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A Resonance in Agriculture

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AGRI FINTECH START UP'S

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Times of Agriculture
A Resonance in Agriculture

From the Editor's Desk

Dear Readers of Times of Agriculture Magazine,

It has always been our priority to bring you insightful articles filled with innovation and progress in the field of agriculture. In line with this vision, the current issue focuses on the emerging domain of **Agri-Fintech**, presenting valuable and engaging information that can significantly benefit our smallholder farmers.

As you are aware, farmers often face considerable challenges in accessing loans, including extensive paperwork and procedural delays, which prevent them from receiving timely financial assistance. However, with India emerging as a digital powerhouse, the integration of finance and technology has given rise to **Agri-Fintech** solutions, enabling farmers to access credit easily through a single application.

Traditional agriculture has long struggled with systemic inefficiencies in areas such as credit access, insurance coverage, risk management, and supply chain finance. Small-scale farmers, in particular, face immense difficulty obtaining formal credit due to lack of collateral, complicated documentation processes, and the opaque nature of traditional banking systems.

In response, **Agri-Fintech** startups are bringing innovation, inclusivity, and scalability to tackle these challenges head-on. These startups are not only reshaping the rural financial landscape but are also elevating the agricultural sector to new heights.

Companies like **Samunnati, Jai Kisan, Agriwise, and Whrrl** are redefining the dynamics of rural credit distribution and usage.

Let us together explore this transformative system—**one app, one loan, and one empowered farmer**—and help share this knowledge with our farming communities.

Thank you, Enjoy Reading....

Editor-In-Chief

CONTENT

Times of Agriculture
A Resonance in Agriculture

AGRICULTURE UPDATES

Cabinet approves Rs 24,000 crore for PM Dhan Dhaanya Yojana

The Union Cabinet chaired by Prime Minister Narendra Modi approved the **Prime Minister Dhan-Dhaanya Krishi Yojana** for a six-year period beginning in 2025–26, to be implemented in 100 districts. Inspired by NITI Aayog's Aspirational District Programme, this is the first scheme focused exclusively on agriculture and allied sectors.The scheme aims to enhance agricultural productivity, promote crop diversification and sustainable practices, bolster post-harvest storage infrastructure at panchayat and block levels, improve irrigation facilities, and facilitate both long- and short-term credit for farmers. It fulfills the Budget 2025–26 commitment to developing 100 districts under this initiative. Districts will be selected based on three key indicators: low productivity, low cropping intensity, and limited credit disbursement. One district is guaranteed per State/UT, with additional districts allocated proportionally based on net cropped area and operational holdings. Implementation will involve convergence of 36 existing schemes from 11 Central departments, state-level initiatives, and private-sector partnerships.

Committees will be constituted at the district, state, and national levels for planning, implementation, and monitoring. Each district will form a District Dhan Dhaanya Samiti—including progressive farmers and chaired by the Collector—to finalize a District Agriculture and Allied Activities Plan aligned with national goals like crop diversification, water and soil conservation, organic farming, and agricultural self-sufficiency. Progress will be tracked monthly via an online dashboard with 117 key performance indicators, under the oversight of NITI Aayog and dedicated Central Nodal Officers.

The scheme will benefit approximately 1.7 crore farmers across the targeted districts, providing a significant boost to rural livelihoods and local economies. With an annual budget outlay of ₹24,000 crore, the initiative also aims to foster value addition in allied sectors such as dairy, fisheries, and horticulture, while promoting climate-resilient agricultural practices.

IFFCO to Set Up India's First Overseas Nano Fertiliser Plant in Brazil

In a significant step towards globalizing India's agricultural innovation, the **Indian Farmers Fertiliser Cooperative (IFFCO)** is set to establish its first overseas **nano fertiliser manufacturing plant in Brazil**. This landmark venture, executed in collaboration with Brazilian firm **NANOFERT**, is strategically positioned to meet the rising demand for sustainable and efficient crop nutrition across South America. With an annual production capacity of 4.5 million litres, the facility will cater to high-demand crops like corn, soybean, and sugarcane, predominantly grown in the region.

This initiative marks a historic milestone for India's agri-input sector as IFFCO extends its nano fertiliser technology beyond national borders. Nano fertilisers are cutting-edge formulations engineered to improve nutrient uptake efficiency, boost crop yields, and significantly reduce traditional chemical fertiliser usage. Field trials have already demonstrated strong results in both India and abroad, positioning IFFCO as a key player in the future of sustainable agriculture. The move aligns with India's broader vision of becoming a global leader in agri-tech and climate-smart farming solutions.

The Brazil-based plant, located in Curitiba, Parana Province, will operate as a joint venture in a 7:3 ownership ratio between IFFCO Nanoventions (India) and NANOFERT (Brazil). Trial production is scheduled to commence by the end of **2025**. Once operational, the facility will not only strengthen IFFCO's global footprint but also contribute to the shift toward eco-friendly farming practices in Latin America. By introducing Indian-developed nano fertilisers to international markets, this venture reinforces India's role in driving innovation and sustainability in the global agricultural landscape.

New Flowering Plant Species 'Begonia nyishiorum' Discovered in Arunachal Pradesh

A remarkable new species of flowering plant, **Begonia nyishiorum**, has been discovered in the high-altitude forests of **East Kameng district** in Arunachal Pradesh by officials from the **Seppa Forest Division**. This rare botanical find is named in honour of the **Nyishi tribe**, the largest indigenous community in the state, recognizing their deep cultural and ecological ties to the region. The discovery was the result of a demanding field expedition undertaken by forest officials and was recently published in the prestigious international journal *Novon: A Journal for Botanical Nomenclature*.

Begonia nyishiorum distinguishes itself through its **unique crimson-fringed petioles**, a morphological trait unseen in any other known Asian Begonia species. Its distinctive appearance makes it not only a significant addition to the botanical records but also a striking symbol of the largely unexplored floral diversity of the **Eastern Himalayas**. The plant now joins the growing list of rare and endemic species found in this ecologically rich zone, underlining the critical importance of the region as a global biodiversity hotspot.

The discovery of this new species underscores the urgent need for **continued scientific exploration and conservation** efforts in Arunachal Pradesh and the broader Himalayan region. As habitats face increasing pressure from climate change and human activities, such findings are vital reminders of the natural heritage that must be protected. **Begonia nyishiorum** stands as both a scientific marvel and a call to action, highlighting the wealth of undiscovered life in India's northeastern frontier.

Assam Launches ₹5 Milk Subsidy and Expands Dairy Processing to Boost Rural Economy

In a major move to boost the rural dairy sector, the **Assam government** has launched a **milk subsidy scheme** offering **₹5 per litre** to dairy farmers. This initiative is aimed at increasing milk production and improving farmers' incomes by incentivizing supply to cooperative societies. Over **20,000 dairy farmers** across the state are expected to benefit from the scheme, which the government envisions as a step toward creating a **rural dairy revolution** and enhancing the livelihoods of farming communities.

Alongside the subsidy, Assam is significantly expanding its largest dairy processing facility—the **West Assam Milk Producers' Cooperative Union Ltd (WAMUL)** plant located in **Panjabari, Guwahati**. Under a ₹104-crore project in partnership with the **National Dairy Development Board (NDDB)**, the plant's **processing capacity will double from 1.5 lakh litres per day (LLPD) to 3 LLPD**. This upgrade is expected to streamline milk collection and processing, helping to stabilize supply chains and reduce wastage in the state's dairy ecosystem.

The expanded plant will increase **pasteurised pouch milk production** from **1.15 LLPD to 2 LLPD** and introduce a **new ice cream production line** with an initial capacity of **20 thousand litres per day (TLPD)**, expandable to **30 TLPD**. In addition, a range of **other dairy products** with a combined capacity of **70 TLPD** will be developed to diversify offerings and cater to growing market demand. These enhancements are set to boost the dairy industry's contribution to Assam's economy, generate employment opportunities, and support long-term rural development.

This integrated approach—combining **direct financial support for farmers** with **infrastructure development and product diversification**—reflects a broader strategy to build a resilient, self-sustaining dairy ecosystem in the state. By improving farm-to-market connectivity and ensuring fair compensation for producers, the government is laying the foundation for inclusive agricultural growth. The initiative also aligns with national goals of **doubling farmers' incomes** and **strengthening India's cooperative dairy model**, setting a precedent for other states to follow.

India Launches First Weather Derivatives Market to Manage Climate Risks

In a landmark move for climate risk management, **India has launched its first weather derivatives market**, a strategic initiative aimed at safeguarding weather-sensitive sectors. Spearheaded by the **National Commodity and Derivatives Exchange (NCDEX)** in partnership with the **India Meteorological Department (IMD)**, this pioneering financial market introduces **weather derivatives**—instruments that allow **farmers, businesses, and financial institutions** to hedge against adverse weather conditions. By mitigating the financial impact of unpredictable weather, this initiative is expected to enhance resilience, improve decision-making, and attract greater investment in agriculture, energy, and other climate-sensitive industries. **Weather derivatives** are financial contracts whose payouts are linked to measurable weather variables such as **temperature, rainfall, snowfall, or wind speed**. Unlike traditional insurance—which compensates for physical losses—weather derivatives help cushion **revenue fluctuations** caused by recurring weather risks. These instruments function by **transferring weather risk** from those directly impacted by climate volatility to market participants willing to assume such risks, thereby offering income stability and reducing uncertainty for stakeholders across the supply chain.

In global markets, **temperature and precipitation** are the most commonly used variables in derivative contracts. **Heating Degree Days (HDD)** and **Cooling Degree Days (CDD)** track temperature deviations from a base level and are widely used by energy companies, while **rainfall contracts** focus on cumulative rainfall totals or variances from long-term historical averages—vital metrics for farmers. Although **snowfall and wind speed derivatives** are more common in advanced economies with specific needs (like ski resorts or wind farms), the Indian market is expected to evolve to incorporate such variables as sectoral demand matures. What sets weather derivatives apart is that they trade on **quantitative weather outcomes**, not qualitative events. For instance, a **rainfall futures contract** might trigger a payout if total rainfall in a particular region falls below a predefined threshold. These contracts rely on **agreed-upon data sources**—such as the IMD—for accuracy and transparency, ensuring verifiable settlements.

Cabinet approves establishment of International Potato Centre (CIP)

The **Union Cabinet**, chaired by **Prime Minister Shri Narendra Modi**, has approved a proposal from the **Department of Agriculture & Farmers Welfare** to establish the **South Asia Regional Centre (CSARC)** of the **International Potato Centre (CIP)** at **Singna, Agra, Uttar Pradesh**. This strategic initiative aims to boost India's leadership in potato and sweetpotato research, bringing cutting-edge agricultural science to the region and supporting food and nutrition security.

The investment is designed to **increase farmers' incomes**, enhance **job creation**, and promote **rural development** by improving **potato and sweetpotato productivity**, strengthening **post-harvest management**, and driving **value addition**. Recognizing the significant potential of the potato sector in India, the centre will support development across the value chain—from **production and processing** to **packaging, transportation, and marketing**—creating widespread economic opportunities in both rural and peri-urban areas.

CSARC will focus on the development of **high-yielding, climate-resilient, and nutrient-rich varieties** of potato and sweetpotato, leveraging CIP's global research expertise. These innovations will accelerate **sustainable agricultural practices** and support regional food systems not only in India but across **South Asia**. The centre aims to act as a hub of **world-class agricultural innovation**, aligning scientific research with the practical needs of farmers and agri-entrepreneurs.

Beej Utsav 2025 Celebrates Indigenous Seeds and Tribal Agricultural Heritage

The **four-day Beej Utsav (Seed Festival) 2025**, held in the tribal tri-junction of **Rajasthan, Madhya Pradesh, and Gujarat**, served as a vibrant celebration of **indigenous seed diversity** and the cultural heritage of India's tribal communities. The event brought together thousands of farmers, women's collectives, youth groups, and local seed savers, all uniting under the shared goal of promoting seed sovereignty and sustainable agriculture. Organized in the heart of tribal territory, the festival reinforced the importance of community knowledge in maintaining food security and ecological balance.

The festival displayed a diverse range of **traditional seeds**, including rare and forgotten varieties of **grains, pulses, vegetables, and fruits**. Seeds of traditional fruits like **wild mango, Aakol, and Timru**, as well as heritage grains such as **Doodh Mogar maize**, **Kali Kamod**, and **Dhimri rice**, were proudly exhibited and exchanged. These seeds, adapted over generations to local climates and soils, represent both a practical and symbolic resistance to industrial agriculture. Through seed exhibitions, farmers' dialogues, cooking demonstrations, and cultural performances, Beej Utsav celebrated the **deep interconnection between seeds, food, tradition, and identity**.

As part of the festival's recognition of grassroots contributions, awards like **Beej Mitra** and **Beej Mata** were conferred upon local custodians of seed heritage—individuals who have actively preserved and propagated traditional seed varieties despite the pressures of commercial agriculture. The event was driven by **community-led organizations** such as Krishi Evam Adivasi Swaraj Sangathan, Gram Swaraj Samooh, Saksham Samooh, and Bal Swaraj Samooh, with voluntary coordination and support from social groups working on tribal livelihoods and agroecology. The hands-on participation of tribal youth and women was a significant feature, ensuring intergenerational transfer of knowledge and skills.

In essence, Beej Utsav 2025 was not just a festival—it was a powerful grassroots movement to reclaim **seed sovereignty**, promote **agro-biodiversity**, and strengthen **local food systems**. It underscored the urgent need to empower farming communities as the stewards of biodiversity and ecological resilience, while reinforcing that true food security begins with **free, diverse, and farmer-owned seeds**.

COVER STORY

AGRI FINTECH START UP'S

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In order to handle growing input costs, embrace new technology, and deal with erratic weather patterns, Indian farmers now face a growing demand for prompt and reasonably priced finance. Due to low savings and seasonal harvest-related revenue volatility, loans are now necessary for buying seeds, fertilizer, equipment, and even for meeting basic home expenses. But there are still inequalities in the current lending environment.

Loans are available from institutional sources such as banks and cooperative societies, but many small and marginal farmers find it difficult to obtain them because of complicated application processes, a lack of documentation proving their land ownership, and a lack of financial literacy. Because of this, a sizable portion still rely on unofficial lenders who impose exorbitant interest rates, trapping farmers in debt cycles. The disparity between credit availability and actual access is still a significant issue, despite the existence of programs like the Kisan Credit Card (KCC), highlighting the urgent need for inclusive and farmer-friendly credit institutions.

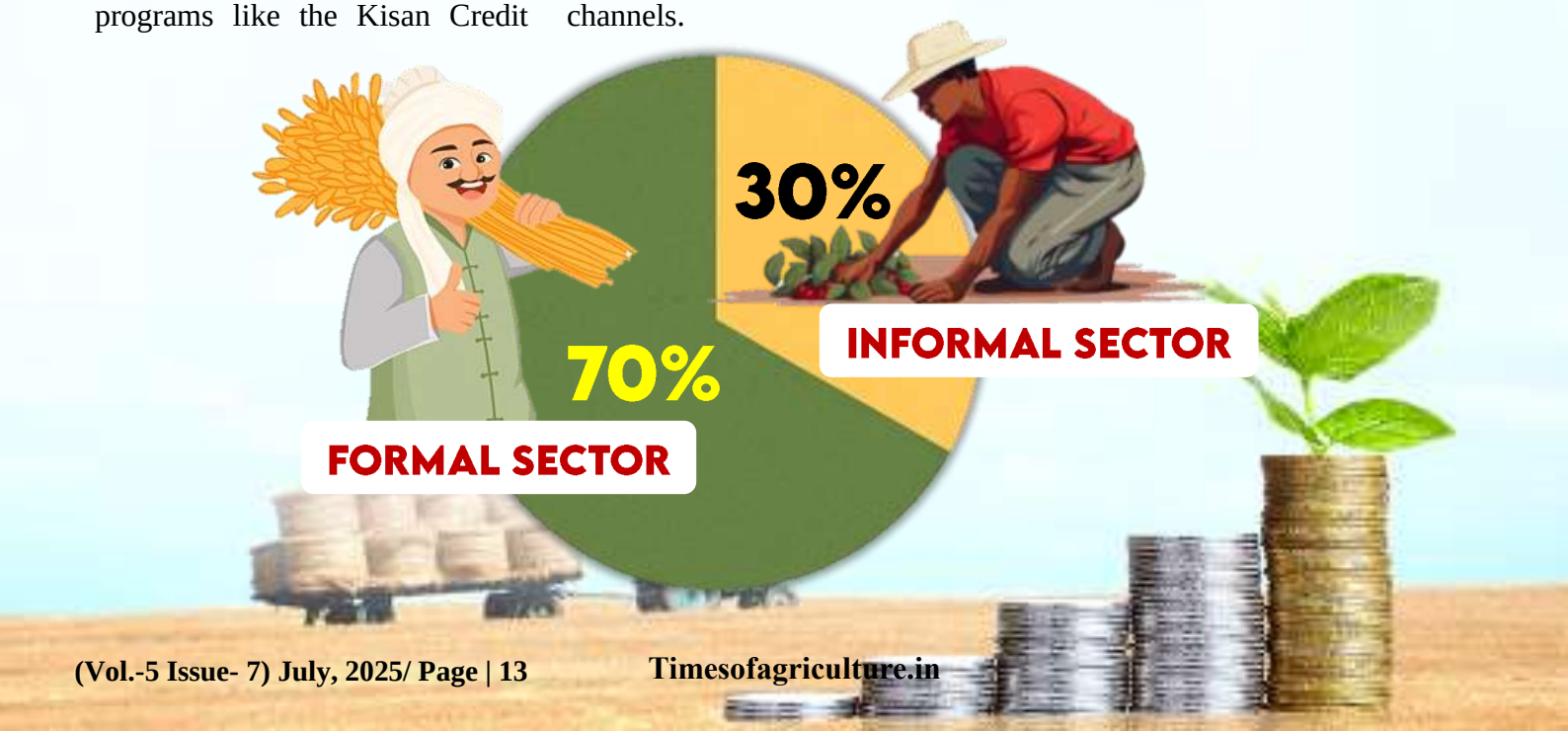
Agri Fintech

Agri-fintech is the field which combines financial technology and agriculture, is dedicated to transforming the financial services market for the agriculture sector. It's a creative solution to the persistent problems that farmers and agricultural enterprises encounter.

It refers to the combination of agriculture with financial technology (fintech), Agri fintech aims to offer farmers, agribusinesses, and rural communities' cutting-edge digital financial solutions. It seeks to use technology to address issues with market access, insurance, payments, and financing in the agriculture industry. The term "Agri fintech" describes technology-driven financial services created especially for the agricultural industry that assist farmers in obtaining loans, insurance, payments, investments, and market data via online channels.

Need of Agri – Fintech

The rise of Agri Fintech startups has become essential to bridge the long-standing credit gap faced by Indian farmers. Traditional banking systems often exclude small and marginal farmers due to lack of collateral, poor credit history, and bureaucratic hurdles. Agri Fintech startups use technology to simplify lending through digital KYC, alternative credit scoring based on farm data, and faster loan disbursements. They also offer flexible, collateral-free credit options and connect farmers directly with formal financial institutions. By leveraging data analytics, satellite imagery, and mobile platforms, these startups bring transparency, speed, and accessibility to rural finance. Their presence is especially crucial in promoting financial inclusion, reducing farmers' dependence on informal moneylenders, and helping them make timely investments to improve productivity and resilience in the face of climate and market uncertainties.



Agri Fintech startups are urgently needed to address the deep-rooted challenges in agricultural financing. Traditional banking systems often fail to meet the needs of small and marginal farmers, who form over 85% of India's farming population. These farmers frequently lack land records, credit history, or collateral—making them ineligible for formal loans. As a result, they rely heavily on informal moneylenders who charge extremely high interest rates, trapping them in cycles of debt. Agri Fintech startups bring innovation by offering digital, accessible, and farmer-friendly financial services. Through technologies like mobile apps, AI-driven credit scoring, satellite-based farm monitoring, and e-KYC, these startups provide faster, paperless loans, insurance, input financing, and digital payments. They promote financial inclusion, improve credit access, and empower farmers to make timely investments in seeds, fertilizers, equipment, and irrigation—leading to improved productivity and income security.

Role of Agri – Fintech Start Up

They assist small and marginal farmers in obtaining savings, insurance, subsidies, and credit.

Even for people without a formal credit history, evaluate creditworthiness using alternative data (such as crop productivity, land records, and satellite data). By Using mobile apps, offering quick loans with interest rates that are frequently lower than those of traditional banks. Provide options for buying seeds, fertilizer, and equipment with a buy now, pay later option. Utilize technology (such as drones and remote sensors) to streamline the claim processing procedure. Facilitating quick and safe online transactions for the selling of food, Agri-inputs, etc. Offer prepaid cards or e-wallets for secure money transfers and storage. Use platforms that guarantee fair pricing to link farmers with mandis, exporters, and food processors. Also Reduce middlemen's exploitation by including real-time pricing information. They Provide post-harvest loans, input finance, and invoice financing. Make loans secured by forthcoming crop sales or warehousing receipts. With help of AI/ ML tools to integrate financial services with weather forecasting, agronomic advice, and crop planning. Assist farmers in making more informed agricultural and financial decisions. Facilitating farmers' digital access to crop insurance programs, PM-KISAN, and government incentives. Make sure money transfers are transparent and have fewer leaks. Only a small portion of the USD 600 billion total addressable market in Agri-finance is held by major businesses like Samunnati, Jai Kisan, and Unnati. To grow their lending business, these startups work with Farmer Producer Organizations (FPOs). FPOs, which are backed by big businesses like ITC, offer governance and assistance, fostering confidence among businesses. Blockchain technology is also being used by startups to digitize warehouses and land records, which enables banks and NBFCs to provide loans secured by tokenized agricultural products. Like traditional moneylenders, several businesses choose the "phygital" model, which combines digital and physical methods to keep a human relationship with farmers. This methodology builds farmers' credit records and aids startups in loan recovery, allowing for more accurate evaluations in the future.

Agri Fintech Starup:

1-Jai Kisan

Jai Kisan was established by Arjun Ahluwalia and Adriel Manigo with the goal of giving smallholder farmers access to reasonably priced finance solutions for the acquisition of agricultural equipment. The startup offers loans backed by profitable assets at interest rates between 8% and 24%. By using their in-depth knowledge of rural value chains, they lead to growth of business of farmers, retailers, MSME.

2-Arya.Ag

Arya.ag was established by Prasanna Rao, Anand Chandra, and Chattanathan Devarajan to solve the problem of smallholder farmers' restricted access to loans. Arya.ag offers warehousing facilities and low-interest financing against stored commodities. With a network of 10,000 warehouses across 25 states, the startup helps farmers store their produce post-harvest and communicate with potential buyers through its digital platform.

3-WHRRL

Founded by Ashish Anand, Abhishek Bhattacharya, and Falguni Pandit, Whrrl offers loans secured by warehouse receipts using blockchain technology. Whrrl ensures secure lending and reduces fraud by tokenizing receipts. In addition, the business intends to launch Bru Finance, which will turn these tokenized assets into NFTs so that investors can purchase and sell them on a blockchain.

4-Samunnati

Samunnati, which was founded by Anilkumar SG, provides smallholder farmers with finance options and market connections. Samunnati links more than 1,500 farmer collectives with a member base of six million farmers in 22 states. The firm helps farmers buy infrastructure and equipment by offering long-term loans, bill discounting loans, and working capital loans.

5-HESA

Hesa, co-founded by Vamsi Udayagiri and Hema Nandi Raju, employs phygital strategy which integrates digital and physical elements to connect rural customers with corporates, banks, governments, and NGOs. Hesa's platform, support transactions and provides financial services to rural areas.

6-Farmart

Established by Mehtab Hans, Lokesh Singh, and Alekh Sanghera. The FarMart, is an Agri-fintech firm, provides smallholder farmers an access to cashless credit via a virtual framework This leads them to purchase agricultural supplies like seeds, fertilizer, and pesticides on credit. The goal is to give farmers access to affordable digital loans by resolving their issue with immediate financing.

7-Agri bazaar

Agri bazaar is a digital platform founded by Mr. Amith Agarwal which leads the farmers to buy and sell agricultural products directly from markets that results in the eliminations for middlemen and links them to the best prices. The goal is to use technology to change the value chain of Indian agriculture and give farmers access to better markets and pricing has created a platform that offers customized crop advisory information and allows farmers to trade online for remunerative pricing for their agricultural products.

Conclusion

Agri FinTech, which combines the strength of digital and financial technology to address some of the most urgent issues facing the sector, is a major change in the agricultural sector. Using technologies like artificial intelligence (AI), the Internet of Things (IoT), blockchain, and data analytics, Agri Fintech is revolutionizing everything from supply chain logistics and financial services to farm management and agricultural production. It is encouraging more sustainable, profitable, and productive agricultural methods while providing farmers all over the world with previously unheard-of chances for financial inclusion and economic expansion. Agri Fintech is more than just increasing agricultural income or production. Fundamentally, the goal is to create a more egalitarian and sustainable agricultural sector that can feed the world's expanding population, protect the environment, and improve the lives of farmers, who are the industry's backbone. Agri Fintech is not just a temporary trend or fashion, it is an essential component.

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GLOBAL FERTILIZER SUPPLY CHAINS POST-PANDEMIC
CHALLENGES AND NEW TRADE CORRIDORS

About Author

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The COVID-19 pandemic disrupted nearly every aspect of the global economy. As countries scrambled to contain the virus, disruptions in production, transportation, and international trade revealed critical vulnerabilities in the global supply chain and fertilizer industry was no exception. Nearly after half a decade later as the economies recover, the fertilizer sector faces both enduring challenges and emerging opportunities.

The fertilizer supply chain, inherently complex and deeply globalized, depends on a delicate interplay of production, logistics, energy availability, and geopolitics. Post-pandemic, this chain has faced disruptions from multiple fronts-geopolitical tensions, energy crises, shifting trade policies and environmental regulations. Yet, this period of disruption has also presented a chance for the industry to reimagine itself through diversification, sustainability, and the establishment of resilient new trade corridors.

This article explores the major challenges facing global fertilizer supply chains post-pandemic, examines emerging trade corridors, and assesses how this industry which is central to food security is recalibrating itself in a world of evolving geopolitics and supply-demand dynamics.

Post-pandemic challenges in the global fertilizer supply chain

Logistical disruptions and port congestion

COVID-19 highlighted the dependency of the global fertilizer industry on complex international shipping systems. Fertilizer shipments faced unprecedented delays due to labour shortages, container scarcities, port closures and increased freight costs. These disruptions affected the delivery timelines of critical inputs like urea, DAP (di-ammonium phosphate), and potash, thus making it difficult for exporters like Russia, China, and Morocco to deliver fertilizers on time, disrupting planting cycles and global food production.

Even in the post-pandemic recovery phase, we continue to grapple with residual logistical inefficiencies, particularly in regions affected by ongoing geopolitical instability like the Red Sea and the Suez Canal. Instability and Houthi attacks in the Red Sea affected shipping from the Middle East and North Africa resulting in diversion of vessels which increased transport time and freight costs for sulphur, ammonia, and phosphates.

Shortage of raw materials & price volatility

Fertilizers are heavily dependent on raw materials such as ammonia, potash, and phosphate rock. These materials, in turn, rely on energy-intensive extraction and production processes. During the

pandemic, production slowdowns were exacerbated by export restrictions. Countries like China and Russia prioritized domestic needs, leading to major global supply shortages, especially in Asia and Africa.

Price volatility, driven by fluctuating energy prices and erratic supply, has become the new norm in today's post-pandemic world. The European energy crisis of 2022 prompted by reduced natural gas supplies from Russia resulted in a surge in Natural gas prices which led to reduced Nitrogen fertilizer production in EU countries, hence increasing dependency on imports. European ammonia production capacity also declined by 35% in 2022 creating a 28-million-ton global supply gap.

Geopolitical tensions and sanctions

From Russia's invasion of Ukraine to sanctions on Belarus and Middle East tensions to India-China tensions, the global fertilizer industry has been significantly affected by geopolitical events. Tensions between India and China strained trade diplomacy, impacting China's fertilizer exports to India. Russia and Belarus are among the world's largest exporters of potash and nitrogen-based fertilizers. War and sanctions resulted in disrupted supply of nitrogen (urea, AN), potash, and phosphates driving up the prices in the global fertilizer market, compelling importers like India and Brazil to reconfigure their procurement strategies and seek alternatives.

Recent escalations in the Israel-Iran conflict have also halted production of Urea and Ammonia in key exporting nations like Iran and Egypt, forcing neighbouring countries such as Jordan to seek alternative energy sources to sustain their fertilizer plants.

Environmental and regulatory pressures

Post-pandemic, the push for sustainability has grown stronger leading to an inclination towards slow-release, nano, and green fertilizers. Fertilizer production is energy-intensive and contributes significantly to carbon emissions. Governments and environmental regulators are now demanding greater transparency, ESG (Environmental, Social, and Governance) compliance, and a shift toward greener alternatives. New EU regulations are also promoting the use of organic and waste-based fertilizers and setting limit values for toxic contaminants like cadmium, mercury, arsenic in fertilizing products to protect soil and human health.

Evolution of trade corridors and diversification strategies

The global pandemic, particularly COVID-19, led to a re-evaluation of long-standing practices and the emergence of new trade dynamics. The pandemic has influenced the formation and strengthening of certain trade corridors and supply chain strategies aimed at building resilience. Fertilizer-importing countries and multinational producers have turned to diversification, resilience planning, and regional collaboration resulting in some of the major shifts.

Africa rising: Morocco and Nigeria in the spotlight

Morocco's OCP Group, which controls over 70% of the world's known rock phosphate reserves, has become a central player. The company has not only expanded its mining and processing capabilities but also partnered with various African and Asian countries to secure long-term supply contracts. Nigeria, with its growing ammonia and urea production capacity, is emerging as a regional hub for West Africa, supported by government incentives and infrastructure investments.

Middle East's strategic expansion

Saudi Arabia, the UAE, and Qatar have strategically positioned themselves as key exporters. Their abundant natural gas reserves have given them a competitive edge in nitrogen fertilizer production.

The India-Middle East-Africa (IMEA) corridor is emerging as a new axis for fertilizer trade. The Red Sea crisis has posed temporary logistical setbacks, but alternative routing strategies and regional cooperation are helping to keep trade flows steady.

Diversified sourcing

The pandemic exposed the vulnerability of highly concentrated supply chains, particularly those heavily dependent on China. India, once heavily reliant on China and Russia, has rapidly diversified its import sources. Strategic deals with Morocco, Jordan, and Egypt have ensured a steady phosphate supply. Similarly, Brazil has increased its imports from North Africa and Canada, reducing dependence on Eastern European suppliers. Both countries are also securing long-term contracts and building reserves.

India has also accelerated domestic capacity building through public-private partnerships and incentivized production under its "Atmanirbhar Bharat" , self-reliant India initiative.

New Trade Corridors: Strategic and Resilient

The formation of new routes is reshaping global fertilizer logistics. Key Fertilizer Trade Corridors Formed or Strengthened Post-COVID-19:

- Middle East–South Asia corridor (UAE, Saudi Arabia → India, Bangladesh).
- North Africa–South America corridor (Morocco → Brazil, Argentina).

- China–Southeast Asia and Latin America corridor.
- Trans-Caspian International Transport Route, offering an alternative to traditional routes blocked by the Russia-Ukraine conflict.
- India-Middle East-Europe Economic Corridor (IMEC), although currently facing geopolitical hurdles, represents a significant long-term opportunity.
- Africa's Growing Intra-Regional Trade: Efforts to enhance connectivity and trade within Africa are gaining momentum.

Policy, sustainability, and industry response

Trade policy reforms and stockpiling

In a significant shift, governments are actively promoting local fertilizer production and building strategic reserves measures now seen as critical for food security rather than economically inefficient. Reflecting this priority, key producers like China and Russia have imposed export bans and quotas to safeguard domestic supply. As a result, the global fertilizer market has tightened, disrupting the flow of both raw materials and finished products across international trade channels.

Long-term agreements and joint ventures

Countries like India are securing 10-15 year deals with key exporters, while regional fertilizer hubs are being established through joint ventures. Africa, for example, is seeing increased Moroccan investment in localized production capacity. India has formed partnerships with Oman (OMIFCO), Morocco (OCP), and a Saudi Arabia (SABIC) to reflect the importance of these relationships. Coromandel International and Saudi Arabia based company named Ma'aden, formed partnership for the long-term supply of Di-Ammonium Phosphate (DAP) and NP/NPK (nitrogen, phosphorus, and potassium) fertilisers.

Sustainability and digital transition

Fertilizer companies are adopting green ammonia, bio-fertilizers, and slow-release formulations to reduce environmental impact. Digital tools for supply chain visibility, weather analytics, and market forecasting are also transforming how we manage risks and ensure delivery.

Rock Phosphate: The strategic backbone

Rock phosphate is the backbone of the phosphatic fertilizer industry, used in products like DAP, MAP, and SSP. Post-pandemic, its strategic importance has grown due to global supply instability and rising food security concerns. While Morocco remains the undisputed leader, China, though a major producer, restricts exports to prioritize domestic needs. However, its mining and quality remains a challenge. Rock phosphate is a non-renewable resource. Its high energy use and carbon emissions causes environmental and sustainable concerns. The European Union has placed stricter controls on cadmium levels in phosphate fertilizers, influencing sourcing decisions globally. Efforts are underway to recycle phosphorus from organic waste and explore green processing technologies.

COVID-19 disrupted mine operations and port logistics. The Russia-Ukraine war shifted focus to phosphate fertilizers, increasing rock phosphate demand. China's 2021-22 export restrictions strained the market. Sanctions on Russia and Belarus triggered supply recalibration in Asia and Latin America. Political instability and infrastructure deficits in parts of Africa also pose risks to consistent supply. These resulted in countries diversifying its sourcing. India secured deals with Morocco, Jordan, and Egypt; Brazil expanded imports from North Africa. Middle East and West Africa corridors are growing due to investments in port infrastructure and joint ventures.

The pandemic, geopolitical upheavals, and environmental imperatives have collectively created the conditions for reinvention. The pandemic was not just a disruption, it was a wake-up call. The fertilizer industry is undergoing a transformation from being globally dependent to regionally resilient. We are transitioning from "just-in-time" to "just-in-case" models, emphasizing redundancy and diversification. Countries within existing trade blocs (like ASEAN, EU, USMCA) are likely to prioritize strengthening internal trade ties to create more robust and self-sufficient regional supply networks.

By embracing diversified trade corridors, green technologies, and regional cooperation, we are not only securing the future of fertilizer supply but also contributing to global food security in an era of uncertainty.

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A NOVEL BIOWEAPON OF THE 21st CENTURY

About Author

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Agro-terrorism makes use of destructive agents, specifically to ruin the agricultural system of any economy. This biological warfare is hard to detect and carries agricultural and health risks. The most recent example includes two Chinese researchers who were charged with smuggling a bioweapon (a fungus named *Fusarium graminearum)* into the United States from China, which is considered a potential agroterrorism weapon of the 21st century. This fungus is known to cause diseases (*Fusarium* Head Blight) in many crops like wheat, rice, corn, and barley. Moreover, it also produces a toxin known as vomitoxin (deoxynivalenol) that again poses a risk to both livestock and human health.

Agro-crime and agro-terrorism: An overview

In a wider aspect, agro-crime refers to a multilayered threat to human health, well-being, and the national economy as a whole. The determination against such crimes demands a one health approach via cooperation between law enforcement agencies, veterinary services, and other stakeholders. The examples include activities like:

1. Falsification of veterinary and animal products.
2. Animal welfare crimes.
3. Illicit wildlife use.
4. Circumventing disease control measures through the smuggling of animals and their associated products.
5. Deliberate release of animal pathogens.

Agro-terrorism is classified as a type of agro-crime. It can be defined as a terrorist attack directly to the crops and livestock of any nation, intentionally to destroy their economy and food supply. In simpler terms, the deliberate release of viruses, bacteria, toxins, or any dangerous agents that can cause illness or death in animals is intended to instill fear among state authorities and civilian populations.

Why agricultural system a soft target?

Agroterrorism offers several advantages over any other use of biological weapons due to their large and highly dispersed nature in geographical areas, poor surveillance, ease of transportation, and hence most susceptible to attacks. The regions where the monoculture of crops is more prevalent are at higher risk compared

to other areas. In addition to these, all the mitigation strategies would be futile if the attack were done with an unknown pest/pathogen. Moreover, the technical know-how to weaponize an anti-agricultural agent is relatively lower than to use any chemical/nuclear biological agent against humans.

Possible agents for agro-terrorist attack

According to an estimate, there are thousands of plant diseases and hundreds of different diseases for a given crop all over the globe, out of which a certain number can be used by terrorists as a weapon to cause havoc under suitable conditions. As a consequence of rapid advancements in the field of biotechnology and genetic engineering, it is now considerably easier for anyone to modify the natural pathogens to make them virulent and tolerant to a wide range of weather conditions.

Recent example of *Fusarium graminearum*: A potent plant pathogen

The recent incident of the arrest of a Chinese researcher who worked at a University of Michigan lab and his fellow for smuggling a dangerous crop-killing toxic fungus in the United States has highlighted the ongoing risks linked with agro-terrorism. The fungus *Fusarium graminearum* is a plant pathogen that is capable of causing a catastrophe in cereal crops (causing Fusarium head blight in wheat, barley, maize, and rice) and thereby disrupting the national food supply as a whole. In addition, this fungus not only reduces the crop's yield but also produces a toxin called Vomitoxin (deoxynivalenol), thus making the grain unsafe for human and animal consumption. As a consequence, a tense relationship emerged between the USA and China, ultimately causing a trade dispute.

Fig 1: Wheat affected by FHB

Another example includes the attack of the desert locust (the world's most destructive pests) during the time of COVID-19. A large group of gigantic swarms of the desert locust spread all over the North-West and Central India regions, ultimately causing huge yield losses. These locusts are native to West Asia and reached India over the Rajasthan-Pakistan border, before the monsoon season. Hence, it is of crucial importance to evolve the area of biosecurity (like surveillance, bio-detection, early warning systems, planning, and preparation) to safeguard the ecosystems.

Table 1: Devastating pests and pathogens in India

Insect pests	Brown plant hopper *(Nilaparvata lugens*) Rice gall midge *(Orseolia oryzae*) Mustard aphid (*Lipaphis erysimi*)
Insect pest (Virus vector)	*Bemisia tabaci*, *Aphids*
Viruses	Rice tungro bacilliform virus Rice tungro spherical virus Cotton leaf curl virus/ other Begomoviruses Groundnut bud necrosis virus Banana bunchy top virus
Bacterial pathogens	*Bulkholderia solanacearum* *Xanthomonas campestris pv. malvacearum*
Fungal pathogens	Cereal Rusts (*Puccinia triticina*) Rice blast (*Pyricularia oryzae*)
Oomycete pathogens	*P. infestans*, *P. nicotianae*, *P. melonis* and *Forest phytophthoras*

The consequence

The possible cascading effects of an agro-crime and agro-terrorism are mentioned below:

Economic and social impact: Plant diseases are known to cause significant damage, like high mortality rates and displaced populations. A good example of this is the Irish Potato Famine of 1845-1849, caused by the pathogen *Phytophthora infestans*. This havoc

resulted in millions of deaths by starvation due to the collapse of Ireland's primary food source, the Potato. Similar is the case of the United States, where one out of six people is linked to the agriculture sector. Hence, an agro-terror attack happened there would not only impact the person who is directly linked, but also the whole economy of the nation would be affected.

India ranks fifth in the production of genetically modified crops. It is also the second-largest exporter of cotton (25% of the total global production) owing to the production of Bt cotton, the principal GM crop produced here. Despite this, the Indian agricultural sector is facing many challenges, like a shortage of water, desertification, and deterioration of farmland. Therefore, it becomes vital to analyse the vulnerable nature of the Indian Agricultural System towards the threat of agroterrorism.

Global conventions related to biological warfare

1) Biological weapons convention (1972): This convention prohibits the development, production, and stockpiling of Bacteriological and Toxin Weapons and their destruction. India has acceded to the convention and is a signatory member. Moreover, this was the first ever disarmament treaty that bans an entire category of Weapons of Mass Destruction (WMD).

2) Geneva protocol (1925): This protocol ensures the prohibition of the use of Asphyxiating, Poisonous, and other gases, along with biological methods of warfare in war. India gave its consent to the protocol in 1960.

The aftermath

In many developing countries, including India, the surveillance system for detecting and mitigating disease outbreaks is not rigorous, which is a primary reason for outbreaks occurrence in comparison to the nations that possess harsh detection systems. Moreover, the methods that are used to detect diseases depend more on classical procedures, making it time-consuming and less sensitive, unlike molecular techniques. Therefore, by developing rapid diagnostic kits that help to identify plant disease, along with increased surveillance, the usage of molecular tools next next-generation sequencing technologies, and remote sensing-based methods proves to be of critical importance to manage and prevent the act of agro-terrorism. Lastly, the ground intelligence will be the key deterrent to contain any deliberate outbreak, which includes the steps to educate farmers and other stakeholders involved to report any unusual or doubtful event to the competent authorities.

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IS IT POSSIBLE TO BOOST AGRICULTURAL PRODUCTION AND SUSTAINABILITY BY REPLACING LABOUR WITH AI & ROBOTICS?

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Agriculture has changed during the past century from being a labor-intensive sector to one that uses power-intensive production technologies and mechanization. There was a constant labor exodus from the land as a result of this change; for instance, in 1900, 41% of US workers were involved in agriculture, but by 2000, that percentage had dropped to just 2%. Agriculture has begun to digitize in the past 15 years. The use of robotics in agriculture has the potential to revolutionize worker productivity. Robots can overcome important human limitations by mimicking or extending human skills. These include the capacity to work in challenging agricultural environments (such as outdoors or hazardous conditions) throughout the day and the potential to lessen the impact of physically taxing, routine, and laborious jobs.

It is obvious that automation and robotics in agriculture can assist alleviate labor shortages in both seasonal and year-round labor markets. There is a great chance that these technologies will boost agricultural output. Furthermore, higher agricultural productivity promotes growth and development in a sustainable economy. Low agricultural productivity might "trap" workers in the industry, preventing them from moving into higher-skilled and more fulfilling positions that are necessary to support developed economies. It is crucial that society establish economies with enough good jobs while facilitating mobility through skill and development programs in order to prevent unemployment when escaping the "trap."

But this only shows one side of the issue. Even while the benefits of restructuring the economy and production itself are well established, this restructuring invariably results in the loss of human employment, whether they are temporary or permanent. Furthermore, autonomous systems may now more frequently perform non-standardized jobs that were previously only performed by humans at cost-effective prices thanks to advancements in programming and engineering and robotics technology. Because of this, automation is no longer limited to the standardized tasks of industrial production; rather, it is incorporated into non-standardized and non-routine processes. More significantly, automation replaces the cognitive processes performed by technical, managerial, and professional functions (such as lawyers and doctors). In light of this, it is anticipated that agricultural production will prioritize both human-machine cooperation and

the replacement of humans by machines, as is also the case in the service sector. Taking into account social interaction, collateral ethics, and legal considerations, this new agricultural ecology is getting increasingly complex.

"What are the effects of robotized agriculture on sector jobs and employment?" is a crucial subject that we examine here. Here, we offer a methodology for evaluation to identify possible effects. This work specifically addresses a conceptual analysis that pinpoints the limitations and connections between labor and technological input. To uncover the special requirements of agricultural automation, we first distinguish the production functions that are different in industry and agriculture. The impact of automation costs on labor replacement is then covered, taking into consideration the lower input costs brought about by the use of automation technologies. The subsequent phase of our methodology addresses the complementary and substitutive character of automation and labor in agricultural operations, as well as the necessary classification of agricultural jobs according to their manual or cognitive nature. We wrap up by offering a number of conceivable scenarios for integrating robotics into bio-production, qualitatively examining the relationships within the production system, and adhering to boundary conditions and limits.

A significant portion of natural resources (air, soil, land, and biodiversity) must be used as production inputs in agricultural production, which sets it apart from other production systems. It is also characterized by uncontrollable inputs that impact the productivity of farming systems, such the climate. As a result, the operating environment in agriculture is very diverse. As a result, a robotic application needs to react and act dynamically to various environmental features and structures.

The natural resource, which includes soil, climate, and plant-seed genetics, determines the potential production per unit of land. Given ideal external conditions (such as weather), a maximum possible yield for a particular combination of the aforementioned parameters exists. However, the actual yield depends on three things: a) the greatest possible yield (natural); b) uncertainty factors, such as unfavorable weather; and c) the physical capital that has been applied (labor and machinery).

The advancement of technology in recent years has led to the partial or total replacement of human labor by robots. Organizations and individuals have increasingly looked to technology as a potential substitute for human labor. It has been suggested that machines make work easier meaning that routine and repetitive work is replaced and hence this substitution between humans and machines occurs.

Based on their physical or cognitive nature and the way standardized and non-standardized operations are carried out, tasks in the industrial and service sectors can be divided into four categories. The debate over task types began in the 1970s as the need for labor input for interactive and non-routine analytical work grew in the quickly computerized industry, driving the need for labor input for routine jobs.

The degree to which machinery and automation are used in agricultural production models varies across industrialized and developing nations. Because of this technological disparity, developping nations are less productive than developed ones; that is, a significantly greater number of workers are needed in developing nations to produce a unit of agricultural output than in developed nations.

In many situations, humans and robots will collaborate. There are intricate social, legal, and ethical ramifications to this new robotic environment. Here, we examine a crucial query: How will robotized agriculture affect sector employment and jobs in the short and medium term? In addition to providing the research design and procedural framework to be followed in order to assess the impact of automation and robotics adoption in agriculture, the presented work describes the circumstances, limitations, and inherent relationships between labor input and technology input in bio-production.

ALIGNING INDIA'S CLIMATE FINANCE TAXONOMY WITH AGRICULTURAL REALITIES: A PRACTITIONER'S PERSPECTIVE

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The Indian Union Budget 2024–25 proposed the introduction of a Climate Finance Taxonomy (CFT) to guide and channel investments toward climate mitigation and adaptation etforts across sectors. In line with this announcement, the Ministry of Finance (MoF), through the Department of Economic Atfairs (DEA), has recently released a draft Climate Finance Taxonomy framework for public consultation. The proposed framework outlines high-level objectives, guiding principles, and the design architecture of the taxonomy. It also defines a methodology to classify sectoral activities and projects aligned with India's climate commitments under the Paris Agreement and its national development priorities. The draft taxonomy marks a critical step toward establishing a robust green finance ecosystem in India, but it is essential that the framework meaningfully incorporates the realities of agriculture sector.

Climate finance taxonomy is a structured system that classifies economic activities based on their contribution to climate goals. It creates a common language for investors, regulators, and policymakers, improving transparency and alignment in climate-related investments that can contribute to India's Nationally Determined Contribution (NDC) commitments. Climate action in any sector includes both Climate mitigation and adaptation, but the current framework of Agriculture sector methodology has classified only climate adaptation/climate resilience activities as to be eligible for climate financing. Though this is in line with India's climate commitments, our belief is that if the taxonomy is adopted in its current form, it may limit the overall flow of climate investments into Agriculture sector.

As part of its voluntary NDC, India has committed to reduce the emission intensity of the GDP by 45% by 2030, as compared to 2005 emission levels. After the Energy sector, agriculture is the second largest contributor (14%) to India's GHG emission profile. GHG emissions from livestock enteric emissions, Rice cultivation, Manure composting, Synthetic fertilizers and crop residue burning are the largest contributors to agriculture related emissions.

Since agriculture development is intrinsically linked to poverty alleviation and rural development in the country, Government of India

has rightfully not included any binding commitments related to agriculture related emissions. Nevertheless, drawing from the country's energy decarbonization commitments, Government of India has been pursuing multiple energy decarbonization programs in the agriculture sector (agriculture consumes nearly 1/4th of the total electricity consumption in the country).

As a climate financing practitioner with ears closer to the ground, we are seeing positive momentum behind multiple climate mitigation activities in agriculture, For example we are witnessing positive momentum built up on bioenergy:

a) Biofuels- Enabled by policy mandate - 15% mandatory blending of bioethanol with petrol, has driven most of the sugar mills to set up distillation plants and are producing ethanol and supplying it to Oil & Energy companies like IOCL, BPCL, and Nyraa.

b) Biomass fed CBG plants- states such as Uttar Pradesh, Telangana, and Madhya Pradesh have approved numerous private sector projects for establishing Compressed Biogas (CBG) plants that utilize biomass as feed.

C) Household Biogas plants- The implementation of biodigesters has also seen significant growth, supported by central government subsidy schemes like PMKUSUM and state-level programs, which have led to a notable increase in household biogas plant installations.

The current draft Climate Finance Taxonomy framework covers Bioenergy under energy sector, but there are other on demand climate mitigation activities in Agriculture which don't feature in the agriculture sector methodology. Biofertilizers, Bio stimulants and Biopesticides- almost all major agri input players have introduced product lines and are continuously innovating, for example seaweed-based bio stimulant is already established in the market. Additionally, Organic fertilizers have become a key focus, with numerous FPOs actively involved in manufacturing and sale of vermicompost, neem cakes, organic compost. Another vital area is food loss avoidance, through innovations in storage, logistics, and handling, small-scale and modular cold storage solutions have been developed, which farmers and farmer collectives can access. These solutions are vital for reducing food wastage and preventing distress sales, especially in perishable produce.

We also see latent traction in the field for other climate mitigation activities within agriculture, such as plant-based proteins, waste-to-value circularity solutions like biochar and low emission animal feeds. Additionally, there are multiple agriculture-based carbon projects that are being implemented in the field, and there are financing requirements for ditferent stakeholders participating in these carbon projects. This presents an untapped demand for climate finance that should be addressed to foster further innovation and sustainability in the sector.

It is in this backdrop that the draft framework for climate finance taxonomy has come in for public consultation. The primary role of a climate taxonomy is to direct flow of climate investments in the country, further once the taxonomy is finalized, it will be adopted by key sectoral and Agriculture nodal agencies like NABARD, SIDBI, and RBI. The classification methodology proposed in the current draft framework for agriculture sector leans exclusively on climate adaptation and climate resilience activities but climate mitigation is not considered in the taxonomy framework.

Given this context, if climate mitigation activities in Agriculture do not feature in the Climate Finance Taxonomy (under Agri Sector Methodology), then these activities will not be recognized for climate financing by key sectoral agencies. Scaling up of these activities are critical for climate action in agriculture sector and most of them have a potential to attract much needed private investments into agriculture. Hence, we believe that the Climate taxonomy in its current form will not enable the flow of much needed private investments into climate mitigation activities in Indian agriculture. Given the climate action potential and ongoing developments in agriculture, we believe the framework should include provisions that recognize climate mitigation activities in this sector, even though they don't contribute to India's NDC commitments.

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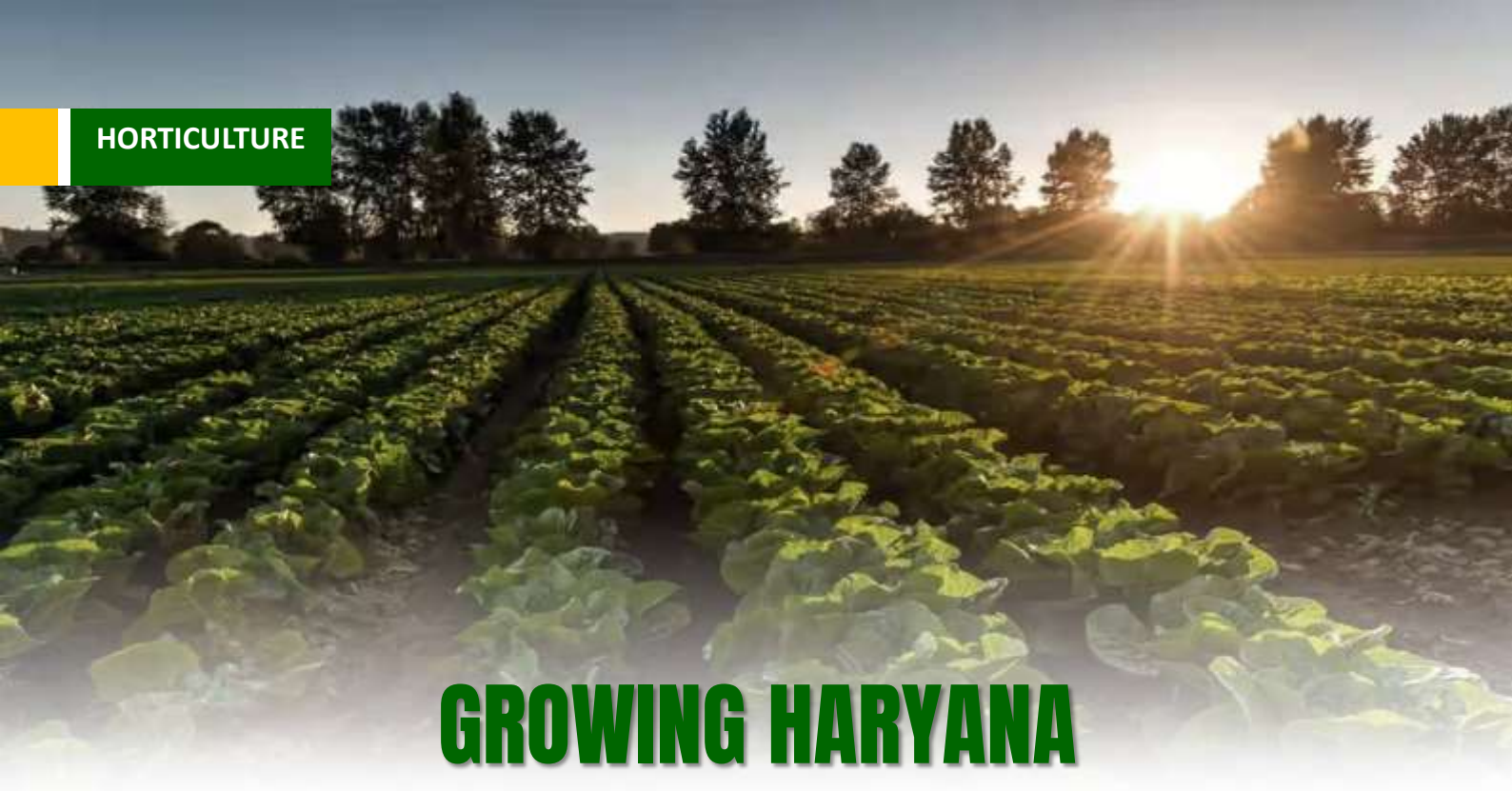
Previous Issues

Website Statistics (June 2025)

149K	58K	3.3M
Monthly Pageview	Monthly Visitor	Monthly Impression

Social Stats

6.5K	5.7K	9.3K	1.7K	2.1K



GROWING HARYANA

THE UNSUNG ROLE OF HORTICULTURE OFFICERS IN FARMERS' SUCCESS

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Haryana, traditionally known for its dominance in wheat and rice production, has witnessed a significant shift towards horticulture in recent decades. Horticulture is a specialized branch of agriculture that focuses on the cultivation of fruits, vegetables, flowers and ornamental plants. In Haryana, horticulture has gained importance as an alternative to traditional farming, offering farmers better returns, crop diversity and reduced dependency on staple crops like wheat and rice. As the demand for fruit, vegetables, flowers and ornamental plants increases, so does the need for professionals to manage and develop this sector. A Horticulture Development Officer (HDO) is one such professional who works to improve horticultural practices. To promote horticulture, the state government has appointed Horticulture Development Officers (HDOs), who play a crucial role in transforming agricultural practices. HDOs assist farmers by introducing them to modern techniques, selecting suitable horticultural crops based on soil and climate conditions, providing information about pest management and helping them access government subsidies and financial assistance. As a result of the combined effort of horticulture promotion and HDO support, farmers in Haryana have experienced significant success. Many have shifted towards high-value crops such as kinnow, guava and vegetables, leading to higher income levels, better crop quality and access to larger markets including export opportunities. In districts like Panipat, Sonipat, Sirsa, Karnal, Hisar etc. farmers have reported a doubling of their incomes within a few years, showcasing how horticulture, with the active involvement of HDOs, has transformed the agricultural landscape and improved farmers' livelihoods in Haryana.

Unveiling the crucial role of horticulture development officers

Horticulture Development Officers (HDOs) play a pivotal role in transforming Haryana's agricultural landscape by acting as key facilitators in implementing government schemes, empowering farmers and promoting innovation. At the grassroots level, HDOs ensure transparency by verifying farmers for subsidy approvals and transferring cutting-edge technologies to the field through programs like "Lab to Land." They are the primary executors of major schemes such as MFMB, MBBY, MPMY and BBY, organizing awareness campaigns, training sessions, and exposure visits, particularly during large-scale initiatives like the Viksit Bharat Sankalp Yatra. Despite limited resources, HDOs handle administrative responsibilities, often

serving as Duty Magistrates and supporting surveillance and law enforcement teams. In their extension role, HDOs certify area proofs for subsidies, assist in third-party inspections under the MIDH scheme and collaborate with various departments on crop verification, water conservation and plantation programs. At the district level, they serve as Technical Assistants (TA) and Assistant Project Officers (APO), managing grievances and administrative tasks. Specialized HDOs manage Government Garden Nurseries and Centres of Excellence, overseeing planting material production, training programs and demonstration plots. At the department headquarters, they contribute to policy execution, budgeting, reporting and interdepartmental coordination.

Haryana's recently recognized progressive farmers

1. Subhash Kamboj – Beekeeping & honey processing

- **Farmer's name**: Subhash Kamboj
- **Location:** Hafizpur Village, Yamunanagar District, Haryana
- **Started beekeeping**: 1996
- **Current bee Boxes**: ~2,000
- **Production scale:**

✓ Produces 120–130 tonnes of honey annually.

✓ Offers 23 varieties of honey and 5 other bee-based products.

✓ Also manufactures value-added products derived from honey and beeswax.

- **Economic impact:**
- Annual turnover of ₹5 crore.
- Provides direct employment to 20 people.
- Organizes training programs and exhibitions at various institutions to promote beekeeping and entrepreneurship.

Awards & recognition:

✓ **Special guest**– *Republic Day Parade 2024–25.*

✓ **CM award**– For excellence in agriculture and rural entrepreneurship.

✓ **Multiple awards**– From the Horticulture Department for innovation and contribution to the apiculture sector.

✓ **1st prize** – Krishi Mela at CCS Haryana Agricultural University, Hisar.

✓ **Featured in** – *Mann Ki Baat*, the national radio address by Hon'ble Prime Minister Narendra Modi.

2. Kanwal Singh Chauhan– Baby corn pioneer (Sonipat, Haryana)

- **Farmer's name:** Kanwal Singh Chauhan.
- **Location:** Aterna Village, Sonipat District, Haryana.
- **Occupation:** Farmer, Agripreneur, Baby corn cultivation expert.
- **Pioneering Work:** Introduced innovative and sustainable practices in agriculture.
- **Organization:** Gulab Fruits and Vegetable Growers and Marketing Cooperative Society Limited.
- **Farmers supported:** Over 200 members in the cooperative
- **Expansion milestone:** Entered vegetable canning and export operations in 2009
- **Contribution:** Elevated the commercial value of baby corn and other vegetables in Indian markets.

Institutional roles:

- **Member**, Food Authority of FSSAI.
- Ex-Governing Body Member, Indian Council of Agricultural Research (ICAR) (2019–2022).
- Ex-Board Member, Central Pollution Control Board (2015–2018).

Awards and recognitions:

- Padma Shri Award, 2019 (for contributions to agriculture and baby corn innovation).
- Champions of Change Award, 2022.
- Agriculture Leadership Award, 2021.
- AIFA Progressive Farmer Award, 2017.
- Mahindra Krishi Sammrat Award, 2015.
- IARI Fellow Farmer Award, February 2014.
- Progressive Farmer Award by the Punjab Government, February 2014.
- Award of Recognition by Directorate of Mushroom Research (ICAR), 2014.
- Award for Agricultural Contribution by Hon'ble Sh. Narendra Modi at the Vibrant Gujarat Summit, 2013.

3. Dr. Jaipal Tanwar– Greenhouse & Protected Farming

- **Farmer's name:** Dr. Jaipal Tanwar.
- **Location:** Patti kalyana, Samalkha, Panipat.
- **Work:** Cultivates vegetables and fruits using modern structures, greenhouses, polyhouses and net houses.
- **Land holding:** Over 25 acres.
- **Recognition:**
  - ✓Best Progressive Farmer Award (2020) at the Progressive Agri Leadership Summit.
  - ✓Widely regarded as a role model for tech-driven, sustainable farming.
- **Irrigation & support systems:**
  - ✓ Drip irrigation for efficient water use.
  - ✓ Bamboo stacking for crop support.
- **Dairy integration:**
  - ✓ A modern cow shed housing 100 cows.
  - ✓ Milk processing unit established on-site for value addition.
- **Concept: Farm-to-Table** – Focused on delivering fresh, high-quality produce directly to consumers
- **Annual Turnover:** ₹4 crore
- **Employment:** Provides livelihood to **65 individuals**, including **3 postgraduates (M.Sc. and Ph.D. holders)**

Recognition & awards:

- ✓ Best Progressive Farmer Award (2020)– Conferred at the Progressive Agri Leadership Summit.
- ✓ National and State Awards for innovation and leadership in agriculture.
- ✓ Recognized as a role model for modern, tech-based farming in India.
- ✓ Managed the farm at the Chief Minister's House, showcasing excellence in agricultural practice.

4. Jitendra Mann – Organic Farming Entrepreneur (Panipat)

- **Farmer's name:** Jitendra Mann
- **Location:** Dharmgarh Village, Panipat District, Haryana.
- **Land holding:** 12 acres.
- **Farming transition:** Switched from dairy farming to organic agriculture in 2015.
- **Current focus:** Cultivation of a wide variety of organic vegetables and fruits.
- **Farming approach:** Emphasizes sustainable and eco-friendly practices.
- **Income:** Generates approximately ₹15 lakh annually from organic farming operations.

Recognition & awards:

- ✓ Vice President, Organic Farming Association
- ✓ Organic Farming Award 2023
- ✓ Krishi Ratan Award 2023
- ✓ Featured in *Krishi Jagran* for his outstanding success in organic agriculture

5. Rampratap – Exotic Vegetable Cultivation (Panipat)

- **Famer name: Rampratap**
- **Location:** Panipat district, Haryana.

- **Land holding:** 6 acres.
- **Farming model:** Direct-to-consumer sales.
- **Income:** ₹4-5 lakh per acre annually.
- **Innovations:** Rampratap, a progressive organic farmer, specializes in growing exotic crops like Thai tomatoes, butternut squash, seasonal watermelons and dragon fruit.
- Agricultural practices**,** including:
  - ✓ Bamboo stacking for crop support.
  - ✓ Mulching to conserve soil moisture and suppress weeds.
  - ✓ Crop diversification**,** which enhances soil health and market value.

Recognition & media coverage:

- ✓ Featured by ETV Bharat for his work in exotic vegetable farming.

- ✓ Featured in MH News, Rohtak (2018) during the Krishi Sammelan.
- ✓ Participated in Krishi Mela 2018, showcasing crop diversification techniques.
- ✓ Honored with the prestigious Haryana Kisan Ratan Award (2019) for contributions to sustainable and diversified farming.

Services Provided by the Horticulture Department, Haryana for Farmer Welfare

The Horticulture Department of Haryana plays a crucial role in empowering and supporting farmers through a wide range of schemes, services and initiatives aimed at boosting agricultural productivity and farmer welfare. Key services include:

- **Financial support & risk management:** Subsidies, BBY for price compensation, and crop insurance under MBBY.
- **Digital empowerment:** MFMB platform ensures accurate crop data for planning and benefits.
- **Capacity building:** Training and skill development programs for farmers.
- **Horticulture & allied support:** Aid for fruit plant purchases, Honey Centres and FPOs under CCDP.
- **Sustainable farming guidelines:** Adoption of best practices per MIDH, MBBY, CCDP and protected cultivation norms**.**
- **Licensing services:** Issuance of Seed and Nursery Licenses for quality crops.
- **Citizen-centric services:** Access to SARAL, RTI, RTS, Jan Samwaad and CM Window for transparency and grievance redressal.

Author's journey as HDO

During my tenure as a Horticulture Development Officer (HDO) over the past four years, Author has witnessed firsthand the profound impact horticulture can have on rural livelihoods. With the added responsibility of overseeing multiple blocks and holding the additional charge of Technical Assistant (TA) and Additional Project Officer (APO), he gained a comprehensive understanding of both grassroots implementation and district-level coordination.

One of the most rewarding aspects of his role was motivating and encouraging farmers to adopt horticulture as a means of income generation and sustainable livelihood. Author played a key role in guiding them towards fruit orchards, mushroom cultivation, bee keeping and protected cultivation. Through regular farmer meetings, exhibitions and field demonstrations, he created awareness about departmental schemes and educated them on modern practices.

It was particularly fulfilling to witness the transformation of farmers who were once hesitant began adopting new techniques with confidence, resulting in significant improvements in crop quality and income. Many farmers across the districts of Panipat, Sonipat and Jhajjar have successfully embraced horticulture and are now earning well through these initiatives.

Author's field experiences reaffirmed a vital truth: no policy can succeed unless it is well-executed at the grassroots. As an HDO, he served as a crucial link between translating policy into action and ensuring that farmers not only benefitted from government schemes but also felt genuinely

empowered in their journey toward self-reliance.

Conclusion

The role of Horticulture Development Officers (HDOs) in Haryana's agricultural landscape is indispensable, yet often unrecognized. These dedicated professionals are not only the primary implementers of government schemes but also the lifeblood of horticulture development at the grassroots level. Their multifaceted duties, ranging from field-level interventions and technical guidance to administrative responsibilities and inter-departmental coordination, ensure that policies and programs are effectively translated into tangible benefits for farmers. HDOs play a critical part in empowering farmers, fostering innovation and driving the transition towards more sustainable, profitable and diversified agricultural practices. The success of Haryana's horticultural transformation can largely be attributed to the unwavering support and dedication of these officers. It is crucial to acknowledge their vital role and further strengthen their capacity to continue this important work. By providing them with the necessary resources, support and recognition, we can ensure that Haryana's horticultural sector thrives, setting an example for other states and fostering long-term sustainability in Indian agriculture.

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GROUNDWATER AT RISK

ADDRESSING URANIUM CONTAMINATION AND SUSTAINABLE REMEDIATION STRATEGIES

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Over-exploitation of ground-water for agricultural, industrial, and domestic purposes has led to a decline in groundwater tables, inducing oxidizing conditions that promote the formation of soluble uranyl carbonate complexes (Coyte *et al.*, 2018). Declining water levels can mobilize soil contaminants, including uranium and arsenic, into water bodies, posing significant risks to water quality. Severe declines in groundwater tables due to intense abstraction have been observed in many regions of India, particularly in the northwestern states. India, the second most populous country in the world, extracts over a third of its groundwater resources, with more than 90% used for irrigation purposes (Dalin *et al.*, 2017). The northwestern region, while experiencing groundwater depletion, also imports surface water through canal systems, which has led to water-logging issues even in ground water deficient areas. Excessive uranium concentrations in the groundwater of northwestern India have emerged as a significant concern. According to the World Health Organization (WHO, 2011), the permissible limit of uranium concentrations in drinking water is 30 parts per billion (ppb). Uranium concentrations in the groundwater of eleven Indian states exceed these permissible limits.

Table 1 presents the affected states and their respective uranium concentrations that surpass safe thresholds. Punjab is the worst-affected state, with nearly 29% of wells testing above the 30-ppb safe limit, as prescribed by both the Bureau of Indian Standards (BIS) and WHO. This contamination is alarming, particularly because groundwater is the main source of drinking water for rural and urban populations in India and across the world. Uranium contamination in groundwater poses severe health risks, making this issue a critical concern globally.

Table 1: States affected by uranium contamination and their respective concentrations

State	Max. Uranium Value (ppb)	% of Samples Beyond BIS Permissible Limit (U > 30 ppb)
Punjab	532	29.0%
Haryana	518	14.4%
Uttar Pradesh	239	9.2%
Rajasthan	186	8.6%
Tamil Nadu	159	3.4%
Madhya Pradesh	149	1.3%
Odisha	61.4	0.69%
Delhi	58.3	3.9%
Telangana	36.1	1.43%
Chhattisgarh	32	0.12%
Bihar	31.4	0.36%

Source: Groundwater yearbook 2021-22

Characteristics and sources of Uranium

Uranium is a naturally occurring element present in trace amounts in most rock, soil, and water. It is the heaviest element that exists in significant natural quantities on Earth, typically found in combination with other elements. Uranium concentrations in various rocks range from 2 to 4 parts per million (ppm), and it ranks as the 48th most abundant element in the Earth's crust. Though weakly radioactive, uranium is classified as one of the heavy metals and serves as a potent source of concentrated energy. The chemical properties of uranium are shown in Figure 1.

Key characteristics:

- **Density**: Uranium is denser than lead, making it an incredibly heavy element.
- **Radioactivity**: Though weakly radioactive, it emits alpha particles during decay.
- **Energy Potential**: Uranium-235 is a key fuel for nuclear reactors and weapons because of its ability to sustain chain reactions.
- **Chemical Reactivity**: Uranium readily forms compounds with oxygen and other elements, typically found as oxides in nature.

Uranium contamination in groundwater can result from both natural and human-made sources. Below are the primary contributors to uranium presence in groundwater (Figure 2). Increased levels of uranium have been detected globally, resulting from both anthropogenic activities (such as uranium mining and waste from nuclear facilities) and natural, geogenic sources (like uranium-rich rocks such as granite) (Abdelouas, 2006). In addition to these sources, other key factors, including the oxidation state, interactions between water and rock, and the formation of soluble uranium complexes, play a vital role in determining uranium concentrations in groundwater.

Factors responsible for Uranium contamination in groundwater

- The amount of uranium in an aquifer's rocks.
- Water-rock interactions that cause the Uranium to be extracted from those rock.
- Oxidation Conditions that enhance the extracted Uranium Solubility in water.
- The interaction of uranium with other chemicals in groundwater,

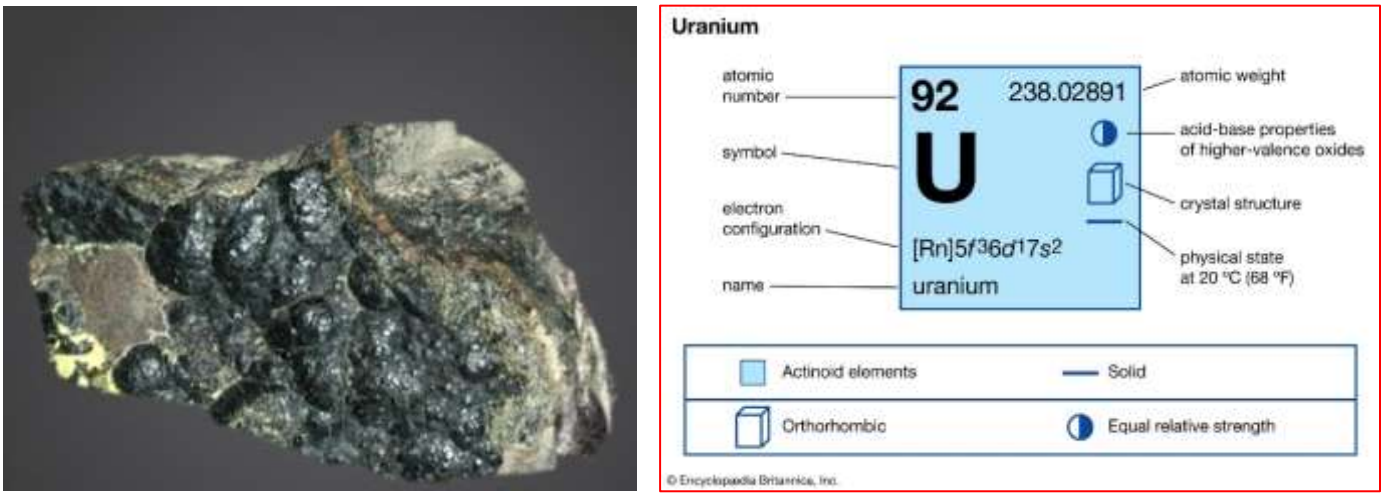

Fig 1. Uranium and its chemical properties

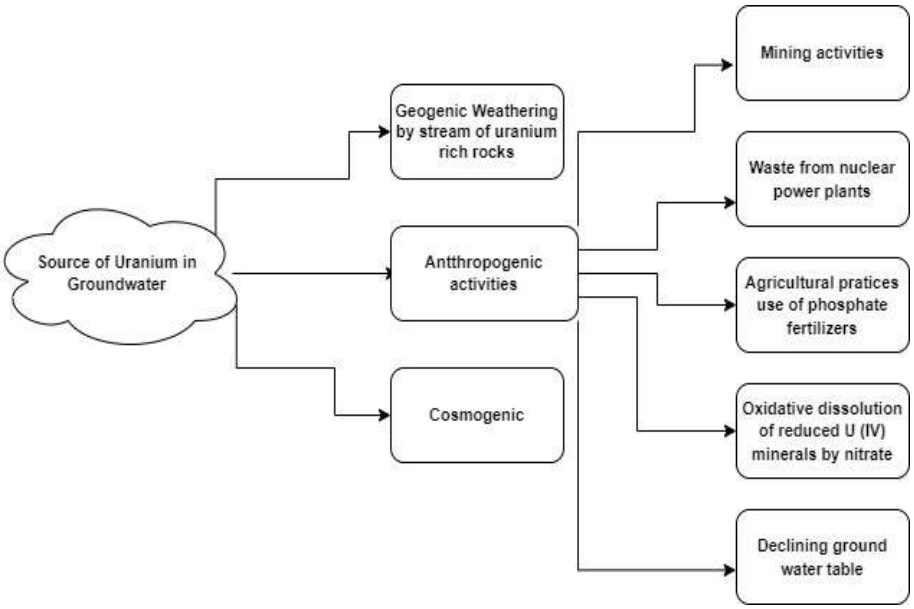

Fig 2. Different sources of Uranium in groundwater

particularly bicarbonate ions, can significantly enhance its solubility.

- Human factors such as groundwater-table decline and nitrate pollution may be exacerbating the problem.
- The formation of soluble aqueous complexes through organic and inorganic ligands significantly enhances the solubility and mobility of uranium in groundwater.
- Use of uranium-containing fertilizers and pesticides increases leaching into groundwater.
- Mining and industrial activities disturb the environment, increasing the mobilization of uranium and other contaminants into surrounding soil and groundwater.
- Uranium decay produce radon gas, which can migrate and dissolve in groundwater, leading to potential contamination of water supplies.
- Groundwater located near uranium mines or processing facilities is at a higher risk of contamination due to the proximity to hazardous materials and mining activities.

Environmental Uranium contamination and its impact on human health

Uranium contamination is a global health concern. Both natural

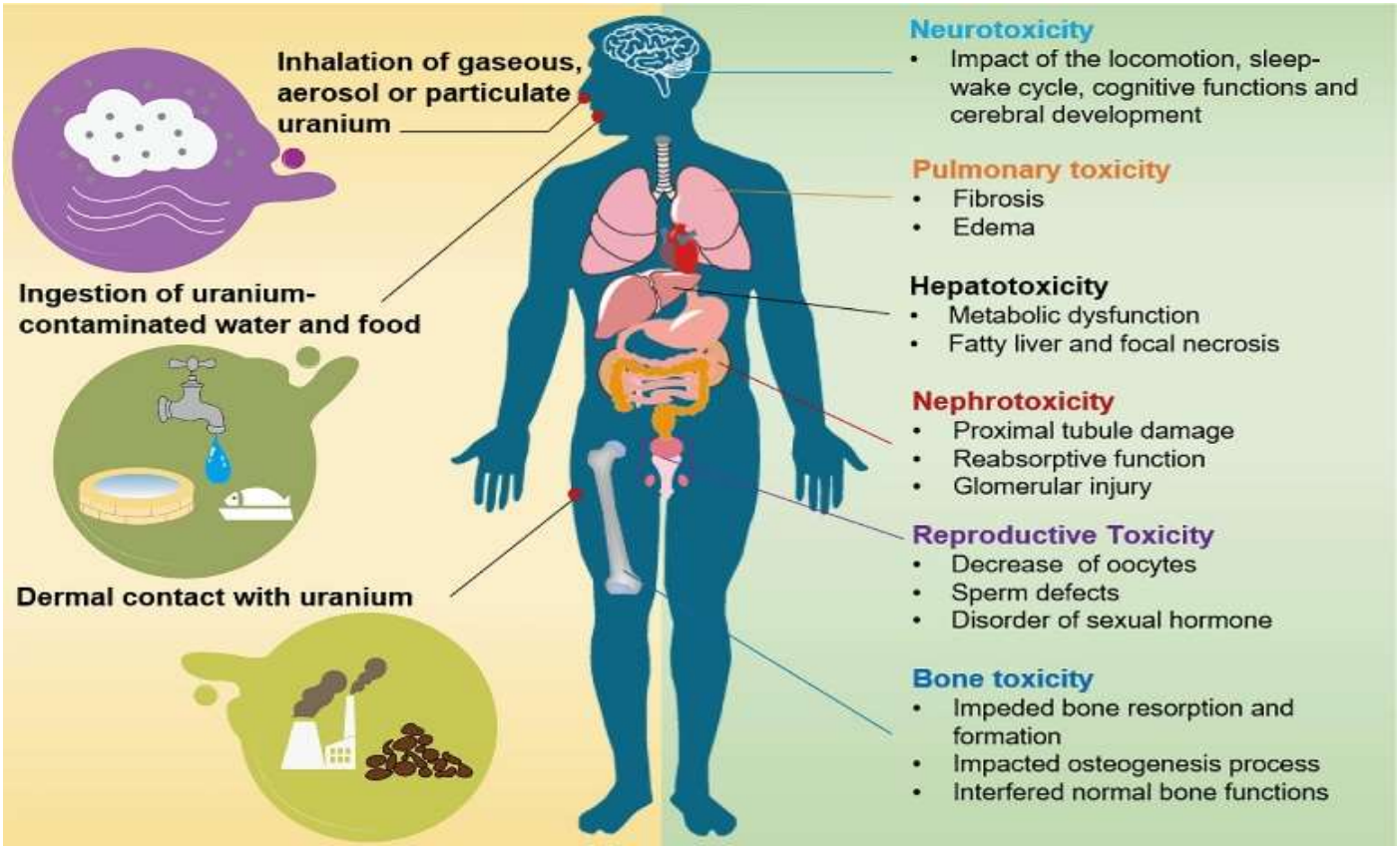

Fig 3. Uranium exposure occurs primarily through inhalation of uranium gases and aerosols, ingestion of drinking water or food, and dermal contact (left). These exposures can cause a variety of health problems, including kidney, bone, liver, brain, lungs, and reproductive system (source: *Ma et al.*, 2020).

and anthropogenic sources of uranium contamination, such as groundwater, mining, phosphate fertilizers, nuclear facilities, and military activities, are major sources of concern. Many epidemiological and laboratory studies have demonstrated that environmental and occupational uranium exposure can lead to a wide range of health problems. Uranium can accumulate in the human body through inhalation of gaseous and aerosol uranium, ingestion of contaminated water or food, and dermal contact. The health risks posed by uranium primarily stem from its chemical toxicity rather than its radioactive properties. Dissolved uranium in groundwater at high concentrations is an emerging global threat to human and ecological health due to both its radioactivity and chemical toxicity. Acute or chronic overexposure to uranium can damage the kidneys, bones, liver, brain, and lungs (ATSDR, 2013). Studies in epidemiology and toxicology have investigated the connection between uranium levels in water and chronic kidney disease (CKD), revealing that uranium exposure through drinking water is linked to nephrotoxic effects. Uranium exposure poses health risks due to both its chemotoxicity and radiotoxicity in natural and anthropogenic contexts. The health risks of natural uranium exposure- such as nephrotoxicity, bone toxicity, reproductive toxicity, hepatotoxicity, neurotoxicity, and pulmonary toxicity- are visually represented in Figure 3 (Ma *et al.*, 2020).

Analytical techniques for the determination of Uranium in groundwater

The determination of uranium concentrations in groundwater requires recent advances in instrumental analytical techniques that enable multi-element and isotope analysis of smaller samples with precision and accuracy. Some of the most widely used analytical techniques for measuring uranium and its isotopic concentrations in water samples are listed below:

- ✓ Inductively coupled plasma optical emission spectrometry (ICP-OES).
- ✓ Laser fluorimetry.
- ✓ LED fluorimetry.
- ✓ Raman spectroscopy.
- ✓ Inductively coupled plasma mass spectrometry (ICP-MS).
- ✓ High resolution inductively coupled plasma mass spectrometry (HR-ICP-MS).
- ✓ Portable analytical techniques/ methods.
- ✓ Techniques for the determination of isotope composition and isotope ratios of uranium.

Sustainable remediation strategies

The adverse health effects associated with uranium exposure through drinking water should be frequently monitored in locations where uranium concentrations exceed acceptable limits. Remedial actions are strongly influenced by uranium speciation, the presence of other pollutants, and the overall composition of the water. Addressing uranium contamination requires a holistic approach that includes prevention, monitoring, and remediation. Advancements in analytical techniques, such as laser/ LED fluorimetry and ICP-MS for lab-based analysis, and portable field instruments like LED fluorimeters and uranium sensors, have significantly improved the detection and understanding of uranium contamination in water**.** In-depth geochemical studies using isotopic tools (e.g., MC-ICP-MS) provide valuable insights into the processes and conditions that control uranium occurrence in groundwater (Balaram *et. al.*, 2022). These advances help in identifying contamination sources and refining remediation strategies**.** The remediation methods used for uranium concentrations in water are classified into physical, chemical, and biological categories. Some important sustainable remediation strategies include:

- Use of biochar and microbes.
- Nano particle technology.
- Adsorption by magnesium (Mg)-iron (Fe)-based hydrotalcite-like compounds (MF-HT).
- Defluoridation techniques (remove fluoride and uranium) and other techniques.
- Phytoremediation.
- Permeable Reactive Barriers (PRBs).
- Ion Exchange and Adsorption Technologies.
- Chemical Precipitation.
- Bioremediation.
- Evaporation.
- Coagulation.
- Adsorption.

■■■

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A quick comparison of the top-performing agriculture websites based on monthly organic search traffic.

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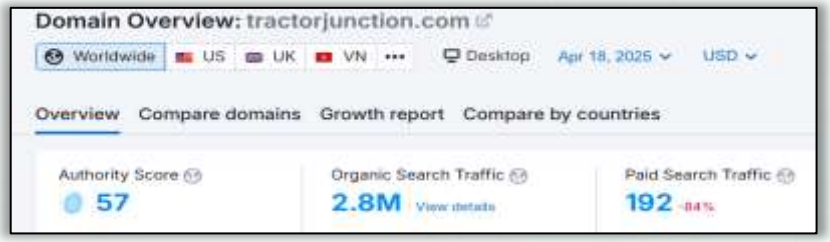

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