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# Climate smart farming: An innovative approach for safer and cleaner production system in Bihar

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*Climate resilient agriculture (CRA) contributes to sustainable crop productivity that is tailored to local hydro-meteorological conditions, while effectively addressing climate change. Through exchange of water between surface and groundwater systems, CRA improves agricultural viability and offers resilience to climate variability. The CRA provides strategies to address present and future food security issues in water-stressed areas such as southern region of Bihar, where demand for water from domestic, industrial and agricultural uses is rising. Approximately one-third of world's soil is degraded. Intensive crop production in India has depleted soils to the point where future production in these regions is at risk. Building resilient crop production systems that can withstand the effects of climate change requires healthy soils. Their diverse community of organisms helps to recycle soil nutrients, control plant diseases, insect and weed populations, and improve soil structure, which in turn has a positive impact on water holding capacity, nutrient supply and retention, and levels of organic carbon.*

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CLIMATE change is no longer merely a theoretical topic; most farmers can share their experiences with it. This development has created uncertainty, which is endangering the agricultural system, making farmers extremely vulnerable. The smallholder farmers make up over 50% of population in our nation are forced to take brunt of incidents, which ultimately fall on government. The magnitude of impoverisher's involvement in agriculture necessitates an attempt to address the climate crisis head-on by implementing resilience-building strategies that combine mitigation and adaptation techniques.

Bihar is experiencing rapid growth and development in recent years for its outstanding achievements in the field of farming system development. This was a turning point for a state that had been stagnant for a long time and had all but accepted its permanent backwardness. The state government's strong commitment to an inclusive and rapid development agenda made these growth visible. Climate resilient agriculture (CRA) is one of the latest agricultural practices introduced in Bihar which promotes sustainable agricultural practices through adoption of climate-smart agriculture practices. It includes use of stress-tolerant crops and varieties, cropping system (crop cycle) optimisation and diversification, conservation agriculture (CA)-based management practices (ZT, DSR, residue management), site-specific nutrient management, precision water management (micro-irrigation, laser levelling), value-added weather forecasts and ICT-based agro-advisories. In Bihar, CRA programme is being implemented by Department of Agriculture, Government of Bihar (GoB) and NICRA programme, being implemented by ICAR-ATARI, Patna through identified KVKs which adopt climate resilient practices among farmers' field.

## Core principles and practices of CRA

***Agroforestry based farming system*:** Agroforestry systems improve soil health through carbon sequestration and better moisture retention, increase biodiversity, integrate trees with crops and livestock. It offers a diversified revenue streams that lessens farmer susceptibility to climate shocks. These methods include alley cropping, home gardens and silvi-pastoral systems which offer strategies for food security, water management and more stable agricultural future against effects of climate change. It serves as carbon sink by incorporating trees and other woody species, absorbing

Sowing by seed-cum-ferti-drill machine

Sowing of paddy by rice-wheat seeder

Wheat cropping in agroforestry-based system

Agroforestry-based farming system

carbon dioxide from atmosphere and assisting in fight against climate change. The coexistence of trees, crops and livestock improves ecological stability by fostering a variety of ecosystems that are home to a greater variety of beneficial insects and other organisms. By providing shade, trees improve the microclimate, which benefits crops and livestock by regulating temperature and humidity.

***Crop establishment technologies*:** The different commonly used techniques are climate-smart seeds, zero-till, Happy seeder and raised-bed technology for direct sowing with less soil mechanical manipulation, crop diversification and rotation, precision water management through use of *pakka*/sandbag check dams and farm ponds, use of cover crops and mulching to protect soil are all examples of climate-resilient crop establishment techniques. The ZT (Zero tillage)-production system is employed in rice–wheat cropping region of Indo-Gangetic plains. In ZT, the planting and drilling seed has to be done mechanically without disturbing soil. It is most effective against numerous crops in both seasons.

Crops such as wheat, maize, mustard, soybean, pigeon pea and others are planted in raised-bed using ridge-furrow method. Multi crop raised-bed planters are used to prepare ridges or beds, which are then reshaped and seeded for following growing season. For high-value crops that are more susceptible to transient water logging stress, this production system is frequently thought to be more suitable. In order to conserve rainwater, use less water, and increase system productivity, farmers frequently grow crops like wheat, soybeans and maize on raised beds. Raised-bed crop planting system in CRA may be especially beneficial in regions, where herbicide-resistant weeds are starting to become an issue and groundwater levels are declining. Irrigation is carried out using a furrow irrigation system, which helps to save irrigation water and cut down on irrigation timing by half. Furrow also serves as a drainage channel during periods of heavy rainfall, protecting crops from excessive moisture, if left longer. When previous crop residue is present in the furrow, the soil becomes softer, lighter, and more friable; as a result, earthworm population rapidly grows and crop appears healthier.

***Decision support and sensor based site-specific nutrient management*:** Decision support tools like Nutrient Expert (NE) (software-based) and sensor-based systems like green seeker enable site-specific nutrient management (SSNM) for climate-resilient agriculture by providing precise fertiliser recommendations, optimising nutrient use efficiency, increasing crop yields, reducing fertiliser costs and minimising environmental pollution from excess nutrients. NE analyses farm and soil data to generate customised recommendations, while green seeker uses optical sensors to measure chlorophyll, biomass, indicating real-time nutrient need for targeted application. NE software acts as a decision support system for farmers, using algorithms based on QUEFTS model to estimate

**Table 1.** Yield and percent enhancement of crops under CRA technological intervention in *rabi* 2023

| Name of technology | Variety | Average grain yield (q/ha) | | Average straw yield (q/ha) | | % increase (Grain yield) |
|---|---|---|---|---|---|---|
| | | Demo | Local check | Demo | Local check | |
| Zero-tillage wheat | DBW-187 | 40.10 | 35.49 | 61.51 | 51.51 | 11.35 |
| Raised-bed wheat | DBW-187 | 42.30 | 36.96 | 61.79 | 53.35 | 12.62 |
| Happy seeder wheat | DBW-187 | 43.97 | 36.69 | 64.68 | 52.41 | 16.55 |
| Green seeker based (Wheat) | DBW-187 | 41.88 | 36.39 | 62.20 | 52.90 | 13.10 |
| Zero tillage lentil | IPL-220 | 11.23 | 8.51 | 20.99 | 16.76 | 24.22 |
| Zero tillage chickpea | PG-186 | 14.86 | 12.27 | 26.87 | 23.55 | 17.43 |
| Raised-bed mustard | RH-725 | 11.60 | 8.30 | 36.23 | 26.03 | 28.44 |
| Raised-bed maize | Acharya | 116.38 | 98.42 | 196.35 | 165.36 | 15.43 |

optimal nutrient requirements. It takes into account local crop yields, nutrient balances, and '4R' nutrient stewardship principles to recommend right source, right rate, right time and right place for nutrient application. Site-specific nutrient (SSN) recommendations for crops such as rice, wheat, and maize are provided by NE. This tool gathers data on farmer practices, soil properties and growing conditions. To guarantee that nutrients are applied at appropriate time, in appropriate amount and in appropriate location for particular field, it uses SSNM principles. It provides customised fertiliser recommendations for individual fields, often through mobile phone applications for accessibility to farmers and extension agents.

A more effective and precise method of applying fertiliser right away is provided by the green seeker which uses an environmental factor and vegetative index called NDVI to determine a crop's potential yield. N is then suggested according to crop's potential yield and responsiveness to more nitrogen. Combination of appropriate N doses guided by green seeker optical sensors at different stages of crop development and prescriptive N doses at planting and crown root initiation stages shows promise for high output. To attain an optimal efficiency, ZT also combines Green Seeker-guided N management techniques with precise water management technologies.

***Precision water management***: By effectively delivering water directly to plant roots through drip, sprinkler or fogging systems, micro-irrigation improves climate resilience in agriculture. This saves a significant amount of water and energy, improves soil health by reducing erosion, increasing moisture retention, increases crop yields, and helps farmers continue to cultivate crops even during extreme weather events like heatwaves and droughts. Together with farmer cooperation through schemes like Group Micro Irrigation (GMI), technologies like IoT, AI further optimise water use, manage risks, enhancing food security and livelihoods. Effective agronomic, soil, and crop management techniques require laser land levelling (LLL). In addition to saving irrigation water and making field operations easier, it increases crop yield and improves produce quality. Uneven land level causes more weeds, uneven crop maturation and uneven crop stands. LLL increases application effectiveness by distributing water uniformly and enhancing water use efficiency, which results in consistent seed germination, increased crop growth, and increased crop yields. Estimates suggest that this strategy could cut irrigation water use by 20–30% without lowering crop yield. One way to improve irrigation efficiency for crop production is to use zero-grade levelling. It is possible to drain or flush fields with zero slope more rapidly. Level fields allow for a more consistent flood depth, reducing water use and pumping costs. While field operations and weather conditions may occasionally call for some minor ground smoothing, benefits of accurate land levelling endure for many years. Precision land levelling with laser control enhances crop yields, reduces weed problems, and improves weed control efficiency. Additionally, it helps to improve crop establishment, improve crop maturity uniformity, increase the cultivable area by ~3 – 5%, save irrigation water, and increase water application efficiency by up to 50%.

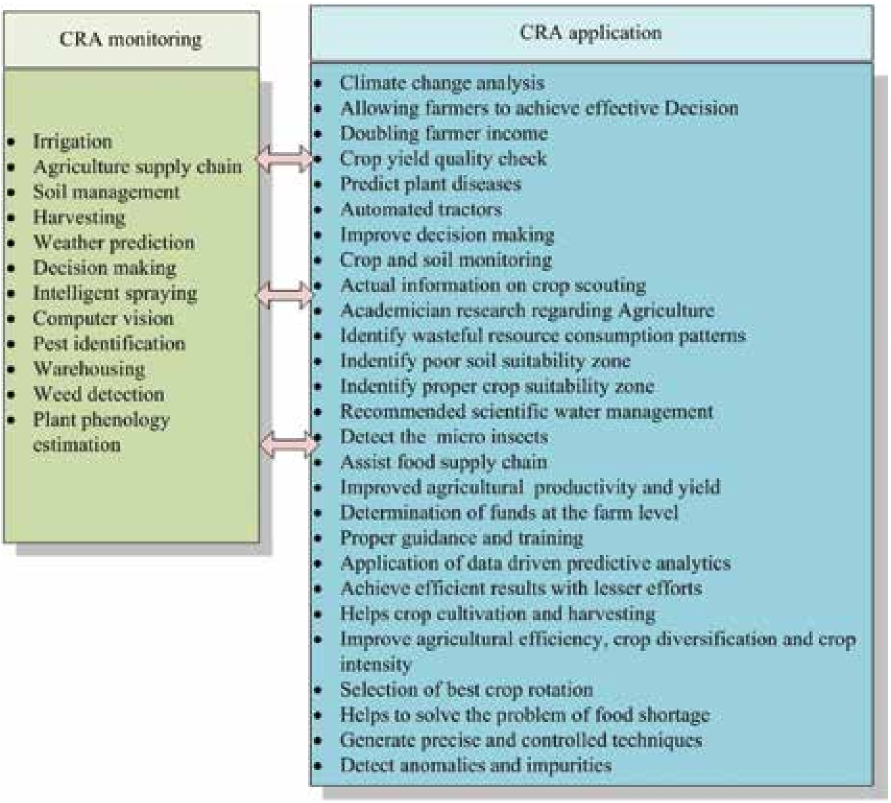
***Weather forecasts and ICT based agro-advisories***: With the help of contemporary technologies like artificial intelligence, Internet of Things, web portal, radio and mobile devices, these forecasts combine agronomic knowledge with localised, real-time data to enable farmers to make proactive, well-informed decisions that reduce risks and boost output. When it comes to providing the farmers with personalised weather-based advisories that combine forecasts with targeted agronomic guidance, mobile platforms are essential. CRA benefits from ICT-based agro-advisories, which give farmers location-specific, real-time information via a variety of technologies. In face of climate variability, these services provide farmers with timely weather forecast and soil moisture data, enabling them to make well-informed decisions about crop selection, sowing dates, and risk management, ultimately increasing productivity and food security. Advisories are more applicable and actionable because they are customised for each farmer's unique location, crop, and stage of growth.

### Challenges in implementing CRA

- Northern Bihar's recurring floods stem from Himalayan rivers (Kosi, Gandak) bringing heavy rainfall from Nepal, compounded locally by silted riverbeds, poorly maintained embankments causing water-logging, deforestation increasing runoff, unplanned development in floodplain, leading to widespread crop damage, livelihood loss and distress migration.
- Recurring drought in the southern Bihar presents significant local challenges, primarily revolving around agricultural

Laser land levelling of field

Application of nano-urea by drone in wheat




vulnerability, water scarcity, economic instability and social strain. These challenges are intensified by highly dependence on the rainfed agriculture, inadequate irrigation infrastructure and neglect of traditional water management systems.

- CRA techniques are not widely adopted by the smallholders in Bihar because they have limited access to basic resources such as credit, high-quality seeds, and agricultural inputs.
- Transition to CRA may also be hampered by cultural norms and traditional practices, particularly those related to gender.
- Although there is a subsidy for agri-machines, mechanised agriculture faces obstacles from poor infrastructure (roads, electricity and storage facilities), and adaptation efforts are made more difficult by erratic monsoons.
- Precision farming is difficult for small-scale farmers in Bihar to implement because of knowledge, technological and financial barriers. Despite ongoing numerous programmes and regulation aimed at addressing climate change adaptation, small/marginal farmers are still not aware of advantages and information that are available.
- Potential economic benefits are also limited by CRA products' limited market access such as organic crops. Adoption of new techniques is significantly hampered by traditional farming methods and belief that tillage is required.


Leaf colour chart use in paddy field

## SUMMARY

Development of a sustainable food future in face of climate change depends on climate resilient agriculture. We can improve agricultural systems' resilience, guarantee food security and lessen effects of climate change by adopting cutting-edge methods, tools and regulations. Prioritising CRA and motivating a new generation of climate-resilient farmers and leaders are crucial as we proceed.

Conservation agriculture and agroforestry are two methods that farmers can adopt to minimise soil degradation, reduce the use of synthetic fertilisers, and sequester carbon. In addition to lowering greenhouse gas emissions, this improves ecosystem services and promotes ecosystem health and biodiversity. However, government, international organisation, and local stakeholders must work together to successfully implement CRA. Farmers must have access to agricultural research, climate information services, and extension initiatives that share technologies and best practices. Policies and incentives, such as insurance plans that guard against climate-related losses or subsidies for climate-resilient inputs, can also motivate farmers to embrace CRA-practices. Only then, we will be able to make the world more sustainable and food secure for everybody.

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