly, in the Jammu region, a similar irrigation system known as kuhls is employed. The traditional irrigation practices in Himachal Pradesh involve surface channels that divert water from naturally flowing streams known as khuds. These community kuhls typically cater to the irrigation needs of 6 to 30 farmers, enabling the cultivation of approximately 20 hectares of land. The system comprises a temporary headwall, often constructed using river boulders, which acts as a storage and diversion point for the water flow through a canal, facilitating its distribution to the fields.

Fig. 2: Kul

➢ *Naula:*

In the hilly regions of Uttaranchal, there exists a unique method of surface-water harvesting called "Naula." These small wells or ponds are constructed by creating a stone barrier across a stream to collect water. The local communities rely on Naulas to fulfill their domestic water requirements, as they are designed to capture water from underground seepages and springs. In the past, sustainability was a key consideration, with the community understanding the importance of preserving water for future needs and implementing measures to prevent excessive exploitation. Naulas are constructed with enclosing walls and feature a tomb-like structure on top, resembling a temple, with a small entrance. This design ensures that animals are kept out and allows only one person to enter the Naula at a time. The Kumaon region of Uttarakhand in the Western Himalayas showcases a notable example of Naulas, which are naturally occurring water aquifers. These stone-lined tanks capture dripping water from springs and streams and hold cultural significance, being revered as sacred structures in the traditional practices and beliefs of Uttarakhand (Jayanti Rawat, 2016).

Fig. 3: Naula

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➢ *Khatri:*

In the hilly regions of Himachal Pradesh, specifically in Hamirpur, Kangra, and Mandi districts, one can find khatris, which are traditional water harvesting structures. They come in two types: one designed for animal use and washing, collecting rainwater from the roof through pipes, and the other intended for human consumption, collecting rainwater through seepage from rocks. Interestingly, khatris can be privately owned or owned by the community. Additionally, government-managed khatris also exist, maintained by the panchayat. These rectangular pits, carved into the hard rocks of hill slopes, serve the purpose of capturing rainwater flowing through the rocks and soil. The capacity of a khatri typically ranges between 30,000 to 50,000 liters, and their construction requires digging a horizontal tunnel followed by a vertical basin. It is important to note that new khatris cannot be dug at lower levels than existing ones, as water naturally seeps down to the lowest available khatri. These ingenious structures play a crucial role in water conservation and distribution, supporting both individual families and the broader community (Sharma et.al 2007).

Fig. 4: Khatri

➢ *Nawn:*

In Himachal, there exists a unique water storage structure called "Nawn" that boasts a significant capacity. Using stones, a tank-like formation is built upon identifying the water source. To maintain cleanliness, a separate channel is designed for washing clothes or bathing, ensuring no contamination of the primary water source. The tank is equipped with a roof and walls on three sides, with sluices on the front to prevent dust or unwanted debris from entering the water. Additionally, outlets are incorporated to prevent containers from submerging. Notably, a smaller tank surrounding a groundwater source is known as "Baudi," while the term "Nawn" refers to a larger tank that serves various purposes. Typically, a village has only one Nawn, while Baudis can be found in multiple numbers (Sharma et al., 2009).

Fig. 5: Nawn

➢ *Kuhl:*

In the lower regions of Kangra, Mandi, and Hamirpur, traditional irrigation practices are exemplified by the kuhls. These surface channels diverge from the natural flowing streams called Khuds, located at higher altitudes, enabling them to irrigate a larger expanse beyond the khud itself. Typically serving 6-30 farmers and covering around 20 hectares of land, community kuhls redirect water through canals to fields using temporary boulder headwalls across ravines. Water flows from field to field, with any surplus returning to the khud. In addition to irrigation, kuhls and khuds facilitate the functioning of traditional gharaats, wooden water mills powered by homemade wheels that harness the kuhl water. The knowledge and expertise required for constructing, maintaining, and operating these kuhls are deeply ingrained in the communities that have flourished under the blessings of these water resources (FAO,2002).

Fig. 6: Kuhl

➢ *Chhrudu:*

A traditional water source in Himachal Pradesh, involves the direct channeling of water from underground sources using pipes. In the past, these pipes, known as "maggaru," were crafted from locally available materials such as maggar or bamboo (Bambusa arundinacea). However, with technological progress, iron or plastic pipes have replaced the traditional bamboo pipes.

Fig. 7: Chhrudu

➢ *Apatani:*

In the Apatani inter-piedmont flat land, a unique and versatile water management system has been implemented. This integrated approach combines land, water, and farming systems to combat soil erosion, conserve water for irrigation, and support paddy-cum-fish culture. Situated in the lower Subansiri district of Arunachal Pradesh, this system covers approximately 30 square kilometers at an altitude of around 1,525 meters above mean sea level in a humid tropical climate. Developed by the local Apatani tribe, it harmoniously combines wet rice cultivation and fish farming. By utilizing both ground and surface water, this system employs terraced plots separated by bamboo-supported earthen dams measuring 0.6 meters in height. Each plot features inlets and outlets on opposite sides, with the inlet of a lower-lying plot serving as the outlet for a higher-lying plot. Channels connect these points, allowing for controlled flooding and drainage of the terraced plots as needed. To harness stream water, a wall is constructed near forested hill slopes, with the water then conveyed to the agricultural fields through a network of channels (Dabral, 2002).

Fig. 8: Apatani

➢ *Zabo:*

An indigenous agricultural system in Nagaland, originates from Kikuma village in the Phek district. Situated at an elevation of 1,270 m above sea level, this method covers an area of 957.9 ha. The term "Zabo" refers to water impoundment, embodying a harmonious blend of forestry, farming, and animal husbandry, while prioritizing soil and water conservation. The system inherently emphasizes water resource development, management, and environmental protection . Remarkably, each farmer nurtures their own land using their resourcefulness, skills, and natural assets.The rainwater flows through protected forest areas on the hilltop, traversing various terraces. Middle terraces collect the water in pond-like structures, followed by cattle yards, and eventually reaching paddy fields at the hill's base, where the run-off naturally meanders (Sharma et al., 1994).

Fig. 9: Zabo

➢ *Cheo-ozihi:*

In Nagaland's Kwigema, the river Mezii gracefully meanders, accompanied by an intricate network of water channels. These channels, including the renowned Cheo-oziihi, meticulously designed by Cheo, branch off from the main channel, diverting water through bamboo pipes to nourish the terraces. Spanning approximately 8-10 kilometers, this remarkable channel sustains a multitude of terraces in Kwigwema and neighboring villages. With three distinct khels, the village's water allocation is thoughtfully divided among them, ensuring equitable distribution within the community (Agarwal and Narain, 1997).

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Fig. 10: Cheo-ozihi

- *Bamboo Drip Irrigation:*

An ancient technique involves utilizing bamboo pipes to transport water for irrigation purposes. The bamboo channels divert water from hilltop springs to lower regions solely relying on gravity. Different sizes of bamboo pipes are used for constructing these channels. This traditional method comprises multiple stages of water distribution, from the diversion point to the application site. However, this system is gradually becoming outdated, being replaced by modern iron pipes and channel irrigation methods. In the state of Meghalaya, villages like Umbir, Mawlyndep, and others in the Revoi district employ a traditional water harvesting system. They collect flowing stream water through bamboo pads for domestic use, while in Jowai district, a community stores stream water in small cement ponds constructed with bamboo. This stored water is utilized by the entire community, with the overflow being used for farming in the catchment areas. The indigenous farmers of the Khasi and Jaintia hills have employed this 200-year-old technique to drip-irrigate their black pepper crops (Bhattacharya, 2015).

Fig. 11: Bamboo drip irrigation

- *Pani Kheti:*

Pani kheti, also known as wet rice terrace cultivation, is a traditional agricultural practice in Nagaland, specifically in the district of Kohima. It has been carried out for generations on terraced areas of hill slopes, particularly in clay soil regions with good water retention capabilities. These terraces are skillfully constructed even on steep slopes exceeding 100%. Maintaining an optimal water level of 8 to 12 cm depth, the terraces are designed with shoulder bunds that facilitate water retention. To ensure adequate water supply, streams are channeled into the terraces when the water level drops. Efficient water channels are constructed at the upper ridge of the stream, allowing the water to flow down to the lower elevation terraces. While most channels are unlined, some areas have lined channels. Additionally, stone patching is employed downstream of the terraces' bunds to enhance stability and strength. Paddy cultivation typically commences in June and continues until mid-November, with harvesting taking place in October (Singh et. al 2018).

Fig. 12: Pani kheti

- *Alder based farming system:*

The traditional agroforestry system practiced by indigenous tribes in Nagaland, India, known as alder-based agroforestry, is an efficient and distinctive method of sustainable agriculture. This system, developed and passed down through generations by tribes like Angami, Chakhesang, Chang, Yimchunger, and Konyak, has proven its effectiveness. The roots of the alder tree play a vital role in fertilizing the soil through their nodules, while their extensive root network aids in preventing soil erosion on slopes. Additionally, the alder tree's deep-rooting system facilitates increased infiltration of rainwater into the soil. By incorporating alder-based agroforestry, the fallow period in cultivation can be reduced, leading to higher yields compared to traditional methods (Rathore et al. 2010; Das et al. 2012).

Fig. 13: Alder based farming system

➢ *Echo:*

The traditional soil conservation method known as Echo has been a long-standing practice among farmers in Wokha district and other districts of Nagaland. Echo, named by the local Lotha community, involves the use of locally available materials like bamboo or wooden logs. These materials are randomly placed across the slopes of jhum fields and typically remain effective for a period of 3 to 5 years. By strategically positioning the logs at intervals of approximately 3.00 meters or based on the slope's steepness, Echo serves as a means to combat soil erosion and preserve moisture. Proper installation of Echo helps control soil erosion and runoff, leading to improved crop growth in the Echo farming areas. This system facilitates increased retention of moisture and nutrients, as observed in field conditions (Singh et al., 2016).

Fig. 14: Echo

➢ *Dong:*

Assam's Bodo community constructs ponds known as "dongs" to collect water for irrigation purposes. These ponds are privately owned and managed. The dongs are fed by natural streams, which are diverted into canals that lead to the fields. Water is then stored in pond-like structures and lifted using a tool called "Lahoni" for distribution to the required areas. Additionally, a wooden boat-like structure called "Koon" is utilized to transport water from the pond to the fields. Each trip with the Koon yields around 25 liters of water, sufficient for irrigating a 4-5 bigha plot in a day. The dongs rely on perennial streams as their water sources (Talukdar, 2018).

Fig. 15: Dong

➢ *Dungs:*

Dungs or Jampois are traditional water conservation structures found in West Bengal, India. These structures are designed to capture and store rainwater, primarily during the monsoon season, to meet the water needs of the local communities throughout the year. Dungs are earthen embankments built across natural depressions or valleys to create small reservoirs. They effectively collect and retain rainwater, preventing runoff and allowing it to percolate into the ground, replenishing groundwater sources. The stored water is then utilized for various purposes, including irrigation, livestock watering, and domestic use. Dungs play a crucial role in mitigating water scarcity and ensuring water availability in regions with limited access to surface or groundwater resources. They also contribute to the overall sustainability and resilience of the local ecosystems by promoting groundwater recharge and supporting biodiversity (Pande 2018).

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Fig. 16: Dungs

- *Ahar Pynes:*

The Ahar-pyne irrigation system, a traditional technique native to the South Bihar plains in India, continues to provide irrigation for significant areas today. This system has developed based on a deep understanding of the region's unique agroclimatic conditions. An Ahar refers to a rectangular embankment structure used for water harvesting, with three sides forming a catchment basin and the fourth side following the natural slope of the land. After the Kharif (summer) cultivation, excess water is drained, and Ahar beds are utilized to cultivate Rabi (winter) crops. Water supply for the Ahar system relies on natural drainage following rainfall (rainfed ahars) or artificial channels known as pynes, which divert water from rivers into agricultural fields. This ingenious system has enabled the cultivation of paddy in South Bihar, an area otherwise unsuitable for this crop (Koul et.al 2012).

Fig. 17: Ahar Pynes

- *Bengal's inundation channel:*

In the past, Bengal boasted an exceptional network of flood canals renowned for their unique characteristics. These canals were notable for their broad and shallow structure, allowing them to carry the nutrient-rich clay-laden waters from river floods while being devoid of coarse sand. They stretched over long distances, running parallel to each other at appropriate intervals for effective irrigation. Utilizing cuts in the canal banks, irrigation activities were carried out by opening and closing these openings after the floodwaters had receded.

- *Dighis:*

Made in Delhi by Emperor Shahjahan. A dighi was a square or circular reservoir about 0.38 m by 0.38 m with staircases for access. Sluice gates were unique to each dighi. People were not permitted to bathe or wash their clothes on the dighi's stairs. One was, however, permitted to take water for personal consumption. A kahar or a mashki was usually employed to get water from the dighis. The majority of the households had their own wells or smaller dighis on their property. Wells were the primary source of water when canal flows did not reach the town and the dighis ran dry (Agarwal et al 1997).

- *Baolis:*

Baolis, also called baoris or vavs, are handcrafted subterranean reservoirs created to function as underground water sources. These architectural marvels have long been renowned in India, particularly in drought-prone regions, and have played a vital role in preserving water. Predominantly found in the western areas of India, baolis supplied villages with essential water for drinking, washing, bathing, and irrigation, especially during dry spells and seasonal variations. Baolis served as inclusive water reservoirs accessible to all, exemplified by the Gandak-ki-baoli, constructed during Sultan Iltutmish's reign. This stunning rock-carved baoli still provides water for bathing and washing (Dey 2019).

Fig. 18: Baolis

- *Kunds / Kundis :*

Nestled like an inverted cup within a dish, kunds serve as remarkable rainwater harvesting structures in the sandy regions of the Thar Desert in western Rajasthan and certain areas of Gujarat. These underground circular wells feature a saucer-shaped collection area that gradually slopes towards the center where the well is positioned. To prevent debris from entering the well-pit, a wire mesh covers the water inlets. Lime and ash disinfect the well's walls, while most pits are equipped with a dome-shaped cover or lid to safeguard the water. When necessary, water can be drawn using a bucket. The dimensions of the kunds vary depending on their intended purpose, be it drinking or fulfilling domestic water needs (CGWB 2011).

Fig. 19: Kundis

- *Kuis / Beris:*

In the arid regions of western Rajasthan, particularly in the Bikaner district, there exist abundant Kuis or Beris. These deep pits, measuring 10 to 12 meters, are strategically dug near tanks to capture seepage water. Additionally, Kuis can serve as rainwater harvesting structures in areas with limited rainfall. To prevent water evaporation, the mouth of the pit is deliberately narrow, while the wider underground section allows water to seep through a larger surface area. These entirely earthen structures are often covered with wooden planks or securely locked. The collected water is utilized sparingly, as a last resort during times of crisis (Jethoo 2022).

Fig. 20: Beris

- *Baoris:*

Baoris, also known as bers, are communal water wells commonly found in Rajasthan, serving primarily for drinking purposes. Constructed by nomadic banjaras to meet their water requirements, these ancient wells have remarkable water retention capabilities with minimal evaporation. Unlike other water bodies, baoris do not possess their own catchment areas or direct connections to watercourses. Instead, they rely on seepage from nearby talabs or lakes for their water supply. Designed to occupy minimal space, baoris are a cost-effective, time-saving, and energy-efficient solution. Jodhpur district in Rajasthan is particularly renowned for its baoris, which experience significantly lower water evaporation rates compared to other sources (CGWB 2011).

Fig. 21: Baoris

- *Jhalaras:*

Artificial reservoirs primarily used for communal bathing and religious ceremonies, exhibit a rectangular layout with steps on three or four sides. They collect underground seepage from an upstream talab or lake. A remarkable illustration is the Maha Mandir Jhalara built in 1660, showcasing exquisite architectural designs that warrant preservation. Some jhalaras now serve irrigation functions. However, mining and industrial activities pose a threat, leading to the destruction of these structures. Immediate action is necessary to safeguard them by regulating activities in the surrounding catchment areas. Effective measures, such as reforestation, can aid in rejuvenating these jhalaras, while desilting becomes crucial for their original purpose to be realized (Amirthalingam 2014).

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Fig. 22: Jhalaras

➢ *Nadis:*

Village reservoirs created by constructing earthen embankments across natural depressions, can be found in the Jodhpur and Rajsamand districts of Rajasthan. The selection of the site is based on the availability and potential yield of water from natural catchments. The duration of water availability in the nadis varies from two months to a year following the monsoon season. In dune areas, the storage capacity ranges from 1.5 to 4.0 meters, while in sandy plains, it extends from 3 to 12 meters. The location of each nadi depends on its storage capacity, which is determined by the associated catchment area and runoff.A Nadi also acts as a source of groundwater recharge through seepage and deep percolation (CGWB 2011).Furthermore, the extensive surface area of the nadis leads to significant water loss through evaporation (Amirthalingam 2014).

Fig. 23: Nadis

➢ *Tobas:*

Tobas, known locally as ground depressions with natural catchment areas, were constructed in a chosen area featuring a solid, impermeable land surface, including depressions and catchment zones. These Tobas serve as vital water sources for both human and livestock consumption, while the surrounding grasslands offer grazing grounds for cattle.To ensure the preservation and enhanced capacity of the Tobas, efforts were made to expand their catchment areas.

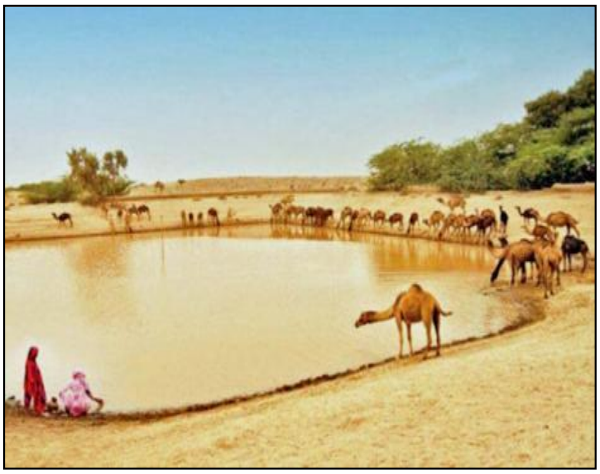

Fig. 24: Tobas

➢ *Tankas:*

Tankas, known as miniature reservoirs, can be typically observed within the primary residence or courtyard of Bikaner-style dwellings. These underground tanks, featuring meticulously crafted circular openings and adorned with elegantly designed tiles, serve as receptacles for rainwater. Through the use of finely polished lime, the tankas ensure the collected water remains refreshingly cool. Such water is exclusively designated for drinking purposes. This unique tanka system has persisted for centuries not only in Bikaner but also in revered pilgrimage towns like Dwaraka in Gujarat (Gaur et.al,2005).

Fig. 25: Tankas

➢ *Khadin:*

The khadin or dhora, a remarkable engineering feat, was devised to harness surface runoff water for agricultural purposes. This innovative system entails constructing a lengthy earthen embankment, spanning 100-300 meters, across the lower slopes of gravelly uplands. Equipped with sluices and spillways, the khadin efficiently drains excess water, transforming the water-saturated land into fertile ground for crop cultivation. Originally pioneered by the Paliwal Brahmins of Jaisalmer in the 15th century, this method bears striking resemblance to the ancient irrigation techniques employed by the inhabitants of Iraq (Yadav, 2023).

Fig. 26: Khadin

➢ *Paar system:*

The western Rajasthan region has a widespread water collection method known as Paar, which involves the flow of rainwater from the agar (catchment) and subsequent percolation into the sandy soil. Typically ranging from 5 to 12 meters deep, Kuis or beris are constructed using traditional masonry techniques. This technique serves as the primary approach for rainwater harvesting in the area, and the collected rainwater is referred to as Patali paani (Prateek 2015).

Fig. 27: Paar

➢ *Talab:*

Talabs, which serve various purposes like irrigation and drinking water, can either be natural or man-made. Natural talabs, such as the ponds in Tikamgarh, Bundelkhand, and man-made talabs like the lakes in Udaipur, exemplify these reservoirs. Smaller reservoirs, covering an area less than five bighas, are referred to as talais, while medium-sized ones are called bandhis or talabs. Larger lakes are known as sagars or samands. In regions where talabs dry up shortly after the monsoon season, the pond beds are utilized for cultivating rice (Agarwal et al., 1997).

Fig. 28: Talab

➢ *Saza Kuva:*

It is a significant irrigation resource in the Aravalli hills of Mewar, eastern Rajasthan, characterized by an open well jointly owned by multiple partners ("saza" meaning partner). To create the well pit, the excavated soil is utilized to construct a large circular foundation or an elevated platform that slopes away from the well. The circular foundation serves as a space for the traditional water lifting device known as "rehat," while the sloping platform accommodates the "chada," a mechanism that utilizes buffaloes to lift water. Typically, a group of neighboring farmers collectively undertakes the construction of Saza Kuva, considering their adjoining landholdings (Dande et.al, 2016).

Fig. 29: Sazakuva

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➢ *Johad:*

Johads, which are compact soil barriers designed to trap and store rainwater, have significantly enhanced water percolation and groundwater replenishment. Over 650 villages in Rajasthan's Alwar district boast approximately 3,000 johads. These structures have remarkably elevated the groundwater level by nearly 6 meters and fostered a 33% expansion in forested areas. As a result, five rivers that previously ran dry soon after the monsoon season now flow consistently throughout the year (Dande et.al, 2016) .

Fig. 30: Johad

➢ *Naada / Bandha:*

Bandha structures can be observed in the Mewar area of the Thar Desert. These check dams, made of stone, are built across streams or gullies with the purpose of capturing rainfall runoff on a specific land area. As the land gets submerged in water, it experiences increased fertility due to the deposition of silt, and the soil retains significant amounts of water, contributing to its moisture content (Dande et.al, 2016).

➢ *Pat:*

In the southern region of Madhya Pradesh, a comparable method is employed to redirect water from flowing streams that originate in the hills. This technique, designed to suit the unique topography, involves diverting water into irrigation channels known as pats using a stone barrier reinforced with leaves. The diversion bunds constructed across the streams consist of stacked stones, carefully lined with teak leaves and mud to ensure water-tightness (Upadhya 2009).

➢ *Chandela Tank:*

Massive earthen embankments were erected to create reservoirs, blocking the flow of water between hills and forming natural groundwater barriers. The embankments, supported by coarse stone walls resembling steps, were over 60 meters wide. Built with lime and mortar, these tanks have endured for centuries, withstanding the test of time.These reservoirs provided essential drinking water for villagers and their livestock (Agarwal et.al 1997).

Fig. 31: Chandela tank

➢ *Bundela Tank:*

The Bundela tanks are larger in scale than the Chandela tanks, featuring well-built staircases that provide access to the water within the tanks.

➢ *Rapat:*

A rapat is a water storage structure designed to collect rainwater from a watershed. It consists of a bund to retain the water and a waste weir to release excess flow. Depending on its size, the bund can be constructed using either masonry or earth materials. In Rajasthan, rapats are predominantly made of masonry due to their smaller scale. While rapats and percolation tanks don't directly provide irrigation, they effectively replenish groundwater within a range of 3-5 km downstream. However, the accumulation of sediment poses a significant challenge for small rapats, leading to a lifespan of 5 to 20 years.

➢ *Katas / Mundas / Bandhas:*

The ancient Gonds, residing in present-day Orissa and Madhya Pradesh, relied on katas, mundas, and bandhas as their primary irrigation sources. These katas were constructed either in a north-south or east-west direction, adjacent to villages. An earthen embankment with curved ends was built across a drainage line, forming an irregularly-shaped water reservoir. The shape of the reservoir typically resembled a long isosceles triangle, with the dam serving as the base. This system controlled a valley with bahal land at the bottom and mal terraces along the sides. Water was directed from the reservoir to fields through channels or terraces, gradually descending to lower fields (CWC 2011) .

Fig. 32: Katas

➢ *Cheruvu:*

Cheruvu, located in the districts of Chitoor and Cuddapah in Andhra Pradesh, serve as reservoirs for capturing runoff. The embankments of Cheruvu are equipped with thoomu, alugu or marva, and kalju structures, as well as kalava canals (Patel 2021).

Fig. 33: Cheruvu

➢ *Kohli Tanks:*

Several centuries ago, a community of farmers known as Kohlis constructed approximately 43,381 water tanks in Maharashtra's Bhandara district. These tanks served as the primary source of irrigation in the region until the government assumed control in the 1950s. Vital for cultivating crops like sugar and rice, these tanks come in various sizes and play a crucial role in delivering water directly to the doorstep of villagers (Agrawal 2020).

➢ *Bhanadaras:*

Ancient structures constructed across rivers to raise the water level and redirect the flow into channels. They also serve as reservoirs, storing water. In Maharashtra, these traditional systems ensured water availability for several months after the rainy season when built across small streams. Villagers or individuals were granted rent-free land in exchange for their contribution to the community by constructing bandharas. Unfortunately, the majority of bandharas have fallen into disuse and are no longer functional (CWC 2011).

Fig. 34: Bandharas

➢ *Phad:*

Approximately three to four centuries ago, the self-governed phad irrigation system emerged in northwestern Maharashtra. This system operated along the Panjhra, Mosam, and Aram rivers within Dhule and Nasik districts. Phads varied in size, ranging from 10 to 200 hectares, with an average size of 100 to 125 hectares. Annually, the village collectively determines the allocation of phads for cultivation or fallow periods. Each phad is dedicated to growing a single crop type, typically sugarcane in one or two phads and seasonal crops in the remaining ones. This practice ensures a beneficial crop rotation system that sustains soil fertility while mitigating risks associated with waterlogging and salinity (Agarwal et.al 1997).

Fig. 35: Phad

- *Kere Tanks:*

Kere Tanks, referred to as kere in the local language of Kannada, served as the primary traditional irrigation system in the Central Karnataka Plateau. These tanks were supplied with water either through diversion channels stemming from small dams constructed across streams or directly from streams flowing through valleys.

Fig. 36: Kere Tank

- *The Ramtek model:*

The Ramtek approach, inspired by the reservoir systems in Ramtek, Maharashtra, is characterized by interconnected tanks constructed and maintained by landowners known as Malguzars. These tanks form a connected network that stretches from the foothills to the plains, effectively capturing and conserving a significant portion, approximately 60-70%, of the total runoff. As water fills the upper tanks situated near the hills, the excess flows down to subsequently fill the succeeding tanks through interlinked channels. Any remaining water is often stored in small water holes using this sequential method. The region surrounding the Ramtek ridge in the southern area witnesses rapid runoff and limited percolation due to the steep slopes on both sides (Agrawal 2020).

Fig. 37: Ramtek

- *Surangam:*

A tunnel-like structure called a "surangam" is typically constructed in tough laterite rock formations to tap into water sources. The excavation process persists until a substantial water reservoir is reached. The water seeps through the resilient rock and emerges from the tunnel, eventually collecting in a specially built open pit situated outside the surangam. The term "surangam" originates from the Kannada language and is commonly found in the Kasaragod district of Kerala's northern Malabar region (Agarwal et.al, 1997).

Fig. 38: Surangam

Virdas:

Virdas represent shallow boreholes excavated within shallow depressions known as jheels or tanks, scattered across the Banni grasslands, an integral region of the Great Rann of Kutch located in Gujarat. These structures were constructed by the migratory Maldharis, a community that traditionally inhabited and traversed these grasslands (Bhattacharya, 2015).

Fig. 39: Virdas

➢ *Korambus:*

A makeshift barrier formed at the entrance of channels, is crafted using a combination of brushwood, mud, and grass is usually found in Kerala. The process involves horizontally securing a sturdy wooden beam that connects both banks of the canal. Vertical wooden beams of suitable height are then erected, firmly grounded at the lower ends and fastened to the horizontal beam. A tightly woven coconut thatch is affixed to this structure, coated with mud, and carefully covered with a layer of grass to prevent erosion. The purpose of constructing Korambu is to elevate the water level within the canal and redirect it into the field channels (Pande 2018).

➢ *Eri:*

Tamil Nadu relies on eris, which cover a significant portion of the irrigated land, serving as crucial elements in ecological balance. Eris serve multiple purposes, including flood control, preventing soil erosion, preserving runoff, and replenishing groundwater (Bhalge et.al, 2007). They create a favorable microclimate vital for local regions, particularly for cultivating paddy. While eris were traditionally maintained by community efforts, the arrival of the British brought a decline as the village communities struggled to sustain their upkeep and maintenance (CGWB 2011).

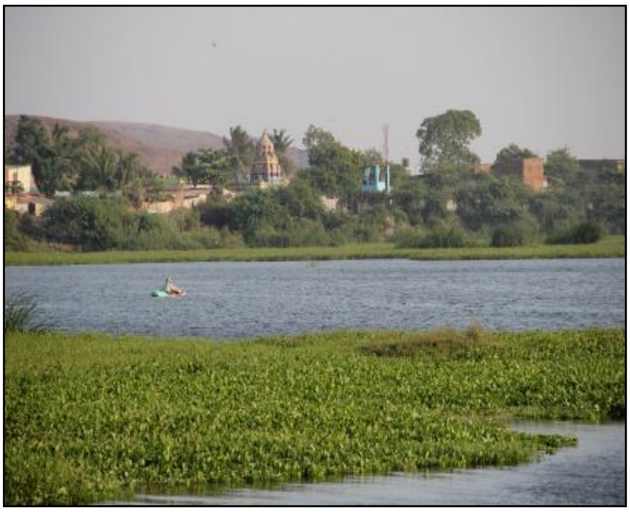

Fig. 40: Eri

➢ *Ooranis:*

Ooranis, small reservoirs that accumulate rainwater and runoff, have served as vital water sources for drinking, washing, and bathing in surrounding villages. With origins dating back thousands of years, Ooranis hold significant cultural and historical importance in Tamil society. Initially established through the generosity of ruling or merchant elites, the local community actively participated in their construction and upkeep, fostering a sense of ownership. However, with the advent of government administration after Independence, the responsibility for village management shifted, leading to the neglect of these Ooranis. In the south of Travancore, the hilly terrain limited the size of the Ooranis, unlike the larger tanks found in Tamil Nadu (Agarwal et.al, 1997).

Fig. 41: Ooranis

➢ *Panam Keni:*

Kenis can be observed in close proximity to forests and either on the outskirts or within paddy fields of Tamil Nadu. These cylindrical structures possess a diameter and depth of approximately four feet. The walls of the kenis are adorned with toddy palms, specifically Caryota urens. Normally, the lower section of the towering palm tree is employed to fashion wooden cylinders. By immersing them in water for an extended duration, the inner core decomposes, while the durable outer shell endures. These wooden cylinders are then submerged in regions abundant in underground water sources, thus ensuring an ample water supply, even in arid environments (Murthy et.al 2022).

Fig. 42: Panam Keni

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➢ *Jackwells:*

The ingenious Jackwell system was devised by the indigenous tribes of Nicolas Island. The resourceful Shompen tribe, residing in this undulating terrain, employed a unique water harvesting technique. They constructed bunds using durable bullet wood logs in the lower regions. Split bamboo pieces were also utilized in their innovative water collection system. By cutting a bamboo lengthwise and placing it along a gentle slope, they created channels that directed rainwater into shallow pits known as Jack wells. A series of interconnected jack wells of increasing size were built, culminating in the largest jack well with a diameter of approximately 6 meters and a depth of 7 meters, ensuring a smooth overflow from one well to the next (Dhiman et.al 2011).

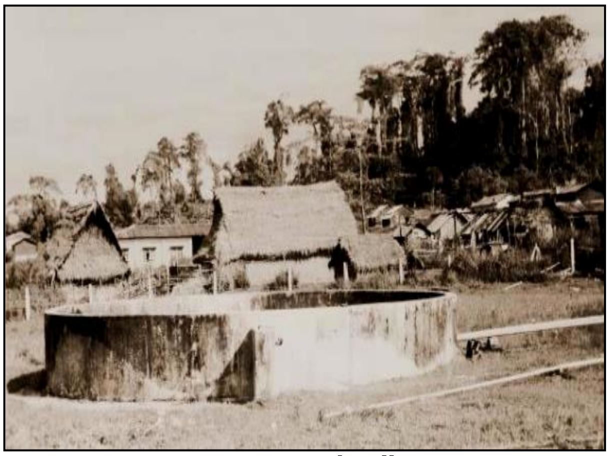

Fig. 43: Jackwell

III. MODERN PRACTICES

A. Mechanical Measures

➢ *Check Dams:*

Check dams are constructed to store rain water and silt on the upstream side. Depending upon size of nala, its slope, watershed area and severity of the problem, suitable type of check dam can be selected.

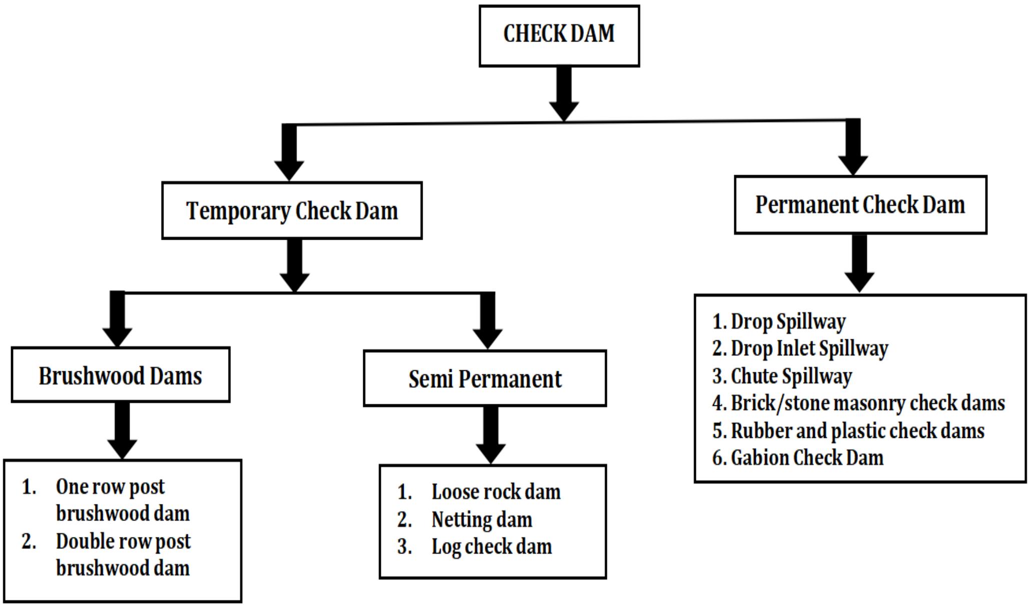

Fig. 44: Check Dams diagram

- **Temporary check dams**

Temporary check dams For stabilization of gullies through vegetation is a difficult task. Temporary mechanical measures are adopted to prevent washing away of the plantation by large volume of run-off that provides to establish the vegetation. Vegetation once established will be able to take care of the gully(Rao et al.,2022).

✓ Brushwood check dam:

Constructed using locally accessible materials, brushwood check dams are affordable and easily crafted by farmers. While they possess the least durability among dam types, they serve as an ideal solution for small gullies with depths ranging from 1 to 2 meters. These dams come in two variations: a single row of poles or a double row of poles. It is important to note that they are temporary structures and not suitable for addressing persistent issues like concentrated runoff. However, they can be effectively utilized alongside land-use modifications such as reforestation or enhanced range management until long-term measures involving vegetation and slope treatment take effect.

- **Semi permanent check dams.**

✓ Loose Rock Dam:

In order to mitigate channel erosion, small stones are strategically positioned throughout the gully. These dams serve to stabilize both emerging and smaller tributaries of the main gully, with a channel length not exceeding 100 meters and a catchment area of 2 hectares or smaller. The construction of these stone check dams predominantly takes place in regions abundant with rock resources. Developing countries such as Nepal, India, and Pakistan frequently employ this technique for gully control purposes.

- ✓ Log Wood Dam:

Constructed from timber logs and stakes arranged across the ravine, an alternative design can utilize sturdy planks or heavy boards. The primary purpose of this structure is to retain sediments, both fine and coarse, transported by the flowing stream within the gully. Employed specifically for stabilizing emerging small and tributary ravines, these measures are suitable for gullies that do not exceed 100 meters in length and have a catchment area of less than 2 hectares.

- ✓ Earthen check dams:

Earthen check dams are small embankments constructed across gullies or streams to slow down runoff, stabilize the area, and store water. They vary in size based on the gully's width, length, and slope. Check dams reduce erosion, promote sediment deposition, and improve soil moisture for better plant growth. They can significantly decrease runoff and soil loss by up to 80%.

- ✓ Bori bund checkdam:

Bori bunds are embankments made of sand-filled polythene bags that block erosion-prone streams. They slow down water flow in areas where traditional plugs are ineffective. Dimensions depend on gully characteristics, with bunds stabilizing beds and banks, storing water, and reducing runoff and soil loss by 80%. Ideal for sandy soil and medium-deep gullies.

- **Permanent check dams**

When temporary or vegetative structures prove insufficient, the implementation of Permanent Gully Control Structures becomes imperative. These long-lasting measures, including masonry check dams, flumes, and earth dams combined with vegetation, effectively redirect runoff across crucial sections of the gully. Notable examples of permanent structures comprise drop spillways, drop inlet spillways, and chute spillways, ensuring sustainable management of gully erosion and water flow (Rao et al.,2022).

- ✓ Drop spillway:

The descent overflow channel functions as a distinct barrier. The water flow traverses the opening, descends onto a nearly level platform or tranquil pool, and subsequently proceeds into the channel downstream. Drop spillways can be built using reinforced or plain concrete, rock masonry, concrete blocks, with or without reinforcement or gabions. This spillway design effectively manages moderate drops, typically within the range of 3.0 meters or less.

- ✓ Drop inlet spillways:

A descending intake channel serves as an enclosed passage that transports pressurized water from a higher position on a mound to a lower level. The primary purpose of this descending intake channel is to safely guide a fraction of the runoff either through or beneath the mound without causing erosion. It proves to be a highly effective construction for managing considerable gully heads, typically exceeding 3.0m in height.

- ✓ Chute spillways:

A chute spillway refers to an unobstructed water channel characterized by a steep incline, enabling the flow to exceed critical velocity. It comprises an entry point, a vertical curve segment, a channel with a sharp slope, and an exit point. The construction of chute spillways commonly involves the use of reinforced concrete, especially for managing large overfall gullies and detention dams, which helps minimize the necessary capacity.

- ✓ Brick/stone masonry check dams:

In areas where natural streams are present in the downstream areas of a watershed, the use of brick or stone masonry check dams can serve as a viable option for harvesting and recycling runoff, effectively managing the impact of unpredictable climatic events like mid-seasonal droughts and floods. However, due to the high construction costs involved, the adoption of these 44 structures remains limited in the absence of suitable schemes or programs.

- ✓ Rubber and plastic check dams:

Rubber and plastic barriers serve as economical and convenient check dams. They offer a solution to minimize construction challenges, making them highly suitable for rainwater harvesting and long-term water management initiatives in watershed projects. Notably, their implementation ensures sustained functionality while keeping maintenance expenses minimal.

- ✓ Gabion Check Dam:

When vegetative or temporary structures prove insufficient, the implementation of Permanent Gully Control Structures becomes essential. These structures, including masonry check dams, flumes, or earth dams, reinforced with vegetation, effectively manage the runoff across crucial sections of the gully. Among the key types of permanent structures are drop spillways, drop inlet spillways, and chute spillways, which ensure the proper conveyance of water runoff.

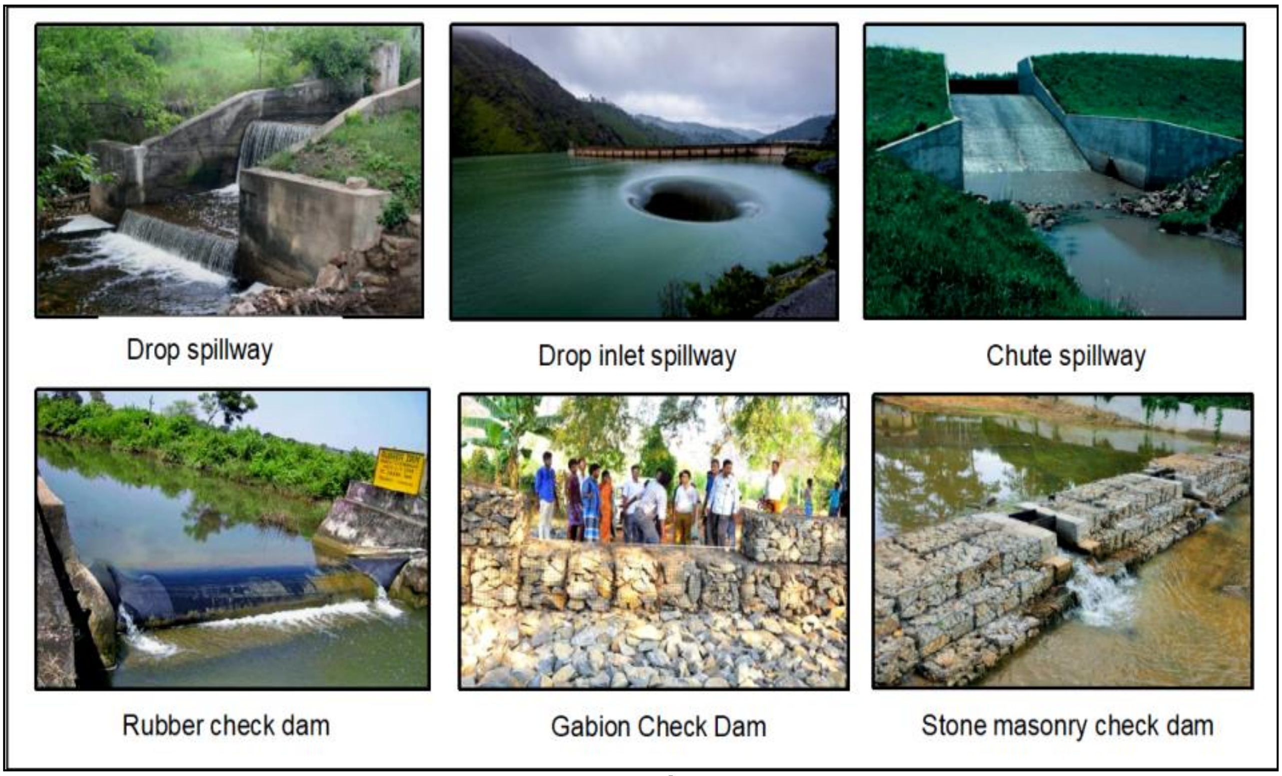

Fig. 45: Permanent water harvesting structures

➢ *Artificial recharge techniques*

Artificial recharge techniques involve direct and indirect methods to replenish groundwater reserves. Direct methods include the construction of infiltration ponds, basins, recharge wells etc. allowing water to infiltrate the ground and recharge the aquifer. Indirect methods involve redirecting surface water, such as rainfall and excess runoff, into underground reservoirs. These innovative approaches help balance water demand and supply, mitigate the impacts of drought, and ensure a reliable water source during periods of scarcity. Additionally, artificial recharge techniques provide environmental benefits by reducing surface water runoff and preventing soil erosion (CGWB 2000; Mukherjee 2016; Bhattacharya 2010).

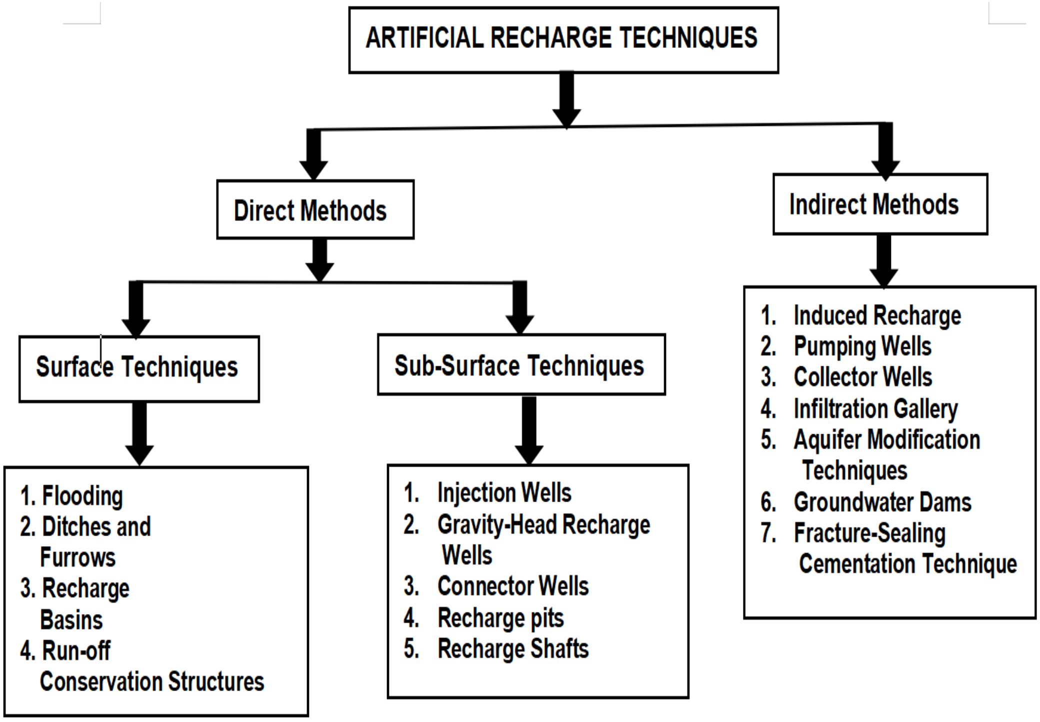

Fig. 46: Artificial recharge techniques diagram

- **Direct Approaches**

✓ Runoff Conservation Structures:

Suitable for regions with low to moderate rainfall, primarily during a single monsoon season. These structures help retain runoff water by creating barriers, preventing water transfer from other areas.

✓ Bench Terracing:

Promotes soil conservation and prolongs the presence of runoff water on terraced areas, leading to increased infiltration and groundwater recharge.

✓ Gully Plugs:

Small runoff conservation structures constructed across small gullies and streams on hill slopes. They mitigate drainage issues in tiny catchments during the rainy season, using local materials like stones, earth, brushwood, and weathered rock.

✓ Contour Bunds:

Watershed management practice aimed at enhancing soil moisture storage. Typically implemented in areas with low rainfall.

✓ Contour Trenches:

Rainwater harvesting structures suitable for both high- and low-rainfall areas. Constructed on hill slopes and degraded lands to promote water retention and recharge.

✓ Percolation Tanks:

Artificially created surface water bodies that submerge highly permeable land areas. Surface runoff percolates into the ground, recharging the groundwater storage.

✓ Injection Wells

Similar to tube wells, these structures inject treated surface water under pressure into overexploited confined aquifers. They help replenish declining groundwater levels and combat seawater intrusion and land subsidence in coastal areas.

✓ Gravity-Head Recharge Wells:

Conventional bore wells and dug wells utilized for pumping can also serve as recharge wells when a source water supply is available. Adequate filtration and disinfection are crucial to prevent aquifer contamination.

✓ Connector Wells:

Special recharge wells that facilitate water flow from aquifers with higher hydraulic heads to those with lower heads. No pumping is required in this process.

✓ Recharge Pits:

Deeper structures designed to overcome the challenge of artificial recharge for phreatic aquifers from surface-water sources. Similar to recharge basins but with a smaller bottom area.

✓ Recharge Shafts:

Used when poorly permeable strata overlay deep-lying water table aquifers. A recharge shaft, smaller in cross-section than a recharge pit, facilitates artificial recharge.

- **Indirect Approaches**

✓ Induced Recharge:

Involves pumping water from a hydraulically connected aquifer to induce recharge in the groundwater reservoir. This method offers the advantage of improving the surface-water quality as it passes through the aquifer materials before discharge.

✓ Pumping Wells:

Induced recharge systems located near perennial streams, where the stream-channel's permeable rock material connects it to the aquifer. The chemical quality of the surface-water source is a crucial factor to consider in induced recharge.

✓ Collector Wells:

Constructed to obtain large water supplies from river-bed, lake-bed deposits, or waterlogged areas. Horizontal wells may be more suitable than vertical wells when the adjacent phreatic aquifer is shallow. Collector wells with horizontal laterals and infiltration galleries maximize induced recharge from the stream.

✓ Infiltration Gallery:

Horizontal perforated or porous structures (pipes) surrounded by a gravel filter envelope. Installed below river-bed strata to tap groundwater reservoirs. Infiltration galleries are typically placed at depths of 3 to 6 meters to collect water through gravity flow. The choice of this method should consider the required yield and economic aspects.

B. Agronomical Measures for Soil & Water Conservation

Preserving soil integrity involves adopting strategies to mitigate or minimize soil degradation and erosion by utilizing its inherent properties and implementing conservation practices to protect and improve its overall quality. Among the various approaches in soil and water conservation, agronomic methods emerge as a highly effective, long-lasting, and economically viable technique. These measures focus on mitigating the effects of rainfall by intercepting it, thus reducing soil erosion. Furthermore, they enhance the rate of water infiltration, resulting in reduced surface runoff. Presented below are several widely utilized agronomic measures aimed at managing water erosion.

➢ *Contour Cropping:*

Contour Farming is an environmentally-friendly agricultural technique employed on sloping terrains to mitigate soil erosion caused by water runoff. This method entails cultivating crops perpendicular to the slope rather than parallel to it. By implementing terrace farming, the fertile topsoil is safeguarded through the reduction of runoff velocity and increased water infiltration. This practice proves particularly advantageous on lengthy and gradual slopes, where flow velocity tends to be higher, as terrace farming diminishes slope length, thus minimizing flow speed. Terrace farming exhibits optimal effectiveness on slopes ranging from 2 to 10 percent (Farahani et al., 2016).

- *Strip Cropping:*

Strip cropping involves the cultivation of narrow strips of crops with limited erosion control capabilities, such as root crops or cereals, interspersed with strips of crops that are effective in preventing erosion, such as fodder crops or grasses that grow closely together. This farming technique is more intensive compared to contour farming and incorporates practices like contour strip farming, cover cropping, conservation tillage, and appropriate crop rotation (Devi et al., 2023). By combining intertilled and close growing crops in a rotation on contoured land, strip cropping promotes food production, fodder supply, and soil moisture conservation. Close growing crops act as barriers, reducing runoff velocity and soil erosion from the intertilled crop strips. Strip cropping can be implemented using three methods for layout design.

- *Mulching:*

The application of mulches serves multiple purposes in land management. It aids in mitigating the impact of rain by minimizing splash, curbing evaporation, controlling weed growth, regulating soil temperature in hot climates, and creating favorable conditions for microbial activity. By breaking the force of raindrops, mulches prevent soil structure degradation, reduce runoff velocity, and safeguard against sheet and rill erosion. Furthermore, they enhance infiltration capacity by preserving a conducive soil structure at the land's surface.

- *Conservation/contour furrow:*

Implementing conservation techniques, such as furrow irrigation, plays a crucial role in preserving rainwater, minimizing soil erosion, and preventing nutrient loss from crop fields. By utilizing bullock-drawn tools, farmers can create conservation furrows after 45 days of sowing, effectively capturing rainwater and reducing wastage. Contour-furrow irrigation offers additional benefits on sloping fields, as it saves water by minimizing surface runoff and over-irrigation. Compared to downhill irrigation, the slower movement of water across 28 contour furrows prevents soil erosion and ensures a more uniform distribution of water, resulting in improved crop yields and higher-quality produce. Addressing the issue of water flowing down sloping fields is vital to safeguard our essential soil and water resources from rapid depletion (Kumar et al., 2018).

- *Ridge-furrow system:*

In arid and semi-arid regions, the ridge-furrow system presents an innovative approach to enhance water efficiency in rainfed farming. By creating alternate ridges and furrows using a plough pulled by bullocks during the onset of monsoon in June, this system aims to maximize precipitation utilization. The furrows, measuring 45 cm wide and 20 cm high, demonstrate favorable performance in both medium and high rainfall areas. In regions with abundant rainfall, this system not only conserves moisture but also serves as an effective drainage solution (Mensah et al., 2022).

- *Broad bed and furrow system:*

The implementation of the wide ridge and trench technique encompasses the creation of a wide ridge measuring 90-120 cm, accompanied by a trench of 45 cm, and the cultivation of crops with a row spacing of 30 cm. In regions with moderate rainfall, this wide ridge and trench (WRT) approach exhibited substantial enhancements in crop yields, particularly for soybean cultivation in Vertisols found in Maharashtra and Madhya Pradesh, surpassing farmer's conventional practices by up to 83%. Additionally, during periods of heavy rainfall, the WRT system efficiently drained excess runoff through the trenches while simultaneously serving as a moisture reservoir during periods of scarcity (Chaudhuri et al., 2008).

C. Vegetative Measures for Soil & Water Conservation

Implementing diverse vegetation-based techniques can effectively mitigate the loss of sediments and nutrients. These include vegetative filter strips, riparian forest buffers, conservation covers, contour buffer strips, alley cropping, and grassed waterways. Live-bunds and vegetative barriers offer additional biological measures that help conserve soil and water by regulating surface runoff and promoting increased infiltration duration.

- *Vegetative filter strips:*

A vegetative buffer zone is an area of dense vegetation, typically short grass, positioned on slopes to filter and remove sediment and pollutants from runoff originating from agricultural land. It serves as a barrier between the higher ground and water collection systems such as ponds, reservoirs, and rivers. By allowing sheet flow, the vegetative buffer zone prevents erosion and sedimentation, capturing soil and nutrients while enabling sediment-free runoff to reach the water bodies (Gharabaghi et al.,2006). Its primary purpose is to filter contaminants, including pathogens and nutrients, from runoff, particularly from grazing areas, safeguarding streams and drainages. When properly managed, these buffer zones can also serve as a source of fodder and contribute to pollution reduction, making established pastures and haylands ideal choices for their implementation.

- *Vegetative barriers:*

The slender grass barriers are narrow bands (about 1.2 m in width) of indigenous perennial grasses with tall, upright, rigid stems. These barriers are strategically planted along the contour lines to diminish sediment flow, slow down and distribute runoff, and aid in creating terraces on slopes. On the other hand, vegetative filter-strips, wider in comparison (exceeding 5 m), are typically positioned between agricultural boundaries and water channels. Vegetative barriers are regarded as cost-effective, environmentally friendly, and beneficial to farmers. Their value is being increasingly recognized as a means to complement or replace traditional earthen embankments (Singh et.al,2017).

➢ *Grassed waterways:*

Grassed waterways serve as vegetated channels that facilitate the non erosive conveyance of runoff to a stable outlet. Enhancements to grassed waterways include incorporating filter strips, which effectively filter runoff and capture sediment beyond the waterway. Vegetation within the channel should lie flat to convey water, while tall and sturdy vegetation in the filter strips prevents submergence and filters sediment from runoff. Appropriately sized and constructed, grassed waterways offer a safe means to transport water through natural draws in fields, acting as outlet channels for terrace systems, contour cropping layouts, and diversion channels. These saucer-shaped channels effectively mitigate soil erosion caused by concentrated water flows, particularly in watersheds with substantial runoff (Fiener et.al, 2003).

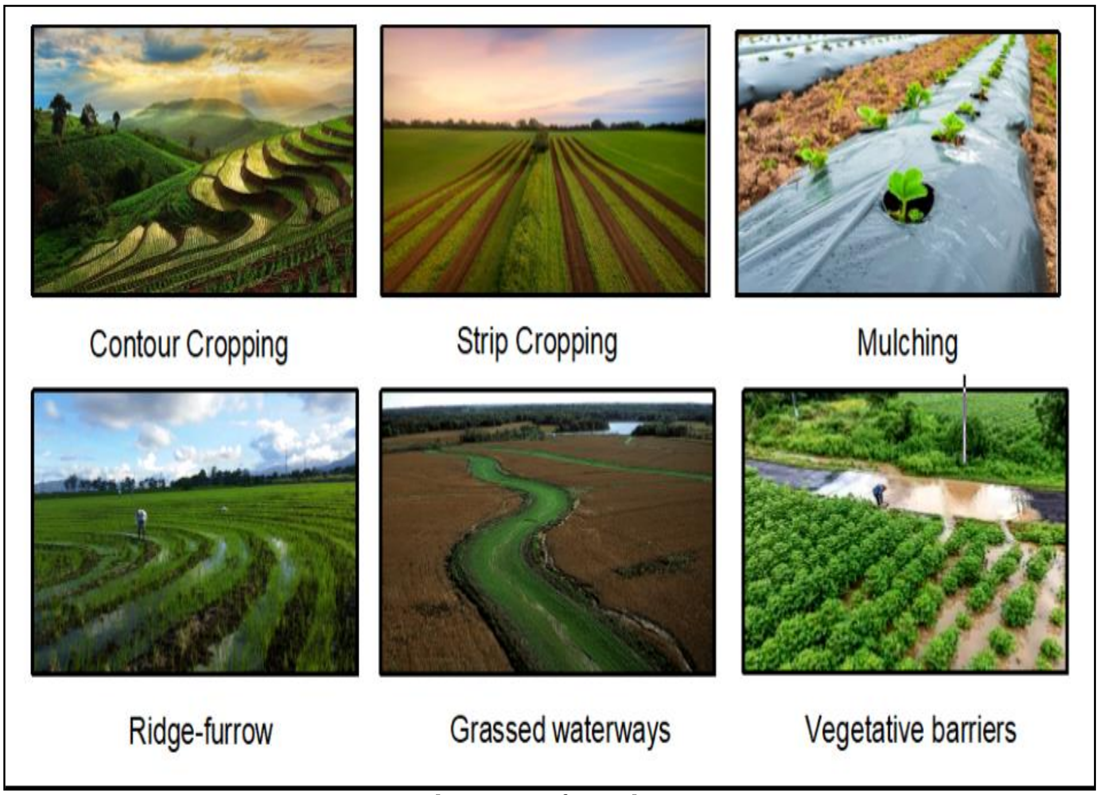

Fig. 47: Agronomical Measures for Soil & Water Conservation

IV. CONCLUSION

In conclusion, the traditional practices of soil and water conservation have been an integral part of various regions in India, showcasing the rich cultural heritage and deep understanding of the local ecosystems. The indigenous communities have developed ingenious methods to harvest and manage water resources, ensuring the sustainability of agriculture and livelihoods in challenging environments. From the compact reservoirs in Ladakh to the kuhls in Himachal Pradesh, and from the alder-based farming system in Nagaland to the johads in Rajasthan, each traditional practice reflects the deep connection between humans and nature. These practices not only conserve soil and water but also contribute to biodiversity conservation, prevent erosion, and support sustainable agriculture.

However, alongside the traditional practices, modern soil and water conservation measures have also gained significance. Mechanical structures such as check dams and spillways, as well as agronomical measures like contour cropping and mulching, provide effective solutions to mitigate soil erosion and conserve water resources. The integration of traditional wisdom with modern techniques can create a holistic approach to sustainable soil and water management.

It is crucial to recognize the value of traditional practices and preserve them as a part of our cultural heritage while embracing innovative solutions for future challenges. By promoting a blend of traditional and modern approaches, we can ensure the long-term conservation of soil and water resources, enhance agricultural productivity, and foster resilience in the face of changing climatic conditions.

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