



Adapting to Drought: Climate-Resilient Crop and Irrigation Strategies

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INTRODUCTION

Drought is among the most critical natural hazards to world agriculture, greatly affecting crop yields, soil health, and water supplies. Climate change that enhances the severity, frequency, and length of droughts places farming communities, particularly in arid and semi-arid areas, under greater stress. Impacts are lower yields, food shortages, and economic insecurity.

Adoption of these challenges takes a holistic and complementary approach that integrates the production of climate-resilient crops with the use of efficient and sustainable irrigation practices. In collaboration, these measures have the essential function of increasing agricultural resilience, water conservation, and food security in evolving climatic conditions.

The Effects of Drought on Agriculture

Drought negatively impacts various components of the farming system:

It diminishes the soil moisture availability, slowing down crop growth and productivity. It disrupts growth phases like seed germination, flowering, and fruiting. Drought stress raises crop vulnerability to diseases and pests, as weakened crops become more prone to infestations. Nutrient absorption is restricted, causing deficiencies in vital macro- and micronutrients. Drought, when prolonged, can lead to crop loss, either partial or total, resulting in farmers' income loss and enhanced food insecurity at the household and national levels. Farmers should, therefore, take site-specific, climate-smart approaches starting with suitable choices of drought-tolerant crops to counteract these effects.

Climate-Resilient Crops: Choosing the Right Varieties

Growing drought-resistant crops and improved varieties is a practical and cost-effective measure in adjusting to dry conditions. Such crops generally have characteristics like deep root structures, compact growth duration, high water-use efficiency, and enhanced tolerance to heat and moisture stress.

1. Millets (e.g., Pearl millet, Finger millet, Foxtail millet)

Millets are severely drought-resistant cereals that need low water and nutrient inputs. They can grow well in poor and marginal soils, and thus are suitable for rainfed agriculture. Millets possess brief growth periods and yield nutritionally superior grains filled with fiber, minerals, and micronutrients. Their thermotolerance and drought resistance make them a dependable crop in climate-risky areas.

2. Sorghum (Jowar)

Sorghum is a deep-rooted cereal crop that is naturally well adapted to dry climates. It can withstand hot temperatures and periodic droughts. Sorghum is dual-purpose grain as well as green fodder, which makes it economically valuable. It has good adaptation to light to medium textured soils under rainfed conditions.

3. Pulses (e.g., Chickpea, Pigeon pea, Cowpea, Green gram)

Pulses are good crops for dryland farming with low water demand and short duration of growth. Improved varieties of many of them mature rapidly, avoiding terminal drought. They also enhance soil fertility through biological nitrogen fixation, lessening the use of synthetic fertilizers. Pulses enhance cropping system variability and food security.

4. Oilseeds (such as Groundnut, Sesame, Sunflower)

Crop oilseeds are inherently tolerant to drought and perform well in low to moderate rainfall regions. Groundnut and sesame possess deep taproots, which facilitate higher water extraction from subsoil horizons. These crops are economically responsive and act as cash crops for smallholders in drought zones. They also help in diversification of farm revenues.

5. Drought-Tolerant Improved Varieties

Plant breeding and biotechnology advances have given rise to climate-resilient crop varieties that are resistant to moisture stress:

- ✓ Sahbhagi Dhan: A drought-resistant variety of rice made for eastern India. It is an early maturing crop and produces good yield even under conditions of water scarcity.

- ✓ Pusa 362: Chickpea variety with superior drought tolerance and appropriate for late sowing in rainfed areas.
- ✓ Kanchan (Maize): This crop exhibits drought tolerance, providing consistent yields in areas with unpredictable rainfalls.
- ✓ Rabi Sorghum Hybrid SPV 2217: It is a high-yielding sorghum hybrid for dryland post-rainy season cultivation. It provides superior grain quality and enhanced drought resistance.

Climate-Smart Irrigation Strategies

With growing water scarcity and inconsistent rainfall patterns, effective irrigation practices are necessary to maintain agricultural productivity. Climate-smart irrigation aims at maximum utilization of water, reducing losses, and providing the crop with the right amount of moisture at the proper time. Such practices not only save water but also make crops more resilient to drought conditions and decrease the environmental impact of agriculture.

1. Drip Irrigation

Drip irrigation is an efficient system that provides water to the root area of plants in a network of tubes, emitters, or pipes. The system greatly conserves water and minimizes evaporation losses since water is supplied where it is required. It is highly suitable for fruit trees, vegetables, and row crops such as cotton and maize. Fertigation can also be done using drip systems to supply fertilizers, enhancing nutrient-use efficiency.

2. Sprinkler Irrigation

Sprinkler irrigation mimics natural rainfall, providing even distribution of water over the field by rotating nozzles or spray heads. They are ideal for hilly landscapes and sandy fields, where surface irrigation is wasteful. Sprinkler irrigation is perfect for forage crops, cereals, and lawns, and can be mechanized for efficient water management.

3. Mulching

Mulching is used to cover the top of the soil with organic coverings (like straw, leaves, or compost) or plastic sheets to retain moisture. Mulch serves as a cover, preventing soil

evaporation, keeping the soil uniformly warm, and inhibiting weed growth. It works well in vegetable crops and orchards, particularly in arid areas.

4. Rainwater Harvesting

Rainwater harvesting refers to the collection and storage of rainwater in tanks, percolation pits, or farm ponds during the monsoon. This water is utilized for supplementary irrigation during dry periods, minimizing reliance on groundwater or canal irrigation. It facilitates groundwater recharging and makes water available at the stages of critical crops.

5. Alternate Wetting and Drying (AWD) in Paddy

AWD is a water-saving irrigation method in paddy fields that does not maintain the field in a state of continuous flooding. The farmer lets the field dry out for a couple of days prior to irrigating again, depending on observable field conditions or inexpensive tools such as a perforated field water tube. This saves 25–30% in water usage without sacrificing yield and reduces methane emission, which makes it environmentally friendly.

6. Irrigation Scheduling by Crop Stage

Optimizing irrigation involves scheduling water application to coincide with the crop's most critical growth phases. Crops are most vulnerable to drought stress in flowering, fruit setting, and grain filling phases. By giving priority to irrigation during these times and withholding watering during vegetative or maturity phases unnecessarily, farmers can maximize water use and enhance yield.

Soil and Water Conservation Methods

In order to adapt to long-term drought, increasing soil health and water-holding capacity is essential. Not only do these methods increase water use efficiency but also soil resilience, enabling crops to resist drought conditions more effectively.

Contour Bunding and Terracing

On sloping lands, building contour bunds and terraces serves to slow down surface water runoff, giving more time to water for seepage into the soil. These bunds and terraces check soil

erosion, save rainwater, and enhance moisture supply to crops sown along the contours.

Cover Cropping

Cover crops like legumes, grass, or clover, planted during fallows, minimize soil evaporation, cover the soil surface, and contribute organic matter in the form of biomass. Cover cropping improves soil structure, water retention, and nutrient cycling to enhance drought resilience overall.

Application of Biochar and Compost

Biochar and compost addition enhances water-holding capacity, microbial activity, and long-term fertility of the soil. Biochar, being of high porosity, traps water and nutrients, and is thus best suited for dry lands.

Integrated Nutrient Management (INM)

The use of a balanced combination of organic and inorganic fertilizers, combined with biofertilizers, provides crops with proper nutrition even during moisture stress. INM increases plant strength and root growth, which enables the crop to resist drought more efficiently.

Technological and Policy Interventions

Strong policy structures and advanced technology are needed to facilitate farmers' decision-making, access to resources, and effective climate variability adaptation.

Remote Sensing and Weather Forecasting

Technologies such as satellite remote sensing and agro-meteorological forecasting enable more effective planning of irrigation schedules and cropping calendars. These technologies enable early warnings and data-based information, which assist farmers in reducing drought risks.

Mobile Applications and ICT Tools

Mobile applications and digital platforms are being widely utilized to share real-time information on drought-tolerant seed varieties, pest infestations, water-saving practices, and crop advisories. These platforms enable farmers to implement timely and effective farming practices.

Crop Insurance Schemes

Weather-related crop loss can have disastrous economic effects. Crop insurance schemes, like

the Pradhan Mantri Fasal Bima Yojana (PMFBY), offer a monetary safety net for farmers by reimbursing losses due to yield shortfalls caused by drought, floods, or other natural disasters.

Government Schemes like PMKSY

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is a flagship program that focuses on improving the water-use efficiency and irrigation coverage in India. It promotes technologies such as micro-irrigation, water harvesting, and water-efficient delivery systems, hence playing a crucial role as a policy intervention towards adaptation to drought.

CONCLUSION

Drought adaptation is no longer a choice it is a must in the age of escalating climate change. The future of farming rests in our capacity to develop climate-resilient farming systems that can produce under conditions of water scarcity. Through the combination of climate-resilient crop types with intelligent irrigation strategies, soil conservation methods, and technological breakthroughs, farmers can substantially diminish their susceptibility to drought and provide uninterrupted food production.

But this change needs not only knowledge it needs investment, policy support coordinated at that, and active engagement of the community. With the appropriate blend of scientific inquiry, farmer education, and government action, a comprehensive and participatory strategy for drought adaptation can lead to a sustainable, secure, and climate-resilient agricultural future.

Implementing climate-smart irrigation practices is essential to maintaining agricultural yields under water and drought stresses. Coupled with

drought-tolerant crops, these practices yield a climate-resilient agricultural system that maximizes use of resources, minimizes environmental degradation, and protects livelihoods in vulnerable areas. Increased awareness, technology accessibility, and enabling policies can scale up these irrigation innovations and improve water security in agriculture.

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