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REVIEW ARTICLE **OPEN ACCESS**

Dry and Rainfed Agriculture- Characteristics and Issues to Enhance the Prosperity of Indian Farming Community

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ABSTRACT

In India, about 69.5% of total net sown area comes under dry and rainfed systems which contribute about 42 percent total food grain production and 80 percent of coarse grains/pulse production. India ranks first among the rainfed agricultural countries in terms of both extent and value of produce. Due to population pressure on agricultural lands, the poverty factor is concentrated mainly in rainfed regions. *Soil and water management in dry land and rainfed areas are the major constraints in enhancing the crop production and productivity future of agri-based industries. These two natural resources have become vital factors for increasing the agriculture share in Indian GDP. Soil and water are very crucial components for agriculture, forestry, environment and industry. The problem of conserving soil and moisture is of great concern in the extensive regions of low and uncertain rainfall areas, forming parts of Punjab, Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh and Karnataka. These tracts are characterized by scanty, ill-distributed and highly erosive rains, undulated topography, high wind velocity, etc. Soil and water resources are indiscriminately contaminated and over exploited, leading to situations where water becomes a scarce commodity in most every parts of the world. Scarcity of water affects the agriculture and farmers' paying capacity. Realizing the gravity of the situation, experts world over are busy finding newer ways to conserve soil and water resources. Governments, NGOs and agri-professionals are busy framing new policies and taking steps to overcome conservation related issues. Soil and water conservation methods like rainwater harvesting, contour bunding, in-situ and ex-situ moisture harvesting, crop rotation, crop cover management, mulching, flood water management and improved agronomic practices, are being harnessed in a big way all over the country to address the looming crisis. Erosion by wind and water has erosion has created some of the world's most productive soils for instance the Indo-Gangetic Plains and Nile Delta; but conversely the accelerated erosion, induced by anthropogenic activities, has had drastically affected ecological diversity and sustainability of landscapes.*

Keywords: *Farming Community, Crop rotation, Indo-Gangetic plains*

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INTRODUCTION

Soil and water are vital natural resources for all living beings. Growing world population and increasing standard of living are placing tremendous pressure on these resources. However man has been mercilessly misusing the soil and water-precious resource given by nature. Despite, years of study, research and investment in remediation and conservation of soil and water use in India and world. Time has come that everyone would realize that soil and water quality is sole essentiality for our life cycle. Soil and water are critical natural resources that must be kept in harmony with the environment for agro-ecosystems to be sustainable. Degradation in soil and water has an adverse impact on agricultural productivity, due to the population increase, soil erosion, deforestation, low vegetative cover and unbalanced crop & livestock production. Bishaw [3], and Negusse, Ya- zew & Tadesse [18] observed that the blind use of natural resource, faulty management and population pressure were the major causes of increased runoff and soil degradation in Ethiopia which resulted in decreasing crop productivity, food insecurity and water scarcity.

Major concerns for the deteriorating natural resources are linked to deforestation, landslides, large-scale downstream flooding, increasing poverty and malnutrition. To overcome these issues, various soil and water conservation technologies have been developed and watershed development programmes were launched in India since independence, aimed at improving agricultural productivity, especially through

soil and water conservation interventions. In Haryana, large quantity of water (1600 mm) is required to grow flooded rice. However, the actual amount of water applied by farmers is much higher than the requirement, especially where rice is grown on light-textured soils in the Indo-Gangatic Plains (IGP). Ground-water contributes 60%–65% of the total irrigation requirement; while the remaining 35%–40% is met through canals. The excess demand for water is being met through over-exploitation of ground-water, leading to falling water-tables. Thus, five decades of rice-wheat cropping system has caused considerable depletion of water resources in this IGP region. About 95%–98% of the area under rice-wheat cropping system in Haryana is irrigated. Damene, Tamene, and Vlek [5] reported that the inappropriate agricultural practices have led to severe land degradation and increased vulnerability of climate change. Reduction in soil organic carbon (SOC) concentration and water holding capacity was also reported by Mengistu *et al*., [14] and Damene *et al*., [5].

Human survival is assured only when soil and water will be sustained. This review integrated and highlights the different soil and water conservation practices, strategies and interventions for dry and rainfed regions to increase productivity, while maintaining soil health and water quality for bringing socioeconomic changes to different parts of India.

Characteristics, Issues and Importance of dry and rainfed agriculture

In India most of the dry and rainfed areas are resource constrained, eroded and dry. In dry areas, the farming is a survival mechanism rather than a growth oriented activity. Rainfed agriculture is practiced under a wide variety of soil type, agro-climatic and rainfall conditions. Crops in these regions are prone to the monsoon breaks, variability in rainfall amount, diversity in crop management practice and variability of the soil type. The prolonged moisture stress may can result in partial or complete failure of the crops. In terms of production, drylands account for nearly 80 percent of the output of coarse cereals, 50 percent of maize, 65 percent of chickpea and pigeonpea, 81 percent of groundnut and 88 percent of soyabean production. Half the output of cotton in the country is from the dry districts *[17]*. Existence of its large size and extremely low productivity levels, a unit rise in productivity in these regions is likely to have the great impact on national aggregate crop productivity. According to the present rate of development of irrigation facilities and also water potentiality of the country, it is estimated that 50% of cropped area in India will remain under rainfed farming system. Such vast areas as of now consume hardly 25% of total fertilizer consumption of the country. Due to lack of management, crop productivity is very low resulting in socio–economic backwardness of the area. Dry land farming is different from rainfed farming (Table 1).

Constituents	Dry land farming	Rainfed farming
Rainfall (mm)	< 750	>750
Moisture	Shortage	Enough / Sufficient
Growing regions	Arid and Semiarid & up lands of sub humid & humid regions.	Humid and sub humid regions.
Cropping system	Single crop or intercropping	Intercropping or double cropping.
Constraints	Wind and water erosion	Water erosion.

Characteristics of dry land and rainfed agriculture

Dry land areas may be characterized by the following features:

- *Uncertain, ill-.distributed and limited annual rainfall*
- *Occurrence of extensive climatic hazards like drought, flood etc.*
- *Undulating soil surface*
- *Occurrence of extensive and large holdings*
- *Practice of extensive agriculture i.e. prevalence of mono cropping etc.*
- *Relatively large size of fields*
- *Similarity in types of crops raised by almost all the farmers of a particular region*
- *Very low crop yield*
- *Poor market facility for the produce*
- *Poor economy of the farmers*
- *Poor health of cattle as well as farmers*

Key elements of effective combat with perils of dry and rainfed agriculture

- Capturing and Conservation of Moisture

- Effective Use of Available Moisture
- Soil Conservation
- Control of Input Costs

Problems of dry and rainfed farming in India

- Moisture stress and uncertain rainfall
- Effective storage of rain water
- Disposal or dry farming products
- Selection or limited crops
- Utilization of preserved moisture
- Quality or the produce

Remedial measures

Water harvesting

Water management systems have been in practiced in India since time immemorial. Preservation and management of water was taken up in a very serious way. Evidence of water harvesting, conservation and management have been found for irrigation and drinking water supply systems in Indus Valley sites by archeologists. Tillage, mulching, contouring, trenching, terracing, waterways, crop planning based on storage moisture capacity of the soils and moisture availability period land use capability classification are the key factor in increased the economical growth of the farming community living in dry and rainfed areas.. Moisture conservation practices helps in increase infiltration and reduce water losses and runoff, Runoff collection and its effective utilization for crops at moisture stress periods. Contingent plans for aberrant weather conditions, moisture stress, drought, excess moisture helped the farmer to modified his plans and saved himself from the risk crop failure. Under arid and semi-arid conditions, crop yields are strongly influenced by rainfall and moisture conservation practices [23]. Conservation tillage is a recent approach with the objective of reduces loss of soil with combination of 30% or greater crop residues on the surface [24].

The no-tillage (zero tillage) be practiced in rice-wheat cropping system for reducing green house gases from rice crop and timely sowing to wheat. In no-tillage system crop is planted directly into the soil without primary or secondary tillage since harvest of the previous crop. No-till is sometimes practiced in combination with sub-soiling to facilitate seeding and early root growth, whereby the surface residue is left virtually undisturbed except for a small slot in the path of the subsoil shank [23]. Tillage methods that provide control of soil erosion by wind include ridges and furrows, roughen clods on the soil surface, bring clod-forming materials to the surface from deep in the profile of sandy soils.

Ground water exploitation and falling water tables

Intensive cultivation leads very high load on ground water which, resulted in deepening of almost double since 1973.. This is the result of an increasing number of submersibles, as the centrifuge pumps are no longer effective in pumping water. NASA (National Aeronautics and Space Administration, Washington, DC, USA) reported that 13–17 km^3 of ground-water is lost permanently every year from the aquifers in the northwestern plains of the Punjab, Haryana, and western Uttar Pradesh Rodell *et al.* [19].

Soil health deterioration

The rice-wheat system is very prevalent in rainfed regions and has resulted in the mining of essential nutrients from the soil, causing to nutrient imbalances Tandon and Sekhon [25]. Continuous mono-cropping system in the IGP consistently depleted soil organic carbon (SOC) Singh *et al.* [22]. Lower organic carbon (SOC) loss containing soils sustain less biotic flora and fauna in these areas accelerating wind and water Bhattacharyya *et al*. [2].

Default crop residues management

Small portion of the total of rice and wheat straw used in fodder , bedding and thatching and the residue or stubble are mainly burned or rarely incorporated after crop harvest Singh *et al.* [21]. In India, Twenty five per cent of the total crop residues produced by rice wheat cropping system Sarkar *et al.* [20]. Lack of manual labour and increasing use of combine harvesting, disposal of crop residues (especially rice residues) has become a major problem. Burning of rice straw causes excessive heat which kills beneficial micro and macro organisms and toxic gaseous emission threaten the health of both humans and ecosystems.

Soil degradation in dry and arid regions

Crop growth shown signs of stress from the start of their life cycle in dry and rainfed area's due to temporal and spatial variability along with poor soil health. Multi nutritional deficiencies and poor organic matter of eroded soil result in declining trend of productivity in these areas [1]. Wind erosion is very active in dry region of Rajasthan. Dey [6] reported that loss of nutrient, suspension of fine particles

and their deposition on railway tracks, roads, residential and commercial establishments. Water scarcity and water logging leads to low plant population, increase incidence of insect, pest and diseases [9].

Impact of green revolution in dry and rainfed areas

In past, the Dry and Rainfed farming system was mainly dependent upon the locally available inputs, crop rotation, mixed cropping which were able to withstand moisture stress. However, in modern times, farmers in these regions started cultivating high value crops and have limited options. Green Revolution was farmed high-yielding varieties, agricultural research framework, incentive structure, price support, input subsidies of wheat and rice, which needed large quantity water and chemical inputs.

Change in the cropping patterns

To reduce vulnerability to rains, Farming is risky in rainfed and dry areas so grew crops such as pearl millet, sorghum and pulses. These crops are less affected by variations in rainfall. Factors affecting crop production and management under rainfed and dry farming areas – climatic factor, soil factors, plant factors and management factors.

Edaphic and climatic variability in dry and rainfed agriculture

i) Soils: - The problematic soils viz. saline, saline sodic land sodic soils do occur in patches in low lying areas. Colour of drought prone areas soil varies from reddish brown to dark gray black. These soils are generally low in organic carbon, available nitrogen, available phosphate and medium to high available potash. Eroded soils also exhibit varying degree of erosion depending on the slope, tillage operations and cropping season. Hence soil and water conservation is a pre - requisite for successful cropping. The soil moisture is always below the moisture at 15 bar (Permanent Wilting Point) which ultimately results in failure of crops in dry land agriculture.

ii) Climate: Wether, is part of climate, plays an important role in crop planning in dry farming area. Out of the several elements of weather, rainfall has key position in success of dry farming. South West Monsoon brings approximately 75% of rainfall in dry land areas. Generally, the rainfall amount, intensity is ill distributed. Time to time fluctuations and ill distributions of rainfall makes the Rainfed farming difficult.

iii) Water availability period: - Water availability depends on rainfall and potential evaporation. Rainfall exceeds potential evapo-transpiration period provides congenial weather for active crop growth. A break period of less than 15 mm rainfall in consecutive weeks is known as dry spell. Wind velocity more than 18 km/hr leads to higher evapo-transpiration. Evaporation demands are also accelerated with high temperature and low humidity. Maximum temperature exceeds 41^0 C during late April and early May and minimum temperature is about 14 to 15^0C generally prevails in the dry and rainfed areas. Under Rainfed farming crop failure are common because of Inadequate and uneven distribution of rainfall.

1. Late on set and early cessation of rainfall.
3. Prolonged dry spells during the crop growth period.
4. Low moisture retention capacity of soils.
5. Low fertility of soils, low humidity, higher temperatures, higher wind velocity.

Soil and Water Conservation Strategies

Conservation can be defined as the management, protection and optimum utilization of natural resources such as soil, water, air, plants, and animals). Soil conservation deals with the preservation of the soil from erosion, texture, nutrients, structure, productivity, fertility and quality [4, 28]. While water conservation ensures the availability of water for the present and future generations, it incorporates all strategies, activities and management techniques for protection and reduction of water. The importance of soil and water conservation in dry and rainfed area is most essential for the continued sustenance and sustainability of India. A number of challenges and problems negatively affect water and soil conservation; these include: erosion, desertification, drought, residue burning, water logging, climate change, pollution etc. [16].The various direct and indirect methods are framed to address the challenges and problems which impacting on soil and water conservation.

Most of these approaches have close connections between the approaches and improving soil and water conservation through construction of structures to reduce run off will reduce soil erosion [8]. These techniques include minimizing evaporation losses, reducing the size of evaporation barren surface, water harvesting, better irrigation scheduling and improved field irrigation practices, varying cropping patterns, usage of anti-transpirants farming in dry and rainfed areas. Modern concepts of soil and water conservation such as no tillage, sustainable land management, minimum tillage and conservation agriculture are more knowledge based [7].Best management practices for soil and water conservation measures are agronomic, biological and physical (mechanical) measures (**Fig. 1)**. Soil and water conservation measures are aimed to harvesting water, reducing soil compaction and to decrease soil erosion.

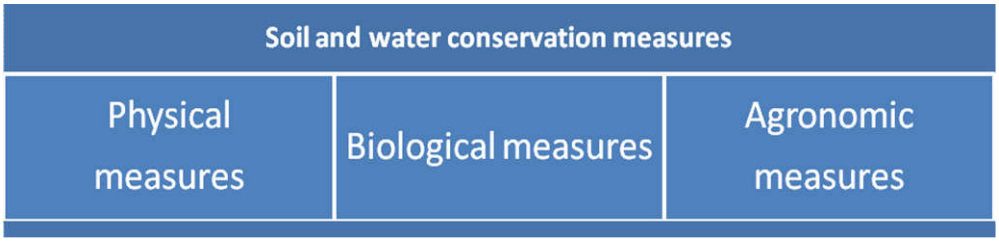

Figure 1: Classification of Soil and Water Conservation Measures

1. **Physical (Mechanical) method:**

These techniques involve the construction of physical structures such as contours ditches, planting pits, check dams, dams, earth bund walls, terraces and grassed waterways for water and soil conservation (Fig. 2) to reduce the volume and velocity of surface runoff and increasing the rates of water infiltration into the soil [15, 10].

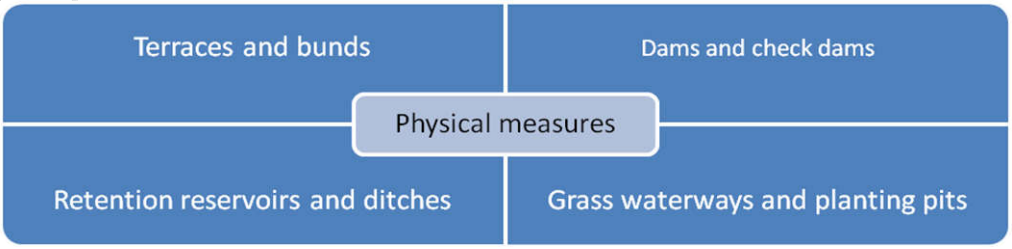

Figure 2: Physical Measures for Soil and Water Conservation

1. Biological methods:

These methods involve the use of vegetation cover for soil and water conservation. Vegetation cover acts to reduce the speed of surface runoff, increase water infiltration into soil, prevent splash erosion and provide cover to soil thereby protecting against erosion (Fig. 3) [15]. Biological methods are very suitable for soil and water conservation due to their cost effectiveness [10].

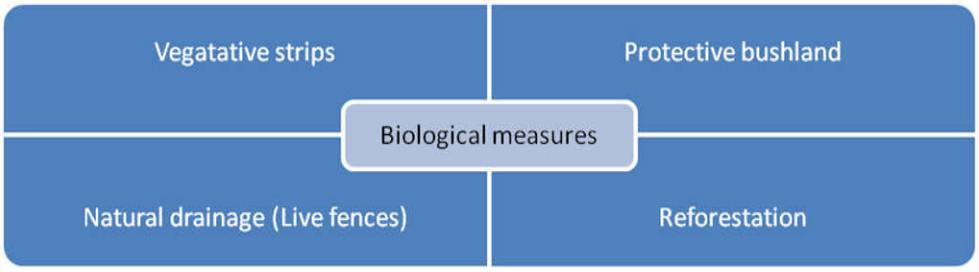

Figure 3: Biological Measures for Soil and Water Conservation

2. Agronomic (Best Management Practices) methods:

Agronomic methods such as contour cultivation, strip cropping, contour ploughing, fallowing, mulching, mixed cropping, inter cropping and agro-forestry for soil and water conservation. These techniques improve soil and water conservation by increasing water infiltration rates into soil, checking surface runoff and to inhibit soil erosion (Fig. 4) [26]. Agronomic methods are difficult to implement as they are more knowledge based and require changes in familiar practices which opposes to physical methods.

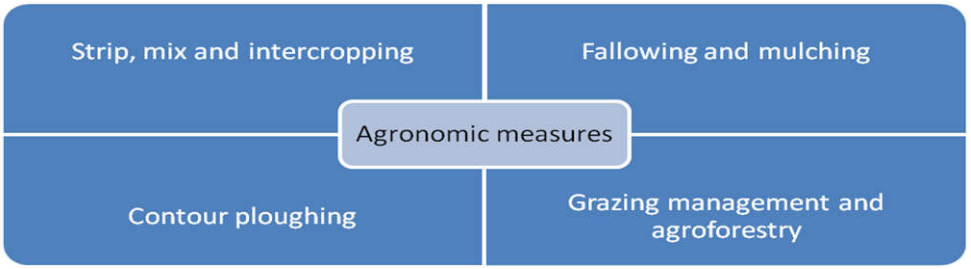

Figure 4: Agronomic Measures for Soil and Water Conservation

A lot of attention has been given to soil and water conservation globally. This has resulted in the institution, adoption and implementation of a number of global initiatives targeted towards addressing issues pertaining to soil and water conservation.

3. Crop diversification

Government has prepared a strategy for improving the production and productivity of major crops while conserving and optimizing the scarce groundwater resource and proposed to encourage farmers growing paddy under well irrigation to go for alternative crops for which, as an incentive, seeds have been provided at subsidy. Promoting mixed farming by encouraging horticulture crops, vegetable cultivation, dairying and poultry etc., is another strategy being adopted by the state government to enable crop diversification.

4. People participation

Since it is the man who is primarily responsible for degradation of environment, regeneration and conservation can only seeking participation of the people who inhabit the watershed. The entire watershed community should be involved to implement IWDP (Integrated wasteland development programme) and maintain the assets created to ensure sustainability of waste lands by fuel wood and fodder plantations etc.

5. Role of government

The government should strictly implement the wasteland development programme provide with credit facilities. Every plan has to be assessed to improved productivity of waste lands, increase in water table, reduction in irrigation, and improvement in status of the people. There is a need to develop policies, for sustainable development and management of land and water resources.

6. Carbon sequestration

Optimum levels of SOC can be managed through the adoption of appropriate crop rotations [2], fertility management, using inorganic fertilizers and organic amendments [11, 13] and conservation tillage In rainfall-scarce environments of tropical and sub-tropical regions characterized by arid and semi-arid climates, soils are inherently low in SOC stock, and food security is strongly related to soil quality [23]. Therefore, curtailing depletion and enriching SOC stock are essential to adapting and mitigating climate change, buffering agro-ecosystems in harsh climates against extreme events (drought), and stabilizing agronomic productivity by ensuring some returns even during the bad seasons. However, crop species also play an important role in maintaining quantity and quality of SOC stock despite diverse nature of crop residues with highly variable turnover or residence time in the soil [12].

Dry farming or Dry Land Farming refers to an improved system of cultivation whereby maximum amount of water is conserved by soil and water management. It involves efficient system of soil and crop management in the regions of low land and uneven distributed rainfall.

CONCLUSION

The soil and water conservation are the necessity measures for improving the socio-economic status of dry and rainfed areas. It is pertinent to say that the conservation of our soil and water resources is vital to continued human existence. Finally, global and national efforts aimed at tackling issues pertaining to soil and water conservation were harped on. These instruments are essential if we are serious about conserving our soil and water resources to ensure sustainable development.

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