CHAHAL ACADEMY

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Kruksheta

NEW FRONTIERS OF FREEDOM

1 AGRICULTURE 4.0 – TOWARDS AGRI-TECH REVOLUTION

1. Importance of Agriculture in India

- **Employment:** Employs 42.3% of India's workforce.
- Contribution to GDP: Around 18.2% of national GDP.
- **Challenges faced:**
  - ➢ Low productivity and yield gaps (20–60% lower than global averages).
  - ➢ Heavy dependence on monsoon (52% farming rainfall dependent).
  - ➢ Fragmented small landholdings (89.4% farmers own <2 ha).
  - ➢ High post-harvest losses (0.92% – 15.88% across crops).
  - ➢ Volatile farm incomes.
  - ➢ Livestock sector issues: lack of fodder, animal healthcare gaps, weak supply chains.

II. Need for Transformation

- Rising demand for food security with a growing population.
- Technology adoption can increase farmer incomes, ensure sustainability, and enhance efficiency.
- **Digital Agriculture:** Use of AI, IoT, blockchain, robotics, big data for precision farming, reducing waste, climate resilience, and market linkages.

III. Concept of Digital Agriculture

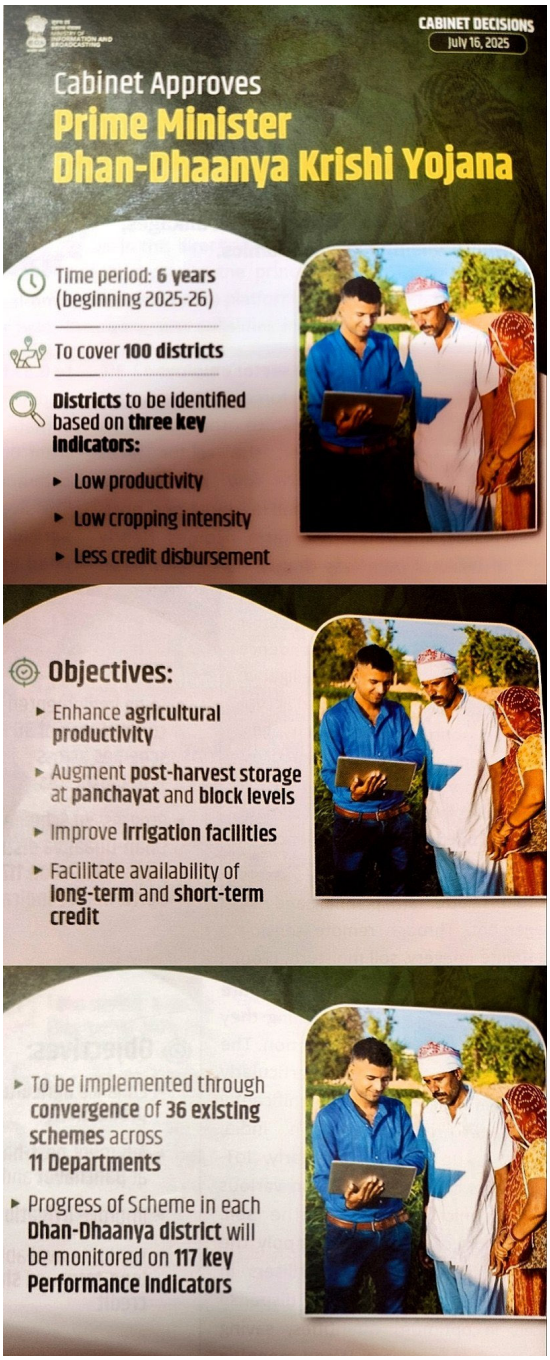
- **Two complementary paradigms:** Together, they form the foundation for Agriculture 4.0 – empowering farmers while upgrading institutional frameworks.

(i) Smart Farm Digitisation (farm-level):

- ➢ IoT-based soil/crop sensors.
- ➢ Drones for spraying/imaging.
- ➢ Automated irrigation.
- ➢ Mobile-based farm management platforms.
- ➢ **Goal:** Transform farms into responsive, precision-driven production units.

(ii) Smart Agri-Sphere Digitisation (ecosystem-level):

- ➢ Satellite-based crop monitoring.
- ➢ Weather forecasting.
- ➢ Blockchain-enabled supply chains.
- ➢ Digital platforms for market access, credit, subsidies, and insurance.
- ➢ **Goal:** Strengthen governance, transparency, and systemic support.



IV. Smart Farm Digitisation – Key Aspects

- **Adoption Gap:** Low adoption in India compared to Japan, South Korea, China.

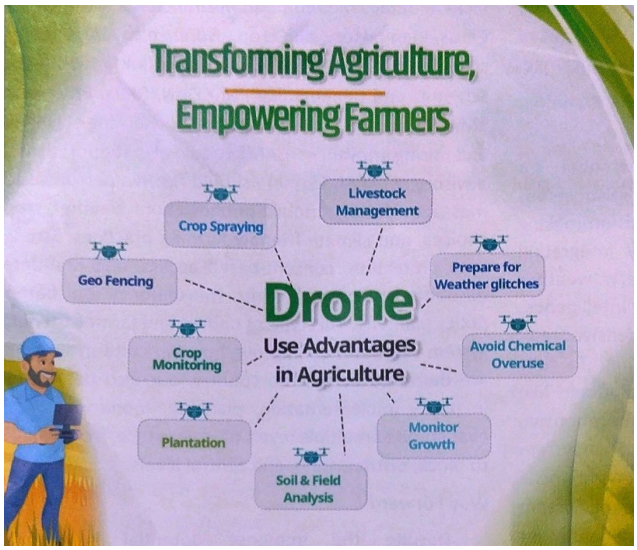
- **Challenges addressed:**
  - **Pest Control:** 30–35% crop losses due to pests; climate change worsens attacks (10–25% yield loss per +1°C rise).
  - **Water Management:**
    - 70–80% farmers depend on groundwater irrigation.
    - 17% groundwater blocks overexploited, 5% critically depleted.
    - IoT sensors can cut water use by ~50%.
  - **Nutrient Management:** Optical sensors apply precise fertilisers, reducing overuse.
  - **Weed Management:** Drone + GPS = weed mapping + targeted spraying.
- **Smartphone as a multipurpose tool:**
  - **Camera:** leaf index, soil images.
  - **GPS:** identify problem zones.
  - **Accelerometer/gyroscope:** monitor movement, alarms.
  - **QR codes:** seed traceability.
- **Automation benefits:**
  - Alleviates labour shortages (90% farmers cite this).
  - Reduces disguised unemployment.
  - Increases efficiency with robotics and AI tools.
- **Digital readiness:**
  - 85.5% households have smartphones.
  - 86.3% have internet access at home.
  - 95.5% of youth (15–29) in rural areas own smartphones.
  - **Potential:** Every farm is a SmartFarm.

V. Smart Agri-Sphere Digitisation – Systemic Level

- **Supply Chain:** Blockchain for traceability "farm to fork"; QR codes for authenticity, boosting exports.
- **Market Access:** Digital marketplaces reduce middlemen, improve price realisation.
- **Weather & Advisory:** AI-based, hyperlocal advisories on pest risk, weather, and crop practices.
- **Geo-tagging**: Asset tracking for farm planning and disaster management.
- **Remote Sensing:** Soil moisture, crop health, pest outbreaks monitored via satellite imagery.
- **Livestock Sector:** Health monitoring, feed tracking, early disease detection.
- **Dairy:** Automation for quality and loss reduction.
- **Fisheries:**
  - Weather updates, market info, digital commerce.
  - Mapping water bodies, tracking ecosystems.
  - Advisories for sustainable fishing.
- **Warehousing:** Sensors for temperature/humidity monitoring to reduce losses (still nascent in India).

VI. Agri Stack India – Comprehensive Agriculture Management System (CAMS)

- **Purpose:** Policy planning, monitoring, and real-time decision-making.
- Components:
  - **Farmer Database:** Aadhaar-linked ID, SHG/FPO membership, landless workers info.
  - **Land & Asset Records:** Geo-tagged parcels, soil health, water resources, ownership status.
  - **Crop/Input Data:** Patterns, yields, fertiliser/seed use, organic/natural farming status.
  - **Real-time Data:** Satellite images, weather alerts, pest/flood/drought warnings.
  - **Infrastructure Records:** Seeds, fertilisers, cold storage, transport, warehouses.
  - **Market Linkages:** MSP, mandi prices, buyers, food processing units.
  - **Credit & Insurance:** Kisan Credit Cards, loan history, PMFBY coverage.
  - **Government Schemes:** PM-KISAN, RKVY, PKVY, SMAM linked for eligibility and grievance redressal.
  - **Advisories:** Personalised SMS alerts on weather, crops, sustainable farming.
- **Safeguards:** Data protection, consent-based access, dashboards for transparency.



VII. Way Forward – Strengthening Agriculture 4.0

- **Infrastructure:**
  - Improve high-speed internet in rural areas.
  - Renewable energy for reliable power.
- **Affordability & Inclusiveness:**
  - Make technologies affordable for all farmers.
  - Inclusive adoption by women farmers, tribal groups, and landless workers.
- **Capacity Building:**
  - Strengthen extension services with training programs.
  - Skill development for farmers and agri-labour in digital tools.
- **Regulation:** Clear policies on drones, AI, cybersecurity.
- **Government Initiatives:**
  - PM-KISAN, Digital India, Soil Health Cards, PMFBY, Kisan Credit Card schemes.
  - Digital India brought broadband to 2.5 lakh villages.
- **Institutions as Enablers:**
  - ICAR institutes (113), Agricultural Universities (74), KVKs (731).
  - FPOs (8,875), PACS (1,01,524).
- **Global Opportunities:** UN's 2025 International Year of Cooperatives – India can leverage cooperatives for Agri-Tech.

VIII. Conclusion

- Agriculture 4.0 is not just about technology—it's about resilient, sustainable, inclusive farming systems.
- With digital adoption, India can:
  - Boost farmer incomes.
  - Strengthen food security.
  - Ensure climate-smart practices.
  - Build a globally competitive agri-economy.
- Transition requires vision, coordination, inclusivity, and farmer-centric focus to make India a global leader in agricultural innovation.

2 CONSERVATION AGRICULTURE PRACTICES AND PERSPECTIVES

I. Background

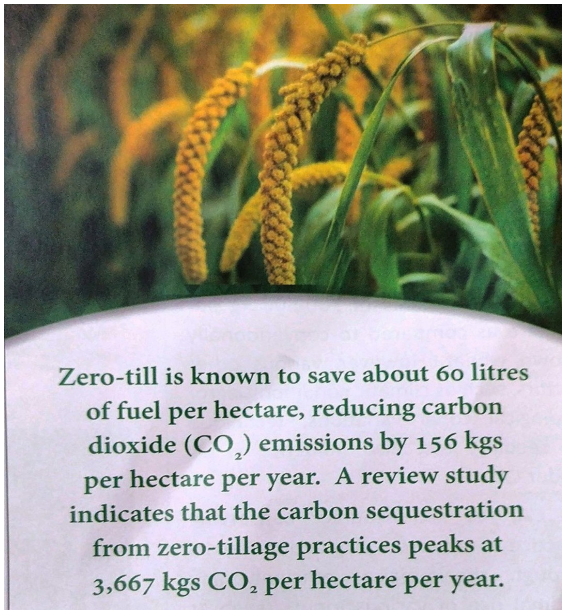
- **Green Revolution (1960s):**
  - Shift from ***animal-based subsistence farming → energy-intensive, chemical-based farming.***
  - Achieved food self-sufficiency and later, surplus.
- **Negative consequences:**
  - Soil health degradation.
  - Water stress and contamination.
  - Deterioration of air quality.
- **Alarm raised (late 1980s):**
  - Reports of resource degradation and stagnating productivity.
  - Led to the search for sustainable, eco-friendly, profitable practices.
- **Emergence of Conservation Agriculture (CA):**
  - The term popularized in the 1990s.
  - Built upon both scientific innovations and traditional farmer practices.

II. Core Principles of Conservation Agriculture (CA)

- **FAO Definition:** A system to ensure food security, profitability, and natural resource protection.
- **Three Key Principles:**
  - **Minimum soil disturbance**
    - Use of Zero Tillage (ZT) and direct seeding.
    - Prevents erosion, preserves organic matter.
  - **Permanent soil cover**
    - Organic mulch/residue shields soil from sun and rain.
    - Conserves moisture, avoids compaction, boosts biodiversity.
  - **Crop diversification**
    - Crop rotation, varied sequences, and intercropping.
    - Improves soil structure, pest/disease resistance, and fertility.
- **Holistic Approach:**
  - All three actions applied simultaneously across farming systems.
  - Improves productivity and soil health together.

Key Practices in CA(Conservation Agriculture)

- **Zero Tillage (ZT):**
  - Eliminates traditional ploughing.
  - Seeds sown directly into unploughed fields with stubble intact.
  - Zero-Till Seed-cum-Fertilizer Drill places seeds and fertilizer efficiently.
  - Crop residues act as mulch—conserve water, control weeds, moderate temperature.
  - Crucial for the rice-wheat **system** (Punjab & Haryana) to reduce residue burning.



Zero-till is known to save about 60 litres of fuel per hectare, reducing carbon dioxide (CO_2) emissions by 156 kgs per hectare per year. A review study indicates that the carbon sequestration from zero-tillage practices peaks at 3,667 kgs CO_2 per hectare per year.

- **Crop Residue Management:**
  - Retained as mulch instead of burning.
  - Improves soil microbial activity and organic carbon.
  - Reduces air pollution and health risks.
- **Crop Rotations:**
  - Legumes in rotation fix nitrogen, improving soil fertility.
  - Residues reduce evaporation → 1–2 less irrigations needed.
  - Maintains soil in wetter condition for longer periods.

IV. Research, Support & Adoption

- **ICAR Initiatives:**
  - NICRA, NATP, NAIP, Consortium Research Platform on CA.
  - Works across 11 national locations.
- **Collaborations with International Institutes:**
  - CSISA, BISA, CIMMYT, IRRI, Rice-Wheat Consortium.
  - Participatory research and field trials.
- **Government Support:**
  - **No dedicated CA policy, but support via schemes:**
    - Sub-Mission on Agricultural Mechanisation (machines like Happy Seeder, Laser Land Leveler).
    - Subsidies for crop residue management machinery.
    - Climate-change mitigation schemes support CA indirectly.
- **Adoption Scale:**
  - Currently **25–30 million hectares** under CA.
  - **7+ lakh farmers** practicing CA.
  - Concentrated in Punjab, Haryana (rice-wheat belt).
  - Expanding to Bihar, West Bengal, Eastern UP, Odisha, Central India, Andhra Pradesh, NEH & Konkan.
  - **Crops:** Wheat, rice, maize, sorghum, mustard, chickpea.

V. Success Story – Rajapur Village (Bihar)

- **100% adoption of Zero-Tillage in wheat.**
  - Supported by CSISA & ICAR-KVKs since 2010.
  - Farmers sow wheat by mid-November → higher yields, lower cost.
  - **Example: Rahul Rai,** progressive farmer:
    - Shifted from conventional → ZT wheat & direct-seeded rice.
    - Wheat yield increased from 3.5–4 t/ha (2014) → 5.5 t/ha (2023).
    - Became a champion farmer promoting CA in neighbouring villages.

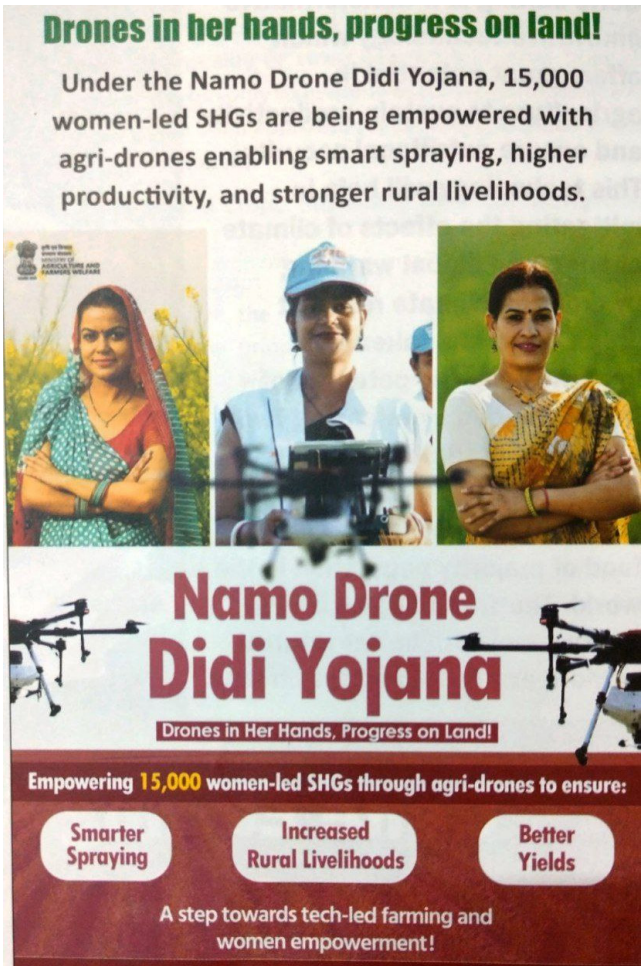
VI. Benefits of CA

- **Yield:**
  - Initial years may show minor decline due to nutrient immobility.
  - Over time, improved soil health and moisture increase yields.
  - **Indo-Gangetic Plains:** ZT gave 10–17% higher rice & wheat yields.
  - **Wheat yield improvement:** 200–500 kg/ha more than conventional.
- **Cost Reduction:**
  - Savings on fertilisers, herbicides, labour, water, and fuel.
  - **Cost reduction:** 15–16% per hectare.
  - Indo-Gangetic Plains: Avg. savings of ₹5,760 per hectare.
- **Climate & Environment:**
  - **Carbon sequestration:** 3,667 kg CO_2/ha/year.
  - Saves ~60 litres of fuel/ha (reducing CO_2 by 156 kg/ha/year).
  - 67% lower fuel use compared to conventional farming.
  - **Water saving:** 25–35%.
  - Reduces residue burning → lowers air pollution.
- **Human & Social Benefits:**
  - Reduces groundwater contamination.
  - Cuts drudgery for women farmers (less nursery/tillage work).
  - Improves public health through cleaner air and safer water.

VII. Challenges in Adoption

- **Technical & Financial:**
  - High cost and limited access to ZT machinery.
  - Smallholder farmers struggle with affordability.

- **Knowledge Gaps:**
  - ➢ Lack of awareness and training among farmers.
  - ➢ Requires participatory research, demonstrations, and capacity-building.
- **Field Issues:**
  - ➢ Small and fragmented landholdings.
  - ➢ Competing use of residues (e.g., fodder).
- **Social & Cultural Resistance:** Practices differ sharply from traditional farming beliefs.



VIII. Way Forward

- **Policy & Support:**
  - ➢ Establish CA mechanisation hubs in potential villages.
  - ➢ Develop sustainable business models for CA adoption.
  - ➢ Strengthen subsidy and support schemes.
- **Research & Innovation:**
  - ➢ Focus on problem-solving research in CA.
  - ➢ Scale up trials and demonstrations for farmer confidence.
- **Knowledge & Awareness:**
  - ➢ Learning platforms for CA practitioners.
  - ➢ More farmer training, participatory extension models.
- **Expansion Potential:**
  - ➢ Bring barren/fallow lands under CA.
  - ➢ Promote profitable cropping systems.
- **Future Priority:**
  - ➢ Conservation Agriculture must be central in India's agricultural policy.
  - ➢ Aims for sustainability, profitability, and intergenerational benefits.

3 GENERAL EDITING TECHNOLOGY – TRANSFORMING AGRICULTURE

1. Introduction to Gene Editing in Agriculture

- **Definition and Scope**
  - Genome editing is a revolutionary innovation in biosciences, with a high impact on agriculture.
  - Helps in tailoring crops with desirable traits for:
    - Increased productivity and quality
    - Resistance to pests and diseases
    - Resilience to climate-induced stresses
- **Role of Genome vs. Genes**
  - **Genes:** Control specific heritable traits.
  - **Genome:** Defines the whole organism, influencing overall characteristics.
- **Evolution of CRISPR**
  - CRISPR is derived from the bacterial immune system for viral defence.
  - Studied in detail by **Francis Mojica (1990s).**
  - **2012: Jennifer Doudna & Emmanuelle Charpentier** developed CRISPR-Cas9 genetic scissors.
  - Awarded **Nobel Prize in Chemistry (2020).**
- **Applications Beyond Agriculture**
  - **DNA editing possible in:**
    - Humans (medical therapies)
    - Animals (better breeds)
    - Plants (improved crops)
    - Microorganisms (biotechnological uses)
- **Advantages of CRISPR over Older Techniques**
  - More precise than transgenic/GM methods.
  - Faster development cycles compared to traditional breeding.
  - Versatility in editing across multiple species.

II. Gene Editing for Crop Improvement

- **Core Mechanism**
  - Uses site-directed nucleases (SDNs).
  - **Capable of:**
    - Small deletions
    - Substitutions
    - Nucleotide additions
- **Technological Refinement**
  - All-in-one CRISPR toolbox (University of Maryland).
  - Works in both monocots (e.g., rice) and dicots (e.g., tomato).
- **Global Application Status**
  - Genome editing applied to **>40 crops.**
  - Being used in **25+ countries.**
  - Commercialised varieties in US and Japan so far (only 6 approved).

III. Gene Edited Crops: Sustaining Food & Nutritional Security

- **Significance of Staple Crops**
  - Rice, maize, wheat → 60% of global calorie intake.
  - Staple food for >4,000 million people worldwide.
- **Yield Enhancement Examples**
  - **Rice:**
    - **OsAPL gene** → higher yield.
    - OsSXK1 gene → better photosynthesis, grain yield.
    - OsBADH2 gene → improved aroma (consumer preference).
  - Over 55 rice genes edited for:
    - Stress tolerance
    - Architecture changes
    - Grain yield improvements
- **Nutritional Improvements (Biofortification)**
  - **Golden Rice**: beta-carotene for vitamin A.
  - Zinc-enriched rice and wheat (OsNAS genes).
  - **Golden Maize:** improved pro-vitamin A content.
- **Specific Crop Examples**
  - **Wheat:**
    - Reduction of gliadin (helpful for celiac patients).
    - Knockout of **asparagine synthetase** → less acrylamide formation in bread.

- **Maize:** Editing lysine pathway → higher lysine content (protein quality).
- **Potato:**
  - **gbss gene** editing → amylose-free starch with smoother texture.
  - Reduced acrylamide formation in fried/ baked potato.
- **Soybean:**
  - Reduced phytic acid → better iron/zinc absorption.
  - Enhanced oil content & protein quality.
- **Apple & Tomato:**
  - Longer shelf life.
  - Controlled fruit ripening.

- **Commercialised Products Globally**
  - Waxy corn, high-oleic soybeans.
  - Non-browning mushrooms.
  - Omega-3 enriched camelina (false flax).
  - Sicilian Rouge High GABA tomato (Japan).
  - **Gene-edited fish:** Madai sea bream & Tiger puffer (Japan).

IV. Managing Biotic and Abiotic Stresses

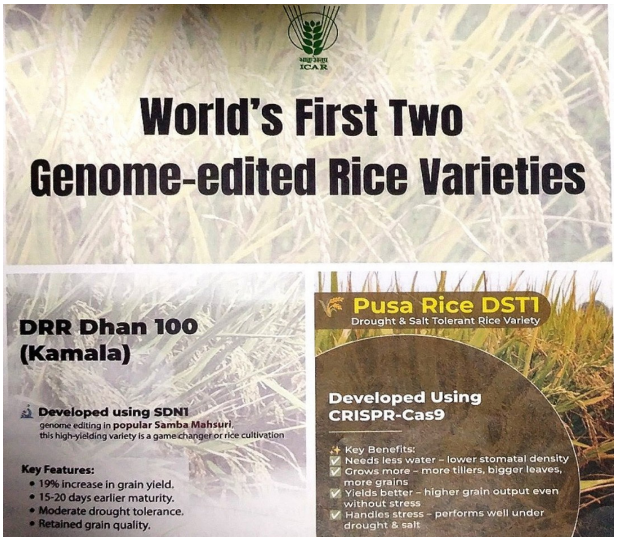
- **Abiotic Stress (Non-living)**
  - **Drought tolerance:**
    - **ZmHDT103 gene** in maize → improved drought resilience.
    - **TORPK1 gene** in wheat → deeper roots, better water absorption.
  - **Flood tolerance:** modified root structure for flood lodging.
  - **Salinity tolerance**: targeted editing of salt sensitivity genes.
  - **Heavy metal tolerance:** disruption of sensitivity genes (Se genes).
- **Biotic Stress (Living threats):** Disease resistance via knockout of susceptibility (S) genes.
  - **Rice:**
    - **OsERF922** knockout → resistance to blast disease.
    - **SEC3A** editing → boosts salicylic acid, stronger defence.
    - Edits against bacterial blight **(Xanthomonas oryzae)**.
  - **Citrus:** Editing **LOB gene** promoter → resistance to citrus canker.
  - **Banana:** Editing **DMR gene** → control of wilt disease.
- **Insect Pest Control:**
  - **Editing vitellogenin** → blocked egg development in **diamondback moths.**
  - Editing abdominal-A gene → severe defects in fall armyworm (maize/rice pest).

V. Climate Change Mitigation

- **Potential Benefits**
  - Methane-free cows for livestock farming.
  - Development of climate-resilient crop varieties.
  - Carbon sequestration potential in plants.
- **Stress Adaptations**
  - Crops designed for drought, salinity, and temperature extremes.
  - Knockout of sensitivity genes **(Se genes)** → stress tolerance.
  - **Example:** Banana streak virus in Africa deactivated via CRISPR.
- **Reduced Chemical Usage**
  - Pest- and disease-resistant crops = lower pesticide demand.
  - Similar to the Bt cotton revolution.

VI. India's Progress in Gene Editing

- **Achievements in Rice**
  - ICAR launched genome editing research in **2018.**
  - Developed two new rice varieties (2025):
    - **i. DRR Rice 100 (Kamla):**
      - 20% higher yield (up to 9 t/ha).
      - 20 days shorter maturity → saves water/ fertilizer.
      - Reduced methane emissions.
    - **ii. Pusa DST Rice 1:** Tolerant to saline & alkaline soils.



- **Expected Impacts**
  - 19% increase in yields.
  - 7,500 million cubic meters of irrigation water was saved.
  - 20% lower greenhouse gas emissions.
- **Other Indian Examples**
  - Mustard with reduced glucosinolate **(Delhi University).**
  - First gene-edited sheep **(ICAR, Kashmir)** – 30% higher muscle mass.
  - **NBRI Lucknow:** working on tomato, cotton, chickpea, rice, brassica.
  - Genome editing underway in 24 field crops & 15 horticultural crops.
- **Policy & Funding**
  - **Budget 2023–24:** ₹500 crores allocated for genome editing.
  - DBT's Agricultural Biotechnology programme driving research.
  - BIRAC's Biotechnology Ignition Grant → up to ₹50 lakhs for startups.

VII. Regulatory Framework

- **Difference from GM Crops**
  - **Gene editing:** no foreign DNA inserted.
  - More acceptable as changes resemble natural mutations.
- **Global Acceptance:** countries treat gene-edited crops the same as conventional crops.
- **Indian Guidelines (2022)**
  - Genome-edited crops (SDN1 & SDN2) exempted from GM biosafety rules.
  - Institutional Biosafety Committees (IBSCs) oversee testing.
  - Commercial release requires approval from:
    - Ministry of Agriculture & Farmers Welfare
    - Food Safety and Standards Authority of India (FSSAI).

VIII. Commercial Potential

- **Global Market**
  - Agricultural genomics: $4.32 bn (2024) → $10.32 bn (2035).
  - Seed market: $88.82 bn (2024) → $99.94 bn (2030).
- **Indian Market**
  - Genomics market: **$2.2 bn (2024)**.
  - **Seed industry:** $3.61 bn (2024) → $5.01 bn (2030).
  - The private sector controls >65% of the seed industry.
- **Startups & Companies**
  - **Global:** Syngenta, Benson Hill, Cibus, Advanta, Bayer.
  - **India:** 209 biotech startups (second after the US with 302).
  - **Bayer & G+FLAS** collaboration for vitamin D3 enriched tomato.
- **Challenges and Concerns**
  - **Risks:**
    - Off-target effects.

      Gene flow to wild relatives → biodiversity risks.
    - Ethical debates on germline editing."

IX. Conclusion

- Gene editing, especially CRISPR-Cas9, is a **game-changer for agriculture**.
- Helps in tackling food security, nutrition, pest management, and climate resilience.
- India has emerged as a leader with rice, mustard, and sheep breakthroughs.
- Supportive regulations, funding, and private participation will drive future growth.
- Risks and ethical issues must be carefully managed.
- Echoing Dr. Norman Borlaug: advances in plant genetics are essential to meet rising food demand—gene editing is the next great revolution.

4 CARBON FARMING FOR CLIMATE-SMART AGRICULTURE

1. Background and Context

- **Agriculture's importance**
  - ➢ Agriculture is directly and indirectly linked to multiple **Sustainable Development Goals (SDGs)**, including:
    - **SDG 2 (Zero Hunger)** – ensuring food security.
    - **SDG 12 (Responsible Consumption & Production)** – sustainable farming.
    - **SDG 13 (Climate Action)** – reducing emissions. **SDG 15 (Life on Land)** – soil, biodiversity, ecosystem health.
  - ➢ It is central to human survival and planetary sustainability.
- **Climate change effects on agriculture**
  - ➢ Lower crop productivity due to **changing rainfall, drought, and temperature extremes**.
- Intensified **soil erosion** from erratic weather.
- Agriculture itself worsens the climate crisis by emitting greenhouse gases (GHGs).
- **Need for sustainable transformation**
  - ➢ Food security is threatened if agriculture remains carbon-intensive.
  - ➢ Agricultural models must shift to **resilient and climate-smart systems**.
  - ➢ **Key priorities:**
    - Enhance **water retention and filtration** in soils.
    - Increase **biomass production**.
    - Promote **carbon sequestration** for long-term climate mitigation.

II. Dual Role of Agriculture

- **Agriculture as a source of emissions**
  - ➢ Contributes nearly **20% of global emissions** (FAO, 2020).
  - ➢ **Main sources:**
    - Enteric fermentation from livestock (methane).
    - Overuse of chemical fertilisers (nitrous oxide).
    - Paddy cultivation (methane).
    - Stubble burning and tillage (carbon dioxide).
- **Agriculture as a carbon sink**
  - ➢ With sustainable practices, farmland can:
    - **Capture and store CO_2.**
    - Help achieve **global emission reduction goals**.
  - ➢ **Carbon sequestration provides:**
    - Climate mitigation.
    - Extra income for farmers via **carbon credits**.

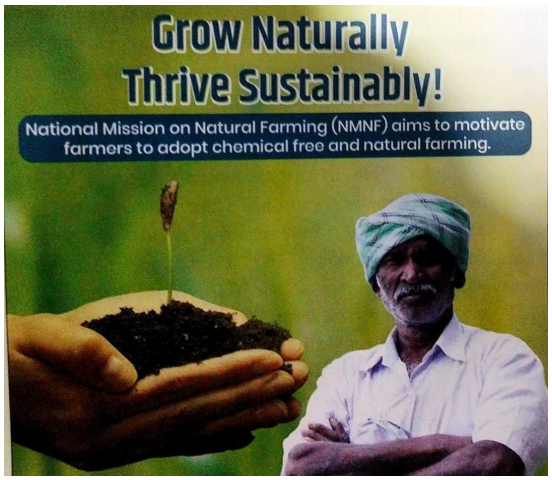
III. Carbon Farming – Concept

- **Definition**
  - ➢ Carbon farming = **agricultural practices designed to increase sequestration of atmospheric CO_2 in soil and vegetation**.
  - ➢ Transforms agriculture from **net emitter** → **net absorber** of GHGs.
- **How it works**
  - ➢ Uses **photosynthesis** to pull CO_2 from the atmosphere.
  - ➢ Improves **soil organic matter** to hold more carbon.
  - ➢ Long-term carbon storage in **plants + soil biomass**.
- **Benefits for farmers**
  - ➢ **Soil health** → better fertility and higher yields.
  - ➢ **Water retention** → resilience against drought.
  - ➢ **Resilient crops** → withstand climate shocks.
  - ➢ **Carbon credits**: 1 credit = removal of 1 tonne of CO_2 equivalent.
- **India-specific opportunities**
  - ➢ 85% of farmers are **smallholders** (GOI, 2021) → large populations can be mobilised.
  - ➢ **Potential: $63 billion worth of carbon revenue** across 170 million hectares.
  - ➢ **Soil capacity: 3–8 billion tonnes CO_2 equivalent storage per year for 20–30 years**.

IV. Core Carbon Farming Practices

- **Forest Management**
  - ➢ Forests act as **natural carbon sinks**.
  - ➢ **Interventions:**
    - ▫ Avoid deforestation.
    - ▫ Reforestation & afforestation.
    - ▫ Enhanced forest conservation.
- **Agroforestry**:
  - ➢ Combines trees + crops/shrubs.
  - ➢ Sequesters CO_2 through photosynthesis.
  - ➢ Adds **co-benefits**:
    - ▫ Biodiversity support.
    - ▫ Timber, fruits, non-timber forest products.
    - ▫ Soil improvement.
- **Grasslands Conservation**
  - ➢ Grasslands store carbon in **deep root systems** of native grasses.
  - ➢ **Benefits:**
    - ▫ Permanent land conservation.
    - ▫ Avoids conversion to monoculture or commercial use.
    - ▫ Protects soil and biodiversity.
- **Reduced Fertiliser Application**
  - ➢ **Problem**:
    - ▫ Excess fertilizer harms soil microbes and reduces carbon sequestration.
    - ▫ Production of fertilisers = **energy intensive** and emits GHGs.
  - ➢ **Solutions**:
    - ▫ Precision farming → match fertilizer to crop need.
    - ▫ Controlled-release fertilisers.
    - ▫ Fertigation (nutrient delivery via irrigation).
  - ➢ **Benefits**:
    - ▫ Reduced costs for farmers.
    - ▫ Lower emissions.
    - ▫ Improved soil health.
- **Biochar Application**
  - ➢ Biochar = **biological charcoal produced from biomass**.
  - ➢ **Properties:**
    - ▫ Stores fixed carbon for centuries/millennia.
    - ▫ Stable and not biologically degraded.
  - ➢ **Benefits:**
    - ▫ Long-term carbon sink.
    - ▫ Enhances soil fertility.
    - ▫ Retains water, reduces fertilizer need.
- **Reduced Tillage**
  - ➢ **Traditional tillage**: releases stored carbon, increases erosion.
  - ➢ **Conservation tillage**:
    - ▫ Minimal soil disturbance.
    - ▫ Maintains soil organic matter (SOM).
    - ▫ Improves soil structure and water retention.
  - ➢ **Outcomes:**
    - ▫ Reduces emissions.
    - ▫ Cuts fuel costs for farmers.
    - ▫ Enhances long-term crop productivity.
- **Cover Cropping**
  - ➢ Growing crops specifically to cover soil.
  - ➢ **Functions:**
    - ▫ Prevent erosion.
    - ▫ Fix nitrogen (legumes).
    - ▫ Improve fertility via organic matter.
    - ▫ Suppress weeds without chemicals.
  - ➢ **Example: Dhaincha in rice–wheat systems** → increases yield, lowers input costs.
- **Crop Rotation**
  - ➢ Growing different crops in sequence.
  - ➢ **Benefits:**
    - ▫ Breaks pest/disease cycles.
    - ▫ Enhances soil microbial diversity.
    - ▫ Utilises nutrients at different root depths.
- **4Rs Nutrient Management**
  - ➢ **Right Time** → match nutrient supply with crop demand.
  - ➢ **Right Rate** → apply only what crops can absorb.
  - ➢ **Right Source** → use fertilisers with efficiency technology.
  - ➢ **Right Place** → ensure placement where roots can absorb.
- **Eliminating Bare Fallows**
  - ➢ **Problem:** leaving land idle loses soil carbon due to heat, wind, rain.
  - ➢ **Solution:** plant **nitrogen-fixing crops** (e.g., clover, vetch) instead.
  - ➢ **Outcome:**
    - ▫ Maintains soil cover.
    - ▫ Enhances carbon storage.
    - ▫ Improves soil fertility naturally.

- **Companion Cropping**
  - Planting crops side by side for mutual benefit.
  - **Example:** pest-repelling crops alongside food crops.
  - **Benefits:**
    - Increased yield.
    - Pest reduction.
    - More diverse root systems.
- **Rotational Grazing**
  - Moving animals between fields.
  - **Benefits:**
    - Allows grass to regrow.
    - Reduces erosion.
    - Increases carbon captured by restored vegetation.



- **Silvopasture**
  - Integration of **trees, pastures, livestock**.
  - **Benefits:**
    - Carbon stored in trees and soil.
    - Increased pasture productivity.
    - Better livestock welfare.
- **Improved Residue Management**
  - Keeping residues (straw, stalks) in fields.
  - **Benefits:**
    - Add mulch.
    - Retains moisture.
    - Improves soil composition.
- **Improved Water Management**
  - Excess water causes erosion and nutrient loss.
  - Smart irrigation practices:
    - Right timing, rate, depth, spacing.
  - **Benefits:**
    - Efficient crop growth.
    - Reduced wastage of water resources.
- **Data-driven Decision Support**
  - Use of **data and digital tools** to guide farming decisions.
  - **Farmers can:**
    - Compare input alternatives.
    - Track variability.
    - Maximise efficiency.
  - Leads to sustainable, **evidence-based farming**.

V. Carbon Market and its Role

- **Carbon Market Basics**
  - System for buying/selling carbon credits (1 credit = 1 tonne CO_2 reduced).
  - Emerged through the Kyoto **Protocol** → Clean Development Mechanism (CDM).
  - Strengthened by **Paris Agreement (2015)** → voluntary mechanisms.
- **India's Position**
  - Early adopter of carbon trading.
  - **Second-highest number of CDM projects globally (after China)**.
  - Indian Carbon Market legalised via **Energy Conservation Amendment Act, 2022**.
- **Benefits for Farmers**
  - Carbon credit sales = **new revenue stream**.
  - Incentives to adopt cover cropping, no-till, agroforestry, residue management.
  - Helps reduce harmful practices like **stubble burning**.
- **Challenges**
  - High cost of CSA technologies (precision farming, efficient irrigation).
  - Limited financing, poor infrastructure in rural areas.
  - Lack of farmer awareness and cultural resistance.

VI. Way Forward

- **Policy and Institutional Support**
  - Launch a **National Carbon Farming Mission**.
  - Integrate Soil Health Card Scheme & National Mission for Sustainable Agriculture.
  - Standardise carbon measurement protocols.
- **Research and Innovation**
  - Develop low-cost carbon measuring devices.
  - Promote crop-specific sequestration techniques.
  - Expand **NICRA(National Institute for**

Research on Commercial Agriculture) programme for climate resilience.

- Establish **demonstration farms** in every agro-ecological region.

- **Capacity Building and Education**
  - Mobilise **Krishi Vigyan Kendras (KVKs)** for farmer training.
  - Conduct workshops, field demonstrations, awareness campaigns.
  - Show farmers the **economic + climate benefits**.
- **Carbon Market Development**
  - Transparent, farmer-friendly trading platforms.
  - Encourage **Carbon FPOs** to pool farmer credits.
  - Develop credible MRV (Measuring, Reporting, Verification) systems.
- **Monitoring and Accountability**
  - Annual reports on carbon sequestration.
  - District-level carbon targets.
  - Align with India's **Net Zero 2070** commitment.

VII. Conclusion

- **Carbon farming = game-changer** in agriculture–climate relationship.
- It allows India to:
  - Increase food productivity.
  - Build resilience against climate shocks.
  - Contribute to global emission reduction.
- Requires **collective effort** of policymakers, scientists, private sector, and farmers.
- With **robust markets, research, policies, and education**, carbon farming can:
  - Provide income security to smallholders.
  - Reduce emissions.
  - Secure India's **sustainable future** for generations.

5 PLOUGHS TO PRECISION

1. Introduction

- Agriculture has long been the cornerstone of the Indian economy.
- Contribution to economy (2023–24):
  - Accounted for nearly **18% of Gross Value Added (GVA)** at current prices.
  - Provided livelihood to over **46% of the population**.
- **Growth in GVA:** Rose from **₹15.02 lakh crore in 2011–12** to **₹48.78 lakh crore in 2023–24** (over 3 times growth).
- **Structural shift:** Agriculture's relative share in GVA is declining due to faster growth in industry and services.
- **Need for modernization:** Integration of **advanced technology and digitisation** is essential for food security, rural livelihoods, and alignment with national growth.

II. Transition from Tradition to Technology

- **Traditional practices:** Dependent on manual labour, simple tools, and weather conditions.
- Modern transformation:
  - Emergence of **digital technologies**: AI, drones, GPS machinery, IoT, satellite imagery.
  - Known as **Precision Agriculture**:
    - Enhances productivity.
    - Provides real-time, data-driven decision-making.
    - Reduces dependence on intuition.
  - Mobile apps now guide decisions on sowing, irrigation, fertilisation, and harvesting.

III. Key Digital Interventions

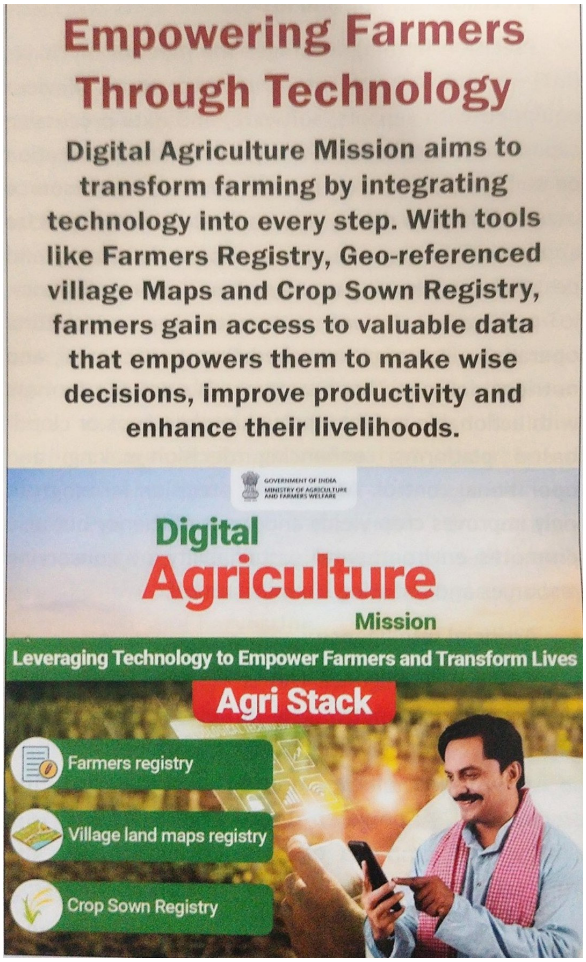
- **Precision Farming and IoT:-**
  - IoT devices collect and analyse real-time data on **soil, weather, and crop health**.
  - Enables **precise application** of water, fertilisers, and pesticides.
  - Automates irrigation, pest control, and nutrient delivery.
  - Promotes **efficiency, higher yields, and environmental sustainability**.
- **Artificial Intelligence (AI):-**
  - Analyses big data: satellite images, weather, soil, and crop records.
  - **Applications:**
    - Soil health monitoring.
    - Pest detection and irrigation scheduling.
    - Yield prediction and advisory services.
  - **Example:** Microsoft's AI Farm Vibes in Baramati:
    - **40% increase in yield**.
    - **25% reduction in fertilizer use**.
    - **50% water savings**.
- **Satellite and Remote Sensing:-**
  - Provide **large-scale monitoring** of crops, soil, and climate.
  - Help in yield forecasting, soil moisture detection, pest monitoring.
  - **Government programme: FASAL** with **ISRO:** Improved crop forecasting and drought warnings.
  - **Private examples: Cropin, Syngenta**—optimise sowing, irrigation, input usage.
- **Digital Marketplaces and e-Governance:-**
  - e-NAM (National Agriculture Market):
    - Links **18+ million farmers** with buyers directly.
    - Promotes fair pricing and reduces middlemen.
  - **Other initiatives: ONDC, e-Choupal, SmartGoon**.
  - **Private platforms:** DeHaat, AgriBazaar, AgroStar.
  - **Mobile solutions:**
    - Kisan Suvidha app for advisories.
    - m-Kisan SMS service reaches **8.93 crore families** in local languages.
- **Blockchain Technology:-**
  - Ensures **traceability, transparency, and trust** in the food chain.
  - Records crop journey from **farm to fork**.

- Promotes food safety, reduces post-harvest losses, and gives farmers access to premium markets.

- **Hardware Automation:-**
  - Use of **drones, automated irrigation, and sensor-based machinery**.
  - Tools like **Nano Ganesh** allow remote irrigation control.
  - Remote-operated transplanters reduce labour effort.
  - Especially beneficial for **small and marginal farmers**.

IV. Government Initiatives

- **Digital Agriculture Mission (2024):-**



  - Approved with **₹2,817 crore outlay**.
  - Focus on **AI, IoT, blockchain, drones, GIS, remote sensing**.
  - Builds a **unified digital agriculture ecosystem**.

- **AgriStack Project:-**
  - Digital database of **11+ crore farmers**, linked with Aadhaar.
  - **Key components:**
    - **Farmers' Registry** (with Aadhaar, land, and finance).
    - **Geo-referenced village maps** using satellite data.
    - **Crop Sown Registry** with real-time crop data.

- **Government Digital Platforms:-**
  - **e-NAM:** Unified digital marketplace, 1,522 mandis integrated.
  - **Kisan Suvidha App:** Real-time info on weather, prices, schemes.
  - **m-Kisan:** SMS-based service for remote areas.

- **Common Service Centres (CSCs):-**
  - Provide services like s**oil testing, insurance, weather info.**
  - As of May 2025: **5.6 lakh CSCs**, of which **77.9% in rural areas**.

- **Sub-Mission on Agricultural Mechanization (SMAM):-**
  - Financial support for **farm machinery and ICT tools**.
  - Supports **Custom Hiring Centres (CHCs)** and **Farm Machinery Banks (FMBs)**.

- **Women-Led Agri-Tech Adoption:-**
  - **Namo Drone Didi (2023):**
    - Empowers rural women to operate drones.
    - **Government funding: ₹1,261 crore**.
    - **Goal:** Distribute **15,000 drones** to Women SHGs by 2026.

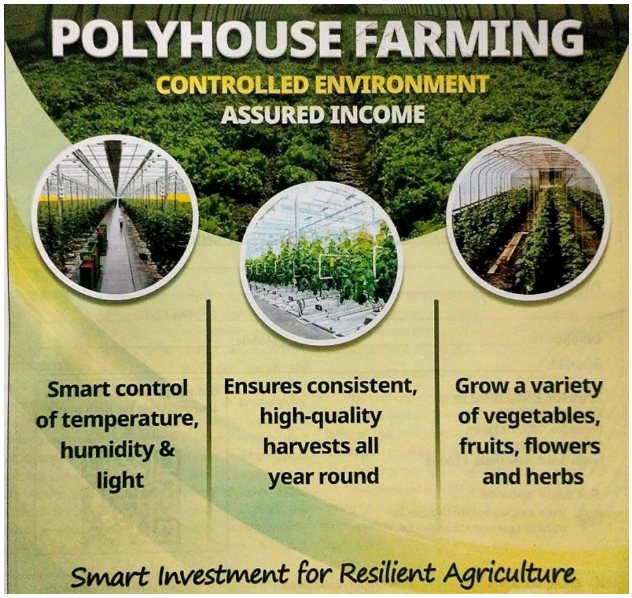
- **Soil Health and Fertility Scheme:-**
  - Launched in 2015 to promote balanced fertilizer use.
  - **2023 upgrade:** GIS mapping, mobile app, geo-tagging.

➢ **Achievements:**

- **24.74 crore soil health cards issued**.
- **8,272 soil testing labs were established**.

V. Benefits to Farmers

- Access to **accurate weather, soil, and crop data**.
- Higher yields due to **precision use of inputs**.
- Saves costs by reducing waste of water, fertilizer, and pesticides.
- Supports **sustainable farming** by conserving resources.
- Direct market access improves **income and livelihoods**.



VI. Challenges Ahead

- **Digital divide:** Poor network in rural areas.
- **Limited digital literacy** among farmers.
- **High costs** of devices and infrastructure gaps.
- **Language barriers:** Lack of localised content.
- Data privacy and ownership concerns.

VII. Way Forward

- **Training and capacity building** in local languages.
- Investment in **digital infrastructure** (internet, power).
- Strengthen **public-private partnerships** (government, startups, FPOs, research bodies).
- Focus on **affordable, farmer-centric technologies**.
- Ensure **inclusive policies** so no farmer is left behind.

VIII. Conclusion

- Indian agriculture is transitioning from **manual ploughs to precision technologies**.
- Tools like **AI, IoT, drones, blockchain, satellite imaging** are making farming more sustainable and profitable.
- Government initiatives (Digital Agriculture Mission, AgriStack, e-NAM, Drone Didi, Soil Health Card) are driving inclusivity.
- With stronger infrastructure, literacy, and policy support, India can build a **resilient, empowered, and digitally enabled farming ecosystem**.

6 AGRI STARTUPS IN INDIA

1. Introduction: Agriculture in India

- Agriculture is the **cornerstone of India's economy**.
  - Employs nearly **50% of the workforce**.
  - Contributes **17% to GDP** (vs global average of 4.4%).
- **Persistent challenges:**
  - Low productivity.
  - Fragmented supply chains.
  - Limited market access.
  - Vulnerability to climate change.
- Emergence of **agritech startups**:
  - Leverage **AI, IoT, data analytics, and business innovation**.
  - Aim to empower farmers and transform agriculture.
  - By 2025, India will have **4,000+ agritech startups**.

II. The Agritech Boom in India

- **Problems faced by farmers**:
  - 80% are smallholder farmers with outdated techniques.
  - Lack of access to quality seeds, fertilizers, and finance.
  - Dependence on middlemen reduces farmer profits.
- **Role of startups:**
  - Bridge gaps with technology, improve productivity, streamline supply chains.
- **Investment and growth:**
  - **$2.4 billion** attracted since 2014 **(Inc42, 2025).**
  - Deal volume up **28% in 2024 vs 2023**.
  - India's agriculture market = **$493 billion**, but tech penetration <1%.
- **Government support**:
  - **Startup India (2016)** – tax exemptions, funding, recognition (**2,800 agritech startups by Dec 2023).**
  - **Digital India** – better rural connectivity for digital solutions.
- **Market drivers:**
  - Rising demand for **quality produce**.
  - Policies + connectivity = fertile ground for innovation.

III. Key Areas of Impact

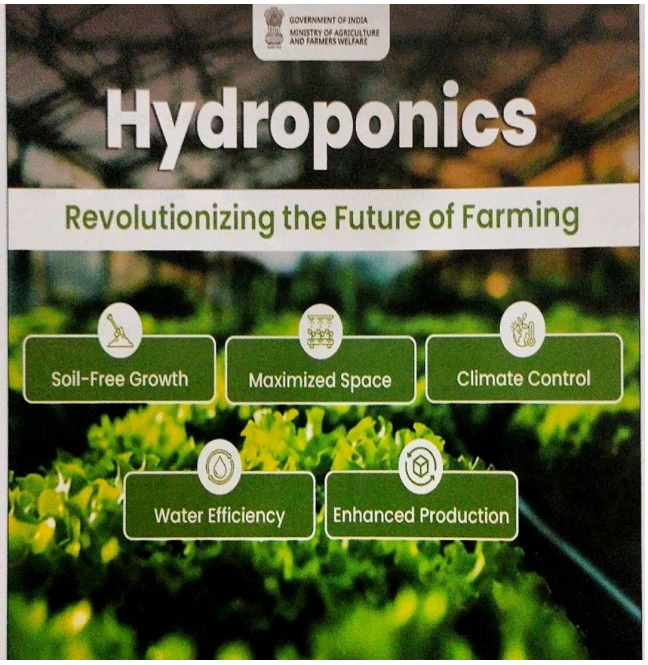
- **Precision Farming**
  - AI, IoT, satellite data optimize resource use.
  - **Tools:** soil sensors, drone monitoring.
  - Yield increase up to **30% (Startup India, 2025).**
  - Sustainable use of water, fertilizers, pesticides.
- **Supply Chain Optimization**
  - **Post-harvest losses** = 20–30% in perishables.
  - Startups like **Ninjacart, Crofarm** reduce waste via direct farmer-buyer connections.
- **Access to Inputs and Finance**
  - Digital marketplaces provide seeds, fertilizers, equipment.
  - Agri-fintech startups like **Arya.ag, Jai Kisan** bridge credit gaps.
  - In 2022, attracted **$52 million funding**.
- **Digital Advisory Services**
  - **Platforms: BharatAgri, KrishiHub**.
  - Provide advice on pest control, crop management, weather forecasting.
  - Delivered via apps, SMS – especially useful in weather-prone areas.
- **Sustainable Practices**
  - **Climate solutions: Ecozen** (solar-powered cold storage, irrigation).
  - Promotes eco-friendly farming, reduces carbon footprint.

IV. The Future of Agritech Startups

- **AI & IoT Integration**:
  - Real-time crop monitoring, pest detection, yield prediction.
  - **Example: Cropin** uses satellite + IoT for data-driven insights.

- AI can increase yields by **20–30% by 2030** (IndiaAI, 2022).

- **Climate-Resilient Farming**:
  - **Solutions:** drought-resistant crops, vertical farming, hydroponics.
  - **Example: Woolly Farms** – controlled-environment farming.
  - Critical for population projected at **1.5 billion by 2030**.



- **Global Collaboration**:
  - Partnerships with global firms and research institutions.
  - **Example: Ecozen's solar solutions are gaining** traction abroad.
  - India is emerging as an agritech **innovation hub**.

- **Agri-Fintech Growth:**
  - **Example**: **Arya.ag** – facilitated **₹15,000 crore** in storage, **₹8,000 crore** in **financing.**
  - Using blockchain for transparency.
  - **Funding expected: $100 million by 2027**.

- **Policy Support**:
  - **Govt schemes: National Mission on Sustainable Agriculture**, **Agriculture Infrastructure Fund**.
  - Startup India recognizes agritech as a **priority sector**.
  - **5,000 startups** projected by **2030**.

V. Success Stories

(i) DeHaat – End-to-End Solutions

- Founded **2012**, operates in Bihar, UP, Odisha.
- **Offers:** AI-based crop advisory, weather updates, soil testing, access to inputs.
- Serves **265,000+ farmers** (target 5 million by 2027).
- **Revenue growth: ₹40.81 cr (FY21) → ₹224 cr (FY23)**.
- **Funding: $68.9 million** from Accel, Syngenta Ventures.
- Farmers' income rose by 20% via direct market linkages.
- Combines tech + ground-level micro-entrepreneurs.

(ii) Farmtheory – Tackling Agri-Waste

- Founded in 2019 by **Arpit & Sakshi Agarwal.**
- Works with **3,000+ farmers** and **1,500+ kitchens**.
- Collects surplus/imperfect produce → sells to processors & retailers.
- **Farmer benefit:** extra **₹15,000/season** for otherwise wasted crops.
- **Clients:** Reliance Retail, Patanjali.
- **Funding**: **$1.45 million (2024)** from Merak Ventures.

- **Contribution**: reduces food waste, lowers greenhouse gas emissions.

VI. Challenges for Agritech Startups

- **Low digital literacy**:
  - Only 23% of rural India has reliable smartphone + internet (NASSCOM, 2023).
  - **Example: DeHaat** uses SMS, vernacular languages, voice-based advisories.
- **High costs of technology:**
  - IoT sensors, drones expensive for smallholders.
  - **Solutions**: **pay-per-use models**, subsidies (Agriculture Infrastructure Fund).
  - **Example: Ninjacart + state governments** distribute subsidized drones.
- **Fragmented landholdings & regional diversity**: Customization required; resource-intensive.
- **Regulatory hurdles & inconsistent policies**: Differing state-level regulations slow scaling.
- **Solutions**:
  - Farmer education & training via cooperatives, KVKs.
  - **Example: Cropin + KVKs** → 15% increase in adoption.
  - Partnerships with FPOs and micro-entrepreneurs.
  - Leveraging **public-private partnerships**.

VII. Conclusion

- Agritech startups are **transforming Indian agriculture** into a **tech-driven, sustainable, and profitable sector**.
- With **$2.4 billion in investments** and **4,000+ startups**, the sector is poised for massive growth.
- Case studies of **DeHaat and Farmtheory** show real impact: better incomes, reduced waste, sustainable practices.
- By integrating **AI, IoT, data analytics, and sustainability**, startups can lead India into the **fourth agricultural revolution**.
- Overcoming digital literacy, affordability, and scalability challenges will be key.
- The future holds promise of a **prosperous, food-secure, and globally leading India in agritech**.

7 COOPERATIVE PATH TO THE SDGS

I. India's Current Development Context

- **Economic Performance**
  - India's real GDP growth for FY 2023–24: **8.2%** (NSO data).
  - GDP per capita at current prices: **₹2,15,000 (~US $2,600)**.
  - Growth is robust due to structural reforms and macroeconomic stability.
- **National Vision**
  - Prime Minister's goals:
    - Achieve **Atmanirbhar Bharat** (self-reliant India).
    - Reach a **$5 trillion economy** in the near term.
    - Become a **developed nation by 2047** (100 years of independence).
- **Global Benchmark for Development**
  - The World Bank defines a high-income country as having **per capita GNI > $13,845 (2022 threshold)**.
  - Achieving this requires:
    - Broad-based human development.
    - Strong institutions.
    - Social cohesion.
    - Empowerment of grassroots communities.

II. India's Alignment with SDGs (Agenda 2030)

- Government of India–UNSDCF 2023–2027
  - Anchored on **four pillars**:
    1. People
    2. Prosperity
    3. Planet
    4. Participation
  - Reinforces inclusive, resilient, and sustainable growth.
  - Promotes **localisation of SDGs** and **South-South cooperation**.
  - Adopted through a **whole-of-government and whole-of-society approach**.
  - Recognises **cooperatives** as vital for ensuring no one is left behind.

III. Cooperatives as Natural Partners for SDGs

- **UN 2030 Agenda (2015)**
  - 17 SDGs to end poverty, protect the planet, and ensure prosperity.
  - Requires state action, private enterprise, and **community-driven institutions**.
- **Cooperative Principles (ICA Statement)**
  - **Values: self-help, democracy, equity, solidarity**.
  - **Principles:**
    - Voluntary and open membership.
    - Democratic member control.
    - Concern for community.
    - Cooperation among cooperatives.
- **Distinct Advantage of Cooperatives**
  - Focus on **people over profit**.
  - Prioritise welfare, sustainability, and inclusiveness.
  - Naturally aligned with SDGs compared to profit-driven corporations.

IV. The Cooperative Advantage in India

- **Scale and Reach**
  - Over **8.5 lakh cooperatives**.
  - Membership of **30 crore+ people**.
  - Active in agriculture, dairy, credit, fisheries, textiles, handicrafts, housing, and services.
- **Historic Contributions**
  - **Green Revolution** – Enabled by agricultural credit and marketing cooperatives (**IFFCO, KRIBHCO**).
  - **White Revolution** – **AMUL** transformed India into the **largest milk producer**.
  - **Blue Revolution** – Fishermen's cooperatives strengthened incomes and sustainable practices.
- **Global Impact**
  - Cooperatives employ **280 million people worldwide**.
  - Countries like Italy, Canada, Kenya, and Japan rely heavily on them for food, housing, finance, and jobs.
- **Policy Push in India**
  - **Ministry of Cooperation** created in **2021.**
  - Prime Minister's motto: **"Sahkar Se Samriddhi" (Prosperity through Cooperation)**.
  - Reforms under Union Home & Cooperation Minister Amit Shah:
    - Model bye-laws for PACS → making them multipurpose.
    - New MSCS in seeds, organic farming, exports.
    - National Cooperative Database + computerisation.
    - "One multipurpose cooperative per panchayat."

V. Typologies of Traditional Cooperatives (ILO Recommendation No.193)

- **Producer Cooperatives**
  - Provide inputs, credit, marketing, technical support.
  - **Indian examples:** agricultural coops, dairy, fisheries, handicrafts, SHG federations.
  - Contribute to SDGs **1, 2, 5, 8, 9, 12, 13**.
- **Consumer Cooperatives**
  - Ensure fair access to goods and protect consumers.
  - **Indian examples:** consumer coops, housing coops.
  - Contribute to SDGs **1, 10, 11, 12**.
- **Worker Cooperatives**
  - Owned and run by workers; ensure decent jobs.

    Indian examples: labour coops, industrial societies.
  - Contribute to SDGs **1, 8, 10**.
- **Multipurpose Cooperatives**
  - Provide multiple services like banking, marketing, and credit.
  - **Indian examples:** credit societies, cooperative banks, tribal coops.
  - Contribute to SDGs **1, 2, 5, 8, 9, 10**.

VI. Emerging Cooperatives: Expanding Horizons

- **Global Innovation in Cooperatives**
  - Renewable energy coops in Europe.
  - Platform coops in US & Europe.
  - Education & health coops in Latin America.
  - Ecotourism coops in Africa & Southeast Asia.
- **India's Need**
  - Current focus remains on agriculture, dairy, and credit.
  - Must expand into **urban, digital, and climate-related areas**.
  - Opportunities in energy demand, urbanisation, youth employment, and climate resilience.
- **Emerging Types & SDG Linkages (Table 2 Highlights)**
  - **Renewable Energy Coops** → SDGs 7, 11, 12, 13 (solar, wind, off-grid).
  - **Platform/IT Coops** → SDGs 8, 9, 10, 17 (fair digital economy).
  - **Education Coops** → SDGs 4, 5, 10 (community schools, skills).
  - **Health & Care Coops** → SDGs 1, 3, 10 (affordable health, elder care).
  - **Ecotourism Coops** → SDGs 8, 12, 14, 15 (livelihood + conservation).
  - **Transport Coops** → SDGs 9, 11, 13 (shared mobility, clean transport).
  - **Service Coops** → SDGs 1, 5, 8 (domestic workers, gig workers).
  - **Manufacturing Coops** → SDGs 5, 8, 9, 12 (women-led units, sustainable crafts).

VII. Challenges Facing Cooperatives in India

- Governance and Leadership Issues
  - Weak management, political interference.

- Lack of transparency and professionalism.
- Reports by RBI (2021) and NABARD highlight recurring lapses.

- **Technology and Infrastructure Gaps**
  - Uneven digital adoption.
  - Poor IT systems and weak supply chain linkages.
- **Youth and Membership Engagement**
  - Lack of awareness among youth.
  - Outdated governance discourages participation.
- **Regulatory Complexity**
  - Multiple Central and State laws.
  - Jurisdictional overlaps hinder multi-state operations.
- **Financial Constraints**
  - Limited access to long-term capital.
  - Reliance on subsidies; difficulty raising funds.
- **Marketing and Value Addition Gaps**
  - Focused mainly on raw production.
  - Lack of branding, processing, and diversification.
  - Competition from corporate agribusiness.

VIII. Conclusion: The Cooperative Path Forward

- Cooperatives have been crucial in **India's agricultural and rural transformation**.
- They embody **democracy, participation, and inclusiveness**—values aligned with SDGs.
- **Modernisation and reform are essential to:**
  - Improve governance.
  - Adopt technology.
  - Engage youth.
  - Simplify regulation.
  - Expand finance and markets.
- **Ministry of Cooperation** + new policies = renewed momentum.
- Cooperatives can make India's growth **people-centered, equitable, and sustainable**.
- Aligns with India's motto: **"Sabka Saath, Sabka Vikas, Sabka Vishwas, Sabka Prayas."**
- Ultimately, cooperatives stand as a **democratic, scalable model** for both economic progress and social justice.
- They are vital for India's aspiration of becoming a **developed nation by 2047**.