National Seed Association of India

Volume 12 No. 2, May - August 2019

Seed Times

The National Seed Association of India Magazine

DIGITAL AGRICULTURE


बीज बदलो...
भाग्य बदलो....
शुरुआत बढ़िया होगी तो परिणाम अच्छा होगा।
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ABOUT NSAI

National Seed Association of India (NSAI) is the apex organization representing the Indian seed industry. The vision of NSAI is to create a dynamic, innovative and internationally competitive, research based industry producing high performance, high quality seeds and planting materials which benefit farmers and significantly contribute to the sustainable growth of Indian Agriculture.

The mission of NSAI is to encourage investment in state of the art R&D to bring to the Indian farmer superior genetics and technologies, which are high performing and adapted to a wide range of agro-climatic zones. It actively contributes to the seed industry policy development, with the concerned governments, to ensure that policies and regulations create an enabling environment, including public acceptance, so that the industry is globally competitive.

NSAI promotes harmonization and adoption of best commercial practices in production, processing, quality control and distribution of seeds.

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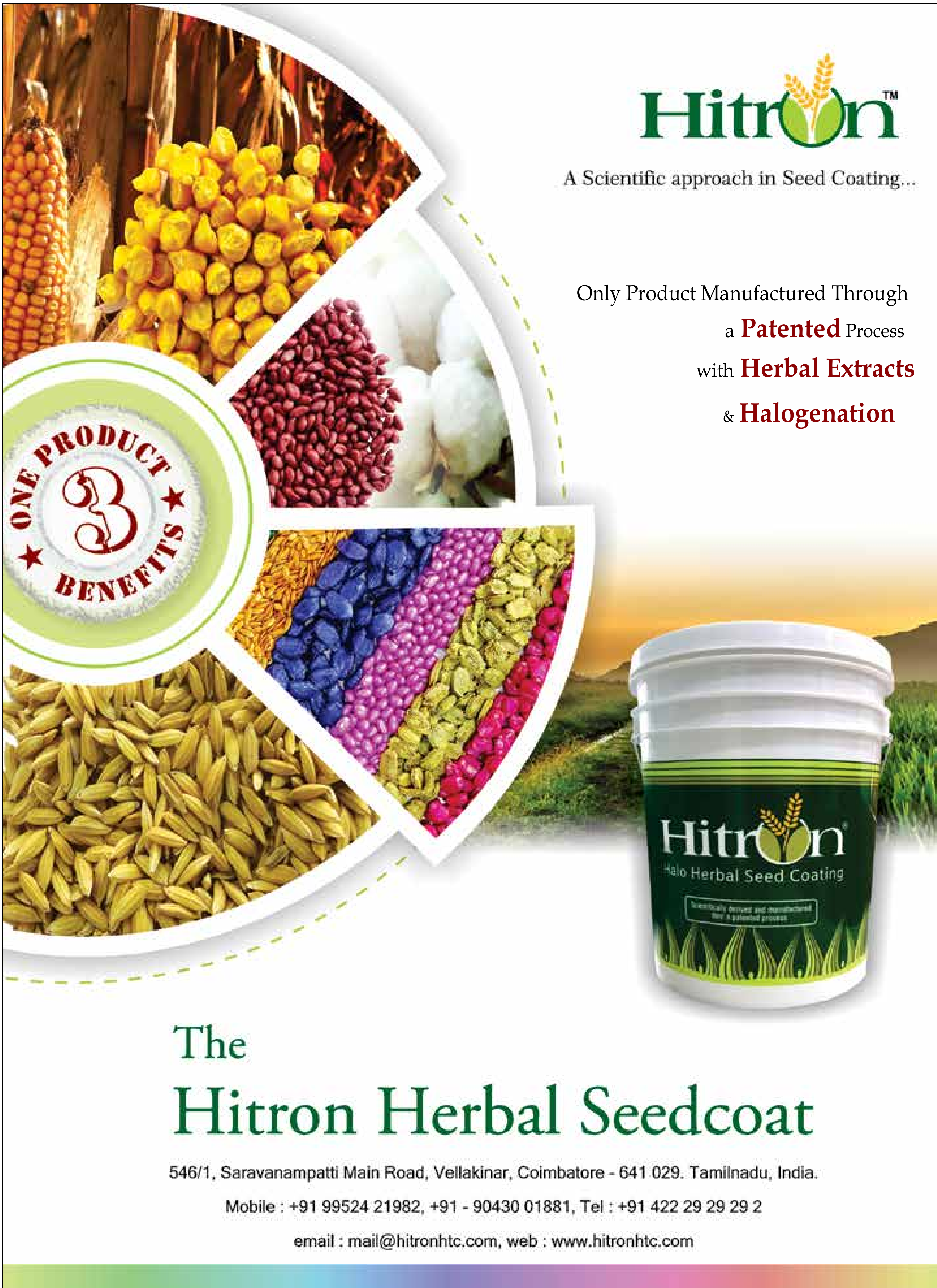
TABLE OF CONTENTS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Message
from Desk of
President

This is the age of New India, and a dawn for Indian agriculture is breaking on the horizon. The influx of the modern technology and indigenous innovation is seeding new growth for our farmers and Indian seed sector.

Our Prime Minister Narendra Modi has already announced India's plans to embrace the Digital Age. The seed industry is rapidly responding to the call of Digital India as it brings efficiency and transparency within sector. One such initiative deals with the bar coding of seed packets. NSAI has been very actively pursuing this cause by conducting workshops and engaging with all stakeholders. Very soon each farmer and trader can authenticate each seed packet. This is part of our digital agriculture mission within the industry.

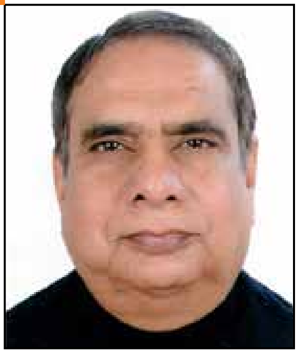
Smart systems can aid the farmer decide on optimal use of fertilizers, seeds and other farm inputs. New technologies such as weather monitoring & forecasting with the help of satellites, drones, AI and integrated farming systems are enabling us to make smart decisions. These steps when synced can generate more prosperity for farmers but also save precious resources such as water. The seed industry can monitor and see progress as our seeds traded across India too. Advancements in digital agriculture have opened up a feedback system for us, through which we can constantly learn and innovate for the future. India has to embrace digital agriculture as a tool to become a leader in agricultural production.

I thank the contributors and team for bringing together this Seed Times on Digital Agriculture. I hope you all read this and help India and your business achieve higher efficiency and success harmonization with new technologies.

Happy reading!

M Prabhakar Rao

Message
from Desk of
Executive Director



With more than half a billion internet subscribers, India is one of the largest and fastest-growing markets for digital consumers. As digital capabilities improve and connectivity becomes omnipresent, technology is poised to quickly and radically change nearly every sector of India's economy. That is likely to both create significant economic value and change the nature of work for millions of Indians.

With internet services connecting most places in India, our villages and farmers are not left out anymore. While the Digital age is creating new work and jobs, it has the capacity to be a catalyst for transformation for the seed sector.

A majority of Indian farmer households now have the power of internet and the smart phone to aid them in making informed choices on seeds and other new methods to boost their farm. Digitalization is enabling improvements in government services and bringing efficiency in the Indian seed market.

In this edition, we have covered the Prime Minister's vision of "Digital India". There is much promise in digital applications to improve farmer livelihoods. Indian agriculture needs to be made more market-oriented through reform in existing policies, as government also provides enabling environments for digital innovation. This laudable objective could not only improve the well-being of our farmers but will also trigger to boost agri-based industrial growth in rural India. All these are vital steps to bring India to the next level of development and ensuring that our national goal of doubling farmers' incomes is met at the earliest.

I hope the readers would greatly be benefited from the magazine.

Happy Reading!

R K Trivedi

Precision Agriculture, Future of Agriculture

Mrinali Manohar
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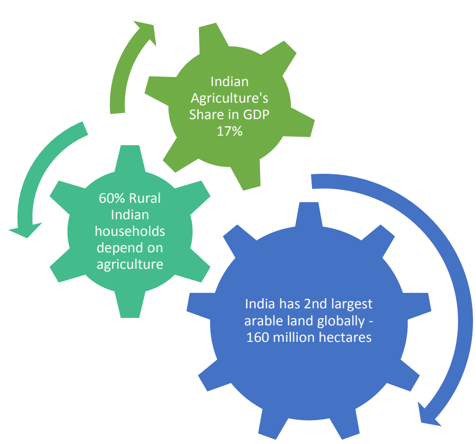
Introduction

Precision Agriculture is an information and technology-based farm management system to identify, analyze and manage inter and intra-field variability for optimum utilization and protection of land & water resources and other farm inputs with an aim towards overall sustainability and profitability.

Precision Agriculture is an information and technology-based farm management system to identify, analyze and manage inter and intra-field variability for optimum utilization and protection of land & water resources and other farm inputs with an aim towards overall sustainability and profitability. Precision Agriculture, also called as **Site-specific or Smart Farming** utilizes advanced technological interventions of current age like Artificial Intelligence(AI) and machine learning, Drones/Robotics, remote sensing and satellite imagery, GPS and GIS, Internet of Things (IoT), Big Data Analytics, Blockchain Technology, Smartphone applications to make better decisions about many aspects of crop production in the cyber-physical farm management cycle.



Need for Precision Agriculture

Two massive challenges in front of world by 2050 would be feeding a population of about 9 billion and mitigating the risk of climate change on global food security (Gerald et al., 2010). The impact of climate change is unprecedented and has been a threat to food security with the potential to adversely impact agricultural production and productivity throughout the world. According to the IPCC Special Report, 2018 human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. Global warming and climate change may lead to various biotic and abiotic stresses like drought stress, salinity stress and heat shocks which may adversely affect yield and quality of farm produce. Farmers usually know that their fields have yield variability across the landscape, which needs to be averaged to optimize farm income. These variations can be traced to management practices, soil properties like total organic matter, texture, structure, moisture, aeration, macro & micronutrient status and landscape position. Alongside, environmental variations like prevailing weather, rainfall, sunshine, presence of pests & diseases also cause crop yield variation. These variations can be marginal to substantial in magnitude that may cause low overall lower yield than expected.

Global warming and climate change may lead to various biotic and abiotic stresses like drought stress, salinity stress and heat shocks which may adversely affect yield and quality of farm produce.

The potential of Precision Agriculture for economic and environmental benefits can be ushered by **Climate Smart Agriculture (CSA)** which calls for reorienting and restructuring conventional agricultural systems with climate-smart farm technologies like precision planting/sowing, precision application of fertilizer/ pesticide/weedicide, automated milking of farm animals. This would optimize cost of cultivation, enhance farm production and productivity and improve farm income.

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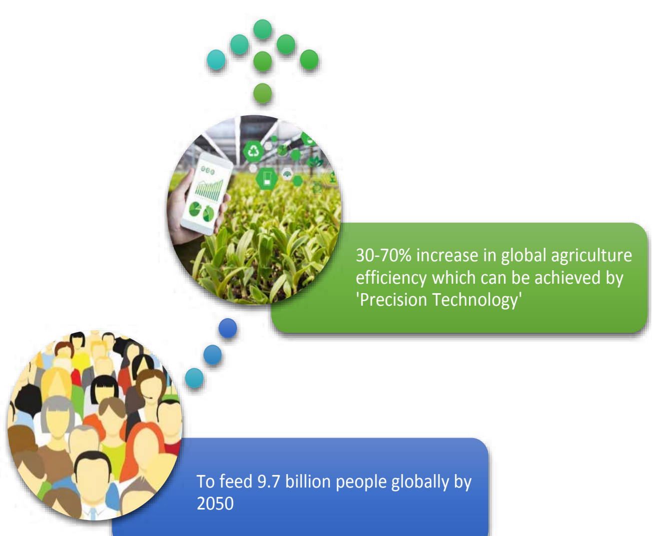

Technologies for Precision Agriculture

1. Global Positioning System (GPS)

GPS does yield monitoring and mapping through highly mechanized systems which provide feedback in determining the effect of managed inputs such as fertilizer amendments, seeds, pesticides, cultural practices including tillage and irrigation.

Global Positioning System (GPS) is a satellite navigation system that furnishes location and time-specific information in all climate conditions to the user (here agricultural scientists and farmers). GPS satellites broadcast real-time signals that allow GPS receivers to compute their location. Having precise location information at any time allows soil and crop measurements to be mapped with an accuracy of 300ft. GPS does yield monitoring and mapping through highly mechanized systems which provide feedback in determining the effect of managed inputs such as fertilizer amendments, seeds, pesticides, cultural practices including tillage and irrigation. Since yield measurements for a single year may be heavily influenced by weather, therefore, yield data of several years is collected including data from extreme weather years to pinpoint whether the observed yield is due to management or climate-induced. GPS also facilitate in grid soil sampling and variable-rate fertilizer application by generating a map of a nutrient requirement called application map.

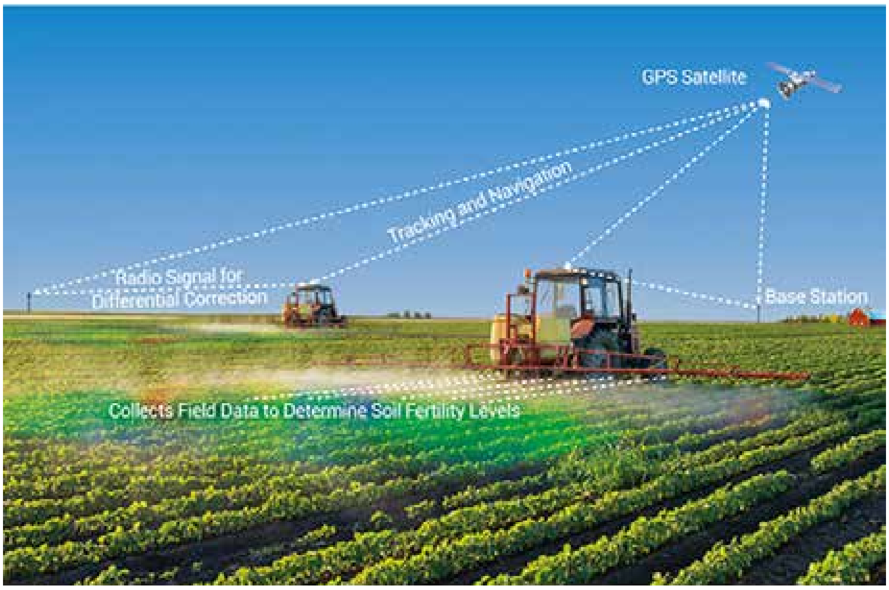

Fig 1: GPS system in agriculture

Satellite imagery (also known as Earth Observation Imagery or Spaceborne Photography) are images of Earth or other planets collected by imaging satellites operated by governments and businesses around the world.

2. Satellite imagery

Satellite imagery (also known as **Earth Observation Imagery or Spaceborne Photography**) are images of Earth or other planets collected by imaging satellites operated by governments and businesses around the world. All satellite images produced by **National Aeronautical and Space Observation (NASA)**, US Space agency are published by NASA Earth Observatory and are freely available at the public domain for scientific use. **NASA's LANDSAT** enables one to analyze the health and vigor of crops as they mature over the growing season; the field-specific needs like fertilizers, number of irrigations, and rotation; planted acreage to forecast crop production; the amount of water for irrigation, the impacts of drought and fight crop insurance fraud. Feasible water footprint (WF) assessment system of agricultural crops for the efficient use of available water resources was developed by the integration of remote sensing technology (Landsat-8 satellite images) and weather data from the agro-meteorological station (Madugundu et al.,2018). NASA's Satellite crop monitoring technology facilitates real-time crop vegetation index monitoring via spectral analysis of high-resolution satellite images for different fields and crops which enables to track positive and negative dynamics of crop development. Food and farming organizations rely on the unbiased, accurate and timely information provided by Landsat satellites. Several other countries have satellite imaging programs, a collaborative European effort launched the **ERS** and **ENVISAT** satellites carrying various sensors. Russian Federal Space Agency manufactured **GLO**bal **NA**vigation **S**atellite **S**ystem **(GLONASS)**, Russia's space-based satellite navigation system operating as a part of a radio navigation-satellite service which provides an alternative to GPS and is the second navigational system in operation with global coverage of comparable precision.

The organization responsible for space program in India is **Indian Space Research Organisation (ISRO)** which has conceptualized crop production forecasts using satellite remote sensing data leading to the success of CAPE (Crop Acreage and Production Estimation) project, done with active participation of Ministry of Agriculture and Farmers' Welfare (MoA&FW), towards forecasting of production of crops in selected regions. To enhance the scope of this project, the FASAL (Forecasting Agricultural Output using Space, Agro-meteorology and Land-based Observations) program was conceptualized, by developing a methodology for multiple in-season forecasts of crops at the national scale. A centre named Mahalanobis National Crop Forecast Centre (MNCFC) was established by MoA&FW in New Delhi on April 2012 which operationally uses space-based observations at the national level for pre-harvest multiple crop production forecasts of nine field crops. Crops covered are wheat, rice, jute, mustard, cotton, sugarcane, rabi & Kharif rice, and rabi sorghum.

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Fig 2: ISRO satellite image of wheat growth progression

3. Remote Sensing

Indian Space Research Organization (ISRO's) remote sensing-based acreage and yield forecasts based on weather parameters or spectral indices are used to provide production forecasts. The center is also actively involved in the national level assessment of horticultural crops and their coverage across the agro-climatic regions in the country.

Remote Sensing is the acquisition of information about an object or any phenomenon without making any physical contact with the object. Electronic cameras record near-infrared images. Remote sensing has found significant use in the field of agriculture like in crop production forecasting, assessment of crop damage and progress, horticulture and cropping system analysis, crop acreage estimate, identification of planting and harvesting dates, crop yield modeling and estimation, crop condition assessment and stress detection, identification of pest and disease infestation, nutrients and compaction, soil mapping and soil moisture estimation, irrigation monitoring and estimation of drought, land cover and land degradation mapping determination of water content of field crop, water resource mapping, weather forecasting. Indian Space Research Organization (ISRO's) remote sensing-based acreage and yield forecasts based on weather parameters or spectral indices are used to provide production forecasts. The center is also actively involved in the national level assessment of horticultural crops and their coverage across the agro-climatic regions in the country. United States Department of Agriculture (USDA) undertakes various field experiments and inter-disciplinary programs like:

A) LandSAT-7Science Team Program which is a NASA funded project that develops operational techniques for the use of Landsat TM and ETM+ data for agricultural and natural resource management.

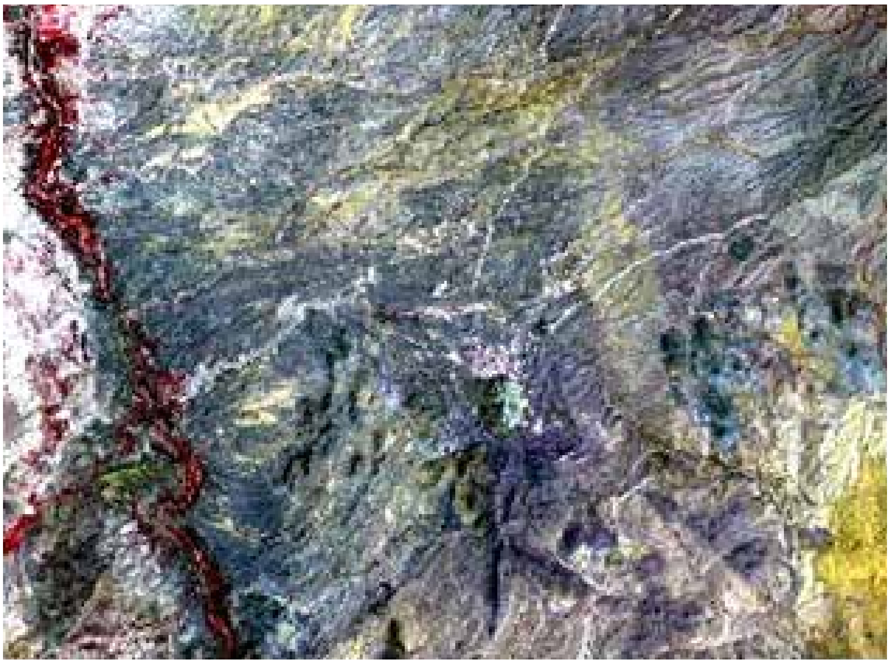

Fig 3: LANDSAT Thematic Mapper plus Color Composite

B) RANGES program proposes to use NASA's EOS (Earth Observation System) products to provide critical information to end-users on an operational basis for livestock management, fire-fuel estimation, wildlife habitat analysis and rangeland health assessment.

Fig 4: NASA's Earth Observation System (EOS)

C) Walnut Gulch '92 was a field campaign conducted during the dry, early-monsoon, mid-monsoon, post-monsoon and "drying" seasons from April through November 1992. The overall research goal was to investigate the seasonal hydrologic dynamics of the region and to define the information potential of combined optical-microwave remote sensing (Moran et al., 1996).

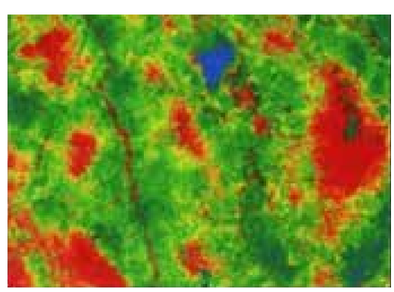

Fig 5: Images of surface temperature and reflectance (color composite) measured by the Landsat-5 TM

4. Artificial Intelligence

Artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially computer systems. Artificial Intelligence in agriculture broadly includes Agricultural Robotics, Crop & Soil Monitoring and Machine Learning. Today, agriculture is the top industry sector for AI application in the government sector in India. Internationally, the estimated value added by the agricultural industry in the USA was estimated at just under 1 percent of the US GDP in 2016. The US Environmental Protection Agency (EPA) estimates that agriculture contributes roughly $330 billion in annual revenue

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to the economy. Factors such as climate change, population growth, and food security concerns have propelled the industry into seeking more innovative approaches for protecting and improving crop yield. As a result, AI is steadily emerging as part of the industry's technological evolution.

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Advancements in AI have facilitated autonomous, large scale analysis of imagery within a minute and with a negligible degree of error. AI can differentiate between different types of soil, forest, vegetation and water tables/groundwater at varied locations. Researchers are using AI in monitoring satellite images for disease & pest management in vineyard and grape as well as to determine wheat and paddy harvest size in developing countries. Projects like SpaceKnow from Los Angeles, case studies conducted in near real-time of deforestation due to wildfires in California by planetary analytics company, manufacturing activity in China, measuring GDP in Africa, deconstruction in rural Mali and Solar energy in Dubai are the excellent examples of the use of AI.

Fig 6: Use of AI in Smart Farming

5. Robotics

Robotics in crop harvesting is also emerging to help address challenges in the labor force. The industry is projected to experience a 6 percent decline in agricultural workers from 2014 to 2024. Lead investor Illumina helped develop the system which uses machine learning to provide clients with a sense of their soil's strengths and weaknesses. The emphasis is on preventing defective crops and optimizing the potential for healthy crop production.

Agricultural Drones are unmanned aerial vehicles applied to the farm to help increase crop production and monitor crop growth. Sensors and digital imaging capabilities can give farmers a richer picture and a bird's eye view of their fields to solve issues such as irrigation problems, trouble spots, soil variation, and pest-fungal infestations. Multispectral images show a near-infrared view as well as a visual spectrum view. The combination shows the farmer the differences between healthy and unhealthy plants, a difference not always clearly visible to the naked eye. Thus, these views can assist in assessing crop growth and production. Automatic Milking Systems are computer-controlled stand-alone systems that milk dairy cattle without human labor. The complete automation of the milking process is controlled by an agricultural robot, a complex herd management software, and specialized computers. Automatic milking eliminates the farmer from the actual milking process, allowing for more time for supervision of the farm and the herd. Farmers can also improve herd management by using the data gathered by the computer. By analyzing the effect of various animal feeds on milk yield, farmers may adjust accordingly to obtain optimal milk yields. Since the data is available down to an individual level, each cow may be tracked and examined, and the farmer may be alerted when there are unusual changes that could mean sickness or injuries.

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Fig 7: Robotics in Agriculture

6. Geographical Information System (GIS)

Geographical Information System uses computer-aided mapping and analyses existing events happening on the earth. GIS technology desegregates database operations like an interrogation and statistical analysis with unparalleled visual imaging and geographical analysis extended by geo-maps. In the field of agriculture, GIS does follow applications -

Geographical Information System uses computer-aided mapping and analyses existing events happening on the earth.

Geotagging is the process of adding geographical information in the form of metadata.

1. GIS uses computer hardware and software systems that further utilize featured attributes and location data to produce maps and store layers of information like yields, soil survey maps, analysis of crop production, remotely sensed data, crop scouting reports, and soil nutrient levels, and pollution control.
2. GIS services include Utility Mapping Services, Remote Sensing, Contour Mapping Services, Topographic Mapping Services, and Image Processing Services.
3. Environmental management uses GIS for natural resource management, water quality, waste management, and groundwater modeling.
4. Forest Department utilizes GIS for the mapping and geo-tagging of flora and fauna in forest areas. Geotagging is the process of adding geographical information in the form of metadata. The data usually consists of coordinates like latitude and longitude, but may even include bearing, altitude, distance and place names.

Farmers in severe-weather prone areas (like flood plains or drought zones) would be able to predict the effect of weather on crops, could move fields to better geographic locations, and could choose irrigation methods based on local water resources and weather patterns. Thus, the world food crisis could be alleviated by the use of GIS.

Internationally, Agricultural Geographic Information System Laboratory (AGIS) at the University of California, Davis is deeply involved in the advancement of the agriculture/GIS relationship. This AGIS lab researches the effects a watershed area has on soil nutrients, the use and movement of pesticides on crops, mapping water use and availability in rural agricultural areas as well as cities, tracking potential plant diseases, and expanding the GIS capabilities to cover the entire state. In addition to expanding the potential uses of GIS the AGIS Laboratory is dedicated to disseminating the information they gather to local farmers, wineries, and city officials to best help promote healthy change in behaviors that affect the agricultural outputs of California. With the permeation of technology in the global culture today it is possible that in a few years GIS could be available to rural farmers in the developing world to better help them grow crops, feed their families, and produce food not only for self-sustainability but also for out boundary shipping. Farmers in severe-weather prone areas (like flood plains or drought zones) would be able to predict the effect of weather on crops, could move fields to better geographic locations, and could choose irrigation methods based on local water resources and weather patterns. Thus, the world food crisis could be alleviated by the use of GIS.

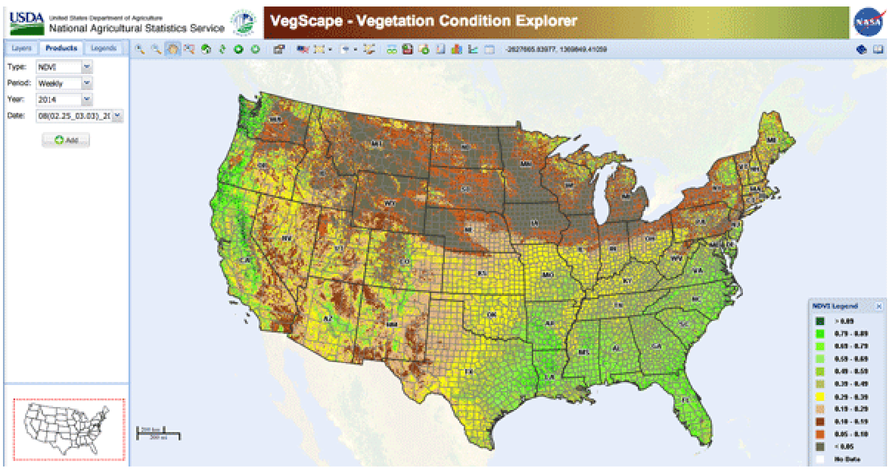

Fig 8: Vegetation Condition Explorer Map by USDA

7. Big Data Analytics

While Precision Agriculture is just taking in-field variability into account, Smart Farming goes beyond that by basing management tasks not only on location but also on data, enhanced by context and situation awareness, triggered by real-time events. Big Data is a term for data sets that are so large or complex that traditional data processing applications are inadequate for their processing. Big data analytics require a set of techniques and technologies with new forms of integration to reveal insights from datasets that are diverse, complex, and of a massive scale. Big Data technologies play an essential, reciprocal role in farming like Farm machines can be equipped with all kind of sensors that measure data in their environment that can be used further by the farmer. This varies from relatively simple feedback mechanisms (e.g. a thermostat regulating temperature) to deep learning algorithms (e.g. to implement the right crop protection strategy). This also implies the importance of metadata i.e. 'data about the data' like time, location, and standards used in farming.

Big Data applications go beyond primary production, influencing the entire food supply chain. These are being used to provide predictive insights in farming operations, drive real-time operational decisions, and redesign business processes for game-changing agribusiness models. Several authors, therefore, suggest that Big Data technologies will cause major shifts in roles and power relations among players in current food supply chain networks (Sjaak et al., 2017). The landscape of stakeholders exhibits an interesting game between powerful tech companies, venture capitalists, often small start-ups, and new entrants in agriculture. The future of Smart Farming may unravel two extreme scenarios: 1). Closed, proprietary systems in which the farmer is part of a highly integrated food supply chain or 2). Open, collaborative systems in which the farmers and stakeholders in the chain network are flexible in choosing business partners as well for the technology as for the food production side.

The future of Smart Farming may unravel two extreme scenarios: 1). Closed, proprietary systems in which the farmer is part of a highly integrated food supply chain or 2). Open, collaborative systems in which the farmers and stakeholders in the chain network are flexible in choosing business partners as well for the technology as for the food production side.

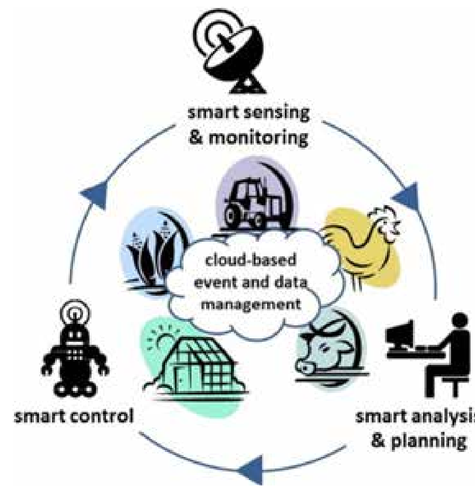

Fig 9: Cyber Physical management of Smart Farming

8. Block Chain Technology

> To overcome this problem, any activity can be documented in a distributed ledger with a consensus with participating stakeholders; each party will have a smart contract and copy of the same distributed ledger that will enable information access in new real-time; transaction done at each level will be updated to all stakeholders through the blockchain.

Blockchain Technology involves block-digital information and chain- public database. A blockchain is a decentralized, distributed, and public digital ledger that is used to record transactions across many computers so that the involved record cannot be altered retroactively, without the alteration of all subsequent blocks. A typical agricultural supply chain involves interconnected processes between various stakeholders like producers, quality control inspectors, inspection and insurance companies, logistics and supply chain agency, banks, manufacturer, the consumer. These stakeholders find it difficult to trace the origin and quality of produce, as the produce and the information flow between these stakeholders is sequential or disrupted (OECD report 2019). To overcome this problem, any activity can be documented in a distributed ledger with a consensus with participating stakeholders; each party will have a smart contract and copy of the same distributed ledger that will enable information access in new real-time; transaction done at each level will be updated to all stakeholders through the blockchain. Most promising uses of Blockchain Technology in agriculture are as follows

1. Overseeing farm machinery
2. Enhancing agricultural supply chains
3. Modernizing farm management software
4. AgTech IoT optimization
5. Tracing and tracking farm commodities
6. Fair pricing

7. Overseeing agricultural subsidies
8. Community-supported agriculture
9. Mobile remittance for Small Farmers
10. Greater accountability for multinationals
11. Incentivizing sustainable practice

Fig 10: Blockchain Technology in Agriculture

Benefits to Indian Farmers –

1. Farmers implementing precision agriculture tools are likely to work closely with several experts in agriculture, GPS, remote sensing, big data analytics, blockchain technologists, computational sciences which would enhance and upscale their farm processes and income.
2. Satellite imagery and GPS would provide farmers with real-time site-specific information in hand which would improve the crop monitoring, crop stress, crop health, livestock management and farm decision making to increase yield as well as income.
3. Use of Artificial Intelligence and Machine learning as in precision seeding, precision sowing and precision planting would provide for more efficient, precise farming with more accountability.
4. IoT with the help of sensors and farm management software would improve the risk-bearing ability of the farmer on crop-loss due to biotic and abiotic stresses.
5. Blockchain technology would help in tracking and tracing Agricultural commodities from farmers to consumers.
6. IoT has a wide scope in managing cold chain, supply chain, and inventory management for monitoring and product quality assurance.

Use of Artificial Intelligence and Machine learning as in precision seeding, precision sowing and precision planting would provide for more efficient, precise farming with more accountability.

7. IoT based Wireless Sensor Network (WSN) for pest and disease forewarning, irrigation scheduling, weather forecasting, etc. has wide application in the future.
8. Robotics/ UAV/Drones in farm operations like harvesting in cotton, plucking in coffee/tea, bud cutting in sugarcane, spraying, irrigation, etc. can streamline the processes in commercial production.
9. Foster greater traceability of farm inputs like seed by barcoding thus, spurious or low-quality seeds can be eliminated from the seed supply chain.
10. Perspective farming i.e. Big Data Analytics on a farm can determine variable planting rates to accommodate varying conditions across a single field, to maximize the yield.
11. Digital grading of fruits, vegetables, spices, etc. can be implemented at low cost covering large geographic areas.
12. Custom Hiring application on farm equipment/inputs through mobile apps can help small and marginal farmers in pooling farm resources on sharing basis.
13. Satellite imaging may also help in exploring actual evapotranspiration, photosynthetic activity, delineation of waterlogged or salt-affected areas and this information may be used in reducing risk and economic losses.
14. Digital herbarium, digital genebanks, digital field data, Gene/QTL sequencing data, digital databases can collaborate with Big Data Analytics.

Foster greater traceability of farm inputs like seed by barcoding thus, spurious or low-quality seeds can be eliminated from the seed supply chain.

Digital herbarium, digital genebanks, digital field data, Gene/QTL sequencing data, digital databases can collaborate with Big Data Analytics.

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PGR Informatics at **ICAR-National Bureau of Plant Genetic Resources**

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Abstract

ICAR-National Bureau of Plant Genetic Resources is the nodal organization in India for the management of plant genetic resources. The Bureau houses the Indian National Genebank which is second largest in the world with more than four lakh accessions belonging to all major crop species conserved ex-situ. PGR Informatics assists genebank scientists in efficient PGR management; facilitates enhanced utilization of diverse germplasm through enhanced access to the information; ensures compliance to information management and sharing in accordance with global conventions and treaties. ICAR-NBPGR

The Bureau houses the Indian National Genebank which is second largest in the world with more than four lakh accessions belonging to all major crop species conserved ex-situ.

has developed various databases (documentation and management) and online applications (public access) demonstrating the in-house strength in PGR informatics which are described briefly in this overview.

Key words: Database; PGR Informatics; PGR Portal; Plant Genetic Resources

Introduction

An organized digital information system provides a fair and just opportunity for all to access. Plant Genetic Resources Informatics or PGR Informatics is the management (creation, storage, retrieval, and presentation) and analyses (discovery, exploration and extraction) of diverse information (facts, figures, statistics, knowledge and news) related to PGR. PGR Informatics has come to the limelight due to (i) Increased awareness about PGRFA; (ii) Various international agreements coming into force; (iii) Availability of information in text, images, maps, videos; (iv) Technologies to record, link and archive such diverse types of information; and (v) Ever-increasing power of computers and internet to facilitate access and retrieval.

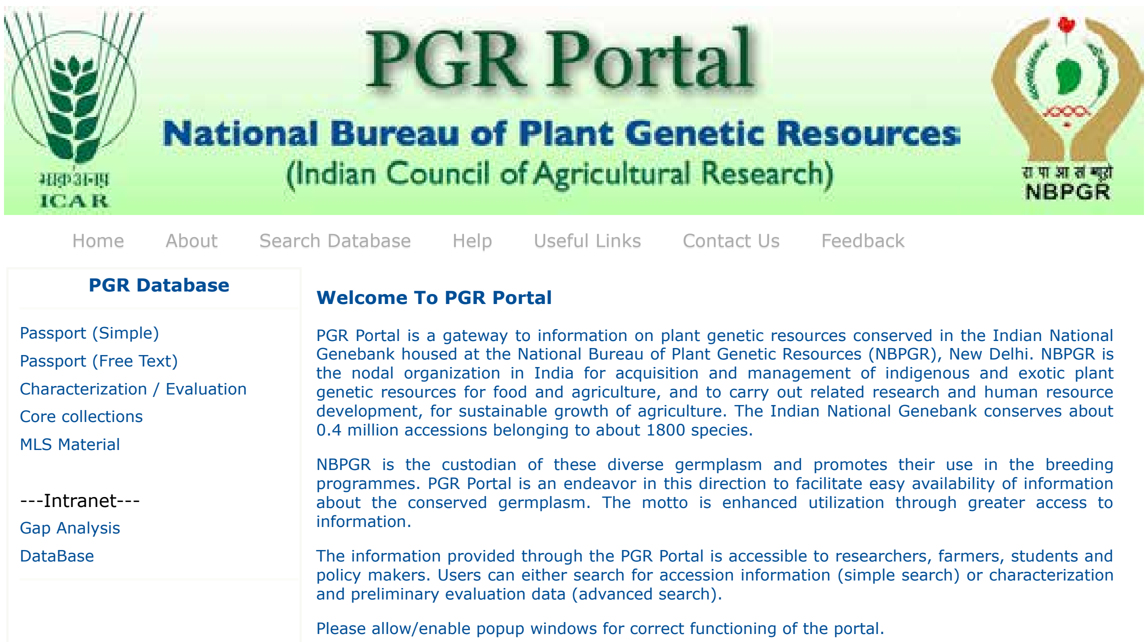
The National Bureau of Plant Genetic Resources (NBPGR) Plans, conducts, promotes, coordinates and provides the lead in activities of collection, conservation, evaluation, introduction, exchange, documentation and sustainable management of diverse germplasm of crop plants, crop wild relatives and landraces.

The National Bureau of Plant Genetic Resources (NBPGR) Plans, conducts, promotes, coordinates and provides the lead in activities of collection, conservation, evaluation, introduction, exchange, documentation and sustainable management of diverse germplasm of crop plants, crop wild relatives and landraces. Ever-increasing challenges to crop production demand the development of varieties that yield better in the face of biotic and abiotic stress. Crop improvement depends upon the availability of diverse germplasm. PGR Informatics assists genebanks in reaching the breeders, researchers, and students. To cater to internal requirements, to make available useful information on PGR to breeders and to keep up with the spirit of international instruments of information sharing, NBPGR has developed in-house information systems. Some of the applications are described here:

PGR Portal:

Information on as many as 3,11,575 indigenous and 52,972 exotic accessions are accessible in the PGR Portal now.

PGR Portal is an open-access information portal on plant genetic resources conserved in the National Genebank of NBPGR. Information on as many as 3,11,575 indigenous and 52,972 exotic accessions are accessible in the PGR Portal now. Information on as many as 25,420 accessions was added in 2014. In addition to the continuous activity of testing and bug-fixing, addition of new features like "Gap analysis" and "Database" were added for internal activities. In PGR database management, about 12,000 new accessions were allocated IC numbers. Data curation and correction of about 60,000 (both IC and EC) accessions was carried out. The target of porting about 4 lakh data records and implementation of genebank database was achieved. Data on crop groups were refined, an option of new species additions was built, and additional user reports for accessing data species-wise or biological-status wise were created.



PGR Portal

National Bureau of Plant Genetic Resources

(Indian Council of Agricultural Research)

भाकृअनुप ICAR

रा पा आ सं ब्यूरो NBPGR

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PGR Database

Passport (Simple)
Passport (Free Text)
Characterization / Evaluation
Core collections
MLS Material

---Intranet---
Gap Analysis
DataBase

Welcome To PGR Portal

PGR Portal is a gateway to information on plant genetic resources conserved in the Indian National Genebank housed at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. NBPGR is the nodal organization in India for acquisition and management of indigenous and exotic plant genetic resources for food and agriculture, and to carry out related research and human resource development, for sustainable growth of agriculture. The Indian National Genebank conserves about 0.4 million accessions belonging to about 1800 species.

NBPGR is the custodian of these diverse germplasm and promotes their use in the breeding programmes. PGR Portal is an endeavor in this direction to facilitate easy availability of information about the conserved germplasm. The motto is enhanced utilization through greater access to information.

The information provided through the PGR Portal is accessible to researchers, farmers, students and policy makers. Users can either search for accession information (simple search) or characterization and preliminary evaluation data (advanced search).

Please allow/enable popup windows for correct functioning of the portal.

Usage statistics: As per the information obtained from Google Analytics, PGR Portal is being used extensively by PGR researchers. In the last six years, it has witnessed 1.8 lakh page views by researchers across the world.

Germplasm Exchange and Quarantine Information System (GEQIS)

An updated version of GEQIS was developed incorporating generation of new reports, enhanced data integrity by introducing automatic detection of data duplication, fee calculations and invoice/receipt printing incorporating new GST rules, allowing indigenous (IC) entry along with exotic (EC) entries, etc.

As per the information obtained from Google Analytics, PGR Portal is being used extensively by PGR researchers. In the last six years, it has witnessed 1.8 lakh page views by researchers across the world.


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ICAR – National Bureau of Plant Genetic Resources
A nodal organization in India for the management of plant genetic resources
Germplasm Exchange & Quarantine Information System

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TAX INVOICE
(Original Handling Charges and Quarantine Processing Fee Receipt for Recipient)

Invoice No.: IQ:330/2017 Dated: 03 Feb 2018

Consignment Handling Charges and Quarantine Processing Fee			
Import Quarantine (IQ) No. 330/2017	Import Permit No. 324/2017	Country Mexico	Crop 150 Seed samples of Wheat
Importer	Dr. T. Venkata Reddy, ITC Limited, ITC Life Sciences & Technology Centre, #3,1st Main Road, Peenya Industrial Area 1st Phase, Bengaluru-560058 (Karnataka) GST No. ITC-LSTC GSTIN: 29AAACI5950L1Z6		
GSTIN: 07AAAAI1830P3ZJ	SAC Code: 998114		Place of Supply: Delhi
Consignment handling charges @ Rs. 3000.00/- per consignment		Rs. 3000.00/-	
Quarantine processing fee @ Rs. 200.00/- per sample(150 Samples)		Rs. 30000.00/-	
CGST @ 9 %		Rs. 0/-	
SGST @ 9 %		Rs. 0/-	
IGST @ 18 %		Rs. 5940/-	
	Total	Rs. 38940/-	

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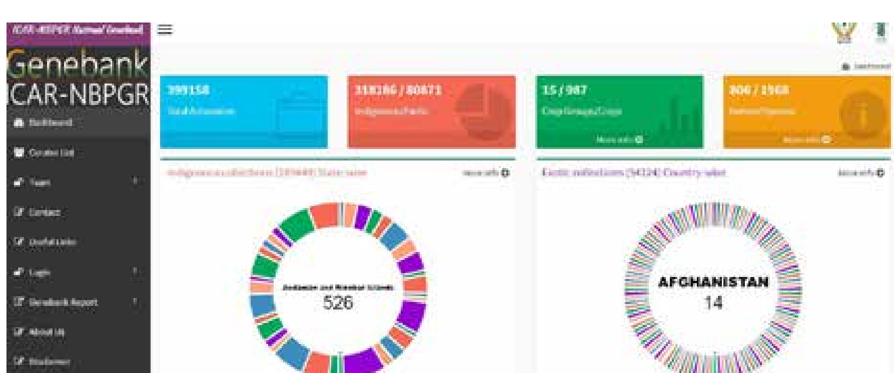
INDIAN COUNCIL OF AGRICULTURAL RESEARCH, MINISTRY OF AGRICULTURE (GOVT. OF INDIA), PUSA CAMPUS, NEW DELHI-110012, INDIA

A user friendly Genebank Dashboard was developed to provide personalized quick access to genebank information to PGR workers, breeders, students, research managers and administrators.

Genebank Dashboard

Quick access to the information on number of germplasm accessions conserved in the National Genebank has been a long-pending demand. A user friendly Genebank Dashboard was developed to provide personalized quick access to genebank information to PGR workers, breeders, students, research managers and administrators. The dashboard was designed to be compatible with old and new computers, tablets and smartphones. The dashboard figures are dynamically updated as and when genebank database is updated.



PGR Map

Map-based data retrieval provides easy and intuitive access to PGR information. The process is vital for developing mobile apps. Computational algorithms for map-based applications in PGR were developed and were implemented as an interactive application called "PGR Map". PGR Map offers three benefits:

The process is vital for developing mobile apps. Computational algorithms for map-based applications in PGR were developed and were implemented as an interactive application called "PGR Map".

"What's around me" helps the user to obtain quickly the accessions that have been collected and conserved in the genebank from a particular location in India where the user is located at the moment. "Search the map" helps the user to list the accessions that have been collected and conserved in the genebank from any selected location in India. "Search for species" helps the user to map the collection sites of a crop species.

Geo-informatics portal in PGR

A study to link germplasm to changing climatic regimes was earlier carried out with the funding of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). A web interface named PGR CLiM was also developed to access information (www.nbpgr.ernet.in:8080/climate). It was improved to be a portal running on a GIS-server that is now interactive to choose layers of germplasm accessions (ten crops); soil type; AEZ; temperature and rainfall (current, 2020 and 2030).

Germplasm Registration Information System (GRIS)

> The Germplasm Registration Information System has been developed to make the entire process of germplasm registration—submission of application, evaluation by experts and decision by Plant Germplasm Registration Committee—a web-based system.

A mechanism for "Registration of Plant Germplasm" was instituted in 1996 by ICAR to serve as a recognized tool for registration of PGRFA at the national level. This would also provide facilitated access to the developed or identified potentially valuable germplasm for utilization in crop improvement programs. Since the institut-ion of this mechanism, a total of 1,313 germplasm belonging to 209 crop species have been registered. The Germplasm Registration Information System was launched by DG, ICAR on 02-08-2017.

Why GRIS: The Germplasm Registration Information System has been developed to make the entire process of germplasm registration—submission of application, evaluation by experts and decision by Plant Germplasm Registration Committee—a web-based system. The system is expected to provide genebank managers, breeders and plant researchers with a hands-on tool for the management of germplasm registration process, and to policymakers with a reliable source of information. With the advent of this system, it is expected that the entire process of germplasm registration is made simple and fast, facilitating transparency and expeditious decision making. GRIS also has advantages like real-time tracking of application, speedy disposal, searchability and retrieval of old records.

PGR-IP management system:

Based on the application reported in 2016, a mobile app, IP-PGR, was developed for easy access to information. Application development was supported by ICAR-National Fellow project. IP-PGR can be downloaded from google play store.

Mobile apps in PGR Informatics

Two mobile apps "Genebank" and "PGR Map" have been developed to enhance access to PGR information with an easy user interface. The apps have been developed for both Android and iOS. The apps have been hosted on Google Play and the App Store.

gene bank

pgr map

National Seed Association of India

Conclusion

In spite of the above mentioned progress, Indian efforts in PGR informatics are yet to achieve progress in many vital are as for the following reasons: (i) NBPGR conserves all crop species; (ii) NBPGR carries out all activities of PGR management and hence has to manage multiple types of data (Passport, Genebank, Characterization, Exchange, Quarantine, DNA fingerprints, etc.); (iii) Connecting more people requires development of multi-lingual applications.

PGR Databases were designed and developed with the support of ICAR through institutional funding. Development of web-based and mobile applications was supported by ICAR-National Fellow Project principally.

Acknowledgements

PGR Informatics products and services at NBPGR are a culmination of efforts and support of several individuals of the Bureau over a long period of time. PGR Databases were designed and developed with the support of ICAR through institutional funding. Development of web-based and mobile applications was supported by ICAR-National Fellow Project principally based on recommendations of the erstwhile National Board for the Management of Genetic Resources.

Area-elevation analysis of Naula watershed using Remote Sensing and Geographical Information System

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Abstract

In this study, the hypsometric curve (HC) and hypsometric integral (HI) of fourteen sub-watersheds (SW) of a hilly watershed, called "Naula", located in upper Ramganga River basin, India, was done using remote sensing (RS) and geographical information system (GIS). The results of analysis revealed that the HI value of fourteen sub-watersheds varied from 0.289 to 0.476, which indicates that 28.9% to 47.6% of the original rock masses still exist in these sub-watersheds. The two geological stages of erosion cycle i.e. monadnock and mature were identified in the study area. The results of this study could be useful for planning and constructing soil and water conservation structures at appropriate locations in the sub-watersheds of Naula watershed.

the hypsometric curve (HC) and hypsometric integral (HI) of fourteen sub-watersheds (SW) of a hilly watershed, called "Naula", located in upper Ramganga River basin, India, was done using remote sensing (RS) and geographical information system (GIS).

Keywords: Hypsometric curve, Hypsometric integral, Naula watershed, GIS, Uttarakhand

INTRODUCTION

Hypsometric (area-elevation) analysis of a watershed is important for integrated planning and management of watershed resources (Hurtrez et al., 1999).

Hurtrez et al., (1999) stated that a watershed is stabilized with convex hypsometric curves and un-stabilized (susceptible to erosion) with concave hypsometric curves.

Hypsometric (area-elevation) analysis of a watershed is important for integrated planning and management of watershed resources (Hurtrez et al., 1999). Strahler (1952) interpreted the concept of the hypsometric curve (HC) for describing the distribution of area with respect to altitude within a basin. The difference in the shape of the curve and hypsometric integral value is related to the degree of vulnerability (Weissel et al., 1994). Strahler (1952) interpreted the shapes of the hypsometric curves by analyzing numerous drainage basins and classified the basins as a youth (convex upward curves), mature (S-shaped curves which are concave upwards at high elevations and convex downwards at low elevations) and peneplain or distorted (concave upward curves). Hurtrez et al., (1999) stated that a watershed is stabilized with convex hypsometric curves and un-stabilized (susceptible to erosion) with concave hypsometric curves.

Over past years, number of studies have been conducted for estimation of erosion status of watershed using hypsometric analysis, and morphometric parameters (Bishop et al., 2002; Markose and Jayappa 2011; Kusre 2013; Sharma et al., 2016; Kandpal et al., 2017; Kandpal et al., 2018a & b; Singh et al.,2018; Walia et al.,2018; Malik et al., 2019a, b, & c). Gajbhiye et al., (2014) estimated the hypsometric integral values of eight sub-watersheds of Shakkar watershed located in Madhya Pradesh, India and found that the hypsometric integral values for all the sub-watersheds ranged between 0.47 and 0.51 and identified the mature stage of erosion cycle. Walia et al., (2018) studied the hypsometry (HC and HI) in ArcGIS 10.3 and Microsoft Excel environment in four micro-watersheds draining into Patiala-Ki-Rao River, Punjab, India, for accessing and comparing the erosion status under different management practices.

In the present research, hypsometric (area-altitude) analysis of fourteen sub-watersheds of Naula watershed located in upper Ramganga River basin, India, was carried to study runoff generation potential and planning for appropriate soil and water conservation measures in the watershed.

MATERIALS AND METHODS

Study area

The Naula watershed is located between 79o 10′ 30″ E to 79° 31′ 30″ E longitude and 29° 42′ 0″ N to 30° 3′ 0″ N latitude in Ranikhet forest sub-division of Ramganga river catchment, Uttarakhand, India (Fig. 1). The boundary of Naula watershed spread in Chamoli, Bageshwar, Pauri Garhwal and Almora districts and drains from North to South (outlet in Almora district). The shape of Naula watershed is nearly rectangular and comprises of 1071.22 km2 area with the minimum and maximum elevations range from 724 m to 3079 m, respectively. The rainfall in the watershed occurs mostly in the middle June to end of September, with mean annual rainfall of 1015 mm. The climate of this watershed ranges from subtropical to sub-temperate with an average annual temperature of 30°C and a mean minimum temperature of 18°C. The maximum area of Naula watershed is covered under forest and woodland,followed by agriculture.

Data collection

In this study, the Digital Elevation Model (DEM) of Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) with 30m x 30m resolution (downloaded from https://earthexplorer. usgs.gov) was used to delineate the boundary and stream network of the watershed, which was further sub-divided into fourteen sub-watersheds (Fig. 2) using ArcGIS 10.2 software.

Plotting of hypsometric curve

The hypsometric curve is obtained by plotting the relative area (a/A) on the abscissa (x-axis) and relative elevation (h/H) on the ordinate (y-axis). The relative area is the ratio of horizontal cross-sectional area (a) to entire basin area (A), while the corresponding relative elevation is the ratio of elevation of a given contour (h) to the total basin elevation (H) as shown in Fig. 3 (a and b). This provided a measure of the distribution of landmass volume remaining beneath or above a basal reference plane (Singh et al.,2008).

Estimation of hypsometric integral

Hypsometric integral (HI) is obtained from the hypsometric curve and provides information about the geologic stages of development and erosion susceptibility of the watershed. Pike and Wilson (1971) developed elevation-relief ratio method for estimating the hypsometric integral (HI) as:

$$ER_r = HI = \frac{h_{mean} - h_{mini}}{h_{maxi} - h_{mini}}$$

where, ER_r is the elevation-relief ratio equivalent to the hypsometric integral; h_mean is the weighted mean elevation of the watershed estimated from the identifiable contours of the delineated sub-watersheds; and h_mini and h_ maxi are the minimum and maximum elevations within the sub-watersheds.

After obtaining hypsometric integral of individual sub-watersheds and comparing it with the typical hypsometric curves (Fig. 3c), the geological stages of development of the sub-watersheds under study are determined with the following criteria (Strahler, 1952):

Hypsometric integral (HI) is obtained from the hypsometric curve and provides information about the geologic stages of development and erosion susceptibility of the watershed.

a) The sub-watershed will be in non-equilibrium (youthful) stage if HI value is greater than or equal to 0.60 ($HI \geq 0.60$)

b) The sub-watershed will be in equilibrium (mature) stage, if HI value ranges between 0.35 and 0.60 ($0.35 \leq HI < 0.60$); and

c) The sub-watershed will be in Monadnock (old) stage if HI value is less than 0.35 ($HI < 0.35$)

RESULTS AND DISCUSSION

The hypsometric analysis of fourteen sub-watersheds of Naula watershed was carried in ArcGIS 10.2 environment using DEM of ASTER with 30m x 30m resolution. The hypsometric curves of fourteen sub-watersheds are presented in Fig. 4, which reveals that the sub-watersheds have attained monadnock and mature stages. The SW-2 and SW-13 attained monadnock stage, the SW-1, SW-3 to SW-12 and SW-14 attained mature stage. It was also observed from Fig. 4 that there was a combination of convex-concave and S shape of hypsometric curves for fourteen sub-watersheds of Naula watershed. This could be due to the soil erosion from these sub-watersheds resulting from the cutting of channel beds, down slope movement of topsoil and bedrock material, washed-out soil mass and cutting of stream banks.

The hypsometric integral (HI) values of fourteen sub-watersheds of Naula watershed are given in Table 1. It was observed from Table 1 that the value of HI as 0.419 under mature stage (SW-1), HI as 0.340 under Monadnock stage (SW-2), HI as 0.439 under mature stage (SW-3), HI as 0.372 under mature stage (SW-4), HI as 0.444 under mature stage (SW-5), HI as 0.476 under mature stage (SW-6), HI as 0.382 under mature stage (SW-7), HI as 0.361 under late youthful stage (SW-8), HI as 0.448 under mature stage (SW-9), HI as 0.351 under mature stage (SW-10), HI as 0.377 under mature stage (SW-11), HI as 0.411 under mature stage (SW-12), HI as 0.289 under monadnock stage (SW-13) and HI as 0.363 under mature stage (SW-14). The hydrologic response of the sub-watersheds attaining the mature stages will have a slow rate of erosion. As HI value ranges from 0.289 (SW-13) to 0.476 (SW-6), which indicates that 28.9% and 47.6% of the original rock masses still exist in these sub-watersheds.

Conclusion

The following specific conclusions are derived from the study:

- The hypsometric curves and hypsometric integral values indicated that only two geological stages of erosion cycle i.e. Monadnock and mature were identified out of fourteen sub-watersheds of Naula watershed.

- The hypsometric integral value ranges from 0.289 (SW-13) to 0.476 (SW-6), which indicates that 28.9% and 47.6% of the original rock masses still exist in these sub-watersheds.
- The SW-1 to SW-14 has a lower value of hypsometric integral (i.e. approaching monadnock and mature stages) and need minimum mechanical and vegetative measures to arrest sediment outflow, but may require more water harvesting structures to conserve water at appropriate locations for its conjunctive use in these sub-watersheds.

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Table1.Hypsometric integral and geological stage of sub-watersheds of Naula watershed.

Sub-watershed number	Area (km2)	^{h}mini (m)	^{h}maxi (m)	^{h}mean (m)	HI	Geological stage
SW-1	75.66	1469	3079	2274	0.419	Mature
SW-2	85.09	1270	2885	2078	0.340	Monadnock
SW-3	78.52	1076	3049	2063	0.439	Mature
SW-4	68.86	1066	3025	2046	0.372	Mature
SW-5	113.02	930	2911	1921	0.444	Mature
SW-6	80.71	946	2416	1681	0.476	Mature
SW-7	87.65	882	2447	1665	0.382	Mature
SW-8	85.15	891	2078	1485	0.361	Mature
SW-9	69.02	923	2731	1827	0.448	Mature
SW-10	104.89	800	1899	1350	0.351	Mature
SW-11	58.81	924	2285	1605	0.377	Mature
SW-12	59.40	854	2036	1445	0.411	Mature
SW-13	47.97	772	1716	1244	0.289	Monadnock
SW-14	56.58	709	1958	1334	0.363	Mature

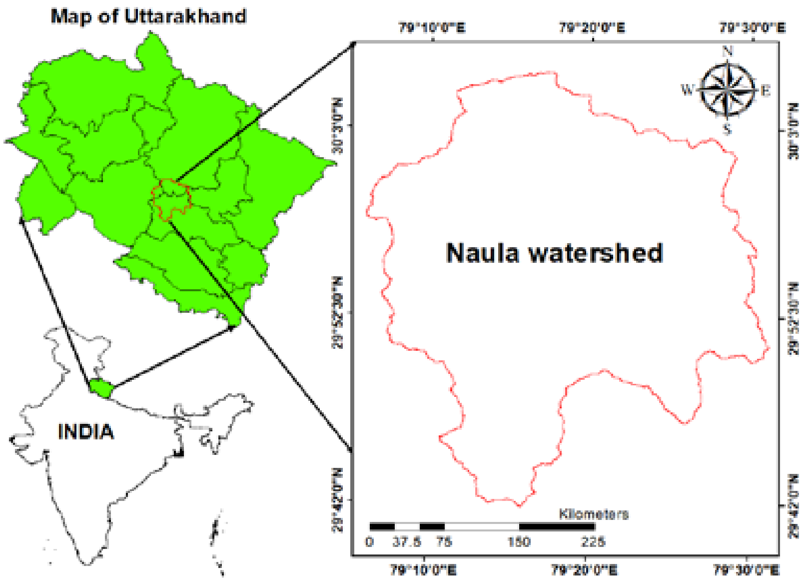


Fig. 1. Location map of Naula watershed.

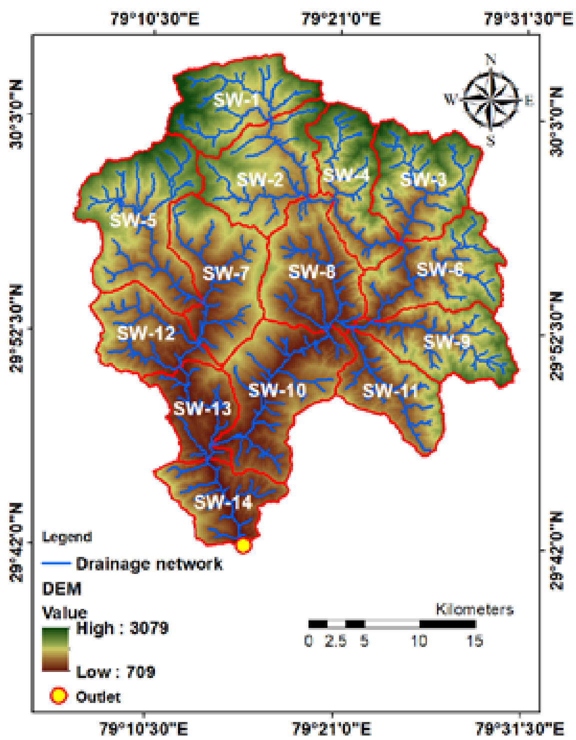


Fig. 2. DEM and drainage network map of the sub-watersheds of Naula watershed.

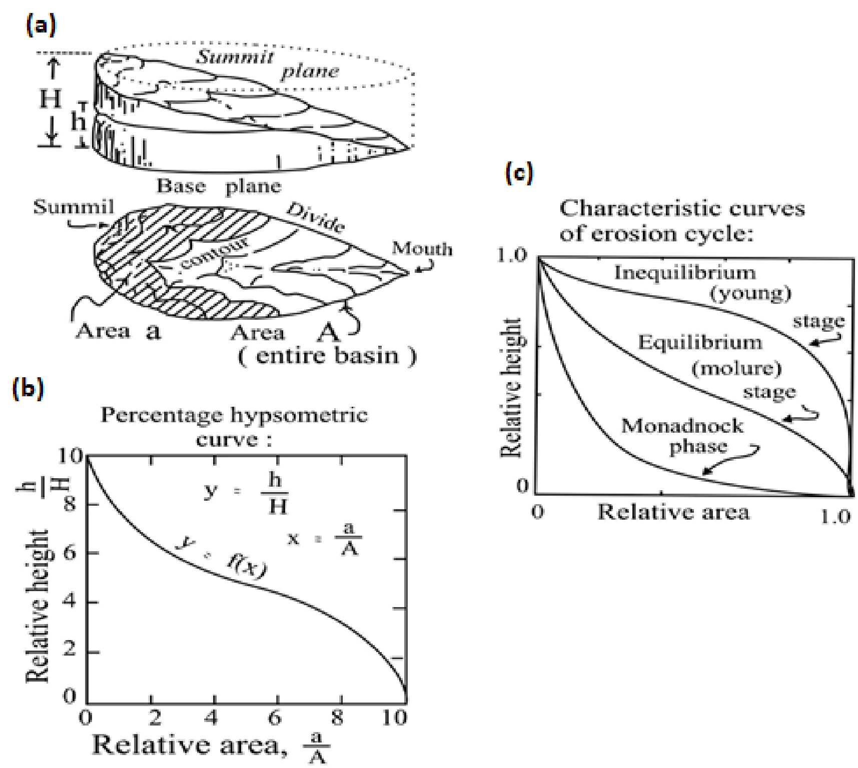


Fig. 3 (a to c). Hypsometric curve and geological stages (Strahler, 1952).

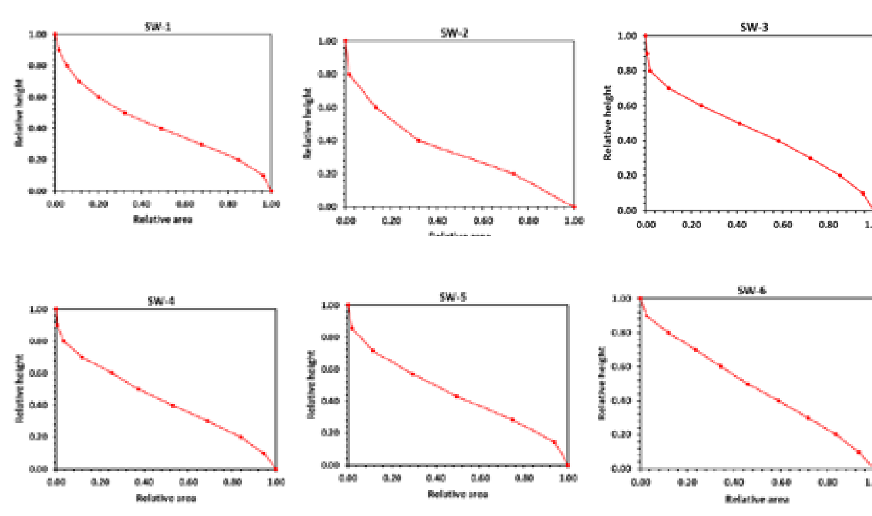
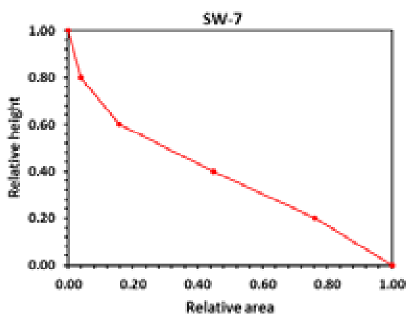
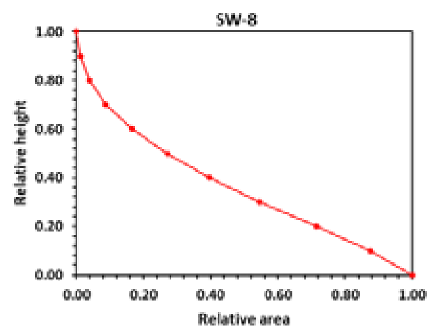
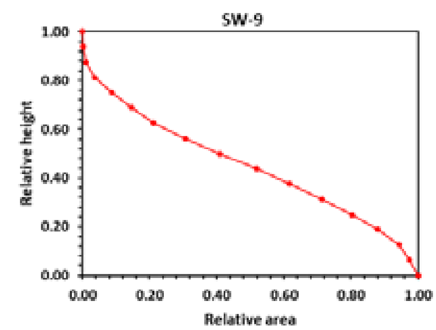
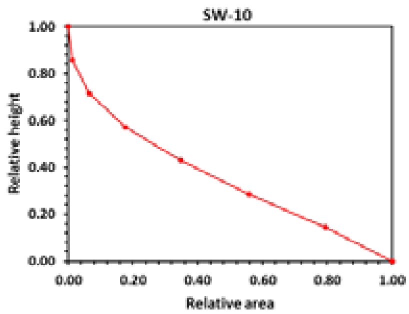


Fig. 4. Hypsometric curves of fourteen sub-watersheds of Naula watershed.


SW-7
Relative height
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.20
0.40
0.60
0.80
1.00
Relative area


SW-8
Relative height
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.20
0.40
0.60
0.80
1.00
Relative area


SW-9
Relative height
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.20
0.40
0.60
0.80
1.00
Relative area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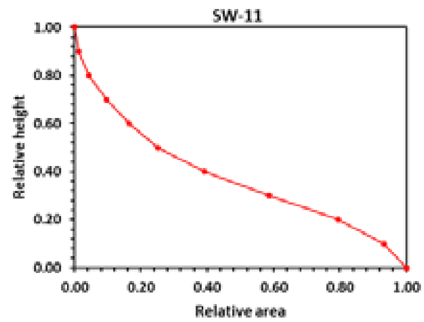
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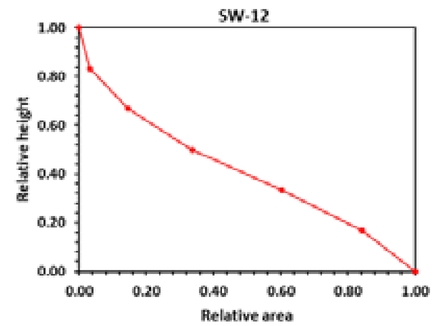
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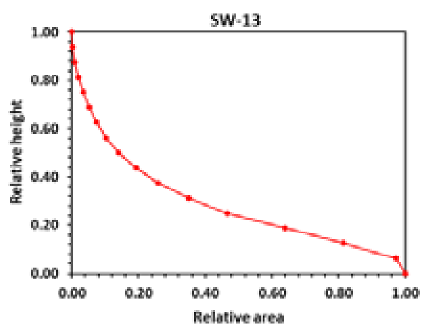
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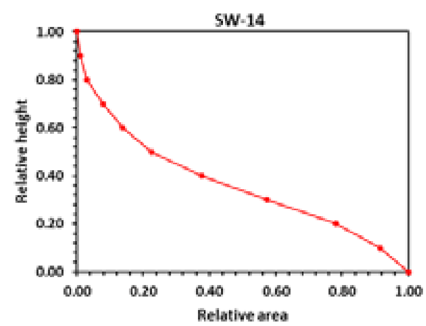
Relative area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0.80
1.00
Relative area

Online Seed Certification Automation System of OSSOPCA: An Innovative & User-friendly Way of Digitalization of Certification System: A National e-Governance Award Initiative

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Odisha is an agrarian state. More than 80% of people are engaged in agriculture. **Good seed** underpins more sustained crop production and livelihoods. The quality seed has in-built power of increasing crop yield by 20-25% given that other inputs are also available. Due to low income, and limited economic opportunities, farmers have limited access to seeds sourced off-farm or from formal seed systems; more so, their seeds are of inferior quality. Importance of good quality seed has been underlined since ancient times and it gained further importance after the introduction of improved and hybrid seeds after the green revolution in raising agricultural production. The Indian seed industry has risen to the challenge of meeting the requirements of **quality seeds.**

Good seed underpins more sustained crop production and livelihoods. The quality seed has in-built power of increasing crop yield by 20-25% given that other inputs are also available.

The challenges confronting seed sector are the increasing demand of quality seed of promising varieties, to ensure food security. Seed technology has emerged as a potent tool to achieve targeted agricultural production.

The role of the formal seed sector (private and government) normally concentrates on seed production and marketing, abiding by appropriate compliance with government policies and regulations.

In Odisha, the major players in the seed sector are OUAT, OSSC Ltd, NSC Ltd, OAIC Ltd, TRIPTI SVP, some private seed producers, Directorate of Agriculture, OSSOPCA, etc. In spite of this, there is a need to make quality seeds available to farmers at remote areas.

Odisha State Seed & Organic Products Certification Agency (OSSOPCA), established in 1978 as per the Seeds Act, 1966, is responsible for seed quality assurance through certification. The purpose of Seed Certification is to maintain and make available to the public, through certification, high-quality seeds and propagating materials of notified varieties. It is done to ensure genetic purity. Seed certification is also designed to achieve prescribed standards.

Functions of Seed Certification Agency:

i. Certify seeds of any notified kind or varieties.

ii. Outline the procedure for submission of applications for growing, harvesting, processing, storage and labelling of seeds intended for certification till the end to ensure that the seed lots finally approved for certification are true to the variety and meet prescribed standards for certification under the Seeds Act or the Rules.

iii. Maintain a list of recognised Breeders of Seeds.

iv. Verify, upon receipt of an application for certification that the variety is eligible for certification that the seed source used for planting was authenticated and the record of the purchase is in accordance with these rules and the fees have been paid.

v. Take sample and inspect seed lots produced under the procedure laid down by the Certification Agency and have such sample tested to ensure that the seed conforms to the prescribed standards of certification.

vi. Inspect seed processing plants to see that the admixtures of other kinds and varieties are not introduced.

vii. Ensure that action at all stages, e.g. field inspection, seed processing plant inspection, analysis of all samples taken and issue of certificates (including tags, labels, seals, etc.) is taken expeditiously.

The role of the formal seed sector (private and government) normally concentrates on seed production and marketing, abiding by appropriate compliance with government policies and regulations.

The purpose of Seed Certification is to maintain and make available to the public, through certification, high-quality seeds and propagating materials of notified varieties.

viii. Carry out educational programmes designed to promote the use of certified seed including a publication listing certified seed growers and source of certified seed.

ix. Grant of Certificates in accordance with the provisions of the Act and Rules.

x. Maintain such records as may be necessary to verify that the seed plants for the production of certified seed were eligible for such planting under such rules.

Inspect the fields to ensure that the minimum standards for isolation, rogueing (where applicable), use of male sterility (where applicable) and similar factors are maintained at all times, as well as ensure that the seed borne diseases are not present in the field to a greater extent than those provided in the standards for certification.

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Problem statement or situation before the initiative

Seed certification is a time-bound work. Technical manpower is the main constraint to carry out the certification works. Area registered and quantities of seed certified by OSSOPCA during last four years are placed below.

Table1. Year wise Area Registered & Quantity of seed certified by OSSOPCA in Odisha

Year	Area Registered (Ha)	Quantity of Seed Certified (Quintal)
2012-13	62019	782842
2013-14	68741	706777
2014-15	55204	981945
2015-16	47885	845432
2016-17	33805	419881
2017-18	25446	401411
2018-19	33593	205140 (Continuing)

To lessen the workload and bring transparency in seed certification and to allow the seed growers to submit applications for certification from home, a complete on-line seed certification portal was envisioned.

The seed producers/ growers reside at distances from the seed certification offices and they face difficulties in submitting applications for certification in time and even loss of time through mobility and risk of loss of money during transit. To lessen the workload and bring transparency in seed certification and to allow the seed growers to submit applications for certification from home, a complete on-line seed certification portal was envisioned and NIC, Bhubaneswar was entrusted with the work for development of all online modules of seed certification during 2013-14 with funding from RKVY. Training on on-line seed certification (e-Governance) to certification personnel & seed growers were carried regularly. Finally, the same was implemented from Kharif 2014 with the launch of the project on 25.07.2014. Issues & short comings in implementation were sorted out; feedbacks were addressed subsequently to make it more user-friendly. Now the online system of Seed Certification is running in the state smoothly & has completed 6 years successfully.

Project Objectives

- Completion of all seed certification activities timely.
- Elimination of manipulation in the certification system.
- Minimization of human error in seed certification.
- Achieving the outcome utilising the minimum workforce.
- Improving the certification monitoring system.
- Generation of real-time data & report at ease.
- Time-tested traceability mechanism in seed certification.
- User-friendly Online system

Project Scope approach and Methodology

Application	Seed Grower can Apply Online through http://ossopca.nic.in
Verification	SCO (Seed Certification Officer) can do the verification or Forward to ASCO for verification as well as Inspection.
Threshing Certificate Issue	ASCO or in certain case SCO himself can do the inspection. Both online as well as offline module through Mobile App.
Sampling Slip Generation	Three sample slips are generated before going to do sampling by concerned ASCO/SCO.
Testing Lab	Seed Testing Lab will submit their report.
TAG Certificate Issue	TAGs are issued by the appropriate authority.

In OSSOPCA, the submission of application for crop registration is done by the seed grower. No application fees are collected and the applicant has to fill single application for multiple crops. To decentralize the responsibility of verification and speeding up the process, SCO (Seed Certification Officer) has been e-enabled to forward applications to any concerned ASCO (Assistant Seed Certification Officer). ASCO inspects of the field assigned to him and he is equipped with two modes of data acquisition modules. ASCO can enter the inspection report in offline mode through **Mobile App in a Tablet with GPS coordinates, Touchpad signature of Seed Grower, uploading of onsite photograph & sending of SMS immediately to the Seed Grower** and then later synchronize with the central database or an online mode has also been provided to support direct submission of inspection report. Threshing Certificate is issued from the concerned authority and further procedures like sample slip generation and TAG certificate are issued by the same authority after the seed testing.

ASCO can enter the inspection report in offline mode through Mobile App in a Tablet with GPS coordinates, Touchpad signature of Seed Grower, uploading of onsite photograph & sending of SMS immediately to the Seed Grower and then later synchronize with the central database or an online mode has also been provided to support direct submission of inspection report.

A complaint monitoring system has also been provided to render backend technical support for any unintentional mistake committed by officials which is expected to provide trustworthy comfort zone to the users. The project covers all the districts of Odisha and around 15000 registrations are currently processed from across Odisha. The main beneficiaries of the project as Seed Growers, Odisha State Seed & Organic Products Certification Agency, Seed Testing Lab and Odisha State Seed Corporation Ltd & the State Agriculture Department.

Use of new technology to improve organization effectiveness

1. In the era of IoT, it is believed that desktop is not the only device for web activity, as many other devices like mobile and tablet are rapidly replacing the PC. So, it is a very important step taken by the department to design the citizen-centric portal in **responsive** mode for supporting devices like mobile and tablet.

2. Real-time information at the right time is the power and **SMS gateway** has been used to provide real-time information to seed growers as well as officials to take necessary steps at the right time. The information delivery mechanism is very effective in this context.

3. As the department is responsible for certification of crop mostly in the rural parts of Odisha and online system may be very difficult for submission of inspection report due to lack of proper or nil network connectivity at these locations. So, an innovative **Online Offline Synchronization module** has been introduced for filling up the inspection report through **Mobile App** even if no network connectivity and later uploads to the server as and when the network gets available. Adequate security measure has also been taken to avoid manipulation.

4. An innovative step in the payment system, **Bank's Easy Pay System** has been integrated along with the manual method of deposit in banks. The **Online Payment System** has also been developed & put in place to carry out the payment at ease from home so that accounts and payment verification can be done without error.

5. **GPS devices** have been provided to all field level officers to take the latitude-longitude coordinates of the fields being inspected for **GIS integration** which is under development.

6. The Online system has been linked with Seed DBT, State Seed Corporation & other flagship Govt online system for proper coordination among another programme.

Joint Ground Nut Field Inspection of OSSOPCA through Tablet App.

In the era of IoT, it is believed that desktop is not the only device for web activity, as many other devices like mobile and tablet are rapidly replacing the PC.

GPS devices have been provided to all field level officers to take the latitude-longitude coordinates of the fields being inspected for GIS integration which is under development.

The Online system has been linked with Seed DBT, State Seed Corporation & other flagship Govt online system for proper coordination among another programme.

Government of Odisha has proposed for 2% reserved budget in every scheme for IT infrastructure development as well as IT services to aid existing e-Gov initiatives and new programs.

The citizen can now register multiple crops using a single application form where the application fees for the registration has to wave out. This enables the seed grower to approach any CSC for initial IT support.

Results achieved/value delivered to beneficiary of the project and other distinctive features/accomplishments of the projects

Benefits achieved through on-line certification:

- Sustainability of the initiative (revenue, technology, security/ privacy, digital encryption etc.

  The project has successfully completed the management of 6 years & 11 seasons. The issue and enquiry have tremendously reduced by every subsequent season. In the perspective of technology, the project has been designed in new technology keeping future manageability and sustainability in mind.

  The system has security audited and got the clearance certificate but still planned for security audit after every 6 months to address new ways of hacking tricks.

  All the User credentials and vital information is kept in the database either as encrypted form or as salted hash form. Use of digital signature also kept in the departmental agenda for future extension.

  Government of Odisha has proposed for 2% reserved budget in every scheme for IT infrastructure development as well as IT services to aid existing e-Gov initiatives and new programs. So, it has been envisioned to take this opportunity for the long run sustainability of the project.

- Convenience for user/ citizen i.e. Seed Grower

  - The citizen can now register multiple crops using a single application form where the application fees for the registration has to wave out. This enables the seed grower to approach any CSC for initial IT support.
  - The citizen can see the status of his certification process in real-time using the mobile apps developed by the department or through SMS.
  - The citizen can now get their documents as well as TAG verified at their nearest ASCO office instead of going to SCO office far away from his home.

- Value delivered for your organization/ agency

  - Optimum utilization of the human resources and avoidance of redundant work has been achieved.
  - Minimization of human error at the same time effective data retention improved the data analysis process multifold.

- Elimination of any chance of manipulation in the certification system by lodging every online activity for security purpose as well as legal purpose.
- Real-time MIS report generation and monitoring of the seed production, as well as certification, is done through this system.
- Crop yield prediction can also be effectively done to address any fore coming shortage of seed in the state.

Other distinctive features/ accomplishments of the project

- Application is very much pluggable for enhanced Interoperability as a result of which this has been integrated with http://odishaseedsportal.nic.in which is an information warehouse about seed by the Department of Agriculture.
- Payment verification of the transactions done by manual process is done with Easy Pay System of Axis Bank & Online Payment with SBI ePay integrated with the current OSSOPCA workflow automation system.

Four Seed Testing Laboratory has also been integrated into the system and MIS of Odisha State Seed Corporation has been integration with the same.

It is believed that Online Seed Certification system of OSSOPCA is the pioneer in implementing the automation of complete workflow of the seed certification process in the country. This project is also very citizen-centric as well as interoperable to other government departmental MIS. **Due to the innovativeness & successful implementation throughout the state of Odisha, the project "Odisha State Seed & Organic Products Certification Agency" has been awarded SILVER under category "Cat-X – Innovative Use of ICT by State Government PSUs/Cooperatives/Federations/Societies" for the National Award on e-Governance 2015-16 during the 19th National Conference on e-Governance at Nagpur on 21-22 January, 2016.**

OSSOPCA & NIC, Bhubaneswar officials receiving Nation e-Governance Award from Honourable CM of Maharastra SJ. Devendra Fadnavis at Nagpur on 22.01.2016 during the 19th National e-Governance Conference.

OSSOPCA has gone one more step forward by implementing the tablet version of the online system of seed certification during Kharif -2016 to make a shift from e-Governance to m-Governance so that the service to the seed growers can be provided easily at any time with a single touch on the screen.

Conclusion:

At the present context, the online system has become the mainstay of many other ambitious government online programmes like Seed DBT, Odisha Seeds Portal, OSSC, etc. Now, OSSOPCA has gone one more step forward by implementing the tablet version of the online system of seed certification during Kharif -2016 to make a shift from e-Governance to m-Governance so that the service to the seed growers can be provided easily at any time with a single touch on the screen.

As such, there is always a scope for improvement in the Online Seed Certification Process of OSSOPCA after successful implementation of the project since 2014-15, such as

a) Inclusion of Land Document as a mandatory field in online Crop Registration.

b) Initiation of Central Coding System for seed samples to send to different laboratories.

c) Upgradation of Online Laboratory Module.

d) Initiation of GOT Module.

e) Strengthening of Online Monitoring System of Seed Certification.

f) Supply of updated Hardware System to Seed Certification Personnel.

g) Maintenance & others.

However, with the success of this model, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India has decided to replicate OSSOPCA model throughout the country from 2019-20. It is a moment of pride for the Organisation, OSSOPCA, who works silently but steadily towards the digitalization in the Agriculture Sector.

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Breeding Informatics: An Approach towards Precise Breeding

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Abstract

Plant breeding and genetics are the important components of the agricultural sciences in ensuring global food security through the improvement of existing varieties or developing a new variety with high yield, biotic and abiotic stress tolerance, disease resistance and potential of expressing its full vigor and yield performance under a particular set of environments. Modern approaches in plant breeding mainly focus on increasing the genetic gain in a short time through the use of smart tools especially the Informatics and Functional Genomics. Contrary to time-consuming conventional breeding techniques, frequent use of Informatics and Integrated Breeding Tools (IBT) saves the time to achieve the precise and desired results.

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Introduction

The conventional plant breeding led to release of numerous regional and agro-climate specific varieties that helped or led to food sufficiency in many countries on the global map, however present situation demands more converged and stipulated work in this area.

Plant breeding plays a crucial role in the sustained achievement of global food and livelihood security of the farming community. Under the changing climatic conditions, growing population, decreasing water table and transmuted and decreased rainfall pattern, breeders all over the world are realizing the need for more emphasis on precise breeding. The conventional plant breeding led to release of numerous regional and agro-climate specific varieties that helped or led to food sufficiency in many countries on the global map, however present situation demands more converged and stipulated work in this area. With changing advent, new breeding systems can act as a pillar for assembling various inputs, soil and plant management techniques to accelerate production and quality processes. Use of techniques like rapid DNA and RNA sequencing, high through put SNP genotyping techniques, trait mapping, functional characterization, genomic selection, rapid generation advance, etc. are playing an imperative role in breeding (Prohens, 2011). However, these efforts have generated very huge data which needs efficient tools for their analysis, interpretation, conclusion, and application where bioinformatics approaches can be highly useful and relevant. Breeding informatics tools which entwine the information technology and life sciences by developing a pool between constructed database, bioinformatics, and statistical genetics. Breeding informatics connects breeders and researchers with computer scientists (Yunbi, 2018) since with advancement of next-generation sequencing, use of various software and analytical tools becomes a need like Marker2sequence, Darwin, WinQTLcart, SMOOTH, Omics Fusion, RECORD (Recombination Counting and ORDering), PediHaplotyper, etc. (Stephan et al., 2014). Other statistical software being used are JMP, R studio, Python, etc. for analyzing the difference between the varieties, estimating the variance components, genomic selection, etc.

Breeding informatics tools which entwine the information technology and life sciences by developing a pool between constructed database, bioinformatics, and statistical genetics.

Scope of breeding informatics

Advanced plant breeding techniques got evolved with time like selection within Open-Pollinated Varieties, development of two way and three-way hybrids, F1 and GMO F1 hybrids. To exploit the biodiversity present in the landraces, primary and secondary gene pool, Mendelian and quantitative selection mechanism were being used.

New plant breeding methods are mainly based on the creation of new genetic blends by sexual hybridization followed by the selection of plants having desired traits but in earlier days it was mostly phenotype-based. The conventional plant breeding was suitable for getting improved cultivars with the continuous pace of time and this led to the enhanced yield of major crops. It was the backbone of the green revolution which helped many countries to get food security in the 1960's. Advanced plant breeding techniques got evolved with time like selection within Open-Pollinated Varieties, development of two way and three-way hybrids, F1 and GMO F1 hybrids. To exploit the biodiversity present in the landraces, primary and secondary gene pool, Mendelian and quantitative selection mechanism were being used. However, the approach of phenotypic selection was being previously used which is driven by the interaction of genotype and environment (G x E) and polygenic inheritance (Gillespie et al., 1989) which identify the genes with a large effect on phenotype. Due to this factor, some of the favourable alleles with small effects remained unnoticed and later they were lacking in the gene pool. Genomics involves the sequencing and analysis of an organism's genome. The genome map of many crops is available nowadays which can be utilized to mark the genotypic advantage. Several genome browsers and database from National Centre for Biotechnology Information (NCBI) are best-known sources to get the information related to the genome (Kunh et al., 2012) which makes the breeding process simpler and more efficient (Table 1). Also, whole-genome sequencing is being used as one of the functional methodologies adapted nowadays for molecular breeding purposes (Pareek et al., 2011). Some recent advances in plant genomics and bioinformatics have a significant impact on agricultural sciences.

Genomics involves the sequencing and analysis of an organism's genome. The genome map of many crops is available nowadays which can be utilized to mark the genotypic advantage.

Table1. Some of web-based genome browsers

Browser	URL	Information
Map Viewer	http://www.ncbi.nlm.nih.gov/mapview/	Species with completed genome sequences including vertebrates, invertebrates, protozoa, plants and fungi as well as dozens of uncompleted plant genomes.
Ensembl	http://www.ensembl.org/	Species with completed genome sequences providing lineage- specific web portals for vertebrates, metazoan, plants, fungi, protists and bacteria.
Phytozome	http://www.phytozome.net/cgi-bin/gbrowse/	Plant species with completed and ongoing genome sequences including monocots, dicots, fern, moss and green algae, with VISTA alignments.
Gramene	http://www.gramene.org/genome_browser/	Plant species with completed genome
		sequences including monocots, dicots, fern, moss and green algae, and the short arm of chromosome 3 of several wild rice species.
Genome projector	http://www.glanguage.org/g3/	Bacterial genomes with circular or linear maps.
Annmap	http://annmap.picr.man.ac.uk/	A genome browser that includes mappings between genomic features and Affymetrix microarrays for human, mouse, rat and yeast.
Barlex	https://apex.ipkgatersleben.de/apex/f?p=284:10	Barley genome explorer

Use of smart analytics tool in breeding

Breeding is not only affected by parents and out-turn genotypes however environmental factors are also equally important. During the selection process and testing of a particular genotype, a researcher can make multi-location trails to get an idea about the environment. Thus, enviro-typing aids in modelling crops and thereby phenotypic prediction. It combines G x E interaction and gives a simulated response concerning biotic and abiotic stress factors (Bai et al., 2018). To study the environment, several models are devised for studying variance and factor analysis, for example, application in a linear mixed model for trail analysis and assimilation of pedigree details related to crop (Byrne, 2005).

To study the environment, several models are devised for studying variance and factor analysis, for example, application in a linear mixed model for trail analysis and assimilation of pedigree details related to crop (Byrne, 2005).

For statistical analysis several tools like **JMP, R studio, python, G-power, SPSS**, etc. can be used to get precise results in a short time. GIS mapping softwares are used frequently in barley (https://agroinformatics.org/). These softwares are used in enhancing and accelerating the breeding process by rapid collection, organization, planning, designing and analysing the data to get a meaningful interpretation of research findings.

Construction of breeding informatics research unit

Breeding informatics requires a defined pattern of studies and comprises of several parts. Data collection and statistical analysis are the backbone of this unit. In this firstly, genotypic, phenotypic, and genomic data is collected which is followed by database construction and analysis (Hee-Ju et al., 2019). A typical scheme is represented hereunder:

Breeding Informatics Unit

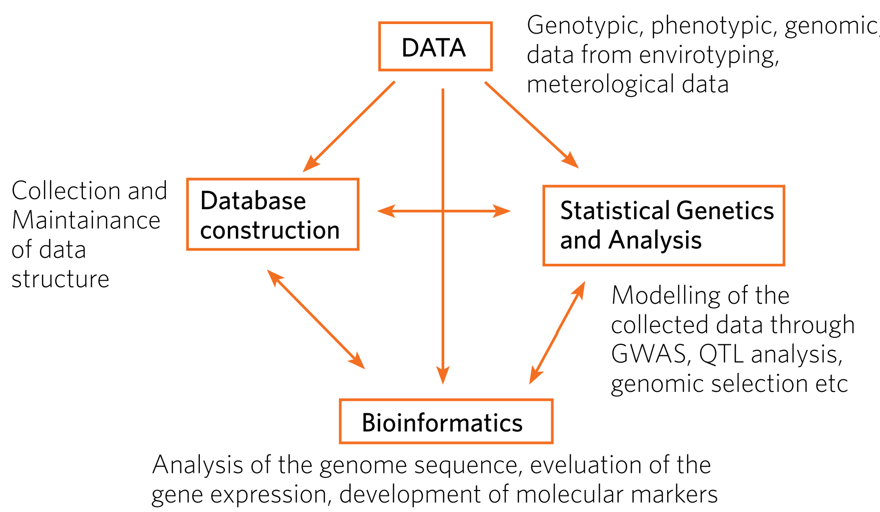


Fig1: Schematic representation of breeding informatics research unit

Integrated Breeding Platform (IBP)

IBP (https://www.integratedbreeding.net/) is an online portal and information management system which serves as a common platform for accessing all the information, analytical tools and related services used in designing the integrated breeding projects for researchers and breeders. It simplifies process right from program planning to decision making.

Table 2. Some of breeding management tools and their application

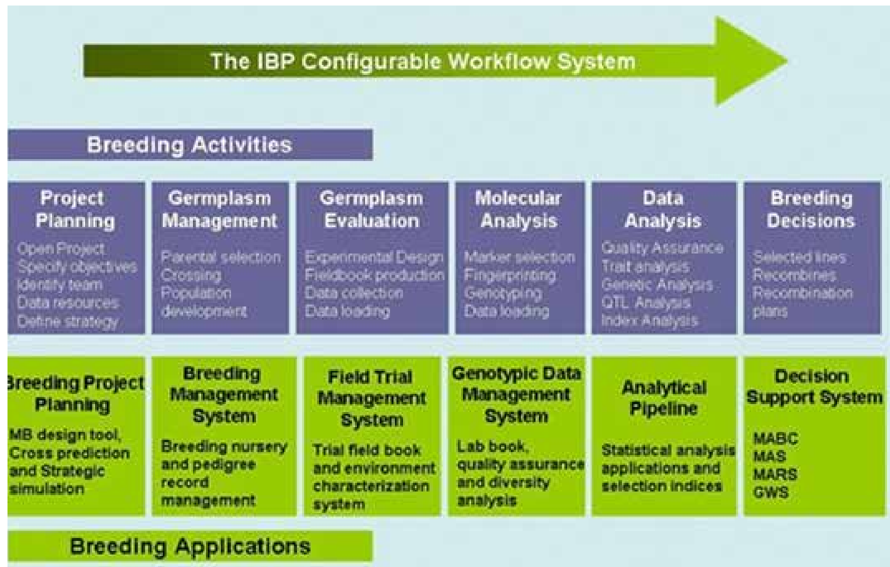
Utility	Function
Trial managing tools	• Specification of germplasm • Specification of location, treatment and experimental design. • Randomization • Creation of harvest label etc.
Trait ontology management	• Helps in editing the new ontology terms • Addition of new ontology terms
Location management tools	• Helps in knowing the location related to breeding and seed storage
Tools managing Genotyping data samples markers, molecular	• Store and retrieve SNP and DNA samples markers, molecular maps and low-density datasets • Aids in sampling of the plants for genotyping
Search, filter and Query tools	• Comparison of performance of the germplasm to the elite ones • Graphic filtering to aid the selection decision
Statistical analysis	• Used in making Trial design, randomization and its analysis

The workflow of Integrated Breeding Platform (IBP)

Managerial activities related to breeding start right from sound planning of the project, which requires access to resources for weaving the best set of ideas. IBP provides ways to the researcher to flare up their ideas for successful planning in any breeding program. The decision regarding the research project is made by the selection of potential parents, their germplasm evaluation, molecular and data analysis, and its interpretation. A typical workflow which follows this pattern is represented below:

IBP provides ways to the researcher to flare up their ideas for successful planning in any breeding program. The decision regarding the research project is made by the selection of potential parents, their germplasm evaluation, molecular and data analysis, and its interpretation.

Fig2: IBP workflow scheme (Source: CGIAR Generation Challenge Program)



Future Prospects

the approach of breeding informatics is still lacking in majority of developing countries which recall on an apparent need to make the platform available to all researchers to attain the food security especially under situations of increasing population.

Breeding informatics is an emerging tool for precise breeding programs since it combines various aspects of science such as information technology, molecular biology, genetics, agronomy, etc. to get the best set of crops in less time span together with its overall management in a significant manner. However, the approach of breeding informatics is still lacking in majority of developing countries which recall on an apparent need to make the platform available to all researchers to attain the food security especially under situations of increasing population.

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Remote Sensing & GIS Techniques for Boosting Agricultural Outputs

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Introduction

Modern farms and agricultural operations have witnessed a wide series of changes as compared to previous decades, primarily because of advancements in technology, including sensors, devices, machines, and information technology. Today's agriculture routinely uses sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and Global Positioning System (GPS) technology. Remote sensing, satellite communication, and global navigation satellite system are the three important arms of space technology which have a direct bearing on agricultural applications.

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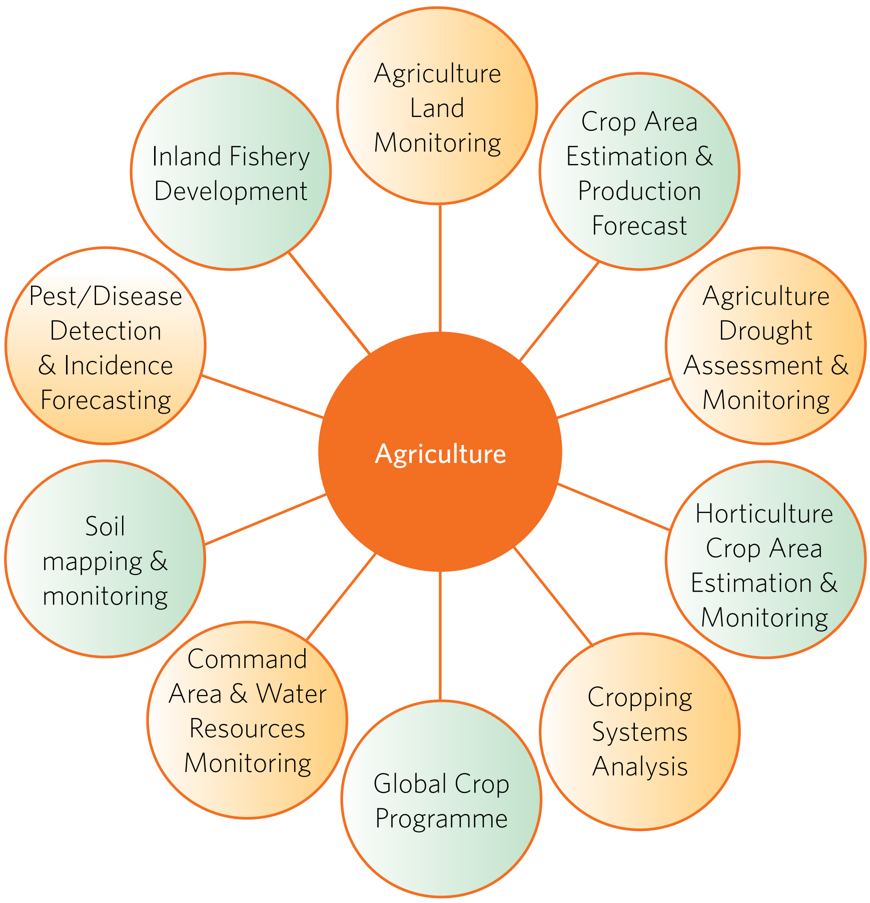
Remote sensing (RS) and geographic information system (GIS) are very important tools having a wide range of applications to modernize the present face of agriculture. These technologies have manifold applications in agriculture including crop discrimination, crop growth monitoring, soil moisture estimation, computation of crop evapo-transpiration, site-specific management or precision agriculture, crop acreage estimation and yield prediction.



Timely and reliable information on crop acreage, growth condition, and yield estimation can be highly beneficial to the producers, managers and policy planners for taking tactical decisions regarding food security, import/ export, and economic impact. Such information on a regional basis can be made available with the use of remote sensing and GIS techniques.

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RS and GIS can also be used very effectively in land use and land cover analysis as well as damage assessment because of drought, floods, and other extreme weather events. Thus, the use of remote sensing, GIS and Unmanned Aerial Vehicles (UAVs) proves to be a boon for Agriculture.

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Precision Agriculture: Precision agriculture (PA) or satellite farming or site-specific crop management (SSCM) is a farming management concept based on observing, measuring, and responding to inter and intra field variability in crops through GIS. PA is based on an innovative systems approach and these systems approach depends on a combination of fundamental technologies such as Geographic Information System (GIS), Global Positioning System (GPS), computer modelling, ground-based/airborne/satellite remote sensing, variable rate technology, and advanced information processing for timely in-season and between season crop management.

Information gathered through different sensors and referenced using a GPS can be integrated to create field management strategies for chemical application, cultivation, and harvest.

Nutrient and water stress

Nutrient and water stress management is one of the most important fields where we can opt for the application of remote sensing and GIS through the application of precision farming. Detecting nutrient stresses using remote sensing and GIS can help in site-specific nutrient management and thereby can reduce the cost of cultivation as well as increase the fertilizer-use efficiency. In the semi-arid and arid regions, judicious use of water can be possible through adaptation of precision technologies. For example, drip irrigation coupled with information from remotely sensed data such canopy air temperature difference can be used to increase the water use efficiency by reducing the runoff and percolation losses (Das and Singh, 1989). Development in remote sensing data acquisition capabilities, data processing and interpretation of ground-based, airborne and satellite observations have made it possible to couple Remote Sensing technologies and crop management systems to improve nutrient and water use efficiency.

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Pest Infestation

The remote sensing approach in assessing and monitoring insect defoliation has been used to relate differences in spectral responses to chlorosis, yellowing of leaves and foliage reduction over a given period assuming that these differences can be correlated, classified and interpreted (Franklin, 2001). The range of remote sensing applications has included detecting and mapping defoliation, characterization of pattern disturbances, etc. and providing data to pest management decision support system (Lee et al., 2010). The possibility of forecasting and vulnerability of forest trees to insect defoliation has also been reported as a tool for timely management (Luther et al., 2004). Ultimately, the modernization in the field of agriculture has enabled us to tackle many hurdles.

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Water resource management

In recent decades, the scarcity of water resources is being experienced at the global and regional level and, therefore, needs to be managed judiciously by applying state-of-the-art technologies. Remote sensing is one of the effective tools for assessing and monitoring water resources. This technology has been widely used in water resource applications (Gitelson and Merzlyak, 1996; Zagolski et al., 1996; McGwire et al., 2000; Coops et al., 2002; Underwood et al., 2003) and in particular, hyperspectral remote sensing is emerging as the more in-depth means of investigating spatial, spectral and temporal variations in order to derive more accurate estimates of information required for water resource applications. The advent of microwave remote sensing has made possible the assessment of soil moisture availability from remote sensing data.

Crop inventory

The satellite data of the crop season is acquired and the image analysis is done to get the area under any crop. The accuracy assessment can also be done using the ground truth data which plays a major role in the remote sensing technology.

The science of remote sensing can play a pivotal role in crop identification and area estimation and, therefore, has a significant role in inventorying database on different crops. Several studies using aerial photographs and digital image processing techniques have been reported in the literature. It helps in reducing the amount of the field data to be collected and provides higher precision of the estimate. The satellite data of the crop season is acquired and the image analysis is done to get the area under any crop. The accuracy assessment can also be done using the ground truth data which plays a major role in the remote sensing technology.

Conclusion

RS applications in agriculture have progressed to a stage where information from RS imagery is being used for several policylevel decisions related to food security, poverty alleviation and sustainable development.

The modern era has witnessed several advancements in the field of agriculture. The latest tools and technology have not only boosted the agricultural production but also helped in improving the problems that were earlier faced by the farmers due to different weather hazards, pest infestations, diseases, nutrition deficiency, etc. Thus, RS applications in agriculture have progressed to a stage where information from RS imagery is being used for several policy-level decisions related to food security, poverty alleviation and sustainable development. Technology thus has proved to be a boon for the fate of farmers.

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Tools for Precision Farming: Common challenges faced in the agriculture industry

Mr. BG Ravindra, Navbharat Seeds Private Limited

CHANGING FARM CONDITIONS

Farming is no longer a community endeavor – it's a global one. Big markets require big farms, and big farms need advanced agricultural technology to stay efficient and competitive.

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Farm acreage is growing in size. As more and more people move into cities, the labour market for farmhands and seasonal help grows smaller. The need for automation in the agricultural sector grows greater than ever.

The research projects represent the exciting potential of digital tools, such as computational models, robotic systems, artificial intelligence and the 'internet of things', to transform agriculture at every step of the food-production process, said Susan McCouch, Ph.D. '90, the Barbara McClintock Professor of Plant Breeding and Genetics and the director of the Cornell Initiative for Digital Agriculture (CIDA).

Drones as aerial surveyors:

At the beginning of the crop cycle, site surveying allows farmers to find the best locations to scout for crops, to inspect the land and plan future crop rotations.

SOIL MAPPING AND SURVEYING

Drones with onboard aerial mapping software can create precise three-dimensional maps and "geographic information system surveys" (GIS surveys), tracking soil quantity and richness, allowing farmers to find high yield zones and determine irrigation and nitrogen management strategies. DRAINAGE PLANNING Digital Elevation Maps (DEM)s allow farmers to plan and understand the topographic movement and elevations of water, soil, and fertilizer.

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PLANTING

As crops grow, drones can calculate the vegetation index to check the density and health of a crop by examining its heat signature.

IRRIGATION MANAGEMENT AND OPTIMIZATION

Multispectral imaging allows drones to identify dry parts of a field so that farmers can adjust their course accordingly.

Drones possess sensor systems that allow them to adjust their altitude and move with field topography, avoiding collisions with low-hanging objects and allowing them to douse crops with the correct amount of water. Drone irrigation sprays in real-time for even coverage.

Aerial spraying techniques simulate natural rainfalls – and are five times more efficient than the old days of sprinklers and pipelines.

MAP PRODUCTION

Ortho mosaic imaging uses high-resolution aerial mapping made up of independently shot and compiled RGB images, creating detailed, high-resolution images that allow farmers to check up on the health of their plants and optimize yields.

Improving strawberry yield through native and robotic pollinators:

The researchers will develop durable and low-power insect camera traps, use drones for rapid crosspollination and create growth models that can be conveyed to a farmer via an online app.

(Kirstin Petersen, Assistant Professor of Electrical and Computer Engineering; and Scott McArt, Assistant Professor of Entomology).

Their work will integrate automated monitoring of wild and managed pollinators with robotic pollination, laying the groundwork for a biological-hybrid system that can observe, predict and improve crop yield. The researchers will develop durable and low-power insect camera traps, use drones for rapid cross-pollination and create growth models that can be conveyed to a farmer via an online app.

Precision Agriculture for Development (PAD) works with various partners across India to build, pilot, and evaluate services informed by our lab setting in Gujarat and other work around the world. IFFCO-Kisan is a mobile phone advisory service offered in partnership with a Telco which now reaches more than 3.5 million farmers across 19 states and offers information customized by agro-climatic zone. They asked PAD to analyze their data for pick-up rates, listening duration, and churn to motivate the design of pilots aimed at improving the product and deepening their engagement with farmers.

Agro star, an agricultural input supply firm that operates through mobile-based sales, is working with PAD to pilot service to 6,000 of their clients to gauge the impact on lead creation and sales. IRRI is working in collaboration with PAD to develop and disseminate personalized messages on nutrient management to rice farmers.

Together with the Government of Odisha's Department of Agriculture and Farmers' Empowerment, PAD is advising on the design and roll-out of service for rice farmers across the state of Odisha with ambitions of reaching 1 million farmers.

In collaboration with Coffee Board of India, PAD is advising on the design and roll-out of service for coffee farmers in the state of Karnataka, with ambitions of reaching 350,000 farmers across all major coffee growing states in India.

The Scope for Artificial Intelligence in Agriculture

Hypothetically, machines can learn to solve any problem on earth relating to the physical interaction of all things within a defined or contained environment by using artificial intelligence and machine learning.

The principle of artificial intelligence is one where a machine can perceive its environment, and through a certain capacity of flexible rationality, take action to address a specified goal related to that environment. The rise of digital agriculture and its related technologies has opened a wealth of new data opportunities. Remote sensors, satellites, and UAVs (Unmanned Aerial Vehicles) can gather information 24 hours per day over an entire field. These can monitor plant health, soil condition, temperature, humidity, etc. The amount of data these sensors can generate is overwhelming, and the significance of the numbers is hidden in the avalanche of that data.

The idea is to allow farmers to gain a better understanding of the situation on the ground through advanced technology (such as remote sensing) that can tell them more about their situation than they can see with the naked eye and not just more accurately but also more quickly than seeing it walking or driving through the fields.

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Seed traceability **through GS1 Global Standards**

Mr Ankit Arora

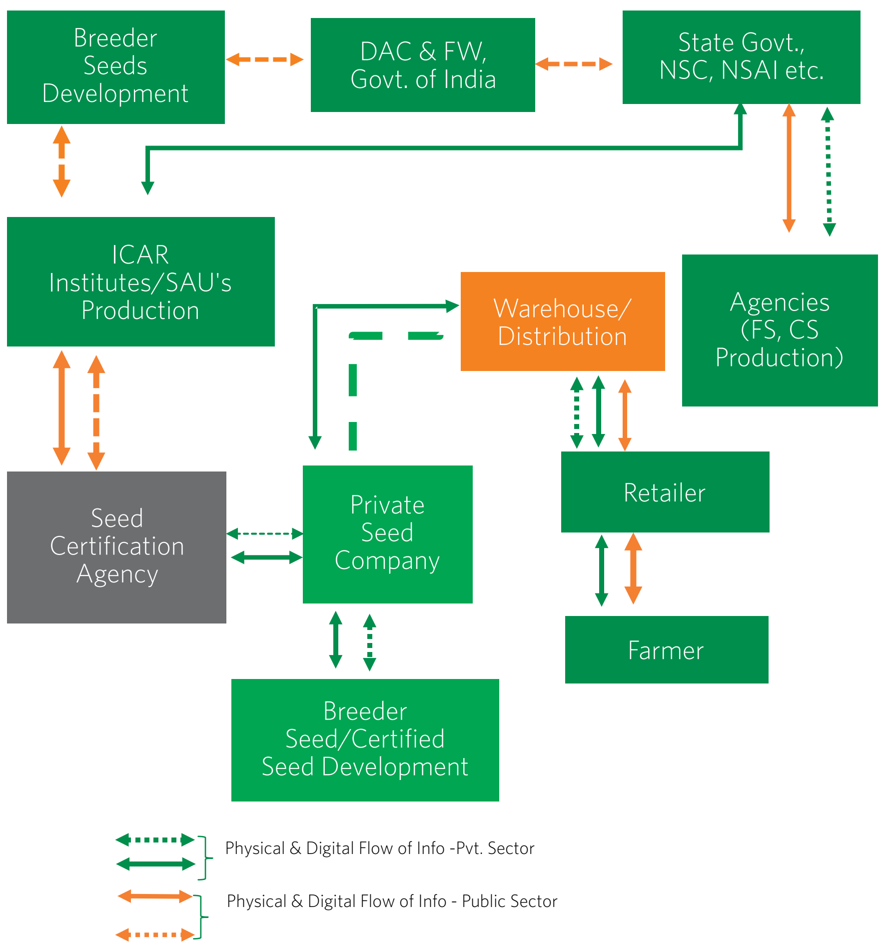
Sr Manager, GS1 India

These standards enable unique identification of products, consignments, legal entities, documents, etc. and subsequently enable, track and trace, authentication, real-time inventory management through software applications built around these standards.

GS1 India is a standards body set up by Ministry of Commerce & Industry, Govt. of India along with BIS, APEDA, Spices Board and apex industry chambers like FICCI, CII & ASSOCHAM to assist Govt. organizations and Indian industry on the adoption of global standards on barcoding, RFID and unique identification. These standards enable unique identification of products, consignments, legal entities, documents, etc. and subsequently enable, track and trace, authentication, real-time inventory management through software applications built around these standards.

IT applications, business processes, technologies or platforms of future are going to be more adaptive & interconnected than ever before, hence it is important to build a platform on a common set of standards. GS1 standards which are ISO endorsed work in a similar direction and brings a common set of standards for business processes, IT applications across different seed producing companies.

Existing Seed Supply Chain



With existing complex supply chains involving seed producers, farmers, regulators, processing units, and research institutes, Government requires the ability to track and trace the source of seeds to the final destination.

Traceability enables products to be made visible across the supply chain, building the fundamental blocks within quality, risk management and other types of systems.

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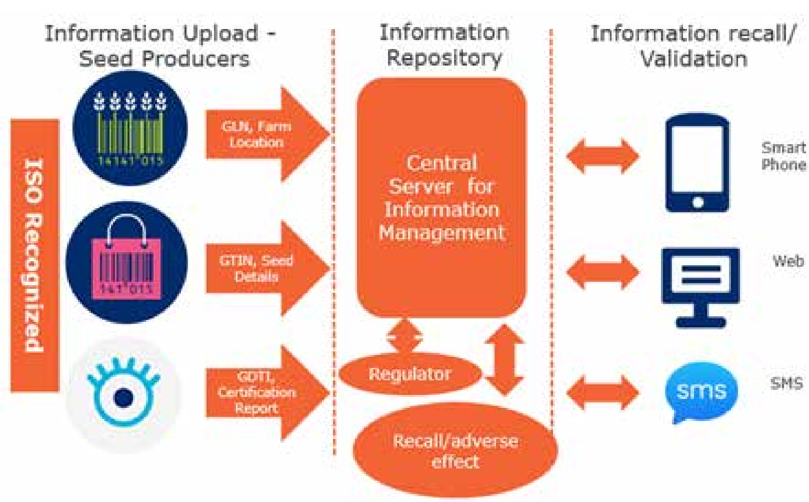
GS1 Global Traceability Standards

The GS1 Global Traceability Standard defines a minimum set of traceability requirements within business processes to achieve full-chain traceability, independent of any technology. It outlines a common framework to build a traceability system using other GS1 standards – such as barcodes, QR codes, data carriers.

This standard allows an end-to-end traceability system, linking the flow of information to physical products. In case of an adverse event, the sharing of traceability information between trading partners in the supply chain is critical to ensure targeted and effective management of products (recall, counterfeit detection, etc.).

The alignment, exchange, and recording of traceability-related data between trading partners is important and described as follows:

- Master data – data which is permanent or relatively constant over time and provides descriptive attributes to the identification of products, parties and physical locations (e.g. name of the company, contact details, address).
- Transaction data – data created from trade transactions triggering or confirming the execution of a function within a business process such as in warding or out warding of goods, or a business process (e.g. time of production, best before date, batch no.).
- Visibility event data - data detailing the physical activity of products or other assets answering the “What, When, Where and Why” at real-time.



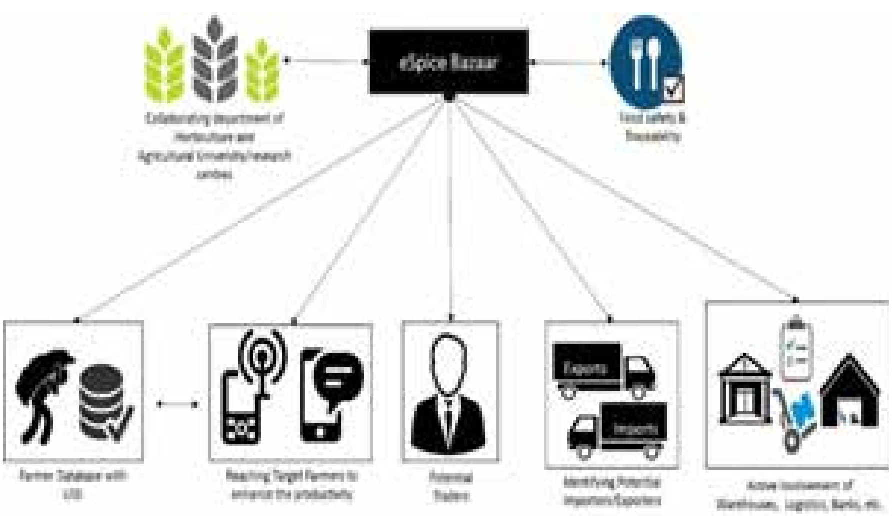
SUCCESS STORIES:

1. Chilli traceability @ e-Spice Bazaar:

e-Spice Bazaar is an Online Market place for spice farmers to promote their produce and find/interact with buyers.

- Enable traceability of produce
- Facilitate transactions between the sellers and Buyers
- Provide various forms of advisory to farmers and Groups at various stages of production and storage

GrapeNetis a similar initiativeforTracing Grapes.



2. Smart Consumer Mobile App:

A joint initiative of Department of Consumer Affairs & GS1 India

Scan a barcode to get -

- Name & Address of the manufacturer
- Consumer care contact details
- Basic product information like Name of the product, Brand Name, type of commodity, qty, Net wt.
- MRP
- FSSAI license number

Harvesting Data and **Analytics to Revolutionize Agriculture**

Dr. Srinivasu Pappula, Ph.D., CISSP
Global Head, Digital Farming Initiatives, Tata Consultancy Services

More than 65% of the Indian population depends directly on agriculture for their livelihood. Yet, pressing agricultural challenges stemming from climate and market-related uncertainties threaten to jeopardize the future of food security in India. Leveraging analytics to transform Indian agriculture can help change this equation.

Making Indian agriculture ‘climate and market smart’

TCS Digital Farming Initiatives (DFI) aims to make Indian farmers and agriculture ‘climate and market-smart’ through the extensive use of data and analytics. Our market-demand and crop-protocol centric Crop Rotation, Optimization and Planning System (CROPS) forms the hub of the revolutionary initiative. CROPS use data-driven decision-making techniques to advise farmers on the best crops that can be grown on their land, thereby optimizing field-level management and resources.

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This involves considering various static data sources such as the historical cropping patterns, geographic climate zones, weather patterns, soil composition, water tables, and water availability maps. In addition, dynamic data elements such as individual farmer constraints, market forces, and predicted prices are also factored into the equation. Through the application of deep learning techniques across disparate data sets, the system generates a shortlist of the best crops that can be grown in a certain area. It also generates the cost of production and the expected income for each option. Once a farmer selects the desired option, CROPS creates a Crop Protocol for the chosen option.

The Crop Protocol comprises personalized information for each farmer. Following the protocol instructions helps farmers achieve the expected yield while maintaining the predicted quality. The revolutionary protocol-centric approach helps farmers better anticipate and smooth out the unexpected vagaries of weather and market using historical and predictive data analytics.

Optimizing crop protocol in real time

During the crop cycle management phase, data from real-time monitoring is analysed to fine-tune the crop protocol.

Here's how:

The first step is to determine the optimal sowing period based on the Moisture Adequacy Index (MAI) - the standardized measure used for assessing the adequacy of rainfall and soil moisture required to meet the potential water requirement of crops. Historic climate data spanning over 30 years is used to determine this sowing window.

Thereafter, real time monitoring of the weather conditions and application of various AI-based techniques helps create an early warning system for pests and diseases. This helps farmers enhance their farm income in two ways.

Moisture Adequacy Index (MAI) - the standardized measure used for assessing the adequacy of rainfall and soil moisture required to meet the potential water requirement of crops.

One, by obtaining advance intimation on the incidence of pests and diseases, farmers are also able to avoid reactive usage of chemical pesticides, saving money as well as the environment. Second, they are able to reduce wastage through proactive disease prevention. The DFI group at TCS has created models for forecasting the incidence of 80 diseases and pests for 30 different crops.

In crop identification, specific crop growing practices are considered when using satellite imagery. For instance, identification of rice across large watersheds can be based on the ponded conditions under which most rice is grown.

Cognitive Remote Sensing Services in Agriculture (CRSSA), the imagery acquired by satellites, is the cornerstone of CROPS. The type of imagery, more specifically its wavelength, plays a key role in the nature of the agricultural problem being addressed. For instance, crop growth measures (such as leaf area index, stomatal activity, chlorophyll content) and soil health metrics (such as soil moisture, salinity, pH) need to be correlated with various wavelengths and scaled up for using satellite imagery. In crop identification, specific crop growing practices are considered when using satellite imagery. For instance, identification of rice across large watersheds can be based on the ponded conditions under which most rice is grown. Crops such as oil palm can be identified by applying machine learning algorithms using their unique leafing pattern as a signature. A combination of spectrum choices and plant phenology-based markers can help in the development of enhanced versions of CRSSA.

The true potential of analytics lies in its ability to crystal gaze into the future and accurately predict success. Deep learning algorithms can analyse a decade of field data comprising insights into how crops performed in various climates and inherited certain characteristics, and use the information to develop a probability model for predicting which genes will most likely contribute a beneficial trait to a plant.

Enabling smart farming through predictive analytics

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Clearly, the time for precision agriculture is ripe and data and analytics will play a key role in ushering a new era in Indian farming.

* Source: p A r I v a r t a n a

NOTES

nsai National Seed Association of India

NSAI PUBLICATION ADVERTISEMENT RATES

Seed Times Magazine:

	Amount in INR
Back Cover	₹ 40,000
Inside Cover (Front)	₹ 25,000
Inside Cover (Back)	₹ 25,000
Inside Page (Full)	₹ 15,000
Inside Page (Half)	₹ 10,000

Note: On Purchasing Yearly advertisement bookings (3 issues of Seed Times) FLAT 20% Off.

NSAI Website:

	6 Months	1 Year
NSAI Home Page Banner	₹ 50,000	₹ 80,000

NSAI e-Newsletter:

	Amount in ₹
Cost for one month issue	₹ 10,000
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