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REVIEW PAPER

Agriculture Based Livelihood Systems in Drylands - Challenges and Strategies

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ABSTRACT

Dryland agriculture is a complicated and uncertain system made up of crops, horticulture trees, livestock and vegetables. India's total geographic area is 328 million hectares, of which 228 million hectares are dryland (UNCCD). A livelihood system is the total combination of activities undertaken by a typical household to ensure a living. Most rural households have several income earners, who pursue a combination of crop and livestock, farm, off-farm and non-farm activities in different seasons to earn a living. Agriculture based livelihood activities occupy a very significant position in the economic development of the Indian economy as agriculture sector has a high employment potential. This paper emphasises the challenges and strategies in agriculture-based livelihood systems in drylands. According to the findings, the primary challenges are land degradation, climate risk, low animal productivity, and output variability. The most important strategies for agriculture-based livelihood systems in drylands are to promote integrated farming systems, boost allied agricultural activities, increase income through dryland horticulture, and integrate on-farm and off-farm activities. In order to promote equitable development, dryland areas require "a paradigm shift from a 'commodity-centred Green revolution' to an 'Integrated resource management and farming Systems-centred rainbow revolution'. Farming areas in dry regions require much more attention.

HIGHLIGHTS

- Dryland agriculture in India covers 69% of the land but struggles with water scarcity, climate variability, and frequent droughts.
- Despite these challenges, dryland regions significantly contribute to national food production and livelihoods.
- Proposed solutions include integrated farming systems, climate-resilient crops, and improved market access for smallholder farmers.

Keywords: Livelihood systems, Dryland, Challenges, Strategies, Climate

Dryland agriculture is an intricate and vulnerable system with components of crops (grains), vegetables, livestock and horticultural trees. They are impacted by prolonged water scarcity, high climatic variability and frequent droughts. India is one of the most drought prone countries in the world and about 53% of the country's geographical area is arid and semi-arid. The drylands of semi-arid areas of central India are more drought prone compared to the other parts. The country's 45 percent of agriculture production comes from these drylands, wherein droughts have been

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causing a devasting loss. India's total land area is 328 million hectares, of which 228 million hectares (or 69.00%) are considered dryland. Dryland agriculture makes up 68.0 % of India's cultivated land and produces roughly 44% of the country's overall food production. These drylands are the source of agriculture output and droughts there have resulted in devastating losses. The area under arid tropics is 31.7 million hectares. The states of Rajasthan, Gujarat, Punjab, Haryana, portions of Karnataka, and Andhra Pradesh are classified as desert tropical areas. There are 95.7 million hectares of semi-arid tropical region in the world. The states of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Punjab, Haryana, Uttar Pradesh and Madhya Pradesh are classified as semi-arid tropical zones. According to the estimate, 10% of the 6.1 billion hectares of drylands on Earth are categorized as other woody area, while 18% are classified as forests. The remaining 71% of the land was designated as other land, and it was primarily made up of bare soil and rock (28% of the total dryland area), meadows (25%), and croplands (14%). The degree of aridity has a significant impact on how land is used.

What are Drylands?

Drylands are characterized by a lack of water, which has an impact on managed and natural ecosystems, limits the number of crops, wood, pasture, and other plants that can be produced, and impacts the provision of environmental services. Drylands are shaped by a mix of human activity, heat waves, droughts, and low precipitation.

What is Dryland Agriculture?

Dryland Agriculture refers to growing of crops entirely under rainfed conditions. Depending upon the amount of rainfall received these areas are categorized into three types.

(i) **Dry Farming:** Cultivation of crops in areas where rainfall is less than 750 mm per annum.

(ii) **Dry land Farming:** Cultivation of crops in areas receiving rainfall above 750 mm.

(iii) **Rainfed Farming:** Cultivation of crops in regions receiving more than 1,150 mm

Concept of Livelihood System

Livelihood:"A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. Livelihood becomes sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Chambers and Conway, 1992).

Livelihood Systems: A livelihood system is the total combination of activities undertaken by a typical household to ensure a living. Most rural households have several income earners, who pursue a combination of crop and livestock, farm, off-farm and non-farm activities in different seasons to earn a living.

Agriculture-based Livelihood Activities

Agriculture-based livelihood activities occupy a very significant position in the economic development of the Indian economy as agriculture sector has a high employment potential In agricultural based livelihoods, crop and livestock production are the major important components.

Crop Based Farming Systems

Crops are the primary source of income in systems of crop-based farming. In these areas where rainfall is less, agri-sheep farming including production of cotton in one hectare of marginal lands and rearing of ten lambs yielded the net returns of ₹ 27500/ha in comparison to growing cotton alone (₹ 8700/ha) at Warangal of Andhra Pradesh (TAR-IVLP, 2003). The IFS model in dryland vertisols at Kovilpatti of Tamil Nadu noted that Crop + Goat + Poultry + Sheep + Dairy recorded the highest gross income (₹ 35301) followed by Crop + Goat + Poultry + Dairy (₹ 30807), while the traditional system having crop cultivation alone gave only ₹ 5860/acre as gross income. The animal waste from cow (20-22 kg/day/animal) sheep and goats (400-450 g/animal/day).

Farmer Centric Farming System

The separate households in this system—especially those of small and the marginal farmers—and the security of their means of subsistence are main focus. According to this method, the farmers' traditional

agricultural systems' advantages and disadvantages must be evaluated in order to determine which interventions for enterprise diversification and selected productivity enhancement should be implemented. This necessitates using participatory farming systems analysis techniques to do a thorough analysis of every household, taking into account their resources, labour availability, investment capability, and other factors. In-depth group discussions, surveys of households, and evaluation of local market demands can be employed to accomplish this.

Multi-enterprise Farming Systems

The Eastern India's wet and fertile alluviums covering 3.28 million hectares where water remain stagnant above ground for longer than half of a year. The physical conditions which are unfavourable allows for the cultivation of a single anaerobic paddy crop with a yield potential of less than 1 tonne per hectare. Several farming models that combined the production of cattle, ducks, pigs, fruits, vegetables, fish and prawn culture, and paddy were seen and evaluated at various locations. Pollutant loading on the environment is also reduced by systems that rely on multiple recycling of carbon, energy, and nutrients from biomass to cattle, poultry, fisheries, etc. (Samra *et al.* 2003).

Challenges of Agriculture Based Livelihood Systems in Drylands

(a) Land degradation

Land degradation will be impacting agricultural productivity, biodiversity loss, environmental change, and its effects on food security**.** The intensive approach to agricultural production system has not focused adequately on conservation of natural resources, and sustainable technologies needed for rainfed production system. As a result, the natural resource base including in rainfed areas has got severely compromised and has led to soil erosion and loss in soil fertility. Rainfed areas have protracted double exclusion, with little support for local measures such as crop waste absorption, composting, application of farmyard manure, etc., and no benefit from chemical fertilizers that build soil health naturally. Soil fertility variation and its depletion due to inadequate nutrition management is another important factor contributing to yield instability in rainfed areas. Soil degradation comes in several forms, including erosion by wind or water, and chemical deterioration such as loss of nutrients or salinization. According to NBBSLUP (2019) average annual rate of soil erosion in the country is 16.35 tonnes per hectare. Other factors that contribute to soil deterioration include salt build up, heavy metal pollution in soils, and the quick loss of soil organic matter (SOM) as a result of poor crop management techniques. Approximately 23.79% of the nation's total geographical area (TGA) that is experiencing desertification or land degradation can be attributed to the following states: Maharashtra, Rajasthan, Gujarat, Ladakh, Karnataka, Jharkhand, Madhya Pradesh, Odisha, and Telangana. The nation's average yearly rate of soil erosion is 16.35 tons per hectare.

Climate risk

Indian agriculture is impacted by climate change and variability, especially rainfed 6 3 agriculture. According to long-term data for India, there are three to four years of drought every decade in rainfed areas. Two or three of these have moderate intensities, and one or two have severe intensities. Rainfed crops are likely to be worst hit due to limited options of coping with variability of 9 rainfall and temperature resulting in a shift in sowing time and shorter growing season, which may necessitate effective adjustment in sowing and harvesting dates. rainfall and temperature resulting in a shift in sowing time and shorter growing season, which may necessitate effective adjustment in sowing and harvesting dates. Rainfall unpredictability within a season is becoming more and more of an issue. Rainfall distribution is becoming more skewed in a number of meteorological divisions, with fewer rainy days and higher intensity rainfall leading to increased soil erosion. In a number of meteorological divisions, the coefficient of variation of the decadal rainfall distribution is rising, suggesting inter-annual variability. This affects how long dry spells last in areas that receive rain.

Poor productivity of livestock

Animal husbandry is a crucial component of rainfed farming systems and, is a significant revenue stream for farmers. Owning cattle, including both

big and small ruminants, provides rural farming communities with a source of funding. Livestock contribute 4.35% of the GDP & 29.35% of the full agricultural GDP. The low productivity of livestock in dry lands due to water scarcity and shrinking of common grazing resources. The shortage in fodder availability is a major reason of Indian livestock's milk productivity. It is lower by 20-60 percent compared to the global average (IGFRI, 2019). The policies on livestock focus only on improvement of cows and buffaloes, while other livestock like (small ruminants) sheep, goat, poultry and piggery are unnoticed.

(b) Yield variability

In several rainfed areas, large yield gaps still remain in several crops and regions between yields obtained at research stations and on farmers' fields. Crop yields vary for different crops and regions in rainfed and irrigated regions, though broadly the productivity of rainfed areas is around 1.1 tonnes/ hectare, as against an average of 3 tonnes/ hectare in irrigated.

(c) Resource poor farmers and in adequate credit availability

Marginal and small farmers are dependent mostly on informal sources of credit. Credit that is met from informal sources is 40.60 per cent, 52.10 per cent, and 30.80 per cent, for the landless, marginal farmers, and small farmers. This shows a lack of access to credit facilities and formal financial mechanisms.

(d) No reliable data for rainfed in central database systems

Standardized agronomic, soil, water, market-related, and socioeconomic datasets for agriculture are essential for real-time decision making and sustainability. Despite the substantive scale of rainfed agriculture that exists in terms of cultivation area and the farmer population, huge gaps persist in data availability and data quality. In addition, existing datasets also lack standardization as it prevents inter-operability and decision-making.

(e) Poor market linkages

Smallholder farmers in rainfed areas not only suffer from many production risks due to climatic vulnerability, but are also subject to market risks (high market and price fluctuation) that lead to unstable incomes. Further, farmers often sell their produce at low prices due to unreliable market channels and unregulated markets. Inadequate post-harvest handling and storage facilities which prevent farmers from stocking up and selling at the right time and accessing other markets

Strategies for Agriculture Based Livelihood Systems in Drylands

1. Encourage Allied Agricultural Activities in Rainfed Regions

(a) Enhancing income through animal husbandry in rainfed regions

The development of the livestock sector in rainfed regions has to be based on a multi-pronged strategy covering production, conservation, medical support infrastructure and marketing. Identify exclusive schemes and programs for small ruminants (pigs, goats, sheep), as also poultry, camels and yaks; and tailor interventions based on local resource availability and the socioeconomic status of the farmer. Build adequate veterinary infrastructure for the rainfed livestock ecosystem which at present is concentrated in irrigated districts and for mostly cattle. Provide tailored insurance schemes to livestock rearers for reducing the investment risk faced by them. With more than 27 major traditional pastoralist communities inhabiting 15 states with an estimated population of about 3.4 crores, special policy and funding focus for pastoral ecosystems needs to be developed. Policies to ensure the protection of commons that offer grazing areas and programs for livestock, credit access, and avenues for selling cow dung on scale need to be planned and implemented. Adopt integrated Pastoralism System Development project on the lines of 'Integrated Watershed Development Project' for sustaining the livelihood of migrant pastoralist communities. Create effective techniques for producing pasture and feed in rainfed locations through fodder production on arable lands (encouraging farmers to use at least 10 per cent of their land for fodder production); integrated fodder production system (integrate rearing of ruminants with trees in the form of Silvi-pastoral, Agri-Silvi-pastoral, and Horti-

pastoral systems) and improving and safeguarding Common Property Resources (CPR) for fodder availability

(b) Enhancing Income Through Dryland Horticulture in Rainfed Regions

Horticulture is emerging as the main growth engine of Indian agriculture and has been defined as Sunrise Sector by the Doubling Farmers Income (DFI) Committee, as it contributes more than one third of the agricultural GDP, though it occupies less than one fifth of the cultivated area. Horticulture crops generate employment, provide raw material to various food processing industries, and generates higher farm profitability due to higher production and export earnings from foreign exchange. Diverse agro-climatic conditions in India enable production of all types of fresh fruits, vegetables, herbal and medicinal plants in different parts of the country. Health consciousness among people is growing alongside increase in their purchasing power. With expected diversifications of consumption trends in favour of micro-nutrient carrying agri-horti-produce, the demand for horticultural products will see a rise, and exists to produce more horticultural crops. The relative yield per unit area of horticultural crops is higher than field crops, e.g., currently paddy crop gives average of only 30 q/ha, while banana crop gives 300–450 q/ha and grapes 90–150 q/ha. The technical yield potential of fruits is 19-20 tons/ha and that of vegetable is 20-30 tons/ha. These potential yield levels are much higher than that of field crops. Difficult rainfed areas like the slope lands with uneven or undulating topography are suitable only for horticultural crops. Some fruit trees can also be grown in culturable wasteland or possessing poor quality soil.In addition to increased farm income, nutritional security and other export potential, horticultural systems generate several positive environmental impacts in rainfed areas. Carbon sequestration is one such. Efforts should be more towards promotion of agri-horticultural Integrated Farming System suitable to the agro climatic condition which can bring certain level of resilience to the production system as well as create higher income avenues.

2. Release New Climate-Resilient Varieties

Release of cultivars with high resilience and yield potential is essential, especially for smallholders through decentralized seed system. A suitable delivery mechanism that ensures timely and cheaper availability of the seeds to replace older/ less beneficial ones is needed. Community seed banks (CSBs) in villages are key to providing quality seeds of wide variety of crops at reasonable costs at the right time. This will help increase capacity for adaptation to climate risks, such as planting again in the event that a crop fails. Besides, they will ensure in conserving and mainstreaming the local crop cultivars that are naturally tolerant of to various biotic/abiotic stresses in rainfed regions. Seeds with medicinal/therapeutic properties can be mainstreamed by integrating them into the formal and informal seed chains while preserving genetic purity.

3. Promoting Integrated Farming System (IFS)

Promoting IFS, which synergistically integrates two or more enterprises (agronomic crops, horticultural crops, livestock, aquaculture, poultry/ducks, apiculture, and mushroom cultivation), can offer improved income, resilience, and soil carbon sequestration potential. IFS systems need to be planned according to characteristics of ACZs and followed according to the model approach indicated by the All India Coordinated Research Project (AICRP-ICAR) across 15 agro-climatic regions. This will require a shift from the centrally determined approach of single commodity intensification to location-specific farming systems intensification approach which focuses on system (more than one season in a year) productivity instead of season-based crop productivity (tonnes/hectare) Incentivise pulse, oilseeds and millet-based cropping systems to check shift to cotton and other higher water duty monocropping practices in rainfed regions. Non-conventional legume varieties like rice bean, faba bean, moth bean etc. can be incentivised for their tremendous potential in rainfed areas, in addition to popularly grown varieties. Dryland horticulture needs to be promoted and a shift to horti-millet cropping systems will translate into more nutrition options, income diversity and better market prices. Diversification through kitchen/nutritional gardens in farming and non-farming families can also be encouraged and promoted in rainfed regions through incentives. Integration of higher tock

(both large and small ruminants), poultry, fishery activities will help generate jobs, enhance incomes and minimize enterprise risks. Adopt Secondary Agriculture that includes activities like bee keeping, cultivation of mushrooms etc.; primary processing of main (primary) produce post-the-harvest; and value addition to both primary & by-products which will create local jobs and supplementary incomes. Excavation of ponds in 65% area for aquaculture and raising embankments on the remaining 35% land for horticulture can replace traditional low productive rice-fish culture with 3-5 times enhanced production, income and employment generation from a unit of land.

4. Promoting Efficient Natural Resource Management in Rainfed Agriculture

(a) Improve effective rainfall

As rainfall is the major source of water for rainfed regions, 'Effective Rainfall' as an approach can harness more rainfall for achieving food security and better livelihoods. Specific technologies that can be integrated within the local context from improving soil organic matter to harvesting and retaining moisture through farm ponds, conservative use etc., combined with a scientific and participatory mapping of resources, water budgeting, mobilisation of community to establish usage and extraction norms.

(b) Precision water management practices

Adopting micro-irrigation technologies in the rainfed agriculture - which include drip/trickle systems, surface and sub-surface drip tapes, micro-sprinklers, sprayers, micro-jets, spinners, rotors, bubblers, etc., must be prioritized and incentivized through existing schemes/programmes. According to studies, micro irrigation systems can increase production and income by up to 48% while saving up to 7%-40% of water compared to traditional flood irrigation. It also facilitates application of controlled amounts of water and nutrients in the close to each plant. It is estimated that replacement of Conventional-irrigation by micro irrigation practices to the level of 50 per cent will bring additional cultivation area of 15 per cent in *kharif* and 23 per cent in *rabi* season. At an adoption level of 25 per cent, the estimated additional coverage is 8 per cent in *kharif* and 12 per cent in *rabi*. It is advisable to promote women and youth-led solar driven mobile pump-set based micro irrigation services for protective irrigation in critical periods using the limited available water locally or arranging water from external sources in extreme conditions. This will minimize production losses and consequential losses.

(c) Crop diversification for water intensive crops

According to the studies of NRAA, about 6.72 per cent of rice cultivated area comprising 68 districts and 12.9 per cent of sugarcane cultivated area encompassing 91 districts are not suitable for cultivation of the said crops. Persistence with these crops has been causing a rise in the discrepancy, demand and supply of water much beyond the effective rainfall, available surface water sources and replenishable ground water, resulting in rapid decline in water table, as also alter quality. It is imperative that these districts have a policy that encourages the best cropping pattern 7 and makes the most efficient use of the water resources available. Crop diversification from rice and sugarcane to low duty crops such as pulses and oilseeds would facilitate cultivation of these crops benefiting a greater number of small and marginal farmers. Cultivation of water guzzling crops in these areas may be further discouraged by shrinking the access to input and energy subsidies, as also procurement

5. Minimizing Soil Degradation and Restoring Degraded Soils

It is important to adopt suitable soil conservation measures based on land capability classes, and landscape planning approach. Soil rehabilitation and/or soil restoration should also be a priority, returning degraded soils to productivity, especially in historically sound agricultural or other production systems currently under threat. Reversing the soil degradation due to low soil organic carbon (SOC) is essential to build back soil carbon, enhance agronomic productivity and aid in sequestering carbon. Strategies for improving SOC require improving water and nutrient use efficiencies by decreasing losses and increasing biomass production. Farming practices like conservation

tillage, mulch farming, cover crop, mixed farming/ cropping, agroforestry, ley farming (putting the land under pastures and hay after growing grain crops), utilising organic manures (vermicompost, green manure) are ways to increase SOC and carbon sequestration. There is significant opportunity to enhance income if farmers are compensated for generating SOC and sequestering carbon.

6. Integration of On-farm and Non-farm Activities

An integrated and holistic view of all natural resources including social capital of landless and asset-less, labour, gender, socially and economically disadvantaged sections is called upon for realising the all-inclusive progress, prosperity, peace and social harmony. Creation of non-farm jobs involving micro-enterprising due to low primary productivity and seasonal nature of the agricultural operations in the drylands are the major drivers of the paradigm shift. Diversification into value added chain of aqua-culture, horticulture, agro-forestry and regionally differentiated various permutations and combinations of the production systems are the vast opportunities for harnessing all round development in high rainfall rainfed regions. Livestock rearing and dairying has 4-5 times more employment generating potential compared to crop cultivation Micro financing through self-help groups, scaling up of extension, inputs, services and marketing by producers' companies, cooperatives and their federations have tremendous potential. Imparting training in emerging skills and crafts as per diversified demands in the market will go a long way for realising all-inclusiveness of landless, asset-less, small and marginal farmers.

CONCLUSION

The opportunities in rainfed areas will need "a paradigm shift from a 'Commodity-centred Green Revolution' to an 'Integrated Resource Management and Farming Systems-centred Rainbow Revolution' for inclusive development. In order to ensure long term sustainability for dry land agriculture in India, various components are to be taken into consideration like socio-economic resources, integrated water shed development, improvement of rain water use efficiency, diversification of agriculture through livestock farming alternative land uses and integrated soil–nutrient-water-crop management. Dry land farming areas needs much closer attention.

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