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# Agro-Ecology Specific Strategies for Resilient Rainfed Production Systems

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## Abstract

Rainfed agriculture, practiced in diverse agroecologies contributes, immensely to India's food basket. However, rainfed agriculture in India is constrained with many biophysical and socioeconomic challenges, particularly changing climate and rainfall variability. Managing climate risks, enhancing productivity and profitability, further achieving resilience of the rainfed production systems is need of the hour. To address these, agro-ecology specific crop alignment, agro-ecology specific potential crop zoning and diversifying within farm for sustainable intensification and real-time contingency planning implementation are the key strategies.

**Keywords:** Rainfed production systems, Resilience, Agroecology

## Introduction

Rainfed agriculture is practiced in about 50 percent of net cropped area. It contributes 44% of food grains and supports 40% and 75% human and livestock population respectively. At present, 95% of the coarse cereals, 91% pulses, 80% oilseeds, and 53% rice are from rainfed agriculture. Besides this, it supports two thirds of animal population and a large area of horticultural crops. Thus, rainfed agriculture contributes immensely to country's food production and economy. The key challenges in rainfed agriculture are: i). Managing climatic risks, ii) Resource poor operational land resource base, iii). Bridging yield gaps, (iv). Enhancing water productivity, v). Maintaining soil health and productivity and vi). Low and skewed farm mechanization. Some of the Agro-ecology specific strategies for resilient rainfed production systems are briefed below:

### Agro-ecology specific crop alignment

*a. Climate resilient crops and varieties to cope with delayed onset of monsoon*: As a rule, rainfed crops are sown early with the onset of monsoon to realize higher yields. However, any delay in monsoon beyond normal period affects sowing of crops of longer duration or narrow sowing window. The crops with wider sowing windows can still be taken up during the season without major yield loss by using short duration cultivars. Beyond the sowing window, choice of alternate crops or cultivars depends on the farming situation, soil, rainfall and cropping pattern in the location and extent of delay in the onset of monsoon. For example, pulses and oilseeds are preferred over cereals due to less water requirement and hence can be grown under delayed *kharif* sowing. Beyond the sowing window, choice of alternate crops or cultivars depends on the farming situation, soil, rainfall and cropping pattern in the location and extent of delay in the onset of monsoon. (Ravindra Chary et.al.2010; Ravindra Chary et.al. 2013). Under National Innovation in Climate Resilient Agriculture (NICRA), during 2011 to 2022, more than 100 drought tolerant varieties of major rainfed crops were identified by AICRPDA centres for their suitability to cope with delayed onset of monsoon (Ravindra Chary et.al. 2016).

*b. Agro-ecology specific risk resilient cropping systems*: Crop diversification with intercropping systems enhances resource use efficiency, and overall system productivity and income per unit area to the small holders. Diversifying from the monoculture of traditional staples can have important nutritional benefits for farmers (Ravindra Chary et. al. 2022). Double cropping system aims to make optimum use of land through permitting the production of an extra crop cultivated in winter/*rabi* after *kharif* season. To develop feasible and sustainable double cropping systems, production factors such as length of growing season, cropping sequence, crop compatibility, biological complementarity, and planting time must be considered. Aligning cropping systems *viz.*, monocropping, intercropping and double cropping systems as per rainfall zones and soil types is the key strategy for crop diversification in diverse rainfed agro-ecologies (**Table.1**).

**Table1. Potential cropping systems and agricultural drought vulnerability based on rainfall and soil types**

| Mean annual rainfall (mm) | Major soil order | Growing season (weeks) | Suitable cropping system | Agricultural drought (frequency) |
|---|---|---|---|---|
| 350-650 | Alfisols, shallow Vertisols, Aridisols and Entisols | 15 | Single rainy season | Severe drought (Once in <5 seasons) |
| 350-650 | Deep Aridisols and Inceptisols | 20 | Either rainy or post-rainy season crop | Moderate drought (Once in 5-10 seasons) |
| 350-650 | Deep Vertisols | 20 | Post-rainy season crop | Moderate drought (Once in 5-10 seasons) |
| 650-800 | Alfisols, Vertisols, Inceptisols | 20-30 | Intercropping | Less prone to drought (Once in 10-20 seasons) |
| 800-1100 | Deep Vertisols, Alfisols and Entisols | 30 | Double cropping | Less prone to drought (Once in 10-20 seasons) |
| >1100 | Deep Alfisols, Oxisols etc | 30+ | Double cropping | Nil to less prone to drought (once in >20 seasons) |

## Agro-ecology specific Potential Crop zoning

The cropping pattern in a rainfed areas is largely driven by management (accumulated knowledge), monsoon (south-west) and often with market influence. Currently, there is an imbalance between natural resources endowment and cropping patterns in rainfed areas. The recent trend of shift in climate and impact of rainfall variability in a region/agroclimatic-zone in crop growing season impacting productivity, profitability and stability of rainfed crop production systems and also resulting in poor soil quality. This calls for concerted efforts in efficient Agroecology specific Crop Zoning/Crop Colonies/ Crop Alignment matching natural resources, majorly rainfall and soil resources. *Agro-ecology specific potential crop zoning r*efers to the specific regions /areas of crops and cropping sequences which are bio-physically suitable and also have high productivity and high spread. Efficient crop zones have similar geographic setting in terms of soils, landforms, rainfall, temperature, length of growing period, irrigation potentials, suitable for a specific crops and cropping sequences and have the potentiality to respond similarly for similar kind of management practices (Ramamurthy et.al. 2016). The potential crop zoning helps in developing strategies for various potential zones of the base crop and given in **Table 2**.

**Table.2. Strategies for potential crop zoning**

| Potential zone of the base crop | Strategies |
|---|---|
| Highly Potential Zones | • Technological interventions (soil, water, crop, land, energy based) for higher water productivity, profitability & stability of the base crop<br>• Sustained, quality and adequate quantity seed production of the base crop<br>• Development of cost effective and energy efficient total farm mechanization of the base crop<br>• Development of the value chain, weather indices based insurance etc. of the base crop<br>• Strengthening base crop based traditional rainfed integrated farming systems |
| Moderately Potential Zones | • Base crop based crop diversification/intensification (intercropping/double cropping)<br>• Strengthening traditional rained farming systems /agroforestry systems |
| Marginally Potential and Non-Potential Zones | • Replacing base crop/ Crop substitution with alternate crops/cropping systems and agroforestry systems |

## Diversifying within farm for Sustainable intensification

- Evolving Rainfed Integrating Farming Systems models by strengthening predominant traditional rained farming systems in prioritized rainfed districts that enhance resource use efficiency and livelihoods by providing risk resilience, food and nutritional security, staggered employment and income. Suggested strategies for strengthening traditional rained farming systems are given in **Table 3**.
- Promotion of proven agro-ecology specific alternate land use systems/ agroforestry systems based on land capability in private and public (gomalas, village common/temple lands etc.) for risk resilience and staggered income, biomass production, soil carbon sequestration. Promotion of pasture, silvi-pasture systems, fodder trees, multiple tree based systems in non-arable on large scale, particularly in village common lands. Boundary plantation with perennial tree species for forage, greenleaf manure, mulching and ecosystem services for moderating microclimate at individual farm level.

**Table 3. Suggested strategies for strengthening traditional rained farming systems**

| Rainfall zone (mean annual rainfall) | Strengthening predominant traditional rained farming systems | Agro-ecology specific components along with efficient *in situ* and *ex situ* rainwater management practices |
|---|---|---|
| < 500 mm | Livestock-crop based | Small ruminants, nutritious cereals/millets |
| 500-750 mm/ | Crop-horticulture-livestock based | Small/large ruminants, predominant rained crops and dryland horticulture |
| 750-1000 mm | Crop-horticulture-livestock-poultry based | Predominant rained crops, dryland horticulture, agri-hortisystems, rainfed vegetable crops, small/large ruminants, improved breeds of poultry |
| > 1000 mm | Multiple enterprise based on multiple water use | Predominant rained crops, lowland rice with water saving technologies, dryland horticulture, vegetable crops, other high value crops, agri-hortisystems, small/large ruminants, improved breeds of poultry, fish and other income generating enterprises like seed production, apiary, mushroom cultivation etc. |

Integrating trees into agricultural landscapes is an approach for sustainable intensification of arable systems and contributes towards enhancing productivity in unit time and area with multifarious benefits, thus enhancing the adaptive capacity of farmers to climate risks. Some of the strategies for development of efficient pasture and or fodder production systems in rainfed areas: Fodder production from arable lands; Integrated fodder production systems; Tank beds- Common Pool Resources for fodder production; Intensive rainfed fodder production systems; Perennial non-conventional fodder production systems; Fodder production systems in homesteads and Fodder production as contingency plan.

## Real-Time Contingency Planning Implementation

Real Time Contingency Planning (RTCP) is conceptualized in All India Coordinated Research Project for Dryland Agriculture (AICRPDA) as “any contingency measure, either technology related (land, soil, water, crop) or institutional and policy based, which is implemented based on real time weather pattern (including extreme events) in any crop growing season” (AICRPDA-NICRA Annual Report, 2013-14) as two pronged approach i) Preparedness and ii) Implementing contingency measures on real-time basis. The RTCP aims first to establish a crop with optimum plant population during the delayed onset of monsoon, to ensure better performance of crops during seasonal drought and extreme events, enhance performance, improve productivity and income and to enhance the adaptive capacity of the small and marginal farmers. The preparedness emphasizes on a combination of tolerant variety/crop/ system, rainwater/soil/crop/nutrient management practices along with timely availability of inputs while real-time basis implementation focus on the crop/soil/moisture /nutrient management measures to cope with delayed onset of monsoon, seasonal drought, floods and other extreme events (AICRPDA -NICRA Annual Report 2013).

### Way Forward

i. Delineating Length of growing period (moisture availability period) at sub-district level

ii. Risk assessment in prioritized rainfed districts for crops/varieties alignment and crop diversification with alternate cropping systems and crop intensification in high rainfall zones

iii. Energy efficient and cost effective farm mechanization

iv. Climate resilience in rainfed agriculture can be better addressed through risk and vulnerability assessment at sub-district level; mainstreaming resilient technologies through strong convergence with government schemes and appropriate policy interventions; strong preparedness for weather aberration (based on long term experiences or trends) along with actually responding to the situation and capacity building of primary and secondary stakeholders

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