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Times of Agriculture

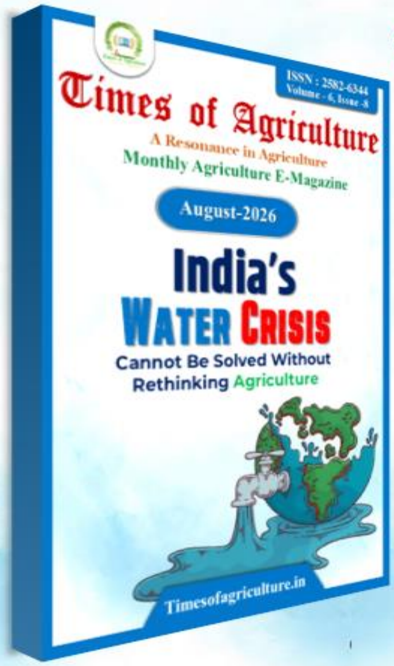
A Resonance in Agriculture

Monthly Agriculture E-Magazine

August-2026

India's WATER CRISIS

Cannot Be Solved Without Rethinking Agriculture



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AGRICULTURE
UPDATES

National Research Centre for Sea Buckthorn Proposed in Ladakh

The Union Ministry of Agriculture and Farmers Welfare has constituted a high-level committee to examine the proposal for establishing a dedicated **National Sanjeevani Research Centre for Sea Buckthorn in Nubra Valley, Ladakh**. The proposal was put forward by Ladakh Lieutenant Governor Vinai Kumar Saxena, who wrote to Union Agriculture Minister Shivraj Singh Chouhan on August 14 seeking a specialised centre for research, development, value addition and commercialisation of the high-value Himalayan crop. Following the proposal, the Indian Council of Agricultural Research (ICAR) constituted the committee on August 21, and its members began field assessments in Ladakh on August 24. The proposed centre is expected to position Nubra as an important national hub for research and innovation related to sea buckthorn, a naturally occurring plant with considerable potential in agriculture, food, nutraceutical and pharmaceutical applications.

The committee, headed by Dr. V. B. Patel, Additional Director General, Horticultural Science Division, ICAR, will examine the existing genetic resources, natural distribution, cultivation practices, production, utilisation and ongoing research related to sea buckthorn in Ladakh. It will also identify research gaps in areas such as genetic improvement, propagation, standardised cultivation, harvesting, post-harvest management, processing and quality assurance. Several institutional models are being considered, including a standalone national research centre, a regional ICAR station or a multi-institutional network involving ICAR, the Ladakh administration, DRDO, CSIR, AYUSH and private industry.

The initiative could provide a major boost to **Ladakh's high-altitude agriculture and rural economy** by transforming sea buckthorn from a largely underutilised Himalayan resource into a scientifically developed and commercially valuable crop. The plant is recognised for its nutritional and medicinal properties and contains several bioactive compounds, making it relevant to food, nutraceutical and wellness industries.

India Launches Its First Non-GMO High-Expansion Popcorn Maize Hybrid

India has taken an important step towards self-reliance in specialised seed technology with the launch of the country's first indigenous **non-GMO, high-expansion popcorn maize hybrid**. The hybrid was launched in August 2026 in Andhra Pradesh, marking a significant development for India's popcorn industry and maize value chain. Developed by **Gourmet Popcornica**, the new hybrid is intended to reduce dependence on imported popcorn genetics and strengthen domestic seed and production capabilities. Popcorn is a specialised type of maize requiring specific genetic characteristics to produce high popping quality and expansion.

The new hybrid could open additional opportunities for farmers by connecting maize cultivation with the growing food-processing and snack-food industries. Unlike conventional maize, which is primarily cultivated for feed, starch and industrial applications, popcorn has a strong consumer market and can generate value through processing, packaging and branding. The development also demonstrates the potential of linking farmers with processors and organised markets. A stronger domestic popcorn value chain could encourage farmers to diversify into specialised maize cultivation, while creating opportunities for seed producers, processors, entrepreneurs and food businesses. The availability of locally developed seed may also help farmers access planting material better suited to Indian growing conditions and reduce dependence on imported technologies.

The launch comes at a time when India's maize sector is rapidly diversifying beyond traditional grain production. Maize is increasingly being used for **food processing, animal feed, starch, biofuel and other value-added products**. Indigenous development of specialised hybrids can strengthen the country's seed innovation ecosystem and contribute to greater value addition within India. The popcorn industry also has potential for expansion into domestic and international markets, particularly as consumers increasingly seek differentiated and quality food products.

PM Modi Calls for Greater Use of Space Technology in Agriculture

Prime Minister Narendra Modi has called for wider use of **space technology in agriculture, livestock management, dairy and environmental protection**, highlighting the potential of India's rapidly expanding private space sector to address challenges faced by farmers and rural communities. During an interaction with the CEOs and founders of **20 Indian space startups in New Delhi on August 21, 2026**, the Prime Minister encouraged entrepreneurs to move beyond conventional space applications and develop technologies that can directly improve people's everyday lives. He particularly emphasised collaboration between space-technology companies, agricultural universities and government departments so that satellite-based technologies and other space applications can help farmers make better-informed decisions and improve productivity. The interaction included startups working in satellite technology, space intelligence and AI-powered hyperlocal weather and climate intelligence, creating opportunities for closer integration between India's space and agriculture sectors.

Space-based technologies are already becoming an important part of India's modern agricultural monitoring system. Satellite imagery, **remote sensing, Geographic Information Systems (GIS), artificial intelligence and drones** are being used for crop monitoring, production forecasting, disaster assessment and agricultural planning. The government's FASAL programme, for example, uses multispectral and Synthetic Aperture Radar satellite data to generate pre-harvest production forecasts for major crops across several states. Satellite-based systems can also provide information on vegetation conditions, soil moisture, drought, floods and hailstorm damage. Such information can support decisions related to crop planning, irrigation, weather-risk management, crop insurance and disaster response.

The growing involvement of private space startups could further accelerate this transformation by creating **farmer-focused and commercially scalable solutions**. Hyperlocal weather intelligence, satellite-based crop health assessment, acreage estimation, drought monitoring and yield forecasting could help farmers and agricultural institutions respond more quickly to changing field conditions. Collaboration with agricultural universities and departments could also help convert complex satellite data into practical advisories that farmers can understand and use.

India's Digital Agriculture Ecosystem Crosses a Major Milestone

India's digital agriculture transformation has reached a significant milestone, with more than **10.31 crore Farmer IDs** created across the country as of August 3, 2026, under the government's **AgriStack and Digital Agriculture Mission**. The development marks an important step towards creating a unified digital foundation for delivering agricultural services to farmers. Farmer IDs are generated by linking farmers' details with digitised land records and are intended to support faster and more transparent access to services such as agricultural credit, crop insurance, weather advisories and minimum support price-based procurement. The Farmer Registry forms one of the key components of AgriStack, alongside geo-referenced village maps and the Crop Sown Registry.

The scale of India's **Digital Crop Survey (DCS)** is another major indicator of this transformation. During the Rabi 2025–26 season, the survey was conducted across **648 districts and covered more than 31.3 crore plots**. The survey generates plot-level information on crops being cultivated, creating a more detailed digital picture of agricultural land use across the country. Such information can support crop production estimation, agricultural planning, insurance assessment and the implementation of government schemes. Digital technologies are also increasingly being combined with artificial intelligence and machine learning. Under the YES-TECH initiative associated with crop insurance, technology-based yield estimation is being implemented for crops including paddy, wheat and soybean.

The expansion of digital agriculture is also bringing greater attention to **data security and farmer privacy**. The government has stated that AgriStack follows the Digital Personal Data Protection framework, with farmer information collected with consent and access intended for authorised entities for specific purposes. With more than 10 crore Farmer IDs and tens of crores of digitally surveyed plots already covered, India is moving towards an agricultural ecosystem in which **digital identity, land records, crop information, artificial intelligence and satellite-based technologies** increasingly work together to support farmers and agricultural governance.

FAO Warns of a New Global Food-Inflation Wave

The world could face a fresh wave of **food-price inflation towards the end of 2026**, according to concerns raised by the Food and Agriculture Organization of the United Nations (FAO). FAO Chief Economist Máximo Torero has warned that the combination of geopolitical conflicts, rising agricultural input costs and the expected strengthening of the **El Niño weather phenomenon** could create significant pressure on global food supplies and prices. The FAO Food Price Index, which tracks international prices of major traded food commodities, averaged **131.1 points in July 2026**, an increase of 0.6% from June and the highest level since January 2023. The increase indicates that global food markets are once again facing greater volatility after a period of relative stability.

Several factors are contributing to the emerging risk. The FAO has highlighted the effects of conflicts in major agricultural and energy-producing regions, disruptions to trade and higher prices for **crude oil, diesel and fertilisers**. The Black Sea region remains particularly important for global grain supplies, while disruptions to energy and fertiliser trade can increase production costs for farmers worldwide. In July, the FAO Cereal Price Index rose by **3.4%**, with global wheat prices increasing by 5.8% amid concerns over Black Sea export disruptions and weather-related crop damage.

The situation could become more challenging if the expected **strong El Niño** develops and disrupts rainfall and temperature patterns across major agricultural regions. Extreme heat, drought and excessive rainfall can reduce crop yields while simultaneously increasing irrigation, energy and other production costs. FAO economists have warned that the effect of higher commodity prices may take several months to reach consumers, meaning that food inflation could become more visible towards the end of the year.

India Faces Potentially Weakest Monsoon Since 2009

India is heading towards what could become its **weakest southwest monsoon since 2009**, raising concerns over agricultural production, rural incomes and food prices. As of August 24, the country had received around **13% less rainfall than the long-term average** since the monsoon season began on June 1. According to weather officials cited in recent reports, seasonal rainfall could eventually finish around **15% below normal**, which would make 2026 the weakest monsoon in nearly two decades. The monsoon is critically important to Indian agriculture, providing around 70% of the country's annual rainfall and supporting millions of hectares of rain-dependent farmland. Rainfall was particularly deficient during June, when the country recorded a deficit of around 35%, while August rainfall was also significantly below normal.

The weakening monsoon has created growing concerns for **kharif crops**, particularly cotton, soybean, maize and pulses, which depend heavily on adequate and well-distributed rainfall. A rainfall deficit does not necessarily mean crop failure because irrigation and regional rainfall conditions can reduce the impact, but prolonged dry spells during critical crop-growth stages can affect yields and farm profitability. The situation is also important for the upcoming rabi season because adequate monsoon rainfall helps replenish reservoirs and groundwater and improves soil moisture before winter sowing. Lower water availability could create additional pressure on wheat, mustard, rapeseed and other rabi crops later in the year. The impact is expected to vary considerably between regions. While some parts of eastern and northeastern India have experienced substantial rainfall deficits, isolated areas have continued to receive heavy rainfall.

A major factor behind the deteriorating outlook is the strengthening **El Niño weather pattern**, which is generally associated with weaker monsoon conditions over India. Weather officials have warned that the rainfall deficit could widen if September rainfall remains below normal and the monsoon withdraws earlier than usual. The consequences could extend beyond agriculture to food inflation, rural consumption and the wider economy.

COVER STORY

India's WATER CRISIS

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About the Author

Arvind Narayanan

Co-Founder

Growize Farms

You wake up one morning to find the taps in your home running dry… not just for a day, but for weeks on end. Wells are empty. Crops wither in the fields. Cities scramble for water tankers. This future is not a dystopian fantasy; for millions, it is already an actual reality and a warning of what's to come. India holds just 4% of the world's freshwater resources while supporting 18% of the world's population. By 2030, water demand is projected to be double the available supply. Yet, policy debates still fixate on urban infrastructure and drinking water, silently sidestepping the true epicenter of the crisis: agriculture.

Agriculture accounts for 87-90% of all groundwater extraction in India. It is where the crisis is deepest, and where the solutions are most urgent.

A Crisis Hidden in Plain Sight

Every year, India draws about 245 billion cubic meters of groundwater; this is more than any other country on Earth. On paper, recent government numbers might seem comforting: nationwide, we're using about 60% of what's available, and the number of "safe" areas is actually up. But those averages hide some big trouble spots. Out of nearly 7,000 areas checked, over 11% are officially "over-exploited" and another 3% are "critical" - mostly in just a few states. Punjab, for example, is using groundwater more than 1.5 times faster than its aquifers can refill; Rajasthan and Haryana aren't far behind.

Here's the real story: India is not running out of water everywhere at once. Instead, we're draining a few key farming states to highly dangerous levels, while the national average covers up the real damage. If we don't change course, we could see 20% fewer crops grown across the country, and as much as 68% less in the hardest-hit areas. This is a serious threat to our food supply.

There's one more problem - India's irrigation systems are only about 38% efficient, compared to 55% in wealthier countries. Our farmers use up to five times more water per crop than those in places like Israel, China, or the US. From 2000 to 2015, India was responsible for more than a third of the world's unsustainable irrigation growth. Much of this waste comes from using flood irrigation and the fact that electricity for farming is heavily subsidised or even free, so farmers can run their borewells nonstop. The result? We're not just running out of water; we're wasting huge amounts of it too.

The Cropping Pattern Problem

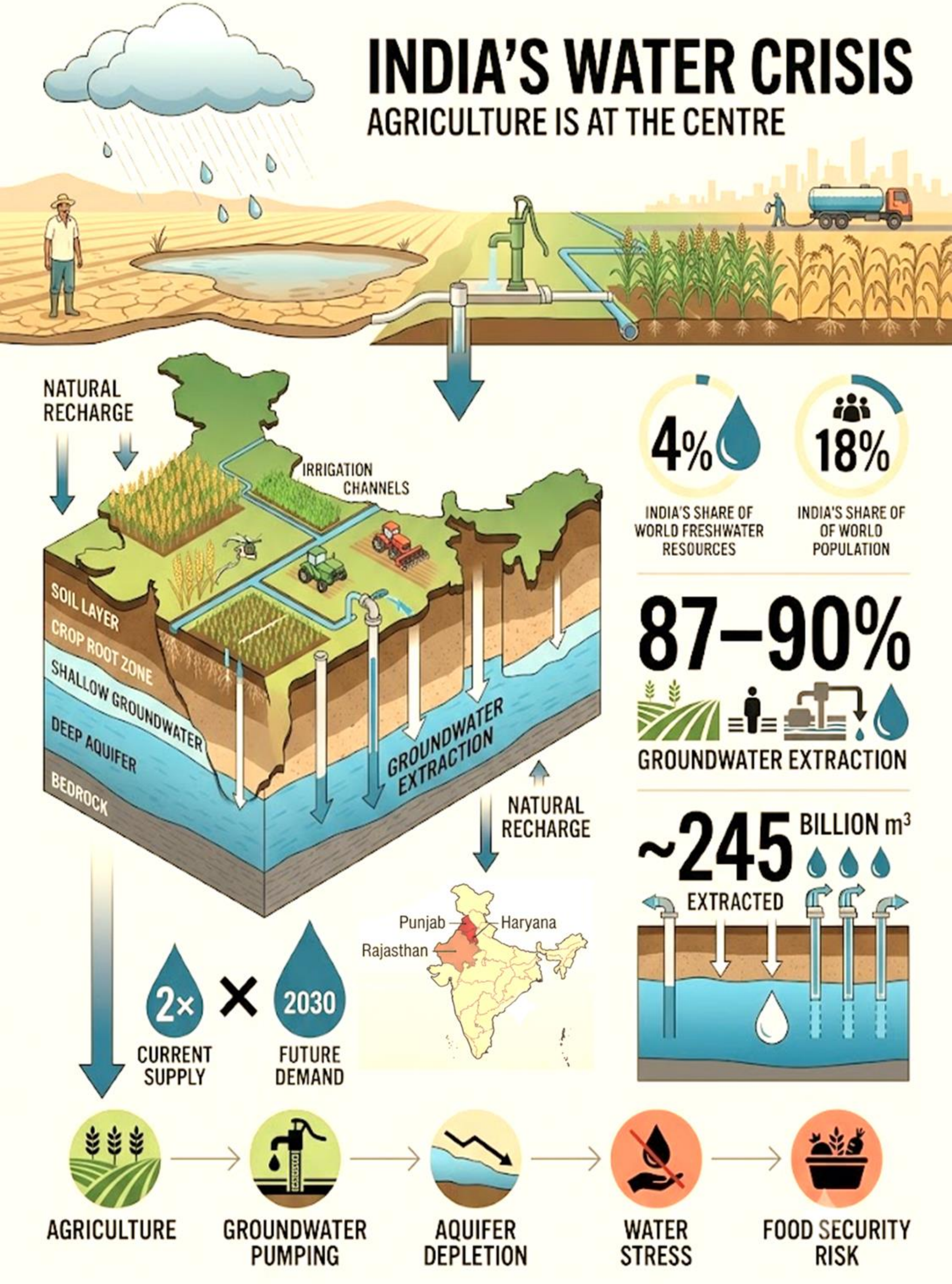
Some of these issues are baked into the system and go back decades. During the Green Revolution in the 1960s and 70s, new policies pushed farmers to grow more wheat and paddy, promising to buy whatever they produced. This was great for fighting hunger - India went from food shortages to having enough grain for everyone in just a generation. But those incentives never really changed. Back in the early 1960s, wheat and paddy made up about 35% of India's crops. Now, they take up almost 85%. Punjab, which is just 1.5% of India's land, grows about a fifth of all the wheat and more than a tenth of the rice, almost all using groundwater the state can't afford to lose. Experts say Punjab pulls out more than ten billion extra cubic meters of water every year to keep this going, and in some parts, water tables have dropped by six to eighteen meters in just thirty years.

It's important to remember: this isn't the farmers' fault. When you're guaranteed a good price for paddy, and your water and power are basically free, why would you risk growing anything else? Most efforts to encourage farmers to switch crops haven't worked. For example, when Punjab farmers tried growing maize, there wasn't a guaranteed buyer, so they had to sell at much lower prices, making it a losing deal. Haryana's program, which pays farmers to move away from paddy, is a rare exception, not the rule. To really fix this, we need to change the entire system of incentives on how crops are bought, how power is priced, and how water is managed.

Technology is part of the Answer for the massive problem

Drip and sprinkler irrigation can save a lot of water. Thanks to the "Per Drop More Crop" program, running since 2015, India now uses micro-irrigation on nearly 11 million hectares of farmland, about half with drip systems and half with sprinklers supported by over Rs 26,000 crore from the government. The goal is to double this by 2030, but that means we'd have to move much faster than before. Where farmers do use drip irrigation, they use up to half as much water and often earn more. The challenge? High upfront costs, patchy support, and, once again, free water and power, which make the switch less appealing.

Even more impressive are new controlled-environment farming methods like hydroponics & aeroponics. These systems grow crops in carefully managed spaces, using up to 95% less water than traditional soil farming and are less affected by extreme climate change. However, this requires deeper R&D and longer trial cycles to ensure its profitable unit economics.


INDIA'S WATER CRISIS
AGRICULTURE IS AT THE CENTRE
NATURAL RECHARGE
IRRIGATION CHANNELS
SOIL LAYER
CROP ROOT ZONE
SHALLOW GROUNDWATER
DEEP AQUIFER
BEDROCK
GROUNDWATER EXTRACTION
NATURAL RECHARGE
4%
INDIA'S SHARE OF WORLD FRESHWATER RESOURCES
18%
INDIA'S SHARE OF OF WORLD POPULATION
87–90%
GROUNDWATER EXTRACTION
~245 BILLION m³
EXTRACTED
Punjab
Haryana
Rajasthan
2×
CURRENT SUPPLY
×
2030
FUTURE DEMAND
AGRICULTURE
GROUNDWATER PUMPING
AQUIFER DEPLETION
WATER STRESS
FOOD SECURITY RISK

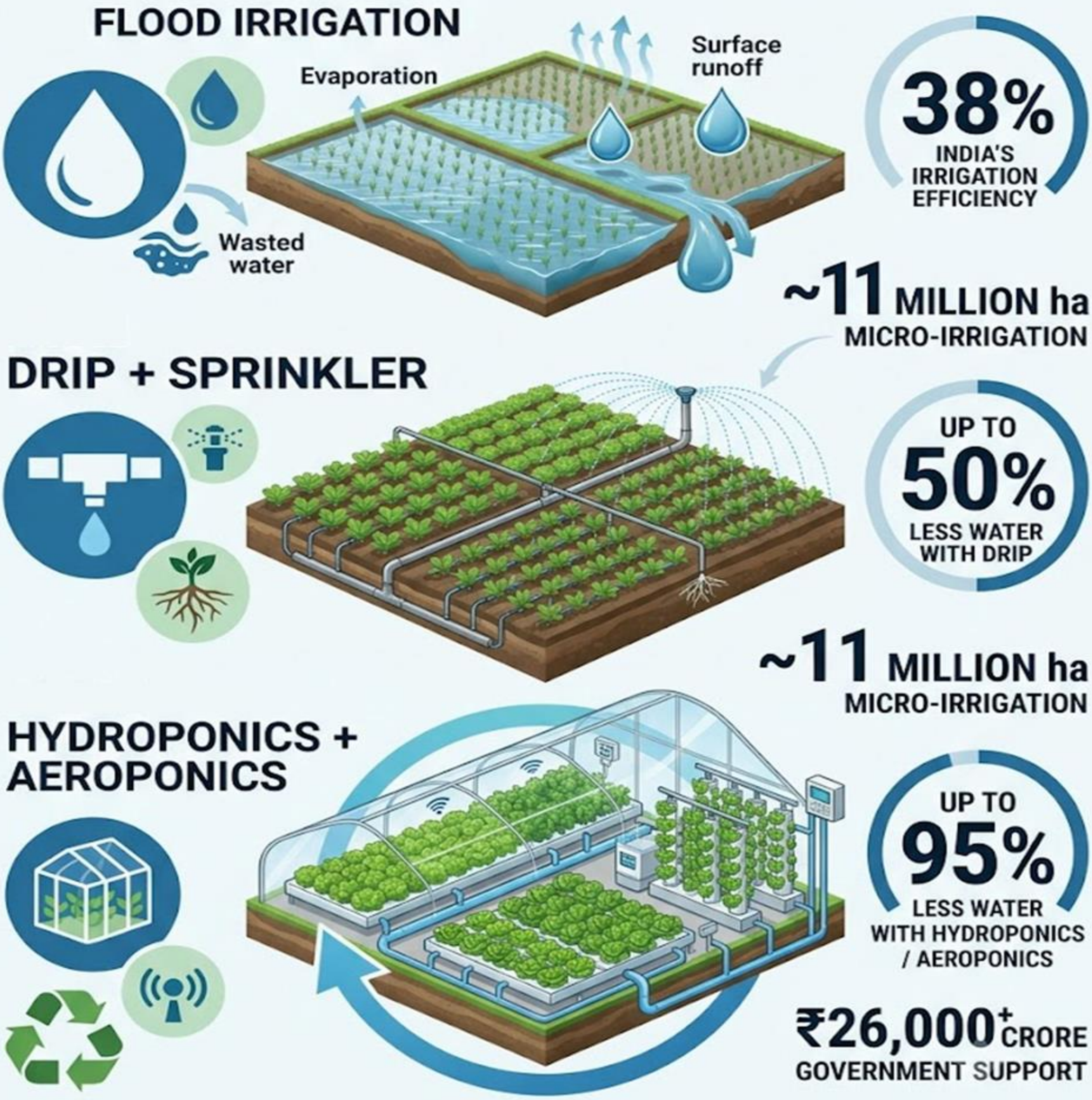
What's exciting is that we could move some of the most water-hungry crops entirely out of open fields, taking pressure off our shrinking aquifers. Most government support for the sector is also still capped at plots of an acre or less, which keeps adoption boutique rather than transformative. What's exciting is that we could move some of the most water-hungry crops entirely out of open fields, taking pressure off our shrinking aquifers, but today's controlled-environment farms mostly grow high-value leafy greens and herbs for urban markets, not the wheat and paddy driving the groundwater crisis. The near-term opportunity is real - it is cleaner, safer, more water-efficient produce for India's cities, but it will take serious investment, not pilot projects, before it meaningfully dents the water math of Indian agriculture as a whole.

Of course, these inventions aren't meant to replace traditional farming. India is simply too big, and too many people rely on agriculture for their jobs. But as complementary, proven working systems alongside regular farming, they could be a powerful way to make India's water use much smarter.

The Policy Conversation That Is Missing

India has rolled out major water conservation initiatives like the Atal Bhujal Yojana, which empowers over 8,500 gram panchayats in seven states to manage groundwater in some of the country's most water-stressed districts. The Jal Jeevan Mission, now extended to December 2028 with an investment of nearly Rs 8.7 lakh crore, aims to bring piped water to every rural household still waiting for it. These are positive moves, but they mostly operate in isolation, focusing on water supply and access rather than tackling the bigger picture. What's missing is a holistic strategy that connects agricultural water use to the wider food system. Neither Atal Bhujal Yojana nor Jal Jeevan Mission addresses the MSP and procurement policies that determine what crops are grown where. To create a substantial difference, policies should reward farmers for conserving water, not through scattered state programs, but as a well-priced national alternative to water-intensive crops like paddy and wheat.

Crop incentives need to reflect what local aquifers can truly support, ideally using granular groundwater data the government already collects. And support for water-efficient farming, like micro-irrigation and controlled-environment agriculture, needs to move beyond pilot projects and scattered loans to become mainstream. Only then will these efforts truly add up to lasting change.



This isn't about coming up with one magic solution. It's about developing our policies to work together. Right now, a farmer in drought-hit Punjab and an official designing water-saving programs are following totally different sets of rules: one formed by old crop incentives, the other by conservation goals that don't touch crop choices. Unless we bring farming, power pricing, and water rules under one big, connected plan, none of these well-meaning schemes will really solve the crisis.

India cannot conserve its way out of a crisis that agriculture is structurally built to deepen. The real fix lies in rethinking how we use water and how we grow our food, and in putting these ideas at the soul of India's water security plan.

Water is running out, and so is time. We have a choice: change how we farm, or face a future in which both water and hope are gone. What will we choose?

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INDIA'S GLOBAL AGRICULTURAL POSITION

AN OVERVIEW

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India is one of the world's leading agricultural nations due to its vast cultivable land, diverse agro-climatic conditions, and large farming population. Agriculture plays a vital role in the country's economy by ensuring food security, generating employment, and contributing to exports.

India is the largest producer of milk, pulses, and spices in the world and is among the top producers of rice, wheat, sugarcane, cotton, fruits, and vegetables. The country is also the second-largest producer of foodgrains and a major producer of tea, coffee, and horticultural crops. In the fisheries sector, India ranks among the top fish-producing countries globally and is one of the leading exporters of marine products.

India is also an important player in global agricultural trade, exporting commodities such as rice, spices, tea, coffee, cotton, sugar, marine products, and fresh fruits and vegetables to many countries. The agricultural sector contributes significantly to national income, employment, and foreign exchange earnings.

Despite these achievements, Indian agriculture faces several challenges, including small and fragmented landholdings, climate change, water scarcity, declining soil health, and post-harvest losses. Continued investment in technology, irrigation, mechanization, value addition, and sustainable farming practices is essential to strengthen India's position in global agriculture and improve farmers' livelihoods.

India’s Position in World Land Area

India is one of the largest countries in the world in terms of land resources. It has a total geographical area of 328.73 million hectares (Mha), which constitutes 2.33% of the world's total area (14,085.41 Mha). Based on total area, India ranks 7th globally, after the Russian Federation, Canada, the United States, China, Brazil, and Australia (Table 1).

In terms of land area, India possesses 297.32 Mha, accounting for 2.28% of the world's land area (13,015.16 Mha), and also ranks 7th in the world.

Table 1. India's Position in World Land Area (As on 2022)

Sl. No.	Items	India	World	India's Share (%)	India's Rank	Next to
1	Total Area (Mha)	328.73	14085.41	2.33	VII	Russian Federation, Canada, USA, China, Brazil, Australia
2	Land Area (Mha)	297.32	13015.16	2.28	VII	Russian Federation, China, USA, Canada, Brazil, Australia
3	Arable Land (Mha)	154.45	1383.84	11.16	I	-

Despite its relatively small share of the world's land area, India has the largest arable land area in the world, with 154.45 Mha, representing 11.16% of the global arable land (1,383.84 Mha). This gives India the 1st rank globally in arable land, highlighting its immense agricultural potential and the importance of agriculture in supporting food security, rural livelihoods, and the national economy.

Table 1 demonstrate that although India occupies only about 2.3% of the world's total land area, it possesses the largest area of cultivable (arable) land, making it one of the world's most significant agricultural countries.

India's Position in World Population

India is one of the most populous countries in the world and has a significant share of the global population. The country has a total population of 1,425.42 million (142.54 crore), accounting for 17.77% of the world's population of 8,021.41 million. Based on these statistics, India ranks second in the world, next only to China (Table 2).

Table 2. India's Position in World Population (As on 2022)

Sl. No.	Items	India	World	India's Share (%)	India's Rank	Next to
1	Total Population (Million)	1425.42	8021.41	17.77	II	China
2	Rural Population (Million)	905.11	3416.80	26.49	I	-

India also has the largest rural population in the world, with 905.11 million people, representing 26.49% of the global rural population (3,416.80 million). This places India first globally in terms of rural population.

The Table 2 highlight the crucial role of agriculture in India's economy, as a large proportion of the rural population depends directly or indirectly on farming and allied activities for their livelihood. The large population also creates a high demand for food, making agricultural productivity and food security key priorities for the country.

India's Position in World crop production

India is one of the world's leading agricultural producers, contributing significantly to global crop production. The country produced 362.47 million tonnes of cereals, accounting for 11.79% of global cereal production, and ranked third after China and the United States (Table 3).

Table 3. India's Position in World crop production (As on 2022)

	In Million Tonnes					
Sl. No.	**Crop Production**	**India**	**World**	**India's Share (%)**	**India's Rank**	**Next to**
1	Total Cereals	362.47	3073.69	11.79	III	China, USA
	Rice (Paddy)	203.62	788.93	25.81	II	China
	Wheat	107.74	811.38	13.28	II	China
2	Pulses	27.62	96.04	28.75	I	-
3	Oilseeds					
	Groundnut (excluding shelled)	10.13	55.05	18.41	II	China
	Rapeseed	3.45	26.69	12.92	IV	Germany, Canada, China
4	Commercial Crops					
	Sugarcane	439.42	1925.50	22.82	II	Brazil
	Tea	6.23	30.89	20.16	II	China
	Coffee (green)	0.34	10.73	3.17	VII	Brazil, Vietnam, Indonesia, Colombia, Ethiopia, Peru
	Jute	1.76	3.79	46.38	II	Bangladesh
	Tobacco Unmanufactured	0.76	5.77	13.23	II	China

In food grains, India is the second-largest producer of rice (paddy) with 203.62 million tonnes, contributing 25.81% of global production, next only to China. Similarly, India produced 107.74 million tonnes of wheat, accounting for 13.28% of world production and ranking second after China.

India is the largest producer of pulses in the world, producing 27.62 million tonnes, which constitutes 28.75% of global pulse production. In oilseeds, India ranks second in groundnut production with 10.13 million tonnes, while it ranks fourth in rapeseed production with 3.45 million tonnes.

Among commercial crops, India is the second-largest producer of sugarcane, producing 439.42 million tonnes, next only to Brazil. It also ranks second in tea production with 6.23 million tonnes**,** second in jute production with 1.76 million tonnes, and second in unmanufactured tobacco production with 0.76 million tonnes, following China or Bangladesh depending on the crop. In coffee (green) production, India ranks seventh globally with 0.34 million tonnes, after Brazil, Vietnam, Indonesia, Colombia, Ethiopia, and Peru.

Table 3 demonstrate India's strong position in global agriculture, particularly in the production of cereals, pulses, rice, wheat, sugarcane, tea, and jute. The country's substantial contribution to world crop production highlights its importance in ensuring global food security and agricultural trade.

India's Position in World Fruits and Vegetable Production

India is one of the leading producers of fruits and vegetables in the world due to its diverse agro-climatic conditions, large cultivated area, and favourable growing conditions. The country holds a significant position in global horticultural production.

Table 4. India's Position in World Fruits and Vegetable Production (As on 2022)

(In Million Tonnes)						
Sl. No.	**Items**	**India**	**World**	**India's Share (%)**	**India's Rank**	**Next to**
1	Vegetables Primary	145.10	1171.28	12.39	II	China
2	Fruits Primary	111.07	943.47	11.77	II	China
3	Potatoes	56.18	373.40	15.04	II	China
4	Onion (Dry)	31.69	111.50	28.42	I	-

India is the second-largest producer of vegetables in the world, producing 145.10 million tonnes, which accounts for 12.39% of global vegetable production (1,171.28 million tonnes), next only to China. Similarly, India ranks second in fruit production, with an output of 111.07 million tonnes, contributing 11.77% of the world's total fruit production (Table 4).

In potato production, India is also ranked second globally, producing 56.18 million tonnes, which represents 15.04% of world potato production, after China. India holds the first position in dry onion production, producing 31.69 million tonnes and contributing 28.42% of global production.

Overall, Table 4 highlights India's strong position in global horticulture. The country is a major contributor to the production of fruits, vegetables, potatoes, and onions, which play an important role in food and nutritional security, agricultural exports, and improving farmers' incomes.

India's Position in World Livestock

India has a significant position in global livestock resources due to its large animal population and the important role of livestock in rural livelihoods, income generation, and agricultural sustainability. The livestock sector contributes substantially to milk, meat, and other animal-based products while supporting millions of rural households.

Table 5. India's Position in World Livestock Population (As on 2022)

(In Million Heads)						
Sl. No.	**Items**	**India**	**World**	**India's Share (%)**	**India's Rank**	**Next to**
1	Cattle	194.15	1557.79	12.46	II	Brazil

2	Buffaloes	111.74	209.31	53.38	I	
3	Camels	0.20	40.76	0.50	XXII	*
4	Sheep	76.75	1325.04	5.79	II	China
5	Goats	153.01	1116.02	13.71	I	-
6	Chicken	844.93	26752.93	3.16	VII	China, Indonesia, Pakistan, Brazil, USA, Iran
***Chad, Somalia, Sudan, Kenya, Saudi Arabia, Niger, Ethiopia, Mauritania, Mali, Pakistan, UAE, China, Mongolia, Yemen, Algeria, Eritrea, Oman, Nigeria, Egypt. Khazaksthan, Tunisia.**						

India has the second-largest cattle population in the world, with 194.15 million cattle, accounting for 12.46% of the global cattle population, next only to Brazil. India holds the first position in buffalo population, with 111.74 million buffaloes, contributing 53.38% of the world's buffalo population, making India the global leader in buffalo resources (Table 5).

In sheep and goat populations, India ranks among the leading countries. It has the second-largest sheep population, with 76.75 million sheep (5.79% of the world population), next to China. India ranks first in goat population, with 153.01 million goats, contributing 13.71% of the global goat population.

India's camel population is relatively small, with 0.20 million camels, accounting for 0.50% of the world's camel population and ranking 22nd globally. In poultry production, India has a chicken population of 844.93 million, representing 3.16% of global chicken numbers, and ranks seventh in the world.

Overall, India's strong position in livestock resources highlights the importance of animal husbandry as a key component of Indian agriculture. Livestock provides employment, nutritional security, supplementary income, and economic stability to rural communities, especially small and marginal farmers.

India's Position in World Animal Products

India holds a prominent position in the global production of animal products due to its large livestock population, growing dairy sector, and increasing demand for animal-based food products. The animal husbandry sector plays an important role in enhancing rural income, employment generation, and nutritional security.

Table 6. India's Position in World Dairy Products (As on 2022)

(In Million Tonnes)						
Sl. No.	**Items**	**India**	**World**	**India's Share (%)**	**India's Rank**	**Next to**
1	Milk Total	230.59	951.85	24.22	I	-
2	Eggs (Primary) Total	7.61	95.25	7.99	II	China, USA
3	Meat Total	12.40	363.24	3.41	IV	China, USA, Brazil

India is the largest producer of milk in the world, with a production of 230.59 million tonnes, accounting for 24.22% of global milk production (951.85 million tonnes). The dairy sector is a major contributor to the rural economy and provides a stable source of income, especially for small and marginal farmers (Table 6).

In egg production, India ranks second in the world, producing 7.61 million tonnes, which contributes 7.99% of global egg production. It stands after China and the USA, reflecting the rapid growth of the poultry industry in the country.

India ranks fourth in global meat production, with an output of 12.40 million tonnes, accounting for 3.41% of world meat production. The major meat-producing countries ahead of India are China, the USA, Brazil, and the Russian Federation.

Overall, these indicators demonstrate India's strong position in global animal product production. The growth of dairy, poultry, and livestock sectors has significantly contributed to food security, agricultural diversification, and improvement of rural livelihoods.

Conclusion

India occupies a leading position in global agriculture despite having only about 2.3% of the world's land area. It ranks among the top producers of several agricultural commodities, including milk, pulses, rice, wheat, fruits, vegetables, and livestock products, making a significant contribution to global food security, agricultural trade, and rural livelihoods. However, challenges such as climate change, water scarcity, fragmented landholdings, and declining natural resources must be addressed through technological innovation, sustainable farming practices, and supportive policies. Continued investment in research, mechanization, value addition, and climate-resilient agriculture will further strengthen India's global agricultural leadership while improving farmers' incomes and ensuring long-term food and nutritional security.

DIGITAL TRANSFORMATION OF AGRICULTURE

A Farmer-Centric Perspective

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Agriculture remains a fundamental pillar of the Indian economy, contributing nearly one-fifth of national income and providing livelihoods to approximately 46.1% of the workforce. Beyond its economic importance, it plays a vital role in food security, rural employment and household livelihoods. However, farmers face numerous challenges, including weather variability, soil degradation, pest and disease outbreaks, rising input costs, limited access to reliable information and fluctuating market prices. These challenges are further intensified by climate change and increasing pressure on land and water resources.

The growing availability of information and communication technologies (ICTs), mobile connectivity and digital platforms offers opportunities to address these challenges through farmer-centred digital agriculture. Farmers can access timely information on weather, soil and crop health, irrigation, fertilizer management, pest and disease control, input availability, market prices and government schemes. Digital advisory systems and remote-sensing technologies can further support preventive and site-specific farm management. From a farmer's perspective, however, the value of digital agriculture depends not merely on technological access but on whether the information provided is reliable, understandable, relevant and actionable. Thus, farmer-centred digital agriculture should focus on empowering farmers to make timely, informed and context-specific decisions, thereby improving resource-use efficiency, reducing production risks and strengthening agricultural livelihoods.

E-Farm Technologies

E-farm technologies comprise a range of digital tools that support farmers in monitoring crops, managing resources, making informed decisions and accessing agricultural markets and services. Technologies such as soil and water sensors provide information on soil moisture, temperature and nutrient status, helping farmers optimize irrigation and fertilizer application while reducing unnecessary input use. Digital technologies such as satellite imagery, remote sensing, drones, robotics, IoT, AI and GIS can support farmers in crop monitoring, resource management, pest and disease detection and site-specific decision-making. Digital marketplaces and blockchain can further improve market access and product traceability. These technologies complement farmers' traditional knowledge with scientific, data-driven information. However, their effectiveness depends on farmers' ability to access, understand, trust and apply the information. Thus, e-farming can improve resource-use efficiency, reduce production risks and costs, strengthen market connectivity and promote sustainable and resilient agricultural livelihoods.

Emergence and Characteristics of E-Farmers

These farmers may be broadly described as e-farmers, referring to individuals who utilize digital technologies, internet-enabled services, mobile applications, online platforms and other ICT-based resources to obtain agricultural information, manage farm activities, access markets and communicate with agricultural stakeholders. The emergence of e-farmers represents an important transition from conventional information sources towards more digitally enabled and information-driven agricultural practices. The characteristics of e-farmers can be considered across several interrelated dimensions, including internet utilization, awareness, perception and utilization, e-readiness, information-seeking behaviour, *etc*.

1. Internet Utilization for Farming

Farmers use internet-enabled devices and digital platforms to access information on weather, crops, inputs, markets and government policies. It also facilitates communication with buyers, extension personnel and fellow farmers.

2. Digital Awareness

Digital awareness refers to farmers' knowledge of available digital technologies and their agricultural applications. Awareness is an important first step towards the effective adoption and utilization of digital tools.

3. Perception and Utilization of Digital Technologies

Farmers' perceptions of the usefulness, reliability, affordability and ease of digital technologies influence their adoption. Positive experiences encourage continued use, while concerns about cost, connectivity, accuracy and trust may limit utilization.

4. E-Readiness

E-readiness indicates farmers' preparedness and capacity to adopt and use digital technologies effectively. It includes access to devices and connectivity, digital literacy, awareness, experience and willingness to learn.

5. Information-Seeking Behaviour

Information-seeking behaviour involves actively searching for information to address specific farming needs and problems. Digital platforms provide new information sources while traditional extension services and interpersonal communication remain important.

6. Scientific Orientation

Digital platforms provide access to scientific and technical information from universities, research institutions and extension agencies. Such information can support evidence-based decisions regarding soil, fertilizers, irrigation, crop protection and other practices.

7. Extension Contacts and Digital Networks

Digital networks connect farmers with extension personnel, experts, fellow farmers and market participants. Online groups, mobile applications and digital advisory services can complement conventional extension systems and enable faster information exchange.

8. Exposure to Mass Media and Digital Markets

Exposure to mass media and digital platforms increases farmers' awareness of technologies, government programmes and market opportunities. Digital markets also help farmers connect with buyers, promote produce and obtain current market information.

Current Scenario of Digital Agriculture

Digital technologies are increasingly transforming agriculture by supporting precision farming, dairy management, agricultural marketing and rural entrepreneurship. IoT-based systems provide farmers with detailed and timely information for improved farm and resource management. In the dairy sector, digital platforms can connect farmers and local milk vendors with organized processors, facilitating efficient milk collection, quality assessment, transportation, traceability and transparent procurement and payment systems. Digitalization is also reshaping agricultural marketing by connecting farmers, traders, processors, exporters and buyers through online platforms. Improved digital connectivity can provide farmers with timely market information and opportunities to access wider markets beyond their local areas. Emerging technologies such as artificial intelligence (AI), machine learning, blockchain, IoT, remote sensing and GIS are further expanding the scope of digital agriculture. Government initiatives such as the Digital Agriculture Mission aim to strengthen digital infrastructure and data systems for technology-enabled agricultural development. Digital platforms can also support alternative rural enterprises such as agri-tourism by helping farmers promote their farms, attract visitors and reach potential customers. Thus, digitalization is expanding beyond primary production to encompass resource management, dairy value chains, marketing and rural livelihood diversification. Its ultimate value lies in providing farmers with reliable, timely and actionable information while strengthening their participation in increasingly digital agricultural value chains.

Table 1: Farmers issues and their technology-based solutions

Farmer's need/problem	Digital solution	Farmer-level decision	Potential outcome
Uncertainty about irrigation	Soil-moisture sensors	When/how much to irrigate	Better water-use efficiency
Uneven crop growth	Satellite/remote sensing	Identify stressed areas	Site-specific management
Pest/disease risk	AI/digital advisory	Preventive intervention	Reduced crop loss
High labour requirement	Robotics/drones	Mechanize selected operations	Reduced labour/time
Uncertainty about prices	Digital market platforms	When/where to sell	Better market access
Weather uncertainty	Digital weather services	Adjust farm operations	Reduced weather-related risk

Conclusion

The development of e-farmers should be viewed as a multidimensional process involving technological access, awareness, digital competence, information behaviour and effective utilization of digital agricultural services. From a farmer's point of view, e-farm technologies should primarily serve farmers practical needs by providing timely, reliable and easy-to-understand information. Their effective use can help farmers make better decisions, optimize inputs, reduce production risks and costs, and improve access to markets and services. By complementing farmers' traditional knowledge and experience, e-farming can empower farmers and contribute to more productive, profitable, resilient and sustainable farming.

Moving from Aggregate Capacity to Spatial Accessibility of COLD STORAGE INFRASTRUCTURE IN INDIA

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Cold storage is one of the infrastructural achievements of agricultural sector, with India having 8,815 registered cold storage units with a combined capacity of 402.18 lakh metric tonnes (*Press Information Bureau, 2025*). The National Centre for Cold Chain Development (NCCD), the technical body operating under the Ministry of Agriculture and Farmers Welfare, has projected that this capacity will approach 440 lakh metric tonnes by 2031, implying a compound annual growth rate of approximately 2.2 per cent, making India one of the largest holders of refrigerated storage capacity in the world. These confirm that the capacity has been established, but only a little information is available on where the capacities are located. This distinction between looking at these capacities in terms of numbers, and capacity as a spatially distributed resource is the concern. This does not argue that cold storages in the country should be reduced in terms of numbers, but that the next stage of development of cold storages could depend less on the addition of further tonnage, and rather focus on location and diversification, along with the tonnage.

The scale of Indian cold storage network is the outcome of sustained convergence of policy support extended such as the Mission for Integrated Development of Horticulture (MIDH) providing a capital subsidy of 35 per cent in general areas and 50 per cent in the hilly, tribal, and North-Eastern regions for facilities of up to 5,000 Metric Tonnes (MT). National Horticulture Board (NHB) also parallelly administers a credit-linked, back-ended subsidy at comparable rates for larger installations, between 5,000 and 20,000 MT, including controlled-atmosphere storage. Pradhan Mantri Kisan Sampada Yojana (PMKSY), under the Ministry of Food Processing Industries, extends similar grant-in-aid for integrated cold-chain and value-addition infrastructure; its continuation has been approved with an allocation of approximately ₹4,600 crore through March, 2026.

Recently, Agriculture Infrastructure Fund (AIF) has also come into the picture with a 3 per cent per annum interest subvention on loans of up to ₹2 crore, available for a period of seven years, alongside reducing the collateral burden. As of 2025, 2,454 cold storage projects had been sanctioned under the AIF, representing a cumulative outlay of ₹8,258 crore. State governments have supplemented these central schemes with their own capital and interest subsidies, reflecting a rare degree of alignment across multiple agencies toward a common infrastructural goal. The steady rise in both the number and capacity of cold storage facilities over the past decade could be seen as evidence that this coordinated policy support has worked as intended.

Moving from beyond the Capacity

As of 2010, Uttar Pradesh approximately had 37 lakh tonnes of cold storage capacity against an annual horticultural output exceeding 3.5 crore tonnes, representing barely a tenth of its horticultural production. About 70 per cent of this capacity was dedicated to potato storage alone, a crop for which conventional single-temperature technology is well-suited, leaving comparatively limited dedicated capacity for other horticultural produce with shorter post-harvest shelf life. This pattern of commodity concentration is not confined to Uttar Pradesh alone. Assessment of NHB and NCCD data also suggest that a considerable share of national capacity remains concentrated in a small number of states with established potato and grain economies, while several states in the southern, central, and North-Eastern regions retain comparatively limited refrigerated capacity relative to their horticultural output. This reflects that capacities look adequate at the national level but it is unevenly distributed. For horticultural produce that begins to deteriorate within hours of harvest, the distance between farm and facility becomes important. Even if the capacity exists, if it is too far away to reach in time, it becomes inaccessible to the farmer.

Using Spatial Analysis as a Diagnostic Tool

Geographic Information Systems (GIS) and related spatial methods could be applied to address this issue by overlaying the location of registered cold storage facilities against cropping pattern, road networks, and farmer density at the district level. Studies on earlier aerial-distance approaches to cold chain accessibility in the past have also reported that there were a few well-served clusters near towns and highway corridors, while much larger surrounding areas remained too far from any facility to reach easily. This is the problem especially for small farmers as they lack access to refrigerated transport and cannot afford to travel far to reach storage facility, thereby leading to value loss.

Rather than asking whether a state or a district has sufficient cold storage capacity in aggregate, spatial analysis would question if the capacity aligns with the farmers location, enhancing accessibility. A district that appears adequately served on records, still contain a substantial portion of the farmer population unserved. This is not because the facility is absent, but because the cost of reaching it, in time, and the produce quality lost in transit, exceeds what the farmer stands to gain from accessing the cold storage.

Expanding Production Base

Total horticultural production is estimated to approximately be 377.78 million tonnes from 301.51 lakh hectares, with fruit production alone increasing by approximately 3.25 per cent (*Horticulture second advance estimates, GoI, 2025-26*). Potato production has also followed an upward trend, increasing from 531.07 lakh tonnes in 2020-21 to 585.71 lakh tonnes in 2024-25 (*Final estimates, GoI, 2026).*

In comparison, cold storage capacity is growing at a much slower rate i.e., a compound annual rate of about 2.2 per cent. NCCD estimates a shortfall of nearly 35 million tonnes against a national requirement of more than 50 million tonnes of dedicated storage for perishable horticultural produce. The overall trend projects that the production is growing at a faster rate than storage capacity. This makes it increasingly important to locate new storage facilities more carefully and strategically, so that capacity is established where it is actually needed.

WHOLE-BODY VIBRATION EXPOSURE IN TRACTOR OPERATORS

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Agricultural tractors expose seated operators to continuous, multi-axis mechanical vibration transmitted through the seat, backrest, and floor pan. Unlike vibration encountered in most road vehicles, tractor-generated vibration is characterized by low-frequency, high-amplitude, and often transient (shock-type) content, produced by the combination of unsprung or lightly sprung axles, aggressive tire-terrain contact on ploughed or unpaved ground, and reactive loading from towed or mounted implements. Because the dominant frequency content of this vibration typically falls within 0.8–5 Hz-a band that coincides with the resonant frequency of the lumbar spine and trunk whole-body vibration (WBV) is recognized internationally as a principal contributor to occupational musculoskeletal disorders among tractor operators, particularly chronic low-back pain and degenerative spinal changes.

Regulatory Exposure Thresholds

The reviewed literature consistently applies the exposure metrics summarized in Table 1, drawn from ISO 2631-1, ISO 2631-5, and EU Directive 2002/44/EC. These provide the reference points against which field-measured tractor vibration is judged.

Metric	Threshold	Regulatory Basis
Exposure Action Value (EAV)	0.5 m/s^2 (A(8))	EU Directive 2002/44/EC; ISO 2631-1
Exposure Limit Value (ELV)	1.15 m/s^2 (A(8))	EU Directive 2002/44/EC
VDV Action Limit	9.1 $m/s^{1.75}$	ISO 2631-1 (vibration dose value)
Sed(8) - moderate health-risk probability	0.5 MPa	ISO 2631-5 (spinal compressive dose)

Sed(8) — high health-risk probability	0.8 MPa	ISO 2631-5 (spinal compressive dose)

Table 1. Regulatory and standards-based whole-body vibration exposure thresholds referenced across the reviewed studies.

Exposure During Field Operations

Field measurements across tillage, rotavating, and transport operations show a consistent pattern: mean vibration magnitudes frequently exceed the 0.5 m/s^2 exposure action value, and in several studies, calculated spinal compressive dose Sed(8) values exceeded the ISO 2631-5 thresholds associated with a moderate or even high probability of adverse health effects. Vertical-axis acceleration was consistently the dominant component, though lateral-axis exposure exceeded the action value in at least one comparative study of tillage systems.

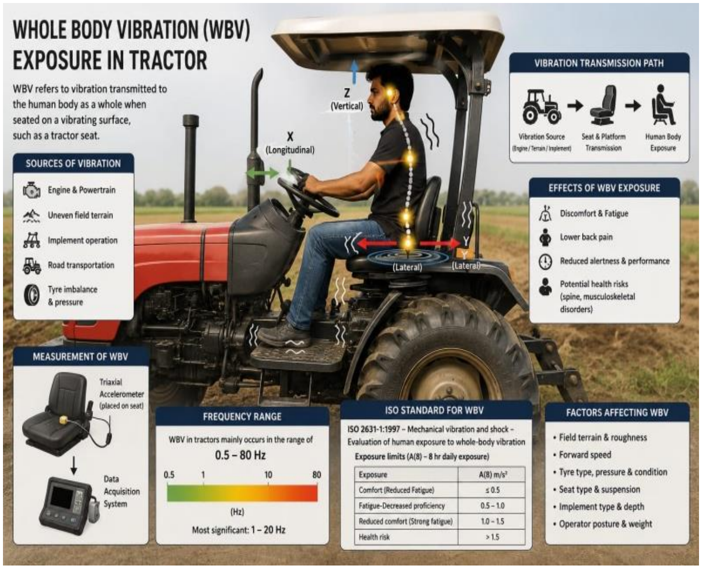

Fig – Whole body vibration exposure in tractor

Determinants of Exposure Magnitude

Across studies, three operational variables were repeatedly identified as the strongest predictors of vibration magnitude: 1. **Travel speed:** vibration magnitude rose sharply with forward speed, particularly on unpaved or rutted surfaces; the exposure action value was reached at lower speeds on rough terrain than on smoother concrete or asphalt tracks.

2. **Pulling/draft force:** in controlled tillage trials using orthogonal experimental design, pulling force accounted for a substantial share of variance in spinal compressive dose, second only to travel speed.

3. **Terrain and surface type:** earthen and grassland surfaces produced markedly higher exposure than paved or well-maintained tracks at comparable speeds.

Secondary factors reported include operator body mass, seat type and suspension characteristics, and tillage depth, each of which modulated the vibration ultimately transmitted to the operator's seat and spine.

Health Outcomes

Occupational epidemiological studies comparing tractor drivers to non-exposed control populations report a consistently elevated prevalence of low-back pain among drivers — on the order of 10 percentage points higher in a large cohort of over 1,100 tractor drivers compared with unexposed office workers. Prevalence and severity of back pain increased with cumulative vibration dose and duration of exposure, and associations with sciatica and, in a subset of drivers, herniated disc were also reported. These outcomes are broadly consistent with the wider literature on professional drivers exposed to whole-body vibration, in which cumulative dose and postural load are identified as joint contributors to chronic low-back disorders.

Conclusion

The evidence reviewed here indicates that whole-body vibration exposure during ordinary tractor field operations routinely meets or exceeds the exposure action value defined under ISO 2631-1 and EU Directive 2002/44/EC, and in a meaningful share of measured conditions approaches or surpasses spinal-risk thresholds defined under ISO 2631-5. Travel speed, terrain roughness, and implement draft force are the most consistent and controllable determinants of exposure magnitude, while cumulative exposure over a career is strongly linked to elevated rates of chronic low-back pain among tractor operators relative to non-exposed workers. Because WBV-related musculoskeletal harm accumulates gradually rather than presenting as an acute incident, it remains comparatively under-addressed relative to more visible agricultural safety hazards. The consistency of findings across independent studies, machine types, and geographic contexts nonetheless points to a well-defined and modifiable risk: improved seat suspension, speed moderation on rough terrain, better-matched implement loading, and structured work-rest scheduling represent practical, evidence-supported interventions capable of bringing routine operator exposure closer into line with recognized health-based limits.

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