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Celebrating WOMEN In Agriculture

INDIAN SOCIETY OF AGRICULTURAL ENGINEERS

...Connecting Engineers in Agriculture

From the Editor-in-Chief

WOMEN
Unsung Warriors of Indian Agriculture

Empowerment of women in India will not be complete without empowering those agri-women who are living at the country's socio–economic periphery. Gender based discrimination continues in multiple ways at all echelons, due to stringent patriarchal traditions! Women are not recognized as farmers in Indian society, thereby denying them equal opportunities. Bridging this gap is essential in order to accelerate the pace of growth in the Indian agriculture sector.

Despite these challenges, there have been **exemplary stories of triumph of women** in many facets of agriculture. As the world commemorates **International Women's Day**, it's pivotal to spotlight the substantial contributions of women to India's agricultural sector, especially in engineering and technology. Women have emerged as key innovators and leaders, driving forward an industry critical to India's economy.

Women have made significant contributions to agriculture throughout history and across cultures. These **untold biographies of perseverance and determination need to be celebrated.** Here are a few areas of their continuous involvement:

Farm labor: Women have been involved in various agricultural tasks such as planting, weeding, harvesting, and processing crops. In many societies, women have played a central role in food production.
Animal husbandry: Raising livestock, including feeding, milking, and caring for animals. In many traditional farming communities, women have specialized knowledge about animal breeding and healthcare.
Food processing and preservation: Processing and preserving food through techniques such as drying, fermenting, and canning. Their knowledge of food preservation methods has been essential for food security.
Environmental stewardship: Women have a deep understanding of the local environment and ecosystems, often passed down through generations. They have been instrumental in sustainable farming practices, such as agroforestry, soil conservation, and organic farming.

Entrepreneurship and market access: Women have increasingly taken on entrepreneurial roles in agriculture, including small-scale farming, agribusiness, and value-added food production. Access to markets and financial resources remains a significant challenge for many women farmers, but initiatives to support women's economic empowerment in agriculture are growing.

Overall, women's contributions to agriculture are multifaceted and indispensable. Recognizing and supporting women's roles in agriculture is essential for promoting food security, rural development, and technology driven, sustainable farming practices.

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Women in Agricultural Engineering

Dr. S. N. Jha
President, ISAE &
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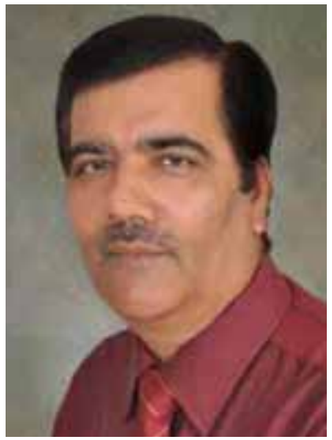
Indian Agri-food system, since years we are hearing, is a male dominant sector. Dynamics of labour force in India is changing at faster rate than any other country of the world. Rapid growth rate in service and industry sectors and increase in income from other sources are affecting the migration of labours from one sector to other one. The Fig.1 depicts the dynamics of labour. In 2011 the agriculture labour force was about 49.26 %, while it is decreasing year-by-year and in 2021 was only about 43.96 %. Some other estimates further indicate that agricultural labour force in 2021 was only about 39.4 %, amongst which 45 % is women. The Fig. 2 indicate the ratio of men and women workforce dynamics in India. As targets of India to become the developed country by 2047, the labour dynamics shall change at faster rate. By 2047 total agricultural workforce may not be more than 30 % of which about 60 % will be women workers.

Indian Agriculture shall be further facing a peculiar condition as far as labour is concered. Farmers are ageing. Majority of them in India are aged above 40. In 2016, the average age of an Indian farmer was 50.1 years and



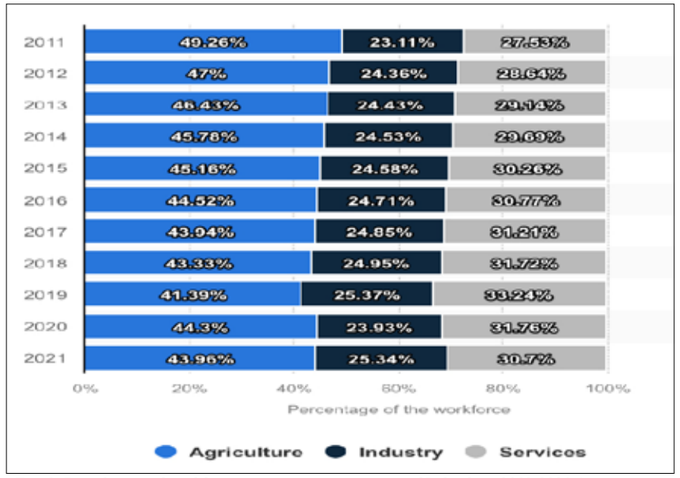


Fig. 1. Distribution of workforce across economic sectors of India from 2011-2021 (source: www.Statista.com)

the next generations of these farmers is not taking up this profession. It means we are approaching a situation where one of the biggest consumers of food will be left with only a few farmers. So importance of half of population not only in agricultural fields but in developing technologies, employing them in field and training the women workforce for using newly developed tools, gadget and machine shall further increase.

The Agricultural Engineering as a profession is the best for employing them for rapid growth of agriculture

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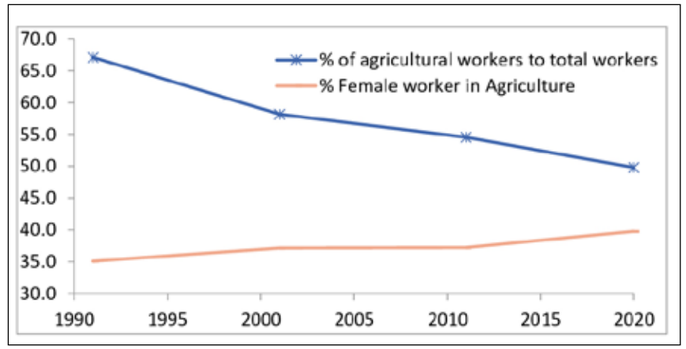

Fig. 2. Change in male and female workers' percentage in Indian agriculture

TABLE 1. APPROXIMATE AVERAGE PERCENTAGE OF GIRL STUDENTS ADMITTED IN AGRICULTURAL ENGINEERING IN LAST THREE YEARS

Sl. No.	University	Girl students, %
1.	PAU Ludhiana	26
2.	BAU Ranchi	40
3.	UAS Raichur	42
4.	PDKV Akola	32
5.	UAS Bengaluru	45
6.	SKUAST-K Srinagar	55
7.	Colleges in Telangana & AP	55
8.	Colleges in UP	38.46
9.	MPKV Rahuri	31
10.	Dr BSKKV Dapoli	32
11.	OUAT, Bhubaneswar	63
12.	CAEPHT Sikkim	35

and so of the rural economy. In 1950 hardly any girl was being seen taking admission in engineering. But now seeing the potential, admission ratio of girls' students has increased phenomenally (Table 1.). In some cases, it has increased to the level of 63 %. This is not only a good sign for Indian agriculture, but for the Indian economy too. The government of India's scheme for certain weightage for girls' admission in IITs and other entrance examinations, employment schemes, booming food processing sectors for better employability, electronics, automation and robotics in agriculture might have influenced the girls students for admission in agricultural engineering. Understanding that a fewer females as compared to male students are opting for STEM" is now changing fast, at least in case of Agricultural Engineering. We therefore expect women agricultural engineers shall be dominating in numbers in getting agri-food system in very near future as compared to just 7% of agritech deals and 3% of the record-breaking volume of dollars invested in the sector in 2018 went to female-founded teams. Of these, only 16% of deals supported start-ups with at least one female co-founder. Wish our women agricultural engineers will fill these gaps and if not more shall be almost equal in days to come.

Numerous women agricultural engineers are at high level posts including that of senior advisor in NITI Aayog, CEO and group editors in agri-media houses to the Head of department, deans, and directors in Indian Agricultural research and education systems. Contributions in planning, monitoring, implementation of schemes, human resource developments, research in new machinery and process/ product developments of women agricultural engineers are immense. The scope and potential of these engineers are increasing many folds due to invent of digital agriculture, electronics, sensors, robotics, drone and application of unmanned vehicles in agriculture.

How to Empower Women Farmers to Unlock Agri Economy

Hemant Sikka
President of Mahindra Farm Equipment

THE SETTING:

In Zaheerabad, Telangana, Misbah's story is nothing short of inspiring. A farmer by profession and a tractor-driving instructor. After getting married, she convinced her husband to move to Zaheerabad, where she joined a tractor-driving programme. Among 80 men in the programme, she was the only woman.

Reflecting on her experience, Misbah said, *"My classmates were curious and teased me about my plans after the training. But with my husband's support I persisted, moving from student to trainer over time."*

Her journey encouraged 40 other women to join the programme. Misbah found fulfilment in knowing that her courage not only allowed her to learn a skill typically associated with men but also inspired others. She realised the immense influence women like her could have in rural communities. *"This realisation fuelled my belief that women can achieve anything they set their minds to."*

In India's rural villages, many women are often overlooked when it comes to securing a plausible income from their family's farmlands. This is in spite of being actively involved in farming. They are the unsung heroes of India's agri economy, carrying a great part of that burden of their families' farmlands, as their spouses are compelled to move to urban centres in the quest to improve their family's economic situation.

As one of the country's most important sectors, agriculture has witnessed remarkable growth over the past decade, contributing around 20% to the country's GDP. It provides employment to over 45% of the country's workforce, with women making up nearly half of that workforce. Having said that nearly 80% of India's employed women are engaged in agriculture.

In addition to augmenting household incomes, these women are also tasked with fulfilling primary responsibilities, like managing their family meals, household chores and caring for their children and the elderly.

Despite their pivotal role, prevalence of gender stereotypes, social restrictions and traditional role expectations, hamper women's access to knowledge and technology in farming, resulting in low productivity. According to the PLFS 2021-2022, the literacy rate of rural women of age 7 years and above is at 68.9% compared to rural men at 83.5% and urban women at 84%. According to the Agricultural Wages in India (AWI) report of May 2020, it is also alarming that in spite of increasing participation of women in farming, the wage gap between men and women is not on par.

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Regardless of these challenges, women farmers are a source of immense inspiration as they serve the nation with a spark in their spirit.

Given this, what actions can policymakers take to greatly encourage women in farming, while establishing the country as the global hub for food? Especially in the context of the government support for agriculture as well as emerging agricultural technologies. What could the next set of reforms be, to take forward the already established momentum of feminisation of agriculture?

Evolving women self-help groups (SHGs), into Farmer Producer Organisations (FPOs)

'Sabka saath sabka vikas' through women SHGs can attain various objectives, including empowerment women by nurturing their knowledge and skills. SHGs can help strengthen their physical and emotional resilience, including that of their families, through education, nutrition and inculcating birth control measures. The government's 'Sabka Saath' initiative is laudable. 84 lakh SHGs with 9 crore women have been integrated into the transformation of the socio-economic fabric of our country. From there on, transforming these women-led SHGs, into women-led FPOs (Farmers Producer Organisation), could go a long way in further creating 'lakhpati didis'. They can collectively guide participants on crop choice, access to microfinance and effective product marketing, gradually morphing into micro-enterprises producing packaged foods, for better earnings, while driving positive change in the lives of rural women. The government's emphasis on agriculture, commitment to modernising storage, supply chains, and branding in the farm sector aligns with this approach, driving value addition and income enhancement through farming, benefiting both farmers and consumers.

Programmes providing access to critical farm equipment

A lot more women are interested in operating their equipment. Government initiatives like SMAM signify a step in the right direction. Under this central governments scheme, farmers are provided with the benefit of subsidies ranging from 50-80% for buying agricultural machinery, with priority given to women farmers. With implementation in all states, it is important for the government to ensure greater access to affordable finance to acquire this farm equipment while establishing custom hiring centres to sample them. Having said that, India also needs to look at farm mechanisation beyond tractors, for affordable solutions catering to varied types of crops, across the lifecycle of the crop. e.g. Better penetration of Rice Transplanting technology can drastically reduce drudgery, over backbreaking manual transplanting, often seen in paddy states like Orissa, Telangana and Tamil Nadu. State governments too can play a role here.

Develop and drive solutions for women, by women

The Indian Council of Agricultural Research (ICAR) contributes to food security through its research. They provide the much-needed support to adopt technology on farms, drive rural innovation, improve farming practices, promote climate-resilient and sustainable farming, while also supporting agri-tech startups. ICAR's network of 113 institutes and 74 agricultural universities across India, makes them one of the largest national agricultural systems globally.

However, more needs to be done to ensure that these centres work towards enrolling more women and fast-track the development of women-friendly farming solutions, with a tailored approach, to impart the required education and sensitivities related to women in farming. Integration of new-age technologies like AI, ML, IoT and app-based solutions too, can help mark a transformative shift for women in farming.

The private sector too can play a major role in delivering affordable and accessible farm solutions developed for women farmers. Innovations are needed among rural women, to feel inclusive, contributing further to agriculture and the Prime Minister's vision of a 'Viksit Bharat'.

In conclusion, India ought to focus on developing core competencies around gender issues in agriculture and more so rural India, with inclusion of the women perspective as an integrated component in policy and research. Progress and growth of women in farming must be closely linked to overall development goals of the country, besides enhancing India's reputation, as it becomes the breadbasket of the world.

The article was first published in Fortune India (FortuneIndia.com)

AI for Addressing Challenges in Agriculture

Samuel Praveen Kumar

Joint Secretary, MoA&FW, Govt of India

INTRODUCTION

Agriculture stands as the backbone of India's economy and is facing enormous, ever-evolving challenges due to the impact of climate change. This is leading to increased uncertainty and inability of farming to realize its true potential. Contributing to approximately 16-17% of the Gross Domestic Product (GDP), this sector not only fuels economic growth but also sustains over 50% of the country's workforce, playing a pivotal role in sustaining rural livelihoods. Beyond its economic impact, Agriculture is the cornerstone of India's food and nutrition security needs, being a global powerhouse in food grain production. From staples like rice, wheat and pulses to an array of exportable commodities like fruits, flowers and spices , Indian agriculture commands a crucial position on the world stage, bolstering the nation's foreign exchange earnings.

The AI implementation strategy adopted by the Ministry of Agriculture and Farmers' Welfare (MoA&FW) encompasses a comprehensive approach aimed at harnessing the power of AI to address the unique challenges faced by farmers. By integrating AI technologies into various aspects of policymaking, resource management, research, and service delivery, the MoA&FW aims

to achieve more efficient and effective outcomes.

CHALLENGES FACED BY AGRICULTURE IN INDIA

Some of the significant challenges faced by Indian Agriculture are :

Small Landholdings:
More than 80% of the farmers have small landholdings limiting their scale and productivity. Fragmented land ownership makes it challenging for farmers to adopt modern agricultural practices, and invest in advanced machinery, innovative and modern technologies while achieving higher yield.

Outdated/Unscientific Farming Practices:
Farmers in India still rely on traditional and outdated farming practices. Limited access to modern/ improved and innovative farming technologies, and education hinders productivity and growth.

Climate Change Impact:
Changing climate conditions affect crop yields, leading to increased risks for farmers. Adaptation strategies and resilient crop varieties and practices are crucial to address and mitigate climate-related challenges.

Post-Harvest Losses:
Lack of proper scientific storage, transportation and processing facilities leads to spoilage and wastage of agricultural produce, impacting farmers' income and food security. More importantly it's a loss to the nation.

Market Access and Price Volatility:
Farmers often face challenges in accessing markets, and unpredictable price fluctuations make it difficult for them to plan and invest in their agricultural activities. This in turn leads to inefficiency in the overall supply chain.

Limited Technology Adoption:
Limited awareness, access, and training hinder the widespread adoption of modern technologies and practices,

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hindering the sector's overall efficiency and competitiveness.

Lack of Credit and Financial Support:
Insufficient financial resources prevent farmers from investing in quality seeds, fertilizers, and machinery, impeding their ability to enhance productivity. Lack of access to institutional finances, forces them into debt trap of money lenders, ultimately making farming even more costlier, un-remunerative and unsustainable.

CAN AI HELP ADDRESS CHALLENGES IN AGRICULTURE?

The potential of Artificial Intelligence (AI) in revolutionizing various aspects of human life is unprecedented. AI technologies possess the capability to analyze vast amounts of data, identify patterns, and make predictions with a level of accuracy that surpasses human capabilities. From enhancing efficiency in industries to improving healthcare diagnostics, AI holds promise in transforming societies globally. Its ability to automate tasks, optimize processes, and facilitate decision-making has already started reshaping the way we live and work. As AI continues to evolve and mature, its potential to drive innovation and solve complex problems across diverse sectors remains immense. In short, AI helps to magnify and amplify manifolds the human capabilities for impact at population scale.

AI presents an enormous scope for addressing national challenges across different domains. Additionally, in governance, AI can facilitate data-driven decision-making, enhance public service delivery, and optimize resource allocation, thereby fostering efficiency and transparency in governance processes. By leveraging AI's capabilities, nations can effectively tackle socio economic issues, strengthen infrastructure, and foster inclusive growth, ultimately leading to a more prosperous and equitable society.

In line with the National Strategy on AI released by NITI Aayog, the Ministry of Agriculture & Farmer Welfare, Government of India has launched several digital initiatives using AI capabilities through the collaborative efforts of public and private agencies. The initiatives aim to create a comprehensive AI ecosystem, based on the principle of inclusivity and transparency, to ensure the efficient delivery of farmer welfare programs, enhance the farmers' capability to access relevant scheme data and address their issues in real-time, facilitate farmers in informed decision-making and capture & share best practices of farmers. The Ministry is integrating AI into its initiatives for providing accessible solutions with advanced technology. Ministry has already created an AI cell and also an Advisory Committee of experts for adopting the best practices. This article outlines key programs and systems, inspiring states to adopt and further develop these forward-thinking approaches.

CUSTOMIZED ADVISORIES AND REAL-TIME QUERY RESOLUTION:

AI can use Large language models (LLM) to understand the intent of the query asked by the farmers/beneficiaries and generate a contextualized and customized advisory based on their location.

a. Kisan e-MITRA

With scheme related grievance redressal being a core problem, the Ministry of Agriculture has developed an AI-powered scheme chatbot for farmers designed to promptly assist farmers with issues and complaints pertaining to payment, registration, eligibility, eKYC updation etc. The chatbot operates in the farmer's local language, facilitating instant support and streamlined grievance resolution for the central and state governments by automating scheme-related processes, thereby reducing manual workload. The Kisan e-Mitra chatbot is powered by AI and leverages speech to text technology and models that identify query intent (based on farmer input) which then connects to the backend to either provide information or retrieve status and communicate response. While this currently supports PMKisan related queries, the vision is to make Kisan E-Mitra a one-stop solution for queries related to all of the schemes implemented by the Ministry of Agriculture and Farmers Welfare, Govt. of India in the coming days.

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b. Krishi Saathi (Chatbot for Kisan Knowledge Management System)

Kisan Call Centers (KCCs), established by the MoA&FW, assist with various types of crop related queries ranging from pest control to market price support. These KCCs receive around 15,000 calls a day, attended by 476 Farm Tele Advisors (FTA's) from 17 locations across the country. However, response rates and farmer-wait times are long-standing issues which can be optimized through the integration of FTA support mechanisms that leverage AI. Krishi Saathi is an AI/ML conversational chatbot that uses Large Language Models (LLM) and web crawlers to provide access to summarized, verified and accurate responses to farmer queries. Not only will this increase the capacity of the KCC to respond to more calls by ~15%, but also reduce farmer-query turnaround time.

CROP MONITORING AND DISEASE DETECTION:

AI-powered image recognition can identify crop diseases, nutrient deficiencies, and pest infestations by analyzing images of plants. Early detection allows farmers to take prompt preventive and corrective action and minimize crop losses.

a. National Pest Surveillance System (NPSS)

India is set to feed 1.7 billion people by 2050, requiring a 35% increase in food production. With an increase in the population of India, producing food sustainably is of prime concern. However, there are several challenges which inhibit India from achieving food security, in a sustainable manner. One major challenge is that of pest attacks and diseases and by 2050, India could face up to 15-20% of crop loss due to pest attacks and diseases. The MoA&FW has built the NPSS as a warning mechanism to identify such pest attacks and diseases, provide accurate advisory and avoid crop loss to boost agricultural productivity. This pest-surveillance system (portal and mobile application) is being built in collaboration with ICAR's National Research Centre for Integrated Pest Management,an organization responsible for collecting and capturing data regarding focus crops and their associated pests, symptoms and disease images at field level. This data is then used to buildAI/ML models to detect crop defects and provide pre-harvest advisories at the national level to stakeholders.

b. Crop Classification: Strengthening the Krishi Decision Support System

The digital crop survey has been introduced to provide accurate and correct information on the crops grown by farmers to State and Central Governments to enable seamless benefit delivery. The Digital Crop Survey currently relies on farmer-captured photographs that are then tagged and cross-referenced to crops. However, the margin for error with respect to crop identification is high given the extent of manual intervention this requires. The MoA&FW is exploring ways in which pictorial analyses can be used to correctly infer crop photographs to eliminate errors that could feed into crop estimation and modeling.

DIGITIZATION AND INFORMATION DISSEMINATION:

a. VISTAAR

The Virtually Integrated System for Accessing Agricultural Resources or VISTAAR, is a flagship initiative by the MoA&FW to revolutionize advisory dissemination to farmers. By creating a network grid containing vast agricultural data, this initiative provides customized advisories and real-time query resolution by leveraging AI's prowess to deliver personalized and contextual advice to farmers. AI is able to not only retrieve data based on input/query but also analyze vast agricultural data to understand nuances like weather patterns and soil conditions. By integrating advisory retrieval solutions into the digital public infrastructure, farmers gain equitable access to agricultural information and technology, fostering innovation and continuous learning in the sector. Through user-friendly platforms, farmers can access real-time updates and expert advice, empowering them to make informed decisions and improve their livelihoods, promising a sustainable future for Indian agriculture. VISTAAR is being developed as Digital Public Infrastructure (DPI) for agriculture, the first such initiative across the globe, which enables an ecosystem level convergence among Government, academic & research Institutions, private players, Agri-startups and social enterprises coming together with a "farmer first" approach. This farmer-centric initiative has the potential to transform agricultural extension services in India and beyond.

b. Farmer Innovation & Best Practices

The Farmer Innovation Repository is the first of its kind platform, aiming to build a knowledge base by farmers regarding innovative farm practices followed across India. The first prototype of this repository brought in the knowledge, insights, challenges, practices of over 1700 diverse farmers as audio recordings from every district of Tamil Nadu. Using the power of AI, this knowledge can be accessed through voice or through text interface and in any Indian language. This will not only build an environment of peer-to-peer learning but will also help the larger ecosystem respond more effectively to the needs of the farming community. Given the success of the TN prototype the plan is to expand this beyond TN to other states and eventually create a pan-India repository which encourages and facilitates knowledge exchanges transcending state boundaries.

c. Scheme Impact Assessment

The conventional approach of conducting assessments is often based on measured observations using various experimental designs that are mostly expensive, time-consuming and require highly skilled evaluators. These are often associated with human bias involved. In the age of exponential technology like AI, assessments can be readily conducted in a way which is much more convenient, low cost, bias-free and at speed and scale. The MoA&FW has created a farmer feedback mechanism which can act as an Impact Assessment Tool. Such assessments captured in the form of voices/audio responses coming from the targeted farmers/beneficiaries are more reliable and trustworthy as they can be traced back to the network of farmers who are the beneficiaries of various schemes and projects. AI-powered assessments give a complete 360-degree view of the impact that can be synthesized based on the input provided by the targeted beneficiaries. This innovation was initially tested for assessing the impact made by Agriculture Infrastructure Fund (AIF) scheme-with a sample of over 200 beneficiaries from across India and it provided comprehensive insights on the impact. Given the success, the assessment is being carried out for other schemes including PM Kisan, Kisan Credit Card, Soil Health Card, Natural Farming etc.

d. Krishi 24/7

Krishi 24/7, an innovative AI-driven Agriculture News Monitoring platform, is dedicated to tracking media content and promptly issuing alerts concerning plant diseases, damages, and natural calamities. Drawing from a vast array of sources including web articles and Google Alerts, the application efficiently sifts through approximately 2.4 million articles per month, selecting relevant pieces across more than 10 categories and scanning through 150+ keywords. These curated articles serve as input to the system, where pertinent updates are extracted and presented. Designed to meet the needs of all the Divisions in the Ministry of Agriculture and Farmers Welfare, the platform operates seamlessly in 12 languages, ensuring widespread accessibility and utility.

CONCLUSION

As AI continues to evolve, its role in Indian agriculture becomes increasingly pronounced. Government initiatives such as Kisane Mitra, VISTAAR, KKMS and AI chatbots are some of the pioneering efforts towards building a more sustainable and tech-driven agricultural sector. These initiatives aim to empower farmers with instantaneous grievance redressal, real-time and contextual advisory and knowledge of crop management practices, thereby enabling them to make informed decisions and optimize their agricultural practices. Such initiatives set into motion a virtuous cycle of knowledge and benefits from harnessing new-age technologies, thus pushing India and its agricultural sector into an era of prosperity.

The integration of AI not only addresses existing challenges such as lack of information accessibility, pest infestation and climate uncertainties but also lays the foundation for a future where Indian farmers can harness the power of technology for improved yields, reduced production costs, and enhanced farm income, leading to better livelihoods and eventually increased agricultural resilience. The synergy between emerging exponential technologies like AI and Agriculture is a promising trajectory that holds the potential to transform India's agrarian landscape, ensuring food security, sustainability, and prosperity for millions of farmers across the country.

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Contributions of Women in Agricultural Engineering & Technology

Dr Falguni Thakar

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Advancement of science and technology in different fields has created new vistas for progress and well-being of humankind. Agriculture is one such field that continues to benefit from new knowledge and technological breakthroughs. An important aspect of all these changes that was missing earlier, but has gradually been realized is the scope and opportunities of agricultural knowledge & technologies for women.

Agriculture is a crucial sector for human survival, and women's contribution to it is undeniable. It is an important engine of growth and poverty reduction. India's economic security is heavily dependent on agriculture. In terms of employment, it is the most important source of income, especially for rural women. Women play a significant and crucial role in agricultural development and allied fields including, main crop production, livestock production, horticulture, post-harvesting operations, agro/social forestry, fishing etc. in addition to household activities. However, the nature and extent of their involvement is different in various agro-production systems. The mode of female participation in agricultural production varies with the landowning status of farm households. Their roles range from managers to landless labourers. In India, about 74 per cent of the entire female workforce is engaged in agricultural operations, but the nature and extent of women's involvement in agricultural operations varies greatly from region to region.

Agriculture--the single largest production endeavour in India, contributing about 18% of GDP, is increasingly becoming a female activity. Agriculture Sector employs 4/5th of all economically active women in the country. 48% of India's self-employed farmers are women. Beyond the conventional market-oriented narrower definition of 'productive workers', almost all women in rural India today can be considered as 'farmers' in some sense, working as agricultural labour, unpaid workers in the family farm enterprise, or combination of the two. Moreover, several farm activities traditionally carried out by men are also being undertaken by women. Together with male migration into non-farm employment, agricultural modernization appears, thus, to be an important factor behind the rising proportion of women in Indian agriculture. The positive impact of this is that more women are moving into wage employment.Thus, rural India is witnessing a process which could be described as "Feminization of Agriculture".

There are 75 million women engaged in animal husbandry as compared to 1.5 million men. A significant shift in approach towards well-being of women from "Welfare during Fifties", to "Development during Seventies" to "Empowerment during Nineties" and to "Participation during Two Thousand" is a most welcome trend. The National Agriculture Policy has recognised incorporation of gender issues in the agricultural development agenda in

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view of women's role as farmers and producers of crop and livestock, as users of technology, as active agents in marketing, processing and storage of food and as agricultural labourers.

Closing "gender gap" in agriculture–or increasing women's contribution to food production and enterprise by providing equal access to resources and opportunities–could reduce the number of hungry people in the world by 12-17%, or by 100 to 150 million people (FAO, 2011). Women's leadership in agriculture can help address gender inequality, promote sustainable agriculture practices, and increase productivity and income.

With the modernisation of agriculture - introduction of high yielding variety seeds, mechanisation of farm operations, use of chemical fertilizers, insecticides, pesticides, weedicides, herbicides, hormone - accelerators etc. the traditional role and status of women has changed. There is immense drudgery in sowing, transplantation, irrigation, fertilizer application, weeding, plant protection and harvesting. Even in post harvest work, women carry out the operations manually in an arduous manner when technologies are now available for threshing, winnowing, and milling as also for shelling of maize and groundnuts. There are hand/pedal-operated cleaners, solar dryers, metallic storage structures; power operated mills, etc. which can reduce the drudgery in these operations.Introduction of modern marketing systems has also affected women's contribution in terms of post-harvest operations, home made consumer goods and decision making in agriculture.

Now, women have managerial and organisational skills so that they themselves can utilise new technologies such as those relating to biofertilizers, seed production, pest surveillance, bio-

mass utilisation, crop livestock and fish integrated production systems. Targeting women for training in technology would also benefit the entire family in terms of better health, nutrition and an improved home environment.

As horticultural crops are gaining importance owing to their commercial, nutritional and export potential, the role of women is likely to be more substantial. Women play an active role in the production of quality planting materials of horticultural and ornamental plants for entrepreneurship and employment generation which will be a small step towards prosperity of farming community. The contribution of women is invaluable in the development of horticulture and dairy farming, poultry farming, bakery, forest industry, fisheries, kitchen garden etc.

In the present scenario of perpetual demand of vegetables and shrinking land holding drastically, protected cultivation is the best alternative and drudgery-less approach for using land and other resources more efficiently. In protective environment (green house glasshouse or poly house), the natural environment is modified to suitable conditions for optimum plant growth which ultimately provides quality vegetables. Nursery for ornamentals, flowers, vegetables, fruits and plantation crops can be successfully developed inside greenhouse. Women can grow the high- priced vegetables such as asparagus, leek, tomato, cucumber and capsicum round the year especially during winter season for sound profit.

Post-harvest management, processing, storage and utilization of vegetables and vegetable products are generally the domain of women at home scale. Cultivation of horticultural crops plays a vital role in prosperity and it's directly linked with health of people. These crops are not only used for domestic consumption but also processed into various products like pickles, preserves, beverages, jam, jelly squash, etc., which offers employment opportunities to the rural women. The focus on the value addition in the horticulture sector is vital for comprehensive development of the rural economy. Processed horticultural products have also good export potential in our country. Vegetables and fruit processing and preservation play a great role to provide employment and industrial base for export of dehydrated and preserved products. Mostly dehydrated vegetables are being exported. The other products that are being exported or consumed within our country are juice, ketchup, pickles and canned vegetables and fruits. Tapioca is used for manufacture of industrial products like sago, stars noodles and quick food products.Entrepreneurs and growers

from Tamil Nadu, Karnataka, Kerala, AndhraPradesh and Maharashtra have recently taken up large scale mushroom cultivation. Various womenshelf help groups in north east region are growing paddy straw mushroom in backyard.

Eco-friendly management practices such as integrated pest management practices, ropping/farming systems, conservation technologies etc. are now frequently used by farm women. Horticulture and floriculture technologies like improved, dwarf, high yielding varieties/hybrids, nursery technologies, protected cultivation, meadow orcharding, inter-ropping and management practices, INM & IPM, use of biotechnology, micro-irrigation etc are also popular and widely used.

Cultural practices such as contour cultivation to prevent soil erosion, summer ploughing, stale seed bed preparation, clean cultivation for weed control, micro watershed development for rain water harvesting, cyclic flooding and drying in rice for water conservation, seed selection and treatments by using germination tests, salt water and hot water, nutrients application on seed, use of pesticides/botanicals for prevention of seed borne diseases are also handled by women. Hybrid technology, a seed producing activity, involves skilful, finite operations which women have been found to have a natural knack for. The industry recognises this and 70% employees in hybrid seed production are women.

Tissue culture technology offers new scope for conservation and rapid multiplication of cells. This is a highly skillful activity that are also learned and applied by women. Women's role as preservers of forest wealth can be further accentuated by technical knowledge on nursery maintenance - nursery grafts of horticulture and perennial crops-,agro-forestry, silvi-pastures etc. which can also generate additional income. These practices can be integrated in the farming system itself so that it can also meet the household biomass needs too. Ethno-botanical techniques are part of habits of tribal groups. Information search on ethics and ethos of these women and on modes adopted to choose plants for conservation is needed, to develop a national database.

Protecting bio-diversity and genetic conservation and women's role in this process has also recognized. Scientific livestock production technologies like"clean" milking concept, new fodder grasses (amenable for multi-cuts and identified for marginal lands)are ways for sustaining production systems. Recycling of wastes and their use as animal or poultry feedsapplied for the animal husbandry component. The number of women professionals in the field of agriculture, veterinary science and allied areas are increasing.

There are many areas where women participation is high such as Dairy, sericulture, bee keeping, mushroom cultivation, poultry, rabbit rearing, livestock management, bio-diversity maintenance, waste land development, pond management (common properties management), nursery management, integrating farming systems, rural crafts, entrepreneurial development and frontier areas such as bio-technology, hybrid seed production, Computer aided water management, renewable energy technologies etc.

The world community today sincerely recognized the role of women in agriculture and the constraints that they face in earning a decent and sustainable livelihood. There are many constraints and challenges to address the gender issues, and createopportunities for women in agriculture in the face of rapidly changing agricultural scenario. It is wellevident that educated, informed and empowered women can contribute to sustainable and inclusivedevelopment.

Role of Women in Agricultural Mechanization

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INTRODUCTION

The women work force in agriculture and allied sectors is estimated to be around 110 million which amounts to about 40% of the total rural workers in the country. Traditionally women workers participated in field operations like sowing behind the plough, transplanting, weeding, interculture, harvesting and threshing and primary processing of agro-produce. As per FAO estimates, women produce 60-70% food in most of the developing nations. They are basically major fraction of agricultural workforce. Studies have shown that the Indian women carry out the most arduous activities on farm apart from household activities. Besides household management, most of the work related to management of cattle/other farm animals is done by women. At present, most of the women carry the role of workers only. Despite Woman's major role in agriculture, gender disparities such as lower access to resources, share in decision making, socio-economical vulnerability is being faced. International studies suggest that women can boost agricultural output by 20-30% if they have access to same agricultural resources as men. The mechanization can prove to be a critical tool for closing the gender productivity gap in agriculture while improving women's empowerment.

There are many case studies carried out in the country regarding women's contribution in agriculture and allied activities. It has been reported that the rate of participation of female labour in farming activities varies accordingly to the socio-economic status, agricultural seasons, crops grown, type of operations needed, cropping pattern and type of technology used. Women provided a very significant part of the total labour used on all size group of farms (33%, 31% and 26% respectively in small, medium and large farms). Out of the total labour used in crop production, female labour constituted 57.2% (43.0% family labour +14.2% hired labour) while men labour constituted 42.8% (34.0% family labour + 8.8% hired labour). Out of the total labour use in tending cattle, share of women and men was 79.4 and 20.6%, respectively. Singh (2024) indicated that for rice cultivation, women participation was crucial in various operations such as sowing/transplanting (86%), weeding (84%), storage of grains (78%), land preparation (72%) and cleaning seed for sowing (70%).

WOMEN EMPOWERMENT THROUGH MECHANIZATION

Mechanization of Indian agriculture stands for modernization of agricultural practices with optimum utilization of inputs. Engineering inputs to on-farm and off-farm practices, agro-processing (Secondary Agriculture) and rural life are very important and vital to prosperity with dignity without undue drudgery. Appropriate mechanization is also needed in natural resource conservation and management. With rapid change in technological advancement, appropriate mechanization of field operations like

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seedbed preparation, sowing and planting, nursery raising and transplanting, interculture and earthing up, irrigation, harvesting, threshing, cleaning and grading, packaging and transport is the need of the hour. Mechanization through use of modern power sources and matching implements brings in added operational capacity, reduces dependence on labour, helps in timeliness in field operations for optimal productivity, precision in metering and placement of inputs like seed, fertilizer, irrigation water, pesticides etc. The mechanization level at present is about 47%, which needs to be increased to 60% by 2030 and to 75% by 2047. There is ample evidence on the positive impact of mechanization on agricultural productivity and growth.

The role of women also needs to change with improving mechanization from a source of power to the role as an operator, manager and decision marker. The cultural divide of gender discrimination needs to change, through improving their capability for other roles. It is necessary to design machines suitable to them and upgrade their skill for operating those machinery. Also, for the role of Manager and Entrepreneur, their knowledge base will have to be suitably updated. Though, considerable work has been done to develop agriculture with major emphasis on technical and economic achievement, very little attention has been given to gender issues. The technology development and transfer programmes are generally carried out on the assumption that the technologies are either gender-neutral or that the men are the main users and decision makers. This is often incorrect because women have quite different technological needs than men due to their different ergonomical characteristics, level of education, experiences, skills, etc. Therefore, many of these programmes prove to be ineffective as the technologies developed are not relevant to the needs of women users, and the transfer programmes do not reach to them. The mechanization at rural level is experiencing a paradigm shift due to movement of male workers to urban areas in search of job in industrial and service sectors. This phenomenon is likely to continue with development of urban infrastructure and industrialization leading to better employment opportunity. Women in rural India has assumed a major role in agricultural economy of our country.

Mechanization produces various positive effects. It minimizes hard labour, reduces drudgery and improve timeliness of operations and reduces overall cost of operation. The mechanization also leads to higher output of woman workers with expanding assets. Increasing pace of mechanization has led to changing role of workers from source of power to operator. Introduction of tractor, power tiller and engine operated equipment requires skill to control, adjust and operate. Initially the same has been taken as male domain. Women in agriculture often forced to operate the tools and equipment being developed considering the requirement of their male counterpart. It has been well established fact that female has different ergonomical characteristics than male workers. Similarly, the strength capabilities of the female are also lower than male workers. To improve the work efficiency of the women workers, there is a need to modify the design of the tools and equipment considering ergonomical requirement of women workers. Operating the tractors and self-propelled equipment has been a male dominant occupation, however with changing rural socio-economic condition, there is a need to make these power sources gender neutral. The workplace layout of tractors suitable for women workers has been developed at Central Institute of Agricultural Engineering, Bhopal. The non-governmental organizations can play a very effective role in transfer of technology as they have many grass root level women workers. The rural women are more comfortable with women trainers and are able to express their views better to them.All the departments which are involved in transfer of technology to rural women should have enough number of women trainers to make technology transfer more successful.

ICAR-Central Institute of Agricultural Engineering, Bhopal, ICAR-Central Institute of Women in Agriculture, Bhubaneswar, centres of AICRP on Ergonomics and Safety in Agriculture located in different SAUs has developed more than 30 tools/equipment suitable for women workers. Efforts are being made to manufacture and make these tools available to farm women for reducing drudgery and enhanced output. The brief details of some of the ergonomically improved tools are given in Table 1.

STRATEGY FOR GREATER ROLE OF WOMEN WORKERS IN MECHANIZATION

In the changing scenario, the participation of women workforce in agriculture is going to increase to 50% by 2030 i.e. out of the total estimated agricultural workforce of 240 million, about 120 million will be women workers. This is expected to happen mainly because male workers will either get involved in other non-farm activities or migrate to towns and cities for other jobs. To meet this situation, it is necessary to take the following steps.

- Design the tools/equipment keeping in view the anthropometric data of women workers
- Make these tools and equipment available in rural areas for purchase by users or create farm machinery bank
- Remove social taboos which makes women not to operate farm machines
- Organize demonstrations and trainings to rural women on various modern tools/ equipment in proper and safe operation.
- Encourage manufacturers/ entrepreneurs to fabricate improved tools and equipment – policy intervention
- Test the equipment with women workers
- Assist farm women, after being duly trained to get loans from banks/other organizations to procure various tools/ equipment.

TABLE 1 IMPROVED TOOLS/EQUIPMENT/ENERGY GADGETS FOR REDUCING DRUDGERY OF WOMEN IN AGRICULTURE

S. No.	Operation	Traditional practice and details	Improved tools/ equipment and details	Photograph
1	Seed treatment drum	Done with bare hands. Non-uniform application, possible seed damage, health hazards- chemicals in direct contact with hands.	Cost-Rs. 2000/- Capacity-200 kg/h, contact with chemical avoided, uniform application, no seed damage.	
2	Two row rice transplanter	By hand in bending posture, output-34 m2/h	Cost-Rs. 6500/- Capacity-250 m2/h, bending avoided, about 13% saving of cardiac cost of worker per unit area.	
3	Four row paddy drum seeder	Broadcasting by hand, non-uniform sowing, difficulty in weeding	Cost-Rs.6000/- Capacity-920 m2/h, uniform seeding in rows.	
4	Cono weeder	By hand in bending posture, capacity-30 m2/h	Cost-Rs. 1900/- Capacity-120 m2/h, bending is avoided.	
5	Pedal operated paddy thresher	By hand beating in bending posture	Cost-Rs. 6500/-, Capacity-35 kg/h, discomfort is reduced as work is done in standing posture.	
6	Coconut Tree Climber	By climbing on tree	Cost :3,500/- Capacity: 56 coconuts/h Eliminates the high work stress, severe neck and back pain	
7	Pedal operated arecanut sheller	Manual areacanut shelling	Cost:Rs. 25000/- Capacity: 15 kg/h Increased work output. Saving in the cost of dehusking operation. Reduces drudgery	
8	Fish dressing Platform	Traditional method of working on plastic crates, occupational health issue of low temperature handing	Height of platform: 630-700 mm Material: Stainless steel Cost: Rs. 14500/- Improves the working posture and work efficiency. To avoid low temperature and slippage, double layer of cotton gloves and surgical gloves have been provided.	
9	Cashewnut desheller	Manual shelling	Cost: Rs. 4000/- Capacity: 5.3 kg/h Drudgery involved in deshelling operation is reduced. Reduce finger injury due to cashewnut shell liquid oil.	
10	Hanging type grain cleaner	Manually using supa	Cost:Rs. 5,700/- Capacity: 225 kg/h Weight: 17 kg About 63% saving in cardiac cost of worker per unit of output. Working heart rate 104beats/ min	

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Empowering Innovations: The Critical Role of Women in India's Agricultural Engineering and Technology

Ravi Pokharna

Executive Director, Pahle India Foundation

As the world commemorates Women's Day, it's pivotal to spotlight the substantial contributions of women to India's agricultural sector, especially in engineering and technology. Despite facing systemic barriers, women have emerged as key innovators and leaders, driving forward an industry critical to India's economy. This article, enriched with data and research, highlights their indispensable role and celebrates initiatives like the "Drone Didi" program, which is pioneering change in agricultural practices through technology.

WOMEN IN AGRICULTURE: BY THE NUMBERS

Agriculture employs nearly 60% of India's female workforce, marking it as the most significant sector for women's employment. Traditionally, their roles have been confined to labor-intensive tasks, with minimal visibility in decision-making processes. The advent of technology in agriculture presents new opportunities for women, propelling them from traditional roles to becoming innovators and leaders in agricultural engineering and technology.

BREAKING BARRIERS IN AGRICULTURAL ENGINEERING AND TECHNOLOGY

Women's participation in agricultural engineering and technology has seen a notable increase, with their involvement in research and development growing significantly. A report by the Indian Council of Agricultural Research (ICAR) indicates that women now constitute around 24% of the agricultural research workforce, a leap from 7% three decades ago. Their contributions span across biotechnology, soil science, water management, and the development of agricultural machinery, contributing towards sustainable farming practices.

CASE STUDIES OF WOMEN'S INNOVATIONS

- Dr. Vandana Shiva has been a pioneer in promoting biodiversity and organic farming, integrating traditional knowledge with modern technology for sustainable agricultural solutions.
- Rashmi Bharti co-founded Avani Bio Energy, which utilizes pine needles for electricity generation, showcasing innovative use of natural resources to support agriculture and prevent forest fires.

THE "DRONE DIDI" PROGRAM: A LEAP TOWARDS TECHNOLOGICAL EMPOWERMENT

A remarkable initiative that stands out in empowering women in agricultural technology is the "Namo Drone Didi" program. This pioneering effort of the Government aims to train women in operating drones for agricultural purposes, such as pesticide and fertilizer spraying, land surveying, and crop health monitoring. The program not only introduces advanced technology into farming but also shatters traditional gender norms by enabling women to lead in technological advancements within agriculture. The "Drone Didi" initiative represents a significant step towards modernizing Indian agriculture while promoting gender equality in the agricultural workforce.

OVERCOMING CHALLENGES AND LOOKING AHEAD

Despite their achievements, women in this field often encounter challenges, including limited access to education and societal biases. Addressing these requires concerted efforts from various sectors to provide equal opportunities for women. Programs like "Drone Didi" and "Mahila Kisan Sashaktikaran Pariyojana" are crucial for enhancing women's participation and success in agricultural engineering and technology.

This Women's Day, let's acknowledge and celebrate the contributions of women in India's agricultural engineering and technology. Their work is crucial for the future of agriculture, promising a more sustainable, efficient, and inclusive sector. Supporting policies and initiatives that empower women in agriculture ensures they have the resources, education, and platforms needed to thrive. The "Drone Didi" program exemplifies the innovative spirit of women in agriculture, highlighting the importance of gender equality and technological advancement in creating a sustainable future for Indian agriculture.

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Supporting Women Farmers - Why & How

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Women and men together make families and communities. There is very little, other than biologically ordained functions, that cannot be done with equal efficiency by both the sexes. Yet when it comes to agriculture, there is invariably the practice that women do the tasks with more drudgery or less recognition of the cost of labour. In addition childcare and care of domestic animals is commonly in the feminine domain as is cooking or processing of food. When we buy food items from stores that are commercially prepared and packaged, there is little differentiation that is possible to support women-led enterprises. Discussions and seminars around women empowerment are going to be just words till we put our money where the mouth is, that is to buy directly from women farmers and processing units run by women.

Let us look at the rationale of supporting the women farmers directly. Firstly, its economic recognition of their labour, formalizing the same and enabling local livelihoods. The example of Jabalpur based Lijjat papad is time tested, where urban women are given standardized raw material and the papad they turn in goes through strict quality control. This has effectively recognized their skills and provided gainful employment. Women Farmer Producer Companies (FPOs) or women Farmer Interest groups (FIGs) within mixed FPOs offer many such examples. These are now easy to access to sample and source their products due to digital/ online options of trade.

Secondly, women farmers across the ages have the traditional knowledge of food processing, a large part of which is still in the realm of cultural transmission only. Zarbalfed farmer producer company from Pulwama in J & K has unique products like apple pickle, apple chutney and Kashmiri masala tikki, that can give even the best of chefs a run for their money. Each of these is processed and made exclusively by women FIG members. The apples that are smaller in size do not go in direct sale and are processed into dried apple chips and then pickled. The masala tikki is a laborious process of grinding and roasting spices and drying as a tikki that is a traditional ready to use masala for meats and rajma, without any preservative or chemical. The products are available on buyer apps on the Open Network for Digital Commerce(ONDC) or link https://www.mystore.in/en/seller/zarbalfed-farmer-producer-company-ltd maybe used to view the products.

Thirdly, products from totally women FPOs would be clean, meticulously packed and reasonably priced. This is perhaps because they under charge for own wage. Bhairabi Women Agro Producer Company Limited (https://www.mystore.in/en/seller/bhairabi-women-agro-producer-company-limited) is such a case. They offer a variety of rice, including sugar free rice and dal that has been roasted and milled by traditional processes. The caffeine free Ragi tea also involves slow dry roasting to preserve the flavour. Rice variety cultivars of Laxmi Bhog rice, black rice and indigenous lines have been maintained season to season to preserve the genetic purity. So, sourcing from such women farmers benefits the consumer due to superior quality of the staples, while putting the money directly into hands of the women farmers, without

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any intermediary.

Fourthly, if someone is looking to buy any of the ancient grains like millets, it is best to go the tribal women farmers who know not just how to grow but also the time tested processing methods that unlock the nutrients in these grains. BastaraAgro Producer Company Limited (https://www.mystore.in/en/seller/bastara-agro-producer-company-limited_28q4imuz) is FPO exclusively of women farmers. While most farmers abandoned millets as they were difficult to process; the de-husking of kodo for instance was back breaking work; these women farmers continued cultivating and making food with millets. They offer a range of flours and millets, processed just before shipping to give maximum shelf life to the customer.

Fifthly, ready to eat foods reliably free of chemical preservatives and most suitable for children are best purchased from women FPOs or FIGs. Guilt free snack cravings (https://www.mystore.in/en/seller/bhuj-mahila-farmer-producer-company-limited) or natural nutrition supplements or health mixes (https://www.mystore.in/en/product/millet-health-mix) are the forte of women farmers. The women FIG innovation also leads to development of innovative products like millet cookies baked with honey instead of sugar and fruit jam made with honey (https://www.mystore.in/en/seller/aryahi-fed-farmers-producer-co-ltd)- all products without doubt the better option for children and older people, at the same cost as industry made ones.

The e-commerce option has made it convenient and simple to support and buy from women farmers, to engage for sampling and even B2B transactions on ONDC. If one buys staples, ready to eat and beverages, from a women farmer collective, there is such a positive response from the women's groups that one can month on month witness new product development based on feedback shared with the women collectives. So this Women's day, let us not pledge to do anything but order online from at least women FPOs food products used at home and offices.

Colossal Impact of Technology Access to Women Famers

Dr Sangita Ladha

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I had an opportunity to attend the G20 Ministerial Conference for Women Empowerment in Gandhinagar in 2023 which highlighted on how India's G20 Presidency has driven shift in approach from, "Women Development" to "Women Led Development".

The G20 New Delhi Leaders' Declaration 2023 focuses on 'Enhancing Economic and Social Empowerment', 'Bridging the Gender Digital Divide', 'Driving Gender Inclusive Climate Action' and 'Securing Women's Food Security, Nutrition and Well-Being'.

Since a large Women force in Rural India is engaged in Agriculture, it is unimaginable to achieve the above goals or even the UN – Sustainable Development goals without technological intervention in this sector.

I am especially keen to present a case study on how Technological intervention in Agriculture has led to, ***"Enhancing Economic and Social Empowerment"*** of Women farmers and not just achieve this specific goal of livelihood sustainability but also address Securing Women's ***Food Security, Nutrition and Well-being***.

Case Study of Tangible Impact of Micro Irrigation with Small Holder Women Farmers of Jharkhand:

Geographical Region: The Project of Micro Irrigation was undertaken in one of the Rainfed belt of Jharkhand characterized by dependency on natural rainfall, low investment, low productivity, mono-cropping with Paddy as the dominant crop, small and marginal land holdings with inadequate irrigation facilities. The region have wells run dry during summers, water table going drastically down with hardly any water available for pumping or cultivating crops during non-monsoon-Rabi season. Adding to above the region is also not averse to Climate Change induced change in hydrological cycles with unpredictable , untimely high intensity rains, long dry spells with scenario of high runoff, low water percolation affecting the aquifer recharge.

TECHNOLOGICAL SOLUTIONS – A GAME CHANGER

More than 4000 Small and marginal Womer farmers practicing only Rain-Fed agriculture were provided with Drip Irrigation Systems on just 1000 sq.m each under the Jharkhand State Livelihood Mission. The Growers were trained to operate the irrigation and fertigation systems and were appraised on the economical benefits.

SIGNIFICANT IMPACT OF THE PROJECT

- Drip Irrigation enabled growers to cultivate an additional crop like Vegetables during the Rabi season with the limited available water
- Additional Crop during Rabi season along with market accessibility

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and value chain management naturally led to doubling of farmers' income.

- The Socio -Economic Status of the Women Farmers has been tangible with Year round cultivation of the crops leading to elimination of Poverty.

- Drip Irrigation systems also facilitated survival irrigation addressing long dry spells, untimely monsoon and risk of losing crop during the monsoon season.

CONCLUSION AND WAY FORWARD

While the national average for women's share in agriculture is 32%, Jharkhand reports women's share less than 12%. Such Interventions are Critical Success Factors in upliftment of women to undertake farming based sustainable income.

Encouraging Women farmers to diversified cropping pattern, making irrigation technology accessible, no matter how small the farm size, capacity building, infusion of right mix of technology which are technically simple to operate, economically viable have demonstrated creation of an eco-system of a strong community of sustainable Women entrepreneurs at the grass roots along with Conservation of Natural Resources and Increased Water Use Efficiency.

All these growers could further be upgraded with Polyhouses, Nurseries and momentum of assured economic activities could be generated in the same farm land.

Reform, Perform, Transform is the new mantra spelled to shape the new generation India!!. Imagining a world of Precision, Digital -Smart farming of go-getter rural women growers shall not only make the farming venture joyful but create a tribe of financially independent entrepreneurs.

Role of Machine Learning in Agriculture

Dr Pooja Jain
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Agriculture is regarded as a key pillar of the global economy. To establish a sustainable equilibrium, agricultural production needs to be increased. The crop's ability to produce sustainably is mostly dependent on a number of variables, including the soil, water, climate, and surroundings. Artificial intelligence gives a way to monitor the crop and to predict the yield in an automatized outcome. With today's cutting-edge technology, precision agriculture is crucial to creating an agricultural system that is optimised.

There are many applications of ML in agriculture. According to the recent study, three standard categories were identified which refer to crop, water, and soil management. As far as crop management is concerned, it includes yield prediction; disease detection; weed detection; crop recognition; and crop quality. Crop diseases deteriorate yield, hence, sensing, diagnosing, and alerting the farmer to problems is a huge help using ML techniques. Machine learning algorithms coupled with imaging processing technologies allow for real-time identification and mapping of target weeds. This helps with applying herbicides to specific zones instead of over-spraying fields. The defects can be identified and the produce be sorted by weight, color,

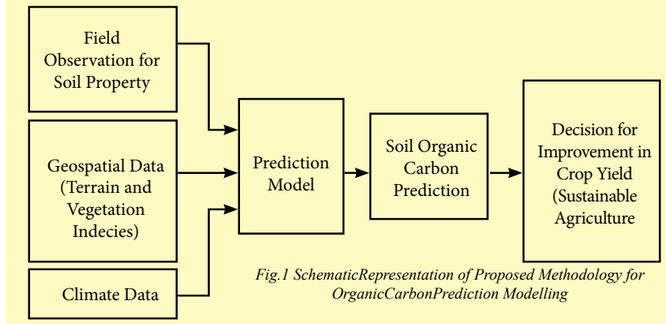

Fig.1 SchematicRepresentation of Proposed Methodology for OrganicCarbonPrediction Modelling

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size, and ripeness of crop.

Sustainable agriculture revolves around organic carbon (OC), which is essential for numerous soil functions and eco-logical attributes. To enhance soil health and yield, farmers are interested in maintaining and adding more soil organic carbon to specific fields. My research predicts the Organic Carbon in Soil using Machine Learning Techniques and Geospatial Data for Sustainable Agriculture. To forecast OC of soil at a 30 m resolution, four machine learning models—Random Forest, Support Vector Machine, Adaptive Boosting and K-Nearest Neighbour were used which gave considerably good results.

The objective of the research was to create a model based on topography and properties of soil for the fore-cast of Organic Carbon (OC) present in soil, which will assist farmers in making proper decisions improving crop yield. Numerous environmental and biological factors, as well as their interactions, regulate the amount of nutrients in the soil. A group of covariates that represent topography, climate, and remote sensing will be chosen as potential predictor factors to forecast soil organic carbon. By altering the support size, this data must be integrated with various spatial, spectral, and radiometric resolutions. As shown in Fig 1, proposed methodology mainly consists of data

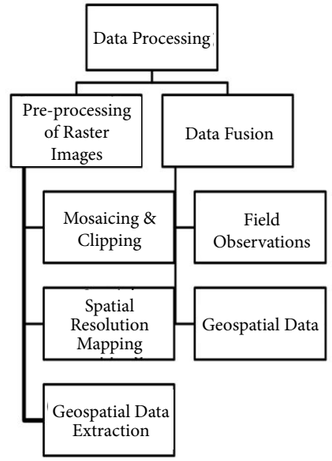

Fig.2 Data Processing Steps

processing and model building steps to determine an estimate of OC which can be used for decision making suitable for sustainable agriculture.

Gathering input data for machine learning model-ling required basic steps as depicted in Fig 2. Pre-processing entails actions that are typically necessary before the primary data analysis and soil information extraction. Data Extraction mainly consists of two steps one is Raster Stacking where raster get combined to retrieve predictor values and second one is Sampling raster values in which Raster values been extracted from stacked raster and stored in temporary file in format suitable for modelling.

ML model	With CV		Without CV	
	R2	RMSE	R2	RMSE
RF	0.1526			
	0.2175	0.1281	0.2207	
SVM	0.0031	0.2359	0.0030	0.2360
KNN	0.2141	0.2604	0.2145	0.2604
Adaboost	0.0633	0.2287	0.0724	0.2447

Table4 Model Performance for Testing Dataset

After gathering the data from different sources, that data to be used as model input was resampled. For data sampling and model analysis, we have used various Python packages.

The performance of the four models for the forecasting of the OC in the Dhamtari District of Chattisgarh, state of India was evaluated and Random Forest algorithm showed the best results as depicted in the Table 1 with and without Cross Validation (CV).

The performance of the models in forecasting the Organic Carbon was validated by using train-test split methodology. Dataset split into two halves: 20% for testing and 80% for training. To make sure the model was stable, cross validation with 10 folds, was operated to train the dataset. To evaluate the model, two error metrics have been used, namely R2 and RMSE. R2 is the statistical measure used to assess the regression model's quality of fit. The coefficient of determination, R2 interpreted as the proportion of the variance in the dependent variable that is predictable from the independent variables. RMSE is statistical measure which implies an estimate of deviation of error.

The study's findings demonstrate how effective digital soil-mapping methods are at producing accurate soil-related data. Farmers can receive the knowledge via digital platforms and mobile applications, among other Information and Communication Technology (ICT) technologies.

Contributions of Women in Agricultural Engineering and Technology

Pitam Chandra

Ex-Director, ICAR-CIAE, Bhopal

The domain of agricultural engineering and technology continues to expand as the agricultural and engineering sciences continue to break newer grounds. Although Jacob E. Waggoner was the first graduate of agricultural engineering from Iowa State University, Iowa, USA in the year 1910, the first agricultural engineering programme in India began only in 1942. The first batch of Agricultural Engineering students graduated in 1944.In view of the physical rigor needed for field work, female students were not encouraged to join the agricultural engineering stream for quite some time. It was in 1972 that Ms. Purnima Ganguly joined agricultural engineering programme at GB Pant University of Agriculture & Technology, Pantnagar. Today, the enrolment of girl students in agricultural engineering is comparable to that in other branches of engineering.

The discipline of agricultural engineering initially focused only on irrigation and farm machinery. However, agricultural engineering today has grown to include the application of engineering science and design principles for all agriculture purposes, combining mechanical, civil, electrical, chemical, food, environmental, instrumentation

& control, and software engineering disciplines to improve the efficiency of farms and agribusiness enterprises as well as to ensure sustainability of natural and renewable resources. This holistic canvas of agricultural engineering and technology promises unlimited professional opportunities for the students. A broad categorization of job opportunities include policy formulation, entrepreneurship, startups, manufacturing, outreach and consultancy, R&D, and teaching. Considering that the entry of women in agricultural engineering began only about 50 years ago, the contributions of women are visible and significant. I am trying to present a flavor of their contributions through the following examples from India and abroad.

Tage Rita is an agricultural engineer from Ziro Valley, Arunachal Pradesh. She is India's first kiwi wine brewer. She received her agricultural engineering degree from NERIST, Nirjuli, Arunachal Pradesh. In 2018, she was honored with the Women Transforming India Awards, organized by the United Nations and NITI Aayog.

Dr (Ms) Neelam Patel is Senior Advisor (Agriculture) at Neeti Aayog. Her professional activities include Policy formulation, block chain technology, price prediction model, monitoring of schemes, decision support systems and automation, micro irrigation, waste water treatment technology, and Hitech horticulture technologies. She received her B. Tech. (Agricultural Engineering) from Allahabad University, M. Tech (Agricultural and Food Engineering) from IIT, Kharagpur, and Ph.D. from ICAR-Indian Agricultural Research Institute, New Delhi. She has been admitted to the Fellowships of NAAS, Institution of Engineers (I), and Soin Conservation Society of India. Neelam has received several awards including

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Dr. RN Singh Award of IARI (twice), Panjabrao Deshmukh Outstanding Woman Scientist Award of ICAR, and Dr. Rajendra Prasad Award of ICAR.

Christine Clark graduated from the Cranfield Institute of Technology (now Cranfield University) in agricultural engineering and acquired a number of other qualifications in engineering design, manufacturing and engineering management. After working at International Harvester, Leyland Vehicles, and Massey Ferguson for 10 years, Christine set up Ascott Clark - Engineering and Management Consultants in 1990. The Company works both in the UK and overseas. She is also a Fellow of the IAgrE, a Chartered Engineer, Member of the Institution of Mechanical Engineers, and a Member of the British Institute of Agricultural Consultants.

Eva Ekeblad was a Swedish scientist, who developed a method to make flour and alcohol from potatoes in 1746. Her work made her the first female inductee of the Royal Swedish Academy of Sciences in 1748 at the age of just 24 years.

Dr (Ms) Sangita Ladha is at present Business Director at Rivulis Irrigation India Pvt LtdPune. She was earlier VP-Marketing and Business Development with Jain Irrigation Systems Ltd., In a career spanning over three decades, she has handled multifaceted assignments and focusses on promotion of advanced technologies in agriculture including micro-Irrigation, solar pumps, digital informatics, command area development, and greenhouse technology. She graduated in agricultural engineering from MPKV, Rahuri and received M.Tech from IIT, Kharagpur. She has her doctorate in agricultural development from Yashwantrao Chavan Maharashtra Open University.

Frida Eversmann (1890-1941) was the first Dutch female agricultural engineer (1919) with research interest in agricultural chemistry. In addition to the supervision of many students, she published her research as lead author. She focused more particularly on the influence of different conditions, such as soil type, type of fertilization and thelike on the taste of potatoes.

Paulina Lescano, a native of Santa Rosa, La Pampa, Argentina, is an agricultural engineer and specialist in commodity markets. She studied at Universidad Nacional de La Pampa. Subsequently, she acquired postgraduate degrees; one in negotiation another in finance. Paulina's career began in a multinational grain company. There, she became the first female commercial operator of cereals and oilseeds in the Rosario Stock Exchange. She has since been involved in many different areas of agribusiness. Paulina was invited, in the year 2022, to address the 'Women in Agribusiness' congress in Dallas, Texas, USA.

Ms Mamta Jain is Group Editor and CEO, Krishi Jagran, New Delhi. She is also the Chief Editor of Agricultural Engineering Today of ISAE. Earlier, she had been with Indian Council of Food and Agriculture, Green TV India, and DSA Magazine & FnB Buzz Magazine @ Ocean Media. Mamta is passionate about unleashing the potential of food and agriculture sector and empowering farms and farmers by mobilizing human, technological and financial resources towards achieving the global food and nutrition security and environmental sustainability. She is an agricultural engineer from Allahabad University.

Fortunately, there exists a highly talented pool of women agricultural engineers as teachers and researchers in the universities and research institutions throughout the country who have been either leading or working as collaborators in pursuit of solutions to the most pressing field problems. Women agricultural engineers have more recently been involved in providing services related to custom hiring of agricultural machinery to needy farmers, repair & maintenance, and advisories. Women agricultural engineers, in very near future, would be seen as successful entrepreneurs and skill providers. As more and more women join the agricultural engineering profession, there will be greater diversification of their contributions.

Contribution of Women to Agricultural Engineering and Technology



Nachiket Kotwaliwale[1], Renu Balakrishnan[2] & Shilpa S Selvan[2]

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Agriculture, the backbone of human civilization, has undergone remarkable transformations over the years, driven by technological progressions. The Green Revolution marked an era of change that commenced in the 1960s, enhancing Indian agriculture into a modern industrial system with widespread adoption of technology. This included the use of high-yielding varieties (HYV) seeds, mechanized farm implements, improved irrigation infrastructure, pesticides, and fertilizers. In this paradigm shift, women have emerged as keyplayers, shaping the landscape of agricultural engineering and technology.Their contribution to the agricultural engineering sector is vital and continues to promote innovation, research, and technological development.

Women have played a pivotal role in shattering barriers and defying stereotypes in traditionally male-dominated sectors like agricultural engineering and technology. Their remarkable presence and accomplishments serve as a beacon of inspiration for future generations of girls and young women, encouraging them to pursue careers in these fields without any boundaries. Presently around 45% of workforce engaged in Agriculture is female and this contribution is expected to increase to 60% by 2047. According to the Agricultural Scientists Recruitment Board (ASRB) annual report of 2021-22, the proportion of successful women candidates in Agricultural Research Service (ARS) examinations has steadily risen from 31 to 43% over the past five years; the 2023 data shows that the proportion of successful women candidates in ARS is 51%. These women are actively involved in empowering farmers by sharing knowledge and innovative practices through educational and extension activities. As agricultural engineers, scientists, educators, and extension agents, they act as vital links between the research institutions and rural communities. Through workshops, training programs, and advisory services, women empower farmers with the latest advancements in agricultural technology, thereby boosting productivity and sustainability on farms.

A series of cutting-edge machinery and process technologies has been developed

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by accomplished women scientists across various research institutions including ICAR-CIPHET-Ludhiana, ICAR-CIAE-Bhopal, ICAR-CIWA-Bhubaneshwar, ICAR-CIRCOT-Mumbai, ICAR-IARI-New Delhi, Central and State Agricultural Universities and very many institutes of CSIR, etc. Significant innovations include mechanized destalking machine for dry red chilies, refractive window dryer for fruit bar production, mechanized system for Hawaijar production (a traditional fermented food), peeling machine for medicinal root crops, pedal-operated de-bunching tool for medicinal root crops, grader designed for medicinal tuber crops, and an integrated processing line for millets, sensor-enabled potato storage system, controlled onion storage structure, PUSA-farm sun fridge, and electronic sensing system for stored onion, etc. Other remarkable contributions in process technology include the creation of nanocellulose impregnated starch based biodegradable packing films, fat-free flavoured makhana, multigrain chapati flour, gluten-free muffins, green chili puree and powder, as well as a multi-nutrient composite mix for biscuits. These innovations collectively aid in enhancing the efficiency and quality across the agricultural value chain.

Women entrepreneurs are making remarkable progress in agricultural engineering and technology, driving innovation and fostering entrepreneurial spirit within the sector. They are leading the way in developing cutting-edge technologies tailored to meet the specific needs of farmers, from precision farming solutions to the establishment of agritechstart-ups. These ventures not only contribute to economic growth but also address critical agricultural challenges such as climate resilience and food security. One notable example is Mallika Srinivasan, the CEO of Tractors and Farm Equipment Limited (TAFE),

who has played a significant role in the company's ascent to become the second-largest tractor maker in India and the third-largest in the world. Her emphasis on technology and innovation has improved TAFE's standing as a supplier of reasonably priced, top-notch equipment to farmers, and she has been acknowledged as an inspiration for women in leadership roles within the Indian agriculture machinery sector.

Another one is the founder of 'Bharat Agro (Sandi),' Tulika Pandey, a manufacturer and distributor of agricultural machinery in Raipur, Chhattisgarh. Pandey is an advocate of modern farming methods and, offers farmers improved and affordable machinery and services to enhance efficiency in both cultivation and post-harvest operations. Nikita Tiwari, Co-founder of Gandhinagar-based agritech start-up NEERx Technovation developed "SHOOL: Smart sensor for Hydrology and Land application," which offers real-time microclimate data, aiding farmers in pest prevention, water retention, and maintaining soil health. The startup received Rs 15 lakh from ICAR's RKVY-RAFTAAR scheme, supporting their mission for sustainable agriculture. Another Gurugram-based agritech business Intello Labs was founded in 2017 by Himani Shah and her friends. Utilizing image and machine learning for B2B produce quality assessment the firm employs AI tools such as computer vision and deep learning, to serve various stakeholders within the food supply and production chain.

Rajni Bector, founder of Mrs. Bector's Food Specialities Ltd., transitioned from a small ice cream brand in Ludhiana to the renowned Cremica, expanding further into Mrs. Bector's, is a leading player in the Indian food processing industry. The success of English Oven bread solidifies the brand's household name, showcasing how passion and entrepreneurship create a successful global brand in the competitive food industry. Krishna Yadav, an Indian entrepreneur, transformed her life through a pickle business after training from Krishi Vigyan Kendra, Delhi. Despite initial struggles, she expanded to four units with a turnover of INR 40 million, earning the Nari Shakti

Puraskar in 2016 for her impact on rural employment. In Arunachal Pradesh, agricultural engineer Tage Rita founded Naara Aaba, a winery utilizing abundant kiwi fruit in Ziro Valley. Supporting the farming sector, the venture purchased 20 metric tons of kiwis in its first year, expanding production to 60,000 liters and achieving a INR4.5 crores turnover. Tage Rita received 'The United Nations Women Transforming India Award' for her contributions to economic growth and addressing agricultural challenges. Francy Joshimon, an entrepreneur from Kerala, founded Minnus Fresh Food in 2018, providing over 50 chemical-free products, including jackfruit puttu powder, and exporting to the US and the UAE. Emphasizing fair trade, the brand sources raw materials locally, supporting farmers and fostering economic growth. While they may not be widely recognized on the larger scale, several women entrepreneurs have made significant contributions in the field of processing and value addition. One such example is Shruti Goyal from Ludhiana, Punjab, who has established herself in the processing

and value addition of horticultural crops, particularly rose petals, under the brand name Swaadaum Labh. Another notable entrepreneur is Sarabjeet Kaur from Jalandhar, specializing in the production of ground/soy milk, groundnut/soy paneer, and peanut butter under the brand name Gill Farms. Renu Mishra, the founder of Siya Ram Food Industries in Delhi, has emerged as a pioneer in value addition to Makhana, showcasing innovation within the industry. Navnoor Kaur, an MBA graduate, from Mohali has entered the field of chemical-free jaggery production with her brand 'Jaggercane', aiming to provide a healthier alternative to refined sugar. These women entrepreneurs, though not globally prominent, have left a lasting impact on the processing and value addition sector, showcasing their spirit and strength.

Promoting environmental sustainability stands as a central tenet of the contributions made by women in agricultural engineering and technology. Through dedicated research and practical implementation on farms, female engineers and technologists lead the way in pioneering and advocating for sustainable agricultural practices. Their innovations range from soil conservation methodologies to water management techniques, all aimed at reducing environmental impacts while optimizing the use of resources. These endeavours chart a course towards a more environmentally friendly and resilient agricultural sector. Notable figures in this field include Rajani Joshi, a distinguished leader in agricultural engineering renowned for her significant contributions to irrigation engineering and water management in India. Her work focuses on developing efficient irrigation systems and techniques to improve water use efficiency in agriculture. Another influential scientist is Suman Sahai, who founded Gene Campaign, an NGO dedicated to promoting biodiversity conservation and sustainable agriculture in India. Gene Campaign serves as a research and advocacy organization committed to the food and livelihood security of rural and indigenous communities, as well as the rights of farmers and local communities. It collaborates with village communities and engages in policymaking to safeguard the rights of farmers and local communities

over their biodiversity and traditional knowledge.

Women's involvement in agricultural engineering and technology plays an important role in empowering rural communities and advancing gender equality. Through active engagement in farm activities, machinery operation, and irrigation management, women significantly contribute to enhanced farm productivity and economic empowerment. Their leadership positions in agricultural cooperatives and community organizations amplify their voices, advocating for inclusive policies and equitable resource access for women farmers. Reema Nanavaty, although not an agricultural engineer by education, has led the Self-Employed Women's Association (SEWA) in India, implementing various programs to empower women in agriculture. SEWA's initiatives, such as community seed banks, organic farming techniques, and micro-irrigation systems, directly benefit women farmers by boosting agricultural productivity and income. Rashmi Sharma has pioneered the design of low-cost agricultural machinery tailored for smallholder women farmers in India. Her innovative tools, including pedal-operated paddy threshers, groundnut decorticators, and vegetable slicers, alleviate labour burdens and enhance efficiency in crop processing for women farmers. Bina Agarwal, an economist and researcher, has shed light on the crucial role of women in agriculture and emphasized the significance of gender-sensitive technologies and policies. Agarwal's research demonstrates that empowering women farmers through access to land, credit, and technology not only enhances their livelihoods but also boosts overall agricultural productivity and food security. Her advocacy for gender-inclusive agricultural innovations has spurred the development and adoption of technologies tailored to the needs and preferences of women farmers. By amplifying women's voices and advocating for their rights, they create an enabling environment for women to thrive as active participants in agriculture.

In conclusion, the significant contributions of women in agricultural engineering and technology have transformed the agricultural landscape, driving innovation, sustainability, and empowerment. From breaking barriers in traditionally male-dominated fields to pioneering sustainable practices and fostering entrepreneurship, women have played multifaceted roles in reshaping the agricultural sector. Their leadership, advocacy, and innovative solutions have not only boosted farm productivity and economic growth but have also addressed critical challenges such as gender inequality, environmental sustainability, and food security. Through their endeavours, women have empowered rural communities, amplified women's voices, and paved the way for a more inclusive and resilient agricultural sector. As we move forward, it is imperative to continue supporting and amplifying the contributions of women in agriculture, recognizing their invaluable role in shaping the future of food production and rural development. By fostering an enabling environment and promoting gender-sensitive policies and technologies, we can ensure that women thrive as active participants in agriculture, driving positive change for generations to come.

Women in Agricultural Mechanization: Overcoming Barriers and Driving Sustainable Change

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Indian agrarian setup relies heavily on the contributions of women. They play a pivotal role in ensuring food security and driving rural development. Despite their significant role, women frequently encounter obstacles that hinder their productivity and economic empowerment. A crucial area demanding improvement is their access to and utilization of agricultural mechanization.

CHALLENGES INAGRICULTURAL MECHANIZATION

Multifaceted challenges for womenin mechanisation of agriculture are categorised in few heads

- **Access:** Financial limitations, inequalities in land ownership rights, and deeply ingrained social norms are several factors contribute to women farmers' restricted access to agricultural machinery and its usage.
- **Social and Cultural Barriers:** Prevalent gender roles and stereotype ness are obstructing adoption of new technologies and usage of machinery traditionally perceived as suitable only for men
- **Design of Implements:** Most

agricultural machinery is designed with male users and this less accessible or comfortable for women and can impede their use of these tools.

- **Training:** Women may have fewer opportunities to receive training in the operation and maintenance of agricultural machinery, hindering their ability to leverage these tools effectively. Initiatives taken across for training of woman farmers have stabilised timely agri operations and enhanced productivity.

EMPOWERING WOMEN THROUGH MECHANIZATION HOLDS THE POTENTIAL TO BRING PROFOUND CHANGES

- **Reduction in Drudgery:** Mechanization has the power to significantly lessen women farmers' physical burdens, giving them more time and energy to pursue other productive endeavours viz their personal and family obligations.
- Increased Productivity: Women with access to mechanization, they can cultivate larger size of land, enhance crop yields, and generate greater income which can transform them into at par with their counter part employed in urban area in service sector.
- **Enhanced Economic Empowerment:** The increase in productivity and income can foster greater economic independence for women farmers. This, in turn, affords them more decision-making power within their homes and communities.
- **Improved Food Security:** Empowering women farmers with advanced tools and mechanization directly contributes to increased food

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production. This strengthens food security at both local and global levels.

HERE ARE KEY WAYS TO ADVANCE WOMEN'S PARTICIPATION IN AGRICULTURAL MECHANIZATION

- **Gender-Sensitive Policies:** Governments and developmental organizations have implemented policies that has helped woman farmers to specifically address the needs and challenges women face regarding access to agricultural mechanization services. Scope in support for woman entrepreneur's wholistically will further accelerate the Woman's contribution.

- **Financial Support:** Women must be provided with access to credit, subsidies, and other financial mechanisms. This would enable them to purchase or rent essential agricultural machinery.

- **Women-Centered Training Programs:** There's a need to establish training programs tailored for women farmers. Programs should focus on imparting knowledge about the operation, maintenance, and repair of agricultural machinery. We observed such activity in Ranchi by the Agricultural Department , where Tribal woman are participating round the year and learn Agri machineries.

- **Women friendly Design:** Manufacturers of tractor and farm machineries could review their design for their machines friendliness with woman in terms of ergonomic, safety and specifically designed for the convenience of woman operators.

- Ms Archana Patel, Promotor of Krishitek, which is leading Reaper manufacturer says days are not far when the entire Reapers will be operated by woman. Krishitek under leader ship

of Archana has developed hydraulic operated Tr mounted reaper first in industry which is highly convenient to use by woman.

- Challenging Social Norms: Fostering awareness campaigns and engaging communities in dialogue can dismantle harmful gender stereotypes. This paves the way for women's active and equal participation in agricultural mechanization. Ms Kirti is Block Mission Manager in Livelihood Mission in Amethi, as per her woman have taken huge interest in recently introduced scheme by govt on Drone. Drone by its design is easy to use and also gives sense of upliftment in society as this is latest technology.

- Success Stories and Role Models: DeHaat & Leading leading Agritech companies are highlighting successful women entrepreneur & farmers who have embraced mechanization for enhanced productivity and culmination in prosperity. They inspire and encourage others. Sharing their stories underscores the transformative potential of technology in empowering women in agriculture. Krish-e and many such Agri Input companies are holding *Goshthies* and share path breaking examples of woman engaged in mechanisation.

Woman's contribution in Agricultural mechanisation will enable faster growth of Rural India in prosperity and with sustained food security. More and more Women will remain in rural and adapt agriculture as lively hood

Women's Role in Agriculture for Value Propositions and Innovations

Ms Priyanka Jha
Environment Specialist @ Namami Gange

Women are a vital part of Indian economy. At the present moment all over the world, with small exceptions, women take an active social role and demonstrate their abilities in a lot of spheres. Nowadays women are active in goods production industry, natural-resources management, educational sphere, community management etc.

The role played by women in the economic and social development in any society is tremendous. It is also a fact that women contribute enormously through invisible economic activities. Although women and girls make up approximately 50 per cent of the global population, they have access to much less than half of the resources in terms of technology, financing, land, training and education. To achieve a balanced development, it is necessary to ensure gender equality.

Over the years, there is a gradual realization of the key role of women in agricultural development and their vital contribution in the field of agriculture, food security, horticulture, processing, nutrition, sericulture, fisheries, and other allied sectors. We are now witnessing a steady improvement in the enrollment of women in schools, colleges and Agriculture profession institutes. In this decade, women are entering into the massive agriculture job markets in increasing numbers both in private and public sectors. In banks, NGOs, Educational Institutions, Research Institutions, Extension systems, Agro-based civil services women are dominating with their performance. As entrepreneurs, women are taking lead in establishing their own Agro-based industries and providing employment for their fellow women. Being farmers, women are becoming very active in improving their farm productivity as well as their net income. To have better access to all the basic amenities, women are entering in to the field of administration, politics and helping their gender for equality.

In rural India, agriculture and allied industrial sectors employ as much as 89.5% of the total female labour. In overall farm production, women's average contribution is estimated at 55% to 66% of the total labour. Dependence on milk for food and nutritional security was high, largely due to the predominance of vegetarians in India. Women were – and remain - a high proportion of the dairy labor force, making the dairy sector an important vehicle for inclusive development (World Bank reports 2015 and 2019).

Women constitute 51% of the total employed in forest-based small-scale enterprises. The tremendous role of women in the fast growing food supply chain of the world means their participation should be central in any program to improve farming techniques or natural resource management. Yet much work in this arena involves technological approaches–mechanized farming, emphasis on cash crops over family consumption assumed to be in the male realm. Women around the world are left to work harder to grow the crops and raise the animals that sustain their families.

Rural women are responsible for the integrated management and use of diverse natural resources to meet the daily household needs. This requires

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that women farmers should have enhanced access to resources like land, water, credit, technology and training which warrants critical analysis in the context of India. In addition, the entitlements of women farmers will be the key to improve agriculture productivity. The differential access of women to resources like land, credit, water, seeds and markets needs to be addressed. With women predominant at all levels-production, pre-harvest, post-harvest processing, packaging, marketing – of the agricultural value chain, to increase productivity in agriculture, it is imperative to adopt gender specific interventions. An 'inclusive transformative agricultural policy' should aim at gender-specific intervention to raise productivity of small farm holdings, integrate women as active agents in rural transformation and engage men and women in extension services with gender expertise. Rural women perform numerous labour-intensive jobs such as weeding, hoeing, grass cutting, picking, cotton stick collection, separation of seeds from fibre, keeping of livestock and its other associated activities like milking, milk processing, preparation of ghee, etc.

A study of entrepreneurship found that start-ups led by women entrepreneurs tend to perform better. High technology firms established by women generated higher revenues and had higher survival rates. The reason? Women were found to be more resilient to setbacks and persevere in the face of adverse outcomes – perhaps the struggles of our mothers and grandmothers have made us women stronger. Start-ups in India have the potential to create two million new jobs for women by 2030, with the ecosystem being uniquely positioned to attract female talent, according to Women in India's Start-up Ecosystem Report (WISER) 2023.

Women should be encouraged to bring their vision and leadership, knowledge and skills, views and aspirations into the development agenda from the grassroots to international levels. Science and technology brings economic growth and well-being to people and it is not only the empowerment of women through science and technology, but also the enrichment of science and technology through women's participation. The developmental programmes sponsored by the scientific departments of our country (e.g. DST & DBT) should be extended to 5-7 years rather than a year or two for ensuring significant impact of the programmes, especially for the rural India. Mahila Kisan Programme should be activated to involve more rural women. The project proposals sanctioned by the funding agencies viz. the DST & DBT should emphasize on impact assessment of the projects; especially, socio-economic and health aspects particularly those funded for the upliftment of women. Women from Home Science must be involved in Anganwadi Programmes to promote the status of women in rural areas. There should be schemes for school teachers, especially those who are mostly M.Sc. dropouts. This major human resource could be tapped to encourage more students in S & T. Efforts must be made to fund the women scientists in underdeveloped regions to protect losing skilled people in those areas; as well as their recognition in the scientific institutions. Introducing new courses for professional development, infrastructural support, emphasis on rigorous academic work, discussion and debate are all essential for good science education for women. Introducing faculty programmes- add-on courses, career options for science students including science option in schools, B.Sc. (4 years) +M.Sc. (optional) +Ph.D. etc., specially designed post-school science programmes and improvement in teaching and research, should also be the part of education for women. A study is required to identify the agricultural crops grown and practices of KAP (Keystone Agricultural Producers) on food and nutrition to identify good and bad farming practices and gaps in knowledge of health and nutrition. Mini food processing-cum-training centres can be set up with the help of CFTRI (Central Food Technological Research Institute) or some private industries as their contribution to a social cause. Quality of teaching is very important; building a community for practicing new ideas, a complex network of ideas with continuous enhancement of skills, knowledge and capacity, to be built up. Health education, (e.g. use of the bio-resources, scientific knowledge and computer education) and skill development,(e.g. agricultural and allied practices like mushroom cultivation, smokeless chullah, biogas technology, floriculture, vermiculture, compost preparation, bee-keeping, fisheries, soil management, low cost bio-fertilizer production, coir mat preparation, fruit and vegetable processing, herbal cosmetics, making traditional paintings etc.), to improve the economic conditions of women, need to be linked to ensure a quality life for women.

ICAR-CIAE's Implement and Machinery Fabricated and Disseminated during 2020-21 to 2023-24



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INTRODUCTION

Agriculture, the backbone of the Indian economy, has seen remarkable transformations over the years, primarily due to advancements in agricultural machinery. The evolution of agricultural engineering in India has been marked by concerted efforts to address the mechanization needs of its diverse agricultural landscape. One pivotal institution in this trajectory is the Central Institute of Agricultural Engineering (CIAE), established under the aegis of the Indian Council of Agricultural Research (ICAR). Rooted in the foresight of a national imperative, the inception of CIAE was a response to the promising necessity for technological interventions in farming practices across the nation. This article endeavors to explore the nationwide impact of machinery developed and disseminated by ICAR-CIAE, examining its pivotal role in transforming agricultural landscapes.The genesis of CIAE can be traced back to the early 1970s when the need for a comprehensive institution specializing in agricultural engineering was recognized. A concerted effort led by Dr. JS Patel, the erstwhile president of the Indian Society of Agricultural Engineers, culminated in the formation of a Task Force Committee to delineate the modalities for establishing a National Institute of Agricultural Engineering. Following meticulous deliberations, the Planning Commission accorded approval for the establishment of the National Institute of Agricultural Engineering (NIAE) in 1973.

However, owing to financial constraints, the institute's focus was streamlined to mechanization and post-harvest operations, eventually leading to its rechristening as the Central Institute of Agricultural Engineering (CIAE).Since its inception in 1976, CIAE has emerged as a forefront institution in agricultural engineering research and development. With a multifaceted approach encompassing mechanization, post-harvest engineering, and energy utilization, CIAE has spearheaded transformative initiatives aimed at enhancing farm productivity and sustainability. The institute's

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comprehensive mandate is underscored by its organizational structure, which comprises divisions dedicated to agricultural mechanization, agro-produce processing, agricultural energy and power, irrigation and drainage engineering, and technology transfer.CIAE's pioneering endeavors extend beyond its institutional confines, manifesting in a network of coordinated research projects and consortia platforms aimed at disseminating technological innovations across the agricultural landscape. Collaborative endeavors such as the All IndiaCoordinated Research Projects (AICRPs) and Consortia Research Platforms (CRP) serve as conduits for disseminating best practices and fostering innovation at the grassroots level. Additionally, the institute's regional centers and Krishi Vigyan Kendra (KVK) play a pivotal role in technology dissemination and capacity building, ensuring the seamless integration of technological advancements into agrarian practices.Central to CIAE's mandate is its commitment to innovation and technological advancement. The institute's research endeavors encompass a wide array of disciplines, including agricultural mechanization, irrigation, post-harvest processing, and energy management. Leveraging state-of-the-art facilities and interdisciplinary expertise, CIAE endeavors to address the evolving challenges facing Indian agriculture, from enhancing farm mechanization to promoting sustainable energy practices. At the core of CIAE's research agenda lies the development and dissemination of farm machinery adapted to the unique needs of Indian farmers. The institute's efforts are characterized by an exhaustive array of implements and machinery designed to optimize farm operations across diverse agro-climatic regions. Notable examples include manual and motorized implements for land preparation, planting, harvesting, and post-harvest processing, each meticulously crafted to enhance efficiency and productivity.

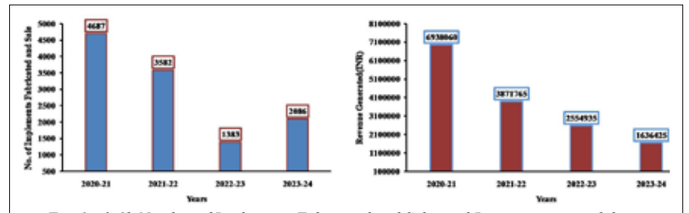

Fig. 1a & 1b Number of Implements Fabricated and Sales and Revenue generated during 2021-21 to 2023-24

VISION OF ICAR-CIAE

The vision of ICAR-CIAE, Bhopal is "to modernize Indian agriculture by improvement in crop productivity through agricultural mechanization, harnessing energy from renewable sources, efficient management of irrigation water, reduction in post-harvest losses and promote agri-business with a view to enhance income and generate employment in rural sector".

MANDATE OF ICAR-CIAE

The institute is mandated to undertake Basic, adaptive, and applied research on farm mechanization, post-harvest food processing & value addition, irrigation & drainage engineering and energy management in agriculture. Human resource development and capacity building through outreach and training programs, commercialization, and utilization of agricultural engineering technologies.

At the core of CIAE's research agenda lies the development and dissemination of farm machinery adapted to the

unique needs of Indian farmers. The institute's efforts are characterized by an exhaustive array of implements and machinery designed to optimize farm operations across diverse agro-climatic regions. Notable examples include manual and motorized implements for land preparation, planting, harvesting, and post-harvest processing, each meticulously crafted to enhance efficiency and productivity. This paper will explore into a comprehensive assessment of ICAR-CIAE's machinery impact from a nationwide perspective. Through a detailed analysis of adoption trends, economic outcomes, and socio-environmental implications, this study aims to elucidate the transformative potential of agricultural machinery in catalyzing rural development and food security.

OVERVIEW OF MACHINERY DEVELOPED AND FABRICATED BY ICAR-CIAE

At the heart of CIAE's innovation ecosystem lies its Prototype Production Centre, a state-of-the-art facility equipped with modern infrastructure and specialized machinery. The center serves as a crucible for the fabrication of prototypes, catering to diverse agricultural requirements spanning land preparation, planting, harvesting, and post-harvest processing. Leveraging a comprehensive suite of machining, welding, grinding, and press work facilities, the center epitomizes CIAE's commitment to precision engineering and quality craftsmanship. The Prototype Production Center (PPC) stands as a testament to CIAE's holistic approach to technological innovation, facilitating batch production of prototypes for multi-location trials and pilot introduction initiatives. Equipped with cutting-edge tools and equipment for heat treatment, tool and die making, and shearing, the workshop embodies CIAE's code of excellence in research and development. Furthermore, the center plays a pivotal role in capacity building, offering training programs for manufacturers and artisans aimed at fostering entrepreneurship and promoting technology adoption at the grassroots level.The machinery and implements developed and supplied by the Prototype Production Centre of ICAR-CIAE across the years 2020-21 to 2023-24 signify a significant step in agricultural mechanization and technology adoption in India (Fig. 1). These developments underscore the institute's commitment to addressing the diverse needs of Indian farmers while fostering sustainable agricultural practices.

STATUS OF ICAR-CIAE'S MACHINERYDURING 2020-21 TO 2023-24

The assessment of nationwide impact is vital in understanding the efficacy and reach of technological interventions in agricultural development. The Central Institute of Agricultural Engineering (CIAE), under the support of the Indian Council of Agricultural Research (ICAR), has been at the forefront of developing and

disseminating agricultural machinery aimed at enhancing farm productivity and livelihoods across India. An analysis of the implement fabrication and dissemination data from 2020-21 to 2023-24 sheds light on the tangible outcomes and challenges encountered in this endeavor. During the fiscal year 2020-21, CIAE fabricated and disseminated a total of 4687 implements, generating revenue amounting to INR 6938060. The top-selling technologies, based on quantity sold, included the Manual Maize Sheller, Manual Twin Wheel Hoe, Manual Naveen Dibbler, Manual Hand Ridger for Women, and Handheld Single Row Vegetable Transplanter. Notably, while these technologies witnessed substantial uptake in terms of quantity sold, the revenue generated was primarily driven by top five technologies, included Pedal cum power operated grain cleaner with motor, Manual Double Screen grain cleaner, Manual Twin wheel hoe, Manually operated Pull type Three Row Planter for Millet-Multi Crops (Model I-Inclined Plate type), and Manually operated Pull type Three Row Planter for Millet-Multi Crops (Model II-Vertical Plate type). This disparity between quantity sold and revenue generated shows up the importance of evaluating not just the adoption rates but also the economic viability and market demand for specific technologies.In the subsequent fiscal year 2021-22, CIAE continued its efforts with the fabrication and dissemination of 3582 implements, generating revenue amounting to INR3871765. The top-selling technologies, in terms of quantity sold, included the Manual Maize Sheller, Manual Twin Wheel Hoe, Manual Peg Type Dry Land Weeder, Manual Hand Ridger for Women, and Manual ConoWeeder. Interestingly, the revenue generated was primarily driven by top five technologies included Manual Double Screen grain cleaner, Manual Twin Wheel Hoe, Manual ConoWeeder, Manual Peg type Dry Land Weeder, and Manual Groundnut Decorticator for women. This highlights the importance of aligning technological innovation with market demand and economic feasibility to ensure sustainable adoption and impact.The fiscal year 2022-23 witnessed a decline in both the number of implements fabricated and disseminated (1383) and the revenue generated (2554935). The top-selling technologies, based on quantity sold, included the Manual Peg Type Dry Land Weeder, Manual Maize Sheller, Multi-Fuel Cooking Stove, Manual Hand Ridger for Women, and Manual Naveen Dibbler. However, the revenue generated was primarily driven byManual Peg type Dry Land Weeder, Cone Penetrometer digital regarding type, Portable Charring Kiln, Manual Groundnut Decorticator for Women, and Manually Pull type Three Row Planter for Millet-Multi Crops (Model I-Inclined Plate type). This underscores the importance of exploring diverse revenue streams and market segments to ensure financial sustainability and resilience in the face of fluctuating market dynamics. The fiscal year 2023-24 witnessed a repetition of the previous year's trends, with 1383 implements fabricated and disseminated, generating revenue amounting to INR 2554935. The top-selling technologies, in terms of quantity sold, included the Manual Maize Sheller, Manual Grubber Weeder, Manual Twin Wheel Hoe, Multi-Fuel Cooking Stove, and Manual Hand Ridger for Women. However, the revenue generated was primarily driven by Multi Fuel Cooking Stove, Manual Twin Wheel Hoe, Continuous Pyrolysis System of Auger Types, Manual Grubber Weeder, and Manual Cycle Wheel Hoe. This divergence between quantity sold and revenue generated underscores the importance of evaluating the economic viability and market demand for specific technologies to maximize impact and sustainability.

CONCLUSION

The nationwide impact assessment of ICAR-CIAE's machinery highlights the importance of evaluating both the adoption rates and economic viability of technological interventions in agricultural development. While the sheer quantity of implements fabricated and disseminated serves as a metric of outreach, the revenue generated provides insights into the economic feasibility and market demand for specific technologies. Moving forward, a nuanced understanding of these dynamics is essential to ensure the effective allocation of resources and maximize the impact of technological interventions on agricultural productivity and livelihoods.

From Field to Lab, Indian Women's Multifaceted Boost to Agriculture!

Tehseen Zaidi
Head Communications, Syngenta India

Women have been making significant contributions to the field of agricultural engineering and technology in India, playing a crucial role in shaping the sector's development and driving innovation. Historically, agriculture in India has been perceived as a male-dominated domain, but over the years, women have broken barriers and emerged as key stakeholders in revolutionizing farming practices through their expertise, creativity, and determination. Braving all odds and challenges, women are contributing significantly to agriculture through sustainable farming techniques.

Indian agriculture has acquired a new dimension in terms of sustainability and resilience thanks to the rapid pace of embracing engineering and technology, which are playing a significant role, particularly in the face of evolving environmental challenges and global food security concerns. By harnessing innovative engineering solutions and cutting-edge technologies, such as precision agriculture, drones, IoT sensors, and genetic engineering, farmers can optimize resource utilization, minimize waste, and enhance productivity while reducing environmental impact.

From sowing seeds to reaping harvest, laboratories to drone training, women are making significant contributions to Indian agriculture. It has been possible thanks to the whole government approach with which women are being promoted in the agriculture sector. To address the gender gap in agricultural extension services, under 'Support to State Extension Programmes for Extension Reforms,' popularly known as Agriculture Technology Management Agency (ATMA), a centrally sponsored scheme, has made adequate provisions for women in farming.

In the past few years, India is witnessing a rapid transition from women's-development to women-led development with the vision of a new India. They are actively involved in engineering and technological breakthroughs. In fact, a large number of women scientists are working in R&D labs, challenging male dominance at all echelons. We cannot forget Pusa-Farm SunFridge (Pusa-FSF), an on-farm green energy refrigeration system, developed by Sangeeta Chopra, Principal Scientist at IARI's Division of Agricultural Engineering in collaboration with Michigan State University researchers.

Similarly, Shelly Praveen and T Vinutha at IARI's Division of Biochemistry have developed a technology for extraction of gluten from wheat dough and its regeneration in pearl-millet and maize flour. Dr K Madhavi Reddy, Principal Scientist and in-charge Head, Division of Vegetable Crops, ICAR-Indian Institute of Horticultural Research, Bengaluru, was awarded honoured with 'Punjabrao Deshmukh Outstanding Women Scientist Award 2021' by then Union Minister for Agriculture and

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Farmers Welfare Narendra Singh Tomar on July 16, 2022 at A P Sinde Seminar Hall, NASC Complex, New Delhi.

It is heartening indeed to note that the government has adopted a multi-pronged approach to address issues of women on a life-cycle continuum basis encompassing educational, social, economic and political empowerment, so that they become equal partners in fast paced and sustainable national development. Under the Central Sector Scheme of Agri Clinics and Agri Business Centres (AC & ABC) of the Ministry of Agriculture and Farmers' Welfare, women beneficiaries are receiving 44 per cent as subsidy while others will get 36 per cent.

One notable area where women have excelled is in the development and adoption of sustainable farming techniques. With a keen understanding of local ecosystems and community needs, women engineers and technologists have been at the forefront of promoting agroecological approaches that prioritize environmental stewardship and social equity. From promoting and adopting modern farming methods to advocating for the use of renewable energy sources in agriculture, their contributions have been instrumental in fostering a more sustainable and resilient food system.

Furthermore, women have played a vital role in leveraging technology to improve agricultural productivity and efficiency. Through the application of precision agriculture techniques, data analytics, and remote sensing technologies, they have helped farmers optimize resource use, minimize waste, and increase yields. Moreover, women-led initiatives in rural areas have facilitated the adoption of digital tools and mobile applications that provide farmers with access to real-time information on weather patterns, market prices, and best agricultural practices, empowering them to make informed decisions and enhance their livelihoods.

In addition to technological innovations, women have been instrumental in promoting inclusive and participatory approaches to agricultural development. Through their leadership in farmer cooperatives, self-help groups, and community-based organizations, they have advocated for the rights and interests of smallholder farmers, particularly women farmers who often face discrimination and limited access to resources. By championing gender-sensitive policies and programs, they have helped create an enabling environment for women to fully participate in and benefit from agricultural development initiatives.

Women in Engineering, Science, and Technology (WEST), a new I-STEM (Indian Science Technology and Engineering facilities Map) initiative, aims at empowering women to contribute to the science, technology, and innovation ecosystem. Through the WEST initiative, I-STEM intends to provide a separate platform to scientifically inclined women researchers, scientists, and technologists for pursuing research in basic or applied sciences in frontier areas of science and engineering.

As we look for more and more women becoming a part of agri engineering and technology, it is heartening to learn that the presence of girls in Science, Technology, Engineering and Mathematics (STEM) is 43 per cent, which is one of the highest in the world. Multiple initiatives for increasing participation of women in STEM) have been undertaken, which will lead to greater participation of women in

agriculture R&D.

However, women in agricultural engineering and technology continue to face numerous challenges, including limited access to education and training opportunities, unequal access to resources and markets, and cultural barriers that restrict their participation in decision-making processes. It is heartening to see that these challenges require concerted efforts from policymakers, civil society organizations, and the private sector to promote gender equality and empower women to realize their full potential in the agricultural sector.
We must remember that women have made invaluable contributions to agricultural engineering and technology in India, driving innovation, promoting sustainability, and advocating for inclusive development. By recognizing and supporting their efforts, we can harness the full potential of women as agents of change in building a more resilient, equitable, and sustainable food system for future generations.

As engineering advancements facilitate the development of sustainable farming practices, including efficient irrigation systems, soil conservation techniques, and renewable energy integration, which are essential for mitigating the effects of climate change and preserving natural resources, we need to involve Naari Shakti in taking agriculture to greater heights of resilience.

Given the fact that technology enables farmers to adapt to changing climatic conditions and unforeseen challenges, enhancing the resilience of agricultural systems, I foresee a greater role for women agri engineers and technologists, and agricultural experts, who can pave the way for a more sustainable and resilient future in agriculture, ensuring food security for generations to come.

As we move towards realizing the goal of Viksit Bharat by 2047, let us be rest assured that our exceptional women farmers, agro-based entrepreneurs, women agri professionals, women agricultural extension officers along with resilient women farm workers, symbolizing exemplary perseverance and determination, will script the real stories of India's self-reliance.

Workshop on Roof Top Solar Power Plant

In connection with the "Suryoday" Scheme declared by Hon'ble Prime Minister Shri. Narendra Modi Ji, a workshop on "Roof top solar Power plant: Opportunities and scheme was organised jointly by Department of Renewable Energy Engineering, CAET, Dapoli and ISAE, Dapoli Chapter on 1st Feb. 2024. The workshop was organised for different stakeholders like farmers, agro industrial owners, hotel owners, residential complex owners and students. Total 60 stakeholders attended the workshop.

The detail deliberations regarding the opportunities and govt. schemes for the roof top solar plant has been carried out by involving all the concern departments who play the role in better implementation of the scheme. All concern personnel viz; Dr. Atul Mohod, Professor (Academic Institute), Shri. Kakde, Dy. Executive Engineer (DISCOM), Shri. Tarange, Manager, UBI, dapoli (Financial Institute) and Shri B. Mali, MNRE Empanelled Member (Supplier) delivered their thoughts in the workshop. Dr. Pramod Sawant, Director of Extension Education, DBSKKV, Dapoli and Dr.P.U. Shahare, Associate Dean, CAET, Dapoli were present for the workshop. The programme was conducted by Er. Poonum chavan, Assistant Professor, DREE, CAET, dapoli.

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Contribution of Indian Women in Organic Agri Enturepreship

*Dr P V S M Gouri
Executive Director & CEO, Association of Indian Organic Industry

Women are making fast strides in every field of carrier today in India as well as globally. The reason being that women are persistent in their journey of life and do not accept defeat. Women have been contributing their energy in any right role they play to be truthful and successful.

In India, though women contribute significantly to farm incomes, they have long been an invisible force. At least 33% of the primary workers on farms are women, says the last census. They contribute significantly as entrepreneurs too. For example, women's participation as self-employed entrepreneurs in agriculture-allied sectors is about 25% in forestry, 20% in plantation, 63% in animal husbandry, 14% in fisheries, and 25% in others.

I would like to focus on the present subject of interest,' Organic farming". There are increasing number of women playing multiple roles as organic cultivators, entrepreneurs and even labourers.

During last two decades women are taking active role in promoting organic farming. The primary reason being that people in general are gravitating towards a healthy lifestyle. Thanks to research and various media reports, everybody is scared about the ill-effects of insecticides and pesticides residues on the vegetables and fruits sold in the market

This has created a paradigm shift for demand for organic food. A sizeable number of middle- and high-income group people are opting for organic produce. In cities many women waste no time to Google to get all the information they could on organic products resulting many are even going for terrace gardening in containers for organic consumption by their family.

Farmers are getting profit as organic farming is sustainable for them. There are several women running NGOs working towards the promotion of women in the villages to become self -reliant for collective activity in the village by adopting organic farming and establishing farmers markets .Such models are many are very impressive in many states. The response has been phenomenal. The key word here is trust. When people know that the person who is selling does not use any fertilizers or pesticides, they go out of their way to get healthy stuff and are even ready to pay a premium.

Several educated women and aspiring agri entrepreneurs are returning to their villages to make significant positive change in the farm economy. Some women are figuring out to manoeuvre through the existing ecosystem of organic certification and put processes in place to ensure that they could get certified produce to source all the way to their stores. They can even think to take further about modern cafes that can exclusively serve only healthy organic stuff. This effort to acquaint people from young age about the benefits of going organic," would further boost the organic movement.

Congratulations to all the women who have established flourishing local organic agribusiness. The next challenge to all is how to scale your business to the next level. Branding, better marketing as well as market access are the key issues.

When the food travels long miles in

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supply chain, it requires a structured approach along with third party assurance system of certification right from farm to fork traceability.

Looking at the space of events leading to organic products in several sectors it appears the only area women have not yet ventured is in setting up of a Certification Body. This requires specific skills and compliance to the Global Standards to establish a credible Organic Certification Program. More attention is needed in development of technical skills in audits (inspection, verification and certification).

Above all building trust in organic produce is necessary to the consumers by ensuring that only genuine items are marketed. This s very essential for the success of organic business.

Contribution as Researcher to the Agricultural Engineering and Technology

Dr Anshuka Srivastava
Professor, Agricultural Engineering, SHUATS

Agriculture is a vital sector for human survival and economic development, providing food, fiber and other essential products. Women are the back bone of agriculture making significant contribution to crop production, livestock management, fisheries and forestry.

Women perform various tasks in farms including sowing seeds, weeding, harvesting and selling the produce.

Women in agriculture often lack access to technology, which limits their ability to adopt sustainable practices. Promoting the use of appropriate technology can increase women's productivity and reduce their workload.

One such appropriate technology is developed by a woman who works as Scientist and always imbibes to reduce the hardships of farming by innovating new, user-friendly and simple machines.Seed Ball technology is one such innovation, which got patent and under the process of field use.A seed ball making machine provides a technique, which can reduce the hardship in paddy cultivation by removing the process of nursery preparation and transplantation in waterlogged field. This technology is not restricted to paddy cultivation only. The machine producing seed balls has been shown in figure no 1.

1. Patent Number 472109

2. Inventor- Dr. Anshuka Srivastava, Dept of Mechanical Engineering

SEED BALLS:

Seed balls are also known as "earth balls". It consists of a number of seeds rolled within a ball of soil. Into this medium various additives may be included, such as manure, humus or compost. These are placed around the seeds, at the centre of the ball to provide microbial inoculants. The seeds may be pre-treated for disease prevention and/or to promote dormancy.

USE OF SEED BALLS:

Seed balls are widely used in zero-till method of sowing seed. This is due to the fact that the seeds are encapsulated in a clay mixture and do not require to be buried. The best thing of seed balls is that it waits unmolested until it has absorbed enough rainwater to germinate. The clay protects the seeds from being eaten by birds, rodents and other animals. The compost provides all the necessary nutrients to the seeds that they require for growing.

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Figure 1: Seed ball making machine

Seed balls may be manufactured manually or by using rotating drum or by automatic machine

Manual seed ball preparation: Manually mixing the seed – soil – manure – water mixture using ones palm or by using a suitable machine that mixes seed – soil – manure – water mixture andDrum technique for seed ball preparation: Same as manual seed ball preparation but in this method a rotating drum is used that enables faster production.

The aforesaid methods are time taking method and cannot be used for bulk production. In this method seed balls manufactured are of different shapes and sizes.Thus an attempt was made to modify the manual/semi-auto system of irregular sized seed ball making. A machine was then finally transforms the mixture to a suitable shape. designed and fabricated which has an automated system for shaping seed balls and should be cost effective.

This machine was tested and it was found that the machine produced equal sized seed balls (15 mm diameter) and the production rate of the present machine is 30 seed balls per minute.

FLOWCHART AS IN FIGURE 2 DESCRIBES THE PROCESS OF MAKING THE SEED BALLS.

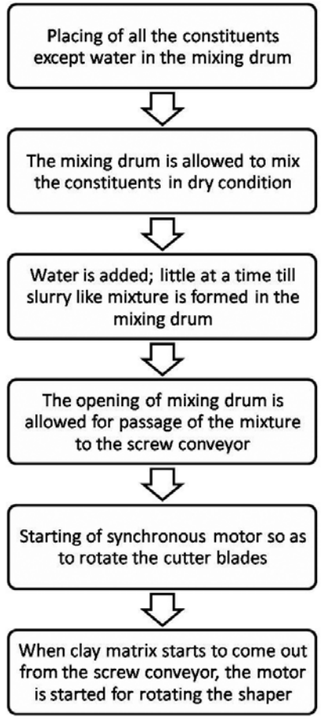

Figure 2: process of manufacturing seed ball

Since the seed balls are of equal size and spherical shape, sowing can be done by seed drill. These balls can be used in grazing lands for continuous fodder production. On the barren lands for cropping fodderIt is felt that the paddy production involves very much hard work. Use of seed ball can be a boon to paddy growers. Balls can be used there for sowing maintaining plant to plan and row to row distance directly on the field. This will remove the nursery preparation and transplantation in waterlogged field. The present machine has four components namely mixing drum, screw conveyor, cutting blade and shaper. The materials considered for the fabrication of the machine has been considered on the basis of the fact that they will be in constant touch with the clay mixture while in operation. To give rigidity to the model, the base is made of iron. The iron base also enhances the balance of the machine when working.

CONCLUSION

The machine was tested for its performance. It was concluded as illustrated in table 1 that the balls manufactured by the machine were of nearly equal size and the shape was spherical. This result ensure that these balls can easily be used for sowing using seed drill thus reducing time of sowing..The machine has been devised, keeping in mind to reduce the time duration of farming and burden of farming. Trails are being carried out with this said machine to make farming easier for women farmers.

Give Me Some Sunshine, Give Me Some Rain

Mrs Anupama Singh
Senior Faculty and Coach, RUDSET Institute

This is truly related to and depicts women's power in the agri industry today.

If we take a reverse journey from today to ancient times, can one imagine the world without SHE?? Throwback proves she has always been there marking impressions of her footprints whenever she got an opportunity.

Women have been an integral part of the Agri world from the ages shouldering responsibilities of agriculture and allied activities under 'RPL (Recognition of Prior Learning). What about those who argue that women's involvement in the agriculture sector has always been limited by sociological and economic barriers and that it will take more than technology to overcome these barriers?

A report by the Food and Agriculture Organization (FAO) of the United Nations reveals that among all self-employed farmers in India, women's share is 48%. The National Sample Survey Office (NSSO)also reports that 46% women workforce is involved in the farm sector, but only 13% are engaged in entrepreneurship contributing to boosting the rural economy. There is a large gap in the adoption of technology gender-wise.

Further, this disparity continues and it has been observed that the rural women workforce is neither part of decision-making processes nor they are seen doing complex mechanized work in the agriculture sector.

Technology has an instrumental role in the transformation of the agri sector helping women to imbibe new skill sets and proficiencies to overcome barriers getting empowered by technological interventions. This has helped circumvent the challenges and facilitate gender-inclusive frameworks to encourage their participation in the workforce. There are role models in the agriculture sector who have emerged as "Change Agents, not only at the community level but also in the technology-led agri-industry. One such name is **Mallika Srinivasan**, popularly known as **'Tractor Queen'** established **TAFE (Tractors and Farm Equipment Limited)** for mass manufacturing of tractors. According to an American global business magazine, she is among India's Most Powerful Women.

Women entrepreneurs are revolutionizing farming practices and have been able to earn a name for their contributionto the growth of the tech-led Agri sector. To name a few who are creating an impact onthe farming community and farm sector are:

Gitanjali Rajamani, co-founder of Farmizen, has turned the dream into reality owning a farm to grow fresh and healthy farm produce for many urban dwellers to own farm in the city, growing fresh and healthy produce right at your fingertips.

Sai Gole, co-founder of Bharat Agri, recognizes the power of mobile apps in providing farmers with real-time information and data empowering farmers to grow more efficiently.

Himani Shah, founder of Intello Labs, works towards creating an intel hub for agriculture using Artificial Intelligence (AI). Shah and her team are dedicated to earning the trust of farmers and advancing the agricultural industry with technology.

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Gurdev Kaur Deol founded the Global Self-Help Group, which engages a community of over 400 farmers in activities such as livestock rearing, bee-keeping, and packaging of fresh produce, fostering a collaborative and sustainable approach.

Innovators like Saradamba Annasamudramand Selavarani Elangovan and are making significant contributions at Corteva Agriscience. The later emphasizes the importance of leveraging cutting-edge technologies such as gene editing, nanotech, and molecular markers to address contemporary challenges in agriculture. Their pioneering work reflects a commitment to advancing the agricultural industry through technological innovation.

The journey from Dalton Ganj, Jharkhand to entering into the dairy industry with Bengaluru-based startup "The Milk India Company" was not easy for Shilpi Sinha who is dedicated to delivering unpasteurized, raw,and pure cow milk in glass bottles focusing on children's health.

With Zama Organics, Shriya Naheta, a first-generation entrepreneur, has provided a solution to the organic farming community connecting over fifty thousand farmers pan India. This agri-tech operates on both models i.e. B2B and B2C offering homemade products and organic produce. Their journey is trying to create a niche in the male-dominated agri-industry.

Kaze Living, a Delhi-based agri-tech, ventures into hydroponics creating a transparent farm-to-fork model by Anisha Goel and Shruti Jain. They provide the hydroponics farmers with technical expertise, farming inputs,

and a platform to sell the produce.

THE GOVERNMENT OF INDIA'SINITIATIVES

Various schemes and programs have been launched to encouragethe adoption of technology for women and to enhance their participation:

❖ The Central Institute of Agricultural Engineering, Bhopal has developed small drudgery-reducing technologies like fertilizer broadcaster, wheelbarrow, paddy winnower etc. and the women are quite familiar now in using these machines, still there is a long way to go to empower them with skill and capacity building training.

❖ The Ministry of Agricultura and Farmers Welfare celebrated Mahila Kisan Diwas and initiated a scheme "Innovation and Agri-Entrepreneurship Development Programme". This scheme is under the Rashtriya Krishi Vikas Yojana (RKVY-RAFTAAR) aiming to foster tech-led enterprises with innovation to provide financial support and nurture the incubation ecosystem.

❖ The role of the Indian Council of Agriculture Research (ICAR) is quite remarkable in backing up agri-based startups. The scheme National Agriculture Innovation Fund (NAIF) was launched in 2016-2017and has funded approximately fifty Agri-Business Incubation Centers (ABICs) to benefit the startups/enterprises led by women. All these centres are operational within the ICAR network for mentoring and guidance.TheICAR is supporting almost 173 women startups/entrepreneurs.

❖ Recently, the SHG women have been trained in "Use of Drone Technology for Irrigation" by Uco Bank RSETI, Begusarai, Bihar as a pilot training to make the women farmers tech savvy and to open the opportunities for them in tech-led agri activities.

THE CONCLUSION

A report by Tech Sci Research reveals that the Indian agriculture market was valued at over $85 million in 2018 and is expected to grow at a CAGR of over 10 percent.There are immense opportunities for women to contribute more by learning AI and setting benchmarks in theagri sector with idea generation, experimenting, and implementing new technology and supply chain mechanisms to meet the industry demand.

ICAR-Central Institute for Research on Cotton Technology, Mumbai Revolutionizing the Cotton Sector through Fibre and Biomass Technologies

In India, cotton the "White Gold" enjoys pre-eminence as anindustrial raw material for the spinning industry with a share of 62%,the rest being chiefly the synthetic fibre like polyester. Since the abolitionof the Multi-Fibre Arrangement (MFA) and the advent of quota-freeglobal trade in 2004, the cotton textile sector is buoyant, and exhibits tremendous growth momentum. Besides, India's progressive economic growth in recent past has resulted in increased spending on clothes dictated by fashion and comfort preferences of consumers, and is helping in expanding the domestic market as well. With the technological advances in cotton processing and value additions increasingly adoptedby the global textile industry, India has emerged as a major player in cotton production, processing and value addition. ICAR-Central Institute for Research on Cotton Technology (CIRCOT), Mumbai is tirelessly working for the benefits of cotton farmers and other stakeholders by carrying out Research and Development activities to tackle various challenges being faced by them in the current scenario and to adopt latest technologies in the cotton sector.

ICAR-CIRCOT, Mumbai

ABOUT ICAR-CIRCOT, MUMBAI

ICAR-CIRCOT, established in 1924, a premier constituent institute of Indian Council of Agricultural Research (ICAR), is engaged in carrying out basic and strategic research in processing of cotton & its agro-residues, development of value-added products and quality assessment of cotton. The Institute extends effective technological support to the country's cotton breeding programme for varietal development with improved productivity and quality that suits industry needs. ICAR-CIRCOT is an ISO 9001:2015 certified institute and is an accredited laboratory under NABL (ISO 17025:2015), functioning as Referral Laboratory for cotton textiles.

Vision:Global Excellence in Cotton Technology

Mission:To Provide Scientific and Managerial interventions to Post-Harvest Processing and Value Addition to Cotton and Utilization of its By-Products to Maximize Economic, Environmental and Societal benefits.

Mandate:

- Basic and Strategic Research on Processing Cotton and its Agro-Residues, Development of Value Added Products and Quality Assessment
- Skill Development and Business Incubation Services and Function as Referral Laboratory for Cotton Fibres

The Institute undertakes research activities in the following 5 major core areas:

- Pre-ginning and Ginning
- Mechanical processing,technical textiles and Composites
- Characterization of Cotton and other natural fibres, yarns and textiles
- Chemical and Biochemical processing of coon and its biomass & by-product utilization
- Entrepreneurship and Human Resource Development

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Director and staff of ICAR-CIRCOT, Mumbai

CONTRIBUTION OF ICAR-CIRCOT IN COTTON TECHNOLOGY

ICAR-CIRCOT has immensely contributed in the modernization of ginning industry in India through Technology Mission on Cotton, Mini Mission IV. The Institute has played a pivotal role in upgrading the skills of personnel engaged in ginning industry through its Ginning Training Centre at Nagpur. Research and Development on Ginning resulted in development of entire line of modern ginning machinery in India, making it self-reliant in manufacturing of ginning machinery.Calibration cotton, Standard Reference Material, for calibrating testing equipment is a hallmark of CIRCOT's achievement.It has a countrywide acceptance withabout 300 corporate users and is preferred over USDA calibrationcotton. The Institute provides objective methods of tests to the cotton breeder for the estimation of quality of new strains of cotton. As a partner in All India Co-ordinated Cotton Improvement Project (AICCIP), the Institute provides guidance for developing strains with enhanced fibre attributes at every stage of breeding program.The other commendable achievements of the institute include development of technologies for processing of naturally coloured cotton and other natural fibre blends, eco-friendly technologies in wet processing and value addition to the by-produce. The Institute is making a steady impact by methodically foraying intocutting-edge research areas like nanotechnology (nanocomposites, nanofertilizers and nanofinishing), green composites, biodegradable packaging, smart textiles and technical textiles.The Institute has also carried out pioneering work on utilization of cottonstalks for production of pulp and paper, kraft paper for preparationof corrugated boxes and particle boards and biomethanation from textile waste by solid state fermentation.

ICAR-CIRCOT has carried out pioneering work in the area of Nanotechnology and has establishment the country's first nanocellulose pilot plant facility in the year 2015 that operates with energy efficient chemo-mechanical process. The pilot plant has the capacity to produce 10 kg of nanocellulose per shift of 8 hours from raw materials like cotton linters and other cellulosic biomass. Also, nanomaterials-based cotton finishing technologies have been developed and commercialized, to impart antimicrobial and UV-absorbing properties. Graphene based conducting ink for smart textiles and nanocomposite films for eco-friendly packaging are under development.

ICAR-CIRCOT plays a vital role in human capacity building in the sector through its skill development initiatives by offering need based expert training programmes. The institute has implemented the Cotton Technical Assistance Programme to strengthen the cotton value chain and capacity building in selected African Countries. ICAR-CIRCOT also provides consultancy services to its stakeholders in the area of ginning, scientific processing of cottonseed, textile processing and application of nanotechnology in textiles and agriculture. Through its services ICAR-CIRCOT has created effective linkage with farmers, industries, machinery manufacturers, and institutions at national and international level. The Institute is an active member of Bureau of Indian

The Institute has a vibrant Agri-Business Incubation Centre, promoting

Nanocellulose Pilot Plant

sustainable start-ups based on post-harvest processing technologies developed in the institute. The Institute's Agri-Business Incubation Center has been selected under Pan-India Rashtriya Krishi Vikas Yojana – Remunerative Approaches for Agriculture and Allied Sectors Rejuvenation (RKVY-RAFTAAR); a unique scheme of Government of India, Ministry of Agriculture and Farmers' Welfare (MoA&FW) in 2017-18. The Institute is successfully nurturing the entrepreneurs and start-ups in the fields of crop value chain, post-harvest infrastructure and agribusiness enterprise development under RKVY-RAFTAAR.

The journey traversed by the Institute has been rewarded with many awards and accolades including the prestigious Sardar Vallabhai Patel Best ICAR Institution award in 2004.The other distinguished awards are; The Best Performing Business Planning & Development unit award in 2013 and Outstanding Team Research Award for 2013-14 under Agricultural Engineering and NRM Division and Cashless ICAR Institute award in 2016. Again, the institute is conferred once again with the prestigious Sardar Vallabhai Patel Outstanding ICAR Institute Award for 2019 for its outstanding contribution towards R & D of various cotton post-harvest technologies and value addition of by-products, skill development of human resources in agriculture and textile sector, prompt commercial testing services, commercialization of technologies, entrepreneurship development programs and start-up generation.

The Institute offers post graduate degree courses like Ph.D (Science) in the field of Microbiology, Physics and Chemistry with the permanent affiliation from University of Mumbai. Also, the scientists of the Institute are recognized guides for other educational institutions like ICT, Mumbai; VJTI, Mumbai; MPKV, Rahuri and DPSKKV, Dapoli. The graduate and post graduate students of other institutions can also undergo their internship under the guidance of the Scientists.

Technology transfer is the most important component of any research organization. The success of the technology development by an institute is attained by transferring the technology to the targeted stakeholders

and bringing about the required social and economic transformation. This division undertakes basic and applied research on ginning, assessment of technology and related areas in post-harvest technology of cotton. Also, if focuses on commercialization of technologies,consultancy services, imparting training on post-harvest technology of cotton to trade, industry and government officials from India and abroad.

The Institute has maintained a set of regional stations since 1928. These stations were initially established as field units at important cotton breeding centres for the purpose of preliminary screening of experimental strains of cotton. These units were carrying out tests for fibre properties of newer varieties cotton under development. Even though locations where the regional unts functioned have undergone changes over the time, they continue to be an important component of cotton research in India. In addition to Ginning Training Centre at Nagpur, the institute maintains regional centers at Sirsa, Surat, Nagpur, Guntur, Dharwad, and Coimbatore. Nagpur unit also have Ginning Training Centre (GTC) and other facilities.

GINNING TRAINING CENTRE, NAGPUR

Ginning Training Centre (GTC) was set up in 1985 as a Regional Unit at Nagpur by ICAR-Central Institute for Research on Cotton Technology (CIRCOT), Mumbai under the Integrated Cotton Development Project (ICDP) by utilizing the World Bank assistance to cater the needs of ginning industry by cutting edge researches, skill development & enhancement of manpower, liasoning with machinery manufacturers for modification and development of essential and allied machinery. Within few years of its establishment, GTC has diversified its activities by venturing into processing and value addition of cotton by-products. GTC is unique of its kind and first in Asia and among 3-4 centres in the entire world that imparts training and carry out research exclusively on Ginning and Value Addition to Cotton By-Products. This centre has done yeomen service to the ginning industry by developing several essential technologies and processes for Indian ginning industry and skill development and enhancement of over 10,000 engineers, technicians, supervisors, fitters, etc. of ginning units dispersed across different states of India and also for African countries. GTC has also played vital role in modernisation and upgradation of Indian ginning industry under Technology Mission on Cotton (TMC). This centre offers technical consultancy services to gin machinery manufacturers for development of latest technologies and upgradation of existing technologies.

Ginning Training Centre, Nagpur

REGIONAL QUALITY EVALUATION UNITS

ICAR-CIRCOT has Regional Quality Evaluation Units located at Coimbatore, Dharwad, Sirsa, Surat and Guntur to support the cotton breeding programs under the All India Coordinated Cotton Improvement Project (AICCIP) of the Indian Council of Agricultural Research (ICAR). Also, the facilities available in the Units have been utilized by the spinning mills located in the nearby regions for quality evaluation and optimization of process parameters for producing quality yarn from Indian cotton. These centres act as a window for transferring the technologies developed at ICAR-CIRCOT to stakeholders. They also act as satellite centre for the Institute's incubation and start-up funding activities.

The institute is etching its way forward to emerge as Centre of excellence in cotton technology, by establishing itself as a hub for technologies, processes, machines and products that will augment the Make in India and Start-up India – stand up India and Atmanirbhar India campaign.

Transforming Agriculture: Empowering Women in Agritech and Engineering

Ms Gubba Deepthi
Chief Operations Officer, Gubba Cold Storage

The Indian agricultural landscape is experiencing a significant transformation, embracing modern technologies like artificial intelligence, data analytics, and connected sensors. This shift not only enhances productivity but also holds the promise of empowering women, who have long been the backbone of the sector.

Despite their pivotal role, women farmers in India have faced historical challenges, including limited access to finances, essential inputs, and land ownership. These obstacles have confined them to unpaid labour and household duties, hindering their individual growth and potential. However, a new era is dawning as government initiatives and innovative technologies aim to reshape the social structure, fostering a more equitable environment.

At the forefront of this transformation is the flourishing AgriTech sector, with over 3050 players actively empowering women farmers. These organizations go beyond conventional assistance, offering specialized training, support systems, and gender-smart solutions tailored to address specific needs and challenges faced by women. The digitization of farming processes introduces flexibility, enabling women to manage workloads efficiently and participate more actively in decision-making and income generation.

Fintech firms contribute by providing pathways for income generation from the comfort of women farmers' homes, fostering financial independence. Innovative initiatives like "peer partner" programs offered by AgriTech startups bridge the knowledge gap, facilitating hassle-free procurement of agricultural inputs and connecting women farmers with experts for improved practices.

Private players recognize the critical role women play not just in cultivation but also in marketing. Initiatives are being undertaken to empower women farmers in navigating regional markets, ensuring fair compensation for their produce. The AgriTech revolution signifies a shift in mindset, nurturing an ecosystem that fosters the growth and empowerment of women farmers.

In parallel, visionary women leaders are making significant strides in the Agritech sector. Sai Gole, Co-founder of BharatAgri, utilizes algorithms to help farmers maximize production and income. NEERx, founded by Nikita Tiwari, develops sensors providing real-time data for farming conditions, contributing to pest prevention, and improving productivity.

Anisha Goel and Shruti Jain, founders of Kaze Living, offer pesticide-free food through hydroponic farms, witnessing consistent growth. Srishti co-founder of Red Otter Farms, utilize predictive analytics in Aquaponics, producing high-quality organic vegetables.

While these strides are noteworthy, there is a pressing need to address the gap in agritech and engineering. Companies in the private sector must actively promote diversity and inclusivity, implementing policies that support work-life balance. Government initiatives should focus on increased investment in education and skill development programs tailored for women, fostering a more equitable landscape.

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India's progress, while commendable, necessitates accelerated efforts, learning from successful global models. By harnessing the full potential of women in agritech and engineering, India can propel itself towards greater innovation and competitiveness on the global stage. Empowering women in these crucial sectors is not just a social imperative but a strategic move for ensuring sustainable growth and development. The collaborative efforts of the government, financial institutions, and private players can bridge the gender gap, creating a truly inclusive agricultural and engineering sector.

The way ahead: addressing challenges and empowering women in agritech

As we navigate the transformative landscape of agritech, a strategic approach is imperative to overcome existing challenges and empower women in the sector. To ensure a more inclusive and equitable environment, several key solutions can be implemented.

Enhancing women's access to financial resources is crucial. Government and financial institutions can collaborate to create targeted financial programs, providing loans and subsidies specifically tailored for women farmers. This would empower them to invest in modern technologies and essential inputs, fostering economic independence.

Promoting skill development programs that cater to the specific needs of women in agriculture is essential. By offering specialized training in technological advancements, digital literacy, and sustainable farming practices, women can actively participate in decision-making processes and contribute more substantially to the sector's growth.

Enacting and enforcing policies that address gender disparities is paramount. Companies within the private sector should be encouraged to adopt gender-inclusive practices, ensuring equal opportunities and fair treatment for women in the workplace. Government initiatives can provide incentives for businesses that actively promote diversity and inclusivity.

Establishing mentorship programs can play a pivotal role in bridging the gap. Successful women leaders in agritech and engineering can mentor aspiring professionals, providing guidance, support, and insights into navigating the challenges of these industries. This not only inspires but also creates a network for knowledge exchange.

Ensuring easy access to technology is fundamental. Government initiatives can focus on providing subsidies for agritech tools and equipment, making them more affordable for women farmers. Additionally, awareness programs can educate women about the benefits of these technologies, breaking down barriers and fostering widespread adoption.

Creating awareness about the critical role women play in agriculture and engineering is essential for societal change. Advocacy campaigns can challenge stereotypes, promote the achievements of women in these fields, and inspire younger generations to pursue careers in agritech and engineering.

By implementing these solutions, we can pave the way for a more inclusive, diverse, and empowered agritech sector, where the contributions of women are not only recognized but actively nurtured for sustained growth and innovation. The collaborative efforts of governments, businesses, and communities are integral to realizing this vision and creating a future where gender equality thrives in the fields of agritech and engineering.

Transformative Role of Women in Agricultural Engineering and Technology

Dr Manjula Jain

Dean Academics, Teerthankar Mahavir University

The presence and contributions of women in Agricultural Engineering and Technology are not just essential; they are transformative. Their diverse perspectives, innovative approaches, and unwavering dedication are driving forces behind the sustainable evolution of agriculture, shaping a future where efficiency, inclusivity, and resilience go hand in hand.

Women have made significant and diverse contributions to Agricultural Engineering and Technology, occupying crucial roles in moulding the contours of contemporary agriculture. Whether through groundbreaking research and innovation or hands-on implementation, women have been indispensable in driving the transformative changes that have reshaped the agricultural sector.

Women play a crucial and substantial role in the development of agriculture and related sectors. According to agricultural statistics, approximately 73.2% of women in rural India are engaged in agricultural activities, but only 12% of them own farmland. In 2020, the Supreme Court ruled that women have an equal right to inherit property as men, recognizing their entitlement to land ownership. (https://timesofindia.indiatimes.com/india/supreme-court-extends-womens-right-to-parents-property-prior-to-56/articleshow/89026076.cms)

Following the liberalization of Indian agriculture, a phenomenon known as the feminization of agriculture emerged, signifying an increased share of women in the agricultural workforce. According to the international humanitarian group OXFAM, nearly 75% of full-time workers on Indian farms are women.(https://www.oxfamindia.org/women-empowerment-india-farmers)Research from the Indian Council of Agricultural Research (ICAR, 2020) highlights women's participation at 75% in major crop production, 79% in horticulture, 51% in post-harvest work, and 95% in animal husbandry and fisheries.(https://pib.gov.in/newsite/PrintRelease.aspx?relid=184202)

In a notable achievement in 2021, Akanksha Kumari made history as the first woman mining engineer to work in an underground mine in India.(https://www.indiatimes.com/trending/social-relevance/akanksha-kumari-indias-first-woman-engineer-to-work-in-underground-mines-548546.html)This accomplishment reflects the breaking of gender barriers in traditionally male-dominated fields, symbolizing the expanding roles and capabilities of women in diverse sectors, including mining and engineering.

Scientists and researchers, particularly women, have introduced novel viewpoints to the realm of agricultural engineering, resulting in innovative technologies and solutions. Their endeavors encompass a wide array of domains, ranging from precision farming and drone technology to sustainable agricultural practices. Through thorough studies and experimentation, these women have propelled the field, presenting innovative approaches to tackle the challenges confronted by farmers worldwide. Their dedication to

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pushing the frontiers of knowledge has yielded advancements in cutting-edge machinery, irrigation systems, and post-harvest technologies, culminating in an overall enhancement of efficiency and productivity in agriculture.

In the realm of education and extension services, women have significantly impacted the field. As educators and extension workers, they have been instrumental in spreading knowledge and advocating best practices in agricultural engineering to farmers. Acting as bridges between research institutions and local communities, women ensure that cutting-edge technologies are not limited to the confines of laboratories but are accessible and advantageous to those actively engaged in agriculture. Through their dedication to extension services, women have equipped farmers with the essential information required to embrace sustainable and efficient agricultural practices, thereby nurturing a more resilient and well-informed farming community.

Within the sphere of farm management, women have become pivotal figures, assuming roles as accomplished farm managers and entrepreneurs. Their impact is observable in the incorporation of cutting-edge agricultural technologies, ranging from precision agriculture to crop monitoring systems. Women farm managers adeptly utilize these technologies to optimize resource utilization, boost yields, and guarantee the economic sustainability of agricultural enterprises. Their proficient management of modern tools and data-driven decision-making processes has not only enhanced the effectiveness of individual farms but has also played a role in the broader modernization of the agricultural sector.

In contemporary agriculture, women play a pivotal role in promoting

sustainability through eco-friendly practices, contributing to the development of technologies for organic farming, water conservation, and waste reduction. Their advocacy and implementation of sustainable practices address environmental concerns and mitigate the impact of climate change on agriculture, emphasizing the importance of balancing productivity with environmental stewardship. Beyond technical contributions, women in agricultural engineering actively engage in rural community development projects, extending their impact beyond individual farms to enhance entire communities. Another significant dimension of women's contributions lies in training and capacity building. Through comprehensive programs, women empower farmers with the knowledge and skills needed for modern agricultural technologies, bridging the knowledge gap and enhancing the overall resilience and adaptability of the agricultural sector.

According to a FAO report, providing women in the agricultural sector with equal opportunities and resources can potentially lead to a 20-30% increase in farm output and yield. In developing nations, resourceful women engaged in agriculture could elevate total agricultural production by 2.5-4%, thereby improving food security. On-going support and mentorship for women in the farming sector are vital for ensuring the sustained growth and development of the entire ecosystem.

(https://timesofindia.indiatimes.com/blogs/voices/how-agritech-companies-are-empowering-women-in-agriculture/)
In conclusion, women's contribution to Agricultural Engineering and Technology is extensive and diverse, spanning research, innovation, and hands-on implementation. Their impact has not only driven technological advancements but has also significantly enhanced the sustainability, inclusivity, and resilience of agriculture. Recognizing and promoting women's contributions is crucial for fostering continued innovation and addressing 21st-century agricultural challenges. Women's active participation in agricultural engineering and technology is not just about equity; it is a strategic imperative for the sector's advancement and sustainability. Emphasizing the importance of women in these fields is essential for building a more resilient, innovative, and inclusive agricultural future. To achieve a progressive India, prioritizing the empowerment of women farmers is imperative, ensuring their equitable access to land ownership, financial resources, modern farming techniques, and sustainable agricultural education.

Gender Neutral Practices For Inclusive Workforce

Ms Dhanashri Mandhani
Founder, Salam Kisan

Salam Kisan is a tech-enabled comprehensive agriculture platform powered by data-driven insights to increase productivity and profitability for farmers. It is an all-in-one solution that brings together different stakeholders across the agricultural value chain. At its core, it is an integrated agricultural ecosystem that provides custom AI-based assistance from pre-sowing preparations to post-harvest activities. We are working towards empowering farmers with a digital platform equipped with AI-driven tools and services, enabling them to boost their yields and profitability.

Last year, in September, Linta Shelke Waghmare became Maharashtra's first female drone pilot. The news was hailed as an indicator of women's foray into traditionally male-dominated sectors.

We currently have 58,000 farmers under Salam Kisan of whom 15% are women. Right now, around 15% to 18% are women farmers. Something that our focus has also been on is increasing women's participation in agriculture, more so formalizing it because women are already participating in agriculture as laborers, or it's mostly informal,

it's not accounted for in the GDP. My main goal with this company is also to formalize women's labor, not just on farms but also within our company. We focus a lot on female hiring, even with drone pilots. We were responsible for the first female drone pilot training in Maharashtra, and she also went on to become the second female drone pilot in the country. So after that, we focused a lot on hiring women as drone pilots. We have special programs, and capacity building programs, to include women in drone pilot training.

I realized the immense difference between the farming ecosystems in India and the United States. While farmers in India earned less than $3,000 each year, those in America earned an average of anything between $60,000 and $180,000. Looking at this disparity, I decided to further get insights and pursue an internship at an agricultural-based company in India.

It led me to set up a call center, through which I interacted with over 100 farmers and more than 50 professionals in the sector. These conversations helped me understand the challenges that they faced on the ground. After keenly observing our nation's agricultural operations for around 8 months, I realized that we can improve farmer productivity and profitability through technological adoption. Hence, Salam Kisan was established, an agritech platform that facilitates data-driven decision-making from pre-sowing to post-harvest for farmers across the country.

We bring together different stakeholders from across the agricultural value chain to fill the gaps in the sector.

I have learned the ropes of running a business from an early age. While still in college, I turned into an entrepreneur by founding Salaam Kisan. Today, Salaam Kisan is hardly a year old but has so far garnered a user base of 58,000 farmers and established

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a team of over 75 people.

Growing up in a business family, I spent my childhood with a keen interest in my grandfather and father's entrepreneurial pursuits. I remember being fascinated by watching my father diversify and build multiple companies from the ground up. The rigor and passion my father had for creating impactful and scalable businesses inspired me to walk the same path. Likewise, my grandfather told me stories from the 1960s where he cycled through financial instability and worked his way up to build a successful business.

I think some of the most important lessons I've learned about being a leader come from being a daughter raised by these two successful men. They taught me the importance of building relationships, treating people with humility and, most importantly, the power of resilience. Their life's work came in as invaluable wisdom to start my journey as a third-generation entrepreneur.

India's agritech sector holds immense potential for rapid growth and evolution in the coming years. With food demand rising and climate volatility impacting yields, the need for innovative solutions to support our farmers has never been greater. I envision precision agriculture, digital advisory, and predictive analytics at the core of this transformation - enhancing productivity and sustainability across crops, soil types, and farm sizes.

Salam Kisan is committed to playing a leading role in the ongoing revolution in Indian agriculture by expanding our comprehensive, data-driven solutions for the farming community. With a successful track record of positively impacting lives in Maharashtra

through our app-based offerings, we are strategically positioned for national expansion. My vision for Salam Kisan involves empowering Indian farmers through our integrated platform, offering hyperlocal weather alerts, customized crop advisory, access to inputs and finance, and end-to-end market linkages. I also want to facilitate women's empowerment by helping them build skills and enhance their livelihood.

- **Salam Kisan adopts gender-neutral hiring practices to create a diverse and inclusive workforce.**

Only 28% of C-suite positions are held by women, when you look at agriculture and in ag-tech the numbers drop. Regardless of the industry, gender neutrality and equal opportunities for women are personal life goals for me and I am glad that I can make this difference through Salam Kisan.

It is also heartening to witness the government taking similar initiatives, such as their upcoming scheme where 15,000 women Self-Help Groups (SHGs) will receive agri-drones across India. It is in alignment with our commitment to leading the charge for diversity in agritech. We intend to elevate female voices across all levels of the agricultural value chain and formally recognise the contributions of hundreds of millions of labour hours dedicated to nourishing our nation.

- **Salam Kisan is actively involved in on-the-ground projects, training 100 women in mushroom cultivation in Nasik, India. The initiative provides not only training but also covers setup costs, offering an expected output of 18,000 rupees per person**

We've started one more project, which is mushroom cultivation in the Nasik belt, where we have identified women beneficiaries who participate in agriculture, but in an informal way.

So what we're doing here with them is we're doing backyard mushroom cultivation, where we are expecting each woman beneficiary to make Rs 18,000 at the end of the crop cycle and we're expecting a return of INR15,000 to 18,000 on each woman's mushroom cultivation

- **Not just a tech-enabled agricultural platform; it's a force for positive change**

We are dedicated to pioneering research in frontier agritech, whether it's utilizing AI-enabled image recognition for crop disease monitoring or employing satellite data and ML models for yield forecasting. With our robust rural workforce and the trust bestowed upon us by the farming community, we ensure that farmers' needs remain at the core of our innovation.

Sustainable Solutions: Conceptual Framework and Process Development for Biogas Slurry Filtration in Drip Irrigation


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India possesses extensive potential in harnessing its native bioenergy resources, encompassing biomass, biogas, and other renewable sources. By tapping into these resources, India can diminish its dependency on imported fossil fuels and reduce greenhouse gas (GHG) emissions. Initiatives that advocate for the utilization of renewable energy and sustainable bioenergy sources play a crucial role in India endeavors to meet its escalating energy needs while addressing climate change.

RENEWABLE ENERGY LANDSCAPE AND BIOGAS PRODUCTION SURGE

The swift adoption of renewable energy systems in developing nation there is an anticipated surge in by-product production. India emphasis extends across various significant renewable energy sources, including biogas, biomass, solar energy, wind energy, small hydropower, and emerging technologies. In the twelfth five-year plan (2012-2017), the Indian government aimed to establish 6.5 lakh biogas plants nationwide under the National Biogas and Manure Management Program (NBMMP), allocated a budget of Rs. 650 crore. The envisioned outcome was an annual production of about 1-6 cubic meters of biogas per day and 4745 lakh cubic meters of biogas. The execution of this program involves collaboration with State Nodal Departments/Agencies, the Khadi and Village Industries Commission (KVIC), and Biogas Development and Training Centers (BDTCs). With the amplified production of biogas, there is a simultaneous generation of biogas digestate, which can be efficiently utilized. The by-product yield ranges from 5% to 80% of the input feedstock, contingent on the type of feedstock used, necessitating the management of a substantial residue for economic and environmental benefits in the biogas production process (Moller and Muller, 2012).

LIVESTOCK CONTRIBUTION AND BIOGAS SLURRY GENERATION

India undeniably boasted a considerable livestock population, totalling approximately 512.05 million heads in 2012. The livestock sector holds significant importance in Indian agriculture and rural economy, sustaining livelihoods for millions and contributing to food production and income generation. In India, a substantial quantity of biogas slurry is generated annually, with the production reaching an impressive 79.8 million tons. The financial value of organic fertilizer is indeed noteworthy, given its potential to boost agricultural productivity

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and deliver tangible benefits to farmers.

CHALLENGES IN CURRENT WASTE MANAGEMENT PRACTICES

This substantial volume of biogas slurry results from the nations increased emphasis on renewable energy sources and sustainable waste management practices. Nevertheless, the current application and storage methods, such as inadequately lined earthen drains and pits, pose potential hazards of nutrient loss from the digestate.

BIOGAS SLURRY COMPOSITION AND AGRICULTURAL BENEFITS

Anaerobic digestion is a process that breaks down organic matter without the presence of oxygen, producing biogas and a nutrient-rich liquid known as biogas slurry. The typical composition of biogas slurry includes 1.5% nitrogen (N), 1.1% phosphorus (P), and 1% potassium (K) (SNV, 2011). This by-product, consisting of 93% water and 7% dry matter, with 4.5% organic and 2.5% inorganic materials, contains essential nutrients such as nitrogen, phosphorus, potassium, and micronutrients vital for plant growth. Farmers can use bioslurry alone or in combination with other organic and synthetic fertilizers to fertilize crops.

ADDRESSING NITROGEN LOSS AND ENVIRONMENTAL IMPACT CHALLENGES

Bioslurry contributes to soil fertility and structure, enhancing water retention capacity and promoting overall soil health, resulting in increased crop yields. Compared to traditional fertilizers like farmyard manure (FYM) and composted manure, bioslurry provides readily accessible nutrients and micronutrients for plants. However, there is a concern regarding nitrogen loss when distributing or directly spreading slurry on land. Nitrogen, particularly in its nitrate form,


is highly soluble and can leach into water bodies, posing risks to aquatic ecosystems and human health. The extent of nitrogen loss depends on various factors, including soil nitrate concentration, water drainage, seasonal management, soil tillage, fertilization practices, soil characteristics, crop nutrient absorption, and weather conditions such as rainfall and irrigation. Managing these factors is crucial to minimize nitrogen losses and mitigate environmental impacts.

India is grappling with significant challenges related to greenhouse gas (GHG) emissions, mainly driven by rapid economic growth and heightened energy demands. As one of the largest global contributors to GHG emissions, the country faces notable environmental impacts. The waste and agriculture sectors stand out as major sources of GHG emissions in India. Emissions from waste management, including solid waste, wastewater treatment, and landfill activities, stem from the release of methane during the decomposition of organic waste in anaerobic conditions. Implementing improved waste management practices and adopting waste-to-energy technologies are essential strategies to mitigate emissions from this sector.

CLIMATE-SMART AGRICULTURE PRACTICES AND FERTIGATION SOLUTIONS

Agriculture, a vital sector supporting a substantial portion of the population, is also a significant contributor to Indias GHG emissions. Adhering to climate-smart agricultural practices, such as alternate system of rice intensification and promoting organic farming can play a pivotal role in emission reduction. To address these challenges, optimizing nitrogen crop interception and providing the right nutrients at the appropriate times are crucial.

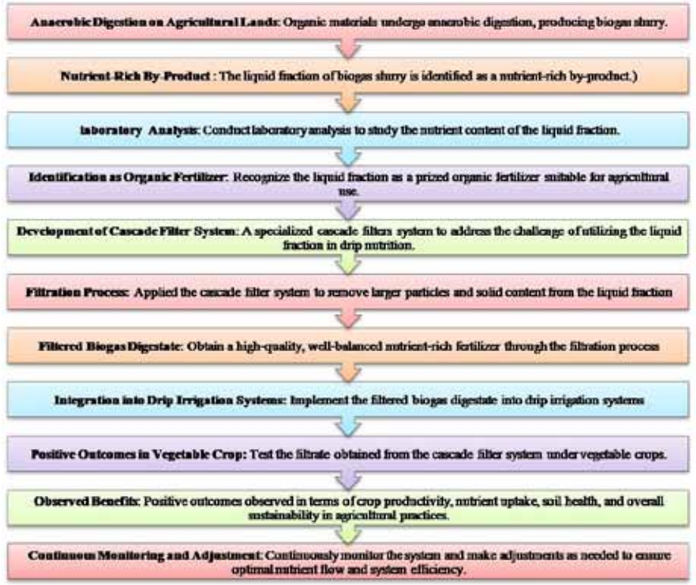

Figure 1:Flow diagram depicting the biogas slurry filtration and drip nutrigation

DRIP NUTRIGATION: TRANSFORMATIVE APPROACH IN AGRICULTURE

Fertigation, the application of fertilizers through irrigation systems, is a viable method to achieve this objective and decrease nitrogen losses (Qiu, X et al.2022).Moreover, applying slurry through fertigation can positively impact the environment by reducing ammonia emissions, minimizing nitrogen seepage into groundwater, and decreasing reliance on chemical fertilizers. However, careful consideration of slurry types and prudent management practices is essential to maximize benefits while minimizing potential negative impacts. The liquid fraction of biogas slurry emerges as a promising alternative, rich in carbon and nutrients derived from the anaerobic breakdown of organic materials (Yin et al., 2019). Utilizing this liquid fraction not only enhances soil fertility and crop productivity but also effectively addresses the issue of secondary pollution. However, applying cattle slurry through drip irrigation poses challenges due to the large capacity of slurry tanks and issues like clogging and biofilm formation in the irrigation system. Precisely managing doses and maximizing crop interception while avoiding excessive nutrient losses becomes complex. Despite these challenges, using slurry in drip irrigation can reduce reliance on chemical fertilizers, potentially saving on costs and minimizing environmental impact. Drip irrigation with slurry conserves water by delivering it directly to the root zone, reducing wastage. Additionally, slurry, derived from organic waste, contributes to waste management and reduces greenhouse gas emissions.

ENHANCING WATER AND NUTRIENT USE EFFICIENCY WITH DRIP NUTRIGATION

Nutrigation, the application of nutrients through irrigation, enhances crop nutrition effectively. When applying biogas slurry through drip irrigation, known as "drip nutrigation," it becomes even more impactful. However, the long-term efficiency of this system relies heavily on the quality of the liquid fraction concerning turbidity and solid content. Research suggested that unconventional water sources, like reclaimed water, can damage drip systems more than conventional sources. Considering biogas slurry liquid fraction as unconventional, its complex composition poses higher anti-clogging demands on emitters. Prolonged application increases the risk of clogging, reducing the overall hydraulic performance of the system.

To address these issues, pre-treatment of biogas slurry liquid fraction is essential. This process, involving filtering or dewatering mechanisms, removes larger particles and solid content, making the slurry suitable for drip nutrigation. Pre-treatment ensures the liquid used is free from potential clogging agents, maintaining efficient nutrient flow. This filtered or dewatered liquid becomes a high-quality, well-balanced nutrient-rich fertilizer, promoting soil fertility and crop productivity without compromising the irrigation systems efficiency. Pre-treatment allows better control over nutrient content, enabling tailored application rates based on specific crop requirements. This targeted approach optimizes nutrient uptake, minimizes losses, and contributes

to sustainable agricultural practices. The liquid fraction of biogas slurry in drip irrigation represents a transformative journey that connects the entire cycle from land to laboratory to industry. Beginning in agricultural lands where organic materials undergo anaerobic digestion, biogas slurry becomes a valuable by-product rich in nutrients.

Through laboratory analysis and study of its nutrient content, it emerged as a prized organic fertilizer, making it an ideal candidate for drip irrigation. As the liquid fraction of biogas slurry is channelled through drip systems, it becomes a crucial resource driving innovation in both the laboratory and industrial sectors. The focus is on optimizing nutrient content and developing filtration techniques to ensure compatibility with drip systems, with industries leveraging its sustainable attributes to enhance agricultural productivity. The integration of biogas slurry in drip irrigation exemplifies a seamless blend of land-based organic waste management, scientific advancements, and industrial applications, fostering a sustainable and circular approach to agriculture.

Addressing the challenge of effectively utilizing the liquid fraction of biogas digestate in drip nutrition, the authors have developed a specialized cascade filter system to remove larger particles and solid content from the liquid fraction of biogas digestate. This innovative filtration process with benefit: cost ratio of 2.3 showed the final filtrate is suitable for integration into drip irrigation systems. The success of this approach has been demonstrated through testing the filtrate obtained from the cascade filter system under vegetable crop. By implementing the filtered biogas digestate in drip, positive outcomes have been observed viz. crop productivity, nutrient uptake, soil health and overall sustainability in agricultural practices through organic farming.

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Empowering Female Farmers through Innovations in Gender-Sensitive Agricultural Engineering

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INTRODUCTION

The agricultural sector stands as the backbone of global food security and rural development. The full potential of this vital sector can only be harnessed when both men and women have equal access to resources, training, and innovative technologies. Recognizing the critical role of women in agriculture, especially in developing nations, there is a pressing need to tailor agricultural engineering technologies to be more gender-sensitive (FAO, 2021). This approach not only enhances productivity but also promotes gender equality and women empowerment (Agarwal, 2020). There are number of innovative, women-friendly agricultural engineering technologies that are paving the way for a more inclusive and sustainable agricultural future. Agriculture is an important component of rural livelihoods. Almost 70 per cent of India's population of 1.2 billion–some 833 million people live in rural areas (Census of India, 2011). In India, agriculture plays an important role in the economy, empowering female farmers through innovations in gender-sensitive agricultural engineering (NABARD, 2018). Despite their significant contributions to the sector, women in India often face unique challenges, including limited access to resources and technology (GOI, 2020). Modifying agricultural engineering innovations to the specific needs of female farmers in India holds the key to overcoming these challenges. Introducing labour-saving technologies, such as small-scale mechanized tools suitable for women, can alleviate the physical burden associated with traditional farming practices (Agarwal, 2014). Additionally, digital and mobile solutions can bridge information gaps, providing Indian women farmers with real-time access to market prices, weather forecasts, and valuable agricultural insights (Kumar and Srivastava, 2017). Emphasizing gender-sensitive approaches in agricultural engineering not only enhances the productivity of female farmers but also contributes to the broader goal of socio-economic empowerment, fostering a more inclusive and sustainable agricultural landscape in India.

The viability of agricultural technology is contingent upon its ecological sustainability and social acceptability, as highlighted by Satyavathi et al. (2010). Despite technological advancements, a predominant design focussing on tools and equipments tailored for male workers has resulted in a misalignment with the anthropometric and physiological characteristics of female farmers. The

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inherent differences in anthropometric dimensions and muscular strength between men and women underscore the inadequacy of tools primarily designed for male users. Recognizing this discrepancy, efforts have been made to develop gender-sensitive agricultural equipments, such as the two-wheel hoe and fertilizer spreader, designed specifically for women. These endeavours represent a step towards addressing the ergonomic needs of female farmers. However, the current state of gender-specific agricultural equipment remains nascent, necessitating further extensive research and development initiatives to bridge the existing gaps and ensure optimal ergonomic compatibility for women in agriculture.

GENDER-SENSITIVE AGRICULTURAL INNOVATIONS

Gender-sensitive agricultural innovations consider the specific needs and challenges faced by women in agriculture. These innovations are designed to reduce labour intensity, increase efficiency, and improve access to markets and financial resources. By addressing the gender gap in agricultural productivity, these technologies play a crucial role in enhancing food security, improving livelihoods, and fostering a more equitable society.

KEY AREAS OF INNOVATION

1. Labour-Saving Technologies

Many women in agriculture perform time-consuming and labour-intensive tasks. Introducing labour-saving technologies, such as small-scale mechanized tools for planting, weeding, and harvesting, can significantly reduce the physical burden on women. Examples include hand-held planters, solar-powered irrigation pumps, and lightweight, ergonomic tools designed for women use.

2. Digital and Mobile Agricultural Solutions

Digital technologies offer revolutionary ways to support female farmers. Mobile apps provide access to weather forecasts, market prices, and agricultural advice, allowing women to make informed decisions without having to travel long distances. Platforms that offer online training and support networks also empower women with knowledge and community connections.

3. Improved Access to Markets

Technologies that facilitate better access to markets are crucial for female farmers. Platforms and services that connect women directly with buyers, provide transport solutions, or offer storage facilities can help women get better prices for their products and reduce post-harvest losses.

4. Climate-Resilient Agricultural Practices

With climate change disproportionately affecting women in agricultural communities, technologies and practices that promote resilience are vital. Drought-resistant crop varieties, water-saving irrigation techniques, and soil conservation methods ensure that women can sustainably manage their resources and mitigate the impacts of climate variability.

ROLE OF TRANSFORMATIVE TOOLS IN AGRICULTURE

In agriculture, women farmers grapple with the absence of activity-specific tools wherein numerous transformative farm tools and equipments play important roles to tailor their needs (Fig. 1). Mechanization in agriculture often results in the marginalization of women, highlighting the critical need for gender-sensitive technological interventions. However, the benefits derived from enhanced tools and equipment are agnostic to gender, serving common objectives for both men and women in the agricultural workforce. Advancements in agricultural technology have significantly contributed to the reduction of drudgery, particularly for female workers involved in farming activities. The implementation of improved farm tools and equipments has alleviated the physical strain traditionally associated with agricultural tasks (Hassan et al.,2019). With innovations such as ergonomic tools and mechanized equipment, the burden on female workers has been lessened, leading to a more sustainable and inclusive agricultural workforce. Increased input utilization efficiency is another noteworthy outcome of technological advancements in agriculture. Enhanced tools play a crucial role in optimizing the utilization of agricultural inputs, ensuring that resources are allocated more efficiently. This optimization not only enhances overall productivity but also contributes to sustainable farming practices by minimizing resource wastage (FAO, 2017).Timeliness in field operations is a key factor in the success of agricultural activities. Mechanized tools have played a pivotal role in ensuring the timely completion of various field operations. This reduction in turnaround time has a cascading effect on subsequent crop cycles, contributing to enhanced agricultural efficiency and productivity (Erenstein *et al.,* 2007).The integration of improved tools has led to significant productivity enhancements in man-machine systems. The synergy between human labour and advanced machinery promotes efficiency in agricultural processes, ultimately leading to increased output (Gupta and Pandey, 2018). This symbiotic relationship between humans and machines is pivotal in addressing the challenges of feeding a growing global population. Efficient tools also contribute to energy conservation in agricultural processes. By minimizing wastage and optimizing resource use, these tools play a crucial role in ensuring sustainable and eco-friendly farming practices (Sharma *et al.,* 2020). Energy

conservation in agriculture is not only environmentally responsible but also economically beneficial for farmers in the long run.The utilization of advanced tools not only enhances efficiency but also results in a marked improvement in the quality of agricultural work and produce. Precision agriculture techniques enabled by technology contribute to better quality crops and more effective resource utilization, positively impacting the overall agricultural output (Kumar et al., 2015). Furthermore, the adoption of improved tools and equipments has a direct impact on the quality of life for female farmers. The reduction of physical strain through the use of modern agricultural technology positively influences the overall well-being of female farmers, contributing to an improved quality of life (McCarthy et al., 2018). This aspect of technological advancement in agriculture highlights its potential for fostering gender equality and inclusivity within the farming community.

WOMEN FARM ERGONOMICS

Ergonomic considerations for women farm workers are integral to optimize their efficiency, well-being, and overall work performance. The scientific study of the interaction between individuals and their working environment, encompasses various facets crucial to women working in agriculture. The ergonomic characteristics of women farm workers involve a comprehensive assessment of the working environment, ambient conditions, tools, materials, work methods, and organizational structures.

1. Physical Anthropometry:

Anthropometric data specific to women, such as body dimensions and proportions, are paramount in designing tools and equipments tailored to their physiological characteristics. For instance, studies have indicated variations in height, reach, and grip strength between men and women, highlighting the need for gender-specific

Fig. 1: Role of Transformative Tools in Agriculture

ergonomic solutions (Stucchi *et al.,* 2019).

2. Tool Design and Operation:

The ergonomic design of farm tools is crucial for ensuring that they align with the biomechanics of women farm workers. This involves considerations such as grip size, handle length, and weight to reduce the risk of musculoskeletal disorders. Research by Dianat et al. (2016) emphasizes the importance of tool design in minimizing physical strain and discomfort among female workers.

3. Work Posture and Movements:

It is vital to analyse the ergonomic aspects of work postures and movements. Studies by Holmes et al. (2018) have explored the impact of different postures on the musculoskeletal health of women engaged in farming activities. Ergonomic interventions, including adjustable workstations and mechanized equipment, can contribute to improved posture and reduced strain.

4. Organizational Factors:

Ergonomic considerations extend beyond the physical realm to organizational aspects. Factors such as task rotation, breaks, and workload distribution influence the overall well-being of women farm workers. The study by Jadhav et al. (2017) underscores the significance of organizational ergonomics in promoting a healthier and more productive work environment for female agricultural workers.

5. Ambient Conditions:

Ergonomic adaptations should also address ambient conditions, including temperature, lighting, and ventilation. Studies by Hedge (2016) highlights the impact of environmental factors on the comfort and performance of women working in agriculture.

WOMEN FRIENDLY EQUIPMENT IN AGRICULTURE

The development and use of tools and machinery that take into consideration the ergonomic and physiological needs of female farmers need to be advocated and promoted for reducing the female farmer drudgery. Women play a crucial role in agriculture worldwide, and creating equipments that are adapted to their needs can enhance efficiency, reduce the risk of injuries, and empower women in the agricultural sector. Certain examples of women-friendly equipment in agriculture are presented in Fig. 2.By considering ergonomic factors, safety measures, training, task-specific tools, mechanization, cultural considerations, and affordability, the agricultural sector can better support and benefit from the valuable contributions of women farmers.

Fig.2: Tools and equipments to reduce the drudgery of female farmers

CHALLENGES

Although there is a potential in advancing gender-sensitive agricultural engineering, obstacles continue to exist. Cultural barriers, restricted access to finance, and a deficiency in training and education remain significant impediments (IFAD,

2021). These obstacles necessitate comprehensive efforts from governments, NGOs, and the private sector to invest in women's agricultural education, provide financial services, and advocate for policies that substitute gender equality in agriculture. Cultural barriers often manifest as resistance to change in traditional roles and practices, hindering the continuous integration of gender-sensitive technologies within agricultural communities. Limited access to finance further intensifies the situation, impeding women ability to acquire the necessary tools and technologies that could substantially enhance their agricultural productivity. Concurrently, the shortage of training and education compounds these challenges by hampering the effective utilization of advanced agricultural technologies. The report of IFAD (2021) underlines the firmness of addressing these challenges through collective action. Governments must take an active role by formulating and enforcing policies that promote gender equality in agriculture. NGOs play a pivotal role in facilitating grassroot initiatives, providing localized support, and fostering community engagement to overcome cultural barriers. Simultaneously, the involvement of private sector is crucial in creating financial mechanisms that make agricultural technologies more accessible to women. A collaborative approach involving diverse stakeholders is imperative to dismantle cultural barriers, empower women through education and finance, and pave the way for a more equitable and progressive agricultural landscape.

CONCLUSION

Empowering female farmers through gender-sensitive agricultural engineering goes beyond technical considerations. It is a crucial step towards achieving global food security and sustainable development. Tailoring innovations to meet the specific needs of women in agriculture is essential for unlocking the full potential of this often-overlooked workforce. It is both a strategic necessity and a moral obligation to ensure that the voices and needs of female farmers guide the development and implementation of agricultural technologies. This collective effort aims to eliminate gender disparities, creating an inclusive agricultural landscape where everyone, regardless of gender, can thrive and contribute to a resilient and sustainable global food system.

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Harvest to Plate: Tackling Agriculture Food Wastage for a Sustainable Future



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ABSTRACT

Despite producing enough food to feed the global population, an estimated 1.3 billion tons of food are wasted annually throughout the agricultural supply chain, from harvest to plate. This wastage represents not only a moral and ethical failure, but also a significant economic and environmental burden. This paper examines the extent and causes of agricultural food waste, its consequences for sustainability, and potential solutions for tackling this multifaceted challenge. We draw upon recent data and website references to support our analysis and recommendations.

INTRODUCTION

Nourishing a growing global population while protecting the planet's resources requires a fundamental shift in how we produce and consume food. At the heart of this challenge lies the staggering reality of agricultural food waste. From field losses during harvest to post-consumer discards, an estimated one-third of all food produced for human consumption never reaches a human stomach (FAO, 2019). This wasted food carries a heavy price tag, estimated at \$400 billion annually (World Resources Institute, 2020). Furthermore, it squanders precious resources like water, land, and energy, exacerbates climate change by generating greenhouse gas emissions, and contributes to biodiversity loss through habitat destruction for non-utilized food production.

EXTENT AND CAUSES OF AGRICULTURAL FOOD WASTAGE

Understanding the specific stages at which food waste occurs is crucial for designing effective interventions. According to the World Bank, post-harvest losses in developing countries can account for up to 40% of all food produced (World Bank, 2019). These losses often stem from inadequate storage infrastructure, inefficient transportation systems, and limited access to processing and packaging technologies. In developed countries, however, a significant portion of food waste occurs at the retail and consumer levels due to factors such as cosmetic appearance standards, short shelf-lives, and poor consumer planning and purchasing habits (WRAP, 2020).

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CONSEQUENCES FOR SUSTAINABILITY

The environmental footprint of agricultural food waste is immense. Producing food that ultimately goes uneaten consumes an estimated 25% of all freshwater withdrawals, 33% of global arable land, and 10% of all anthropogenic greenhouse gas emissions (FAO, 2019). This wasted food depletes vital resources that could be used to nourish vulnerable populations and address climate change. Furthermore, food waste leads to increased landfill methane emissions, further contributing to global warming.

SOLUTIONS FOR TACKLING FOOD WASTE

Addressing agricultural food waste requires a multi-pronged approach that engages stakeholders across the entire supply chain. Some key solutions include:-

- Improving infrastructure and technologies:-Investments in post-harvest handling infrastructure, including storage facilities and transportation systems, can significantly reduce losses in developing countries. Additionally, promoting advanced processing and packaging technologies can extend shelf life and prevent waste.

- Setting clear standards and reducing food loss guidelines:- Establishing standardized food quality guidelines and reducing unnecessary cosmetic appearance requirements can help minimize discards at the farm and retail levels. Implementing "good practices" guidelines for harvest, storage, and transportation can further decrease losses.

- Raising consumer awareness and promoting education:-Educating consumers about the issue of food waste and fostering responsible purchasing and consumption habits is crucial. Awareness campaigns, cooking demonstrations, and educational initiatives can empower individuals to make informed choices and reduce their own food waste footprint.

- Developing innovative food sharing and waste reduction models:-Implementing food rescue programs that redistribute surplus food to vulnerable populations can bridge the gap between hunger and waste. Additionally, exploring initiatives like composting and anaerobic digestion can convert food waste into valuable resources like fertilizer and biogas.

CONCLUSION

Tackling agricultural food waste is not simply a matter of resource efficiency; it is a moral imperative and a critical step towards building a more sustainable future. By implementing the solutions outlined in this paper, we can reduce the environmental burden of our food system, improve food security for vulnerable populations, and ensure that the fruits of our agricultural labor reach the tables of those who need them most. The journey from harvest to plate begins with conscious choices and responsible actions across the entire food supply chain. Let us embark on this journey together, fostering a world where food is valued, respected, and never wasted.

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- Waste & Resources Action Programme (WRAP): https://wrap.org.uk/taking-action/food-drink/initiatives/food-waste-reduction-roadmap

Utilisation of Waste from Millets

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INTRODUCTION

India encourages large-scale production of millets due to their high nutritional value. India is expected to produce 41% of the world's millet, making it the world's leading millet producer. Millets are grown on 15.5 million hectares of land in India, yielding 17.2 million tonnes with a yield of roughly 1111 kg/ha. Thus, along with grain, there is a proportionate production of chaff, stalks, straws, and other agricultural residues as well. Millet peel contains 15% protein and is high in fiber and amino acids like lecithin and methionine, as well as minerals like Fe, K, Mg, and P. Being rich in the beneficial elements, usage of millets' post-harvesting and post-processing residues is limited to compost, and organic manure use only. Thus, this article discusses other possibilities for upcycling millet waste.

EXTRACTION OF BIOACTIVE COMPOUNDS POSSESSING THERAPUTIC ACTIVITIES

Plants' exterior layers, such as shells, peels, and hulls have a high concentration of phenolic compounds, which safeguard the inside material against insect assaults, microbial attack, and environmental stress. It is well known that the phenolics were mostly contained in grain hulls. Free radicals induced base modification, and DNS strand scission may all assault DNA molecules, causing mutagenesis, which can eventually result in cancer.

Natural antioxidants in pearl and kodo millets protect against DNA scission generated by both peroxyl and hydroxyl radicals, indicating their possible application as a functional dietary component to inhibit carcinogenesis. It has been shown that LDL cholesterol oxidation plays an important role in the etiology of atherosclerosis. High amounts of phenolic chemicals have the potential to interact with the protein moieties of LDL cholesterol molecules, rendering them ineffective in preventing cholesterol oxidation.

Millet-grain phenolics may protect membrane lipids from oxidation induced by free radical reactions, hence preserving cell membrane function and integrity. This protective effect might be attributed to millet phenolics' metal ion chelation and free radical scavenging activities. Additionally, phenolic compounds might interact with phospholipids present in the membrane through hydrogen bonding with the phospholipids' polar head groups and may concentrate at the membrane's surface, blocking radical access to the lipid area. Thus, bioactive compounds from millet husks could be extracted using various extraction methods like microwave, ultrasound, enzymatic hydrolysis or fermentation, which can bring about some desirable biochemical changes in the cell wall of the millets husks and ultimately aid in the release of bound phenolic or other bioactive compounds. After enriching the medium with the bioactive compounds, which possess a lot of therapeutic and nutritional activities as well, it could be encapsulated with a wall material, and later, capsules could be made out of the mixture through spray drying or freeze drying. But the limitation that is of utmost importance is enriching the extracting medium with bioactive compounds since the binding materials to be used are quite expensive; hence, unless the medium is enriched with an ample amount of bioactive compounds, it won't be economically feasible to go for encapsulation.

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MILLET HUSKS AS AN ALTERNATIVE SOURCE FOR BRIQUETTE

Researchers investigated the incineration properties of briquettes made from sorghum panicle and pearl millet using cassava starch as a binder and reported that the briquettes formed had a higher calorific and heating value. Starch and gum arabic could be used as binding materials for briquette production. Particle size, compacting pressure, effect of binder composition on the compactness, compressive strength, impact resistance index, porosity, burning and ignition time are to be considered for briquettes that ultimately influence their quality.

BIOETHNOL PRODUCTION FROM MILLET HUSKS

Ethanol has 35% more oxygen than other fuels like coal and gas, which makes it easier for the fuel to burn completely and therefore reduces the amount of particle emissions that are harmful to living organisms. The husks of millet have the ability to make bioethanol. Millet husks, being rich in starch and reducible sugars, could be a good source for ethanol production. As per research on finger millets husk, temperature, hydrolysis time, acid concentration and substrate concentration were found to have profound effects on the quality as well as quantity of ethanol production. Millet husks could be used for bioethanol and biogas production. Millet husks blended with other cereal husks could be one such way of bringing sustainable growth.

MILLET HUSK ASH AS A POTENTIAL SOURCE OF CONSTRUCTION MATERIAL AND FERTILISER

Chemical examination of the husk ash of buckwheat, which is a pseudo-millet, revealed significant levels of primary and secondary nutrients such as CaO, MgO, P2O5, and K2O, as well as micronutrients like Co, Mn, Zn, Fe, Cu and Mo. This implies the possibility of designing a cradle-to-cradle re-forming engineering methodology in which the end product of buckwheat processing, husk ash, may be added back to refill the soil's nutrient profile, resulting in an overall sustainable process. It is vital to utilize solid waste in agriculture sustainably, and efforts have also been made in the past to recover the micronutrients.

Millet husk is burned using an unregulated burning process to produce MHA and this ash may be used as a cementing agent in the production of concrete. According to some research findings, the high quantity of silica found in MHA and its fineness when blended with concrete increased the concrete's transition zone and increased its compressive strength. As a consequence, MHA achieved a maximum compressive strength of up to 10%, beyond which concrete strength begins to decline as it affects the cement's hydration temperature.

One of the most recent innovations in new materials is geopolymer concrete (GC), which produces a cheap, environmentally friendly substance that may be used in place of Portland cement (PC). GC is an inorganic polymeric concrete based on alumino-silicates that may be formed from silicon- and aluminium-rich by-products or geological resources using a very alkaline solution. The PC is entirely swapped out to create the GC. It has been witnessed that PC emits five- to six-times more CO2 than geopolymer cement does. Hence, geopolymer technology uses industrial waste and/or by-products of aluminosilicate composition to manufacture high-value building materials while simultaneously reducing CO2 emissions from the cement manufacturing sector. Other cementitious components and mineral fillers, such as millet husk ash, which is produced by burning millet husk for six hours at 500 to 850 °C, might be utilised to reduce costs, improve fresh and hardened concrete, and for environmental and economic reasons as an approach towards sustainability.

CONCLUSION

Millets, which are known as nutricereal, signify the ample amount of nutritional benefits they possess. Millets, being an ancient crop, are traditionally consumed in cooked or fermented form. But with the advancement of technologies in food processing industries, various value-added products are being produced from millets. Millets husks and stalks, which are generally considered agri-waste and were once used as compost and organic manure, are rich in phenolics and cellulose and possess huge potential in packaging, reinforcing fillers, medicine, nanocomposites, the drug delivery sector, and bioethanol production. They could be upcycled by extracting them through the adaptation of a suitable extraction method.

Fruit Bagging: An Innovative Approach to Enhance Physico-Chemical Quality of Fruit Crops



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ABSTRACT

Fruit quality is important aspect which is influenced by biotic and abiotic factors.The fruit's external appearance is a major determinant of its quality. Various agronomical operations are capable of regulating the fruit micro-environment and improve fruit appearance,quality and market value. Fruit bagging has a vital element of the domestic and international markets for fruits in countries such as India, Japan, China, etc.It is a safe and environment friendly technique for protecting fruits from various negative impact and keeping or increasing overall quality. Despite its growing global relevance, the creation of proper bagging materials and more importantly, their application in the field is extremely tedious, necessitating considerable efforts to improve and standardize bagging material according to crop/fruit needs.

Keywords: Fruit bagging, microenvironment, market value, quality.

INTRODUCTION

Fruit bagging, also known as fruit covering or wrapping, is a cultural operation used to protect fruits from various environmental factors and pests during. It involves placing a bag or covering over individual fruit or cluster of fruits on a plant.The bags or covers used in fruit bagging are made up of paper, plastic film or mesh fabric, etc. These materials allow air and light to reach the fruit while providing a protective shield against insects, birds, diseases and adverse weather conditions.

PRIMARY OBJECTIVES OF FRUIT BAGGING:

The bags are typically applied to fruits when they are at an early stage of development,

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often when they are small and still attached to the plant. They are carefully secured around the fruit to ensure proper coverage and prevent entering of pests. Depending on the fruit type and growth rate, the bags may be removed before harvest or kept on until harvest to maximize protection.

PRE-HARVEST BAGGING MATERIALS:

Various materials can be used for fruit bagging, depending on the specific requirements and desired outcomes. Here are some commonly used materials for fruit bagging:

Paper: They are typically made from brown or white paper and are biodegradable. Paper bags provide some level of protection against pests and sunburn, while allowing air circulation and reducing moisture buildup.

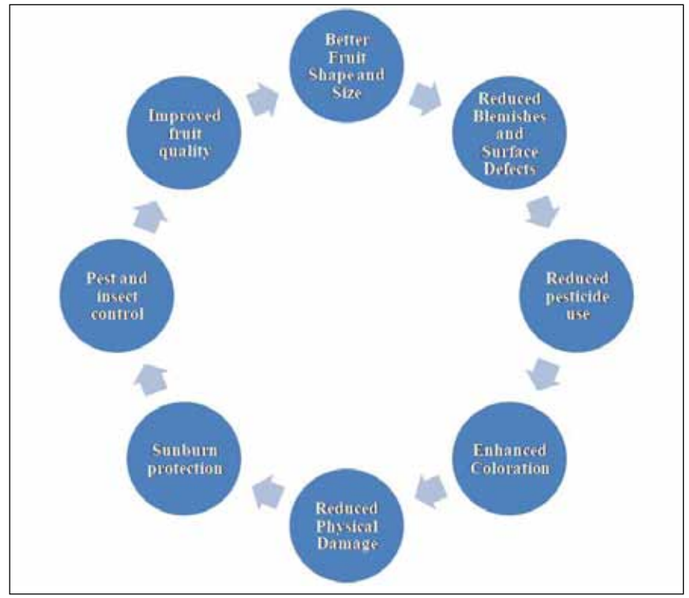

Figure 1: Primary objectives of fruit bagging

Plastic: Plastic bags are used for bagging due to their durability and moisture resistance. Polyethylene bags are commonly used with different thicknesses. Clear plastic bags allow sunlight to reach the fruit, aiding in ripening, while opaque bags provide additional protection against pests.

Fabric: Lightweight fabric materials such as nylon or muslin offer breathability and protect fruits from pests with allowing air and light penetration. Fabric bags can be reusable and favored in organic farming practices.

Mesh: Mesh bags are made from a woven material with small gaps that allow air circulation and protect from insects and birds attack. They are commonly used for bagging fruits like citrus, apples, or pears.

Netting: Similar to mesh bags, netting provides protection against birds and larger insects and allowing airflow. It can be made of materials like nylon or polyethylene and available in various mesh sizes.

Biodegradable Films: Environmentally friendly alternatives to traditional plastic bags are biodegradable films made from materials such as polylactic acid, starchor cellulose-based films. These films offer protection and eventually break down naturally and reduce environmental impact.

The choice of fruit bagging material depends on factors like fruit type, desired protection level, climate conditions, and environmental concerns. Farmers and gardeners often select the most suitable material based on these factors to ensure optimal fruit quality and minimize damage.

ACCORDING TO COLOR FRUIT BAGGING MATERIALS

Various colored bagging materials are often employed to meet specific requirements based on the type of fruit being grown.

Here are some examples of color classified fruit bagging materials commonly used:

White color bags: These are commonly used for various fruit crops including apples, pears, peaches and nectarines. White bags reflect sunlight, reducing heat build-up and preventing sunburn on the fruit's surface.

Brown color bags: This type of bags used for fruits i.e., oranges, grapefruits and lemons. Brown bags helps to protect citrus fruits from sunburn and reduce the risk of pest infestation.

Red color bags: These are often utilized for fruits like cherries and plums. The red color helps to attract beneficial insects that can help control pests while also providing some protection against birds.

Blue color bags: These are sometimes used for fruits such as grapes. The blue color can deter certain insects attack like fruit flies.

Black color bags: This type of bags are employed for certain fruits, including figs. The black color helps to absorb sunlight, keeping the fruit's surface warm and promoting ripening.

Green color bags: These are commonly used for fruits like persimmons and avocados. The green color provides camouflage, blending with the foliage and making it less visible to pests and birds.

Glimpses of fruit bagging in orchard

It's important to consult with local agricultural experts or farmers in your specific region for the most suitable fruit bagging materials and practices, as they may have knowledge of specific recommendations based on local conditions and fruit varieties.

CHALLENGES AND LIMITATIONS:

Pre-harvest fruit bagging requires careful monitoring and management to ensure proper ventilation and prevent the development of microclimates that may favor pests or diseases. Additionally, the cost of materials and labor associated with bagging can be a limiting factor for large-scale implementation.It's important to note that the conclusions presented here are based on the information available earlier years. Further research and advancements in the field may have provided additional insights or modified our understanding of the technique's effectiveness. It is recommended to consult more recent literature and seek advice from local agricultural experts for the most up-to-date and region-specific recommendations regarding preharvest fruit bagging.

FUTURE TRUST

The future of pre-harvest bagging materials in fruit crops holds promising potential for several reasons:

It is important to note that the future trust in preharvest bagging materials will also depend on economic factors, availability and practical considerations for farmers. Cost-effective and easily implementable solutions will be essential for widespread adoption. Additionally, local conditions, crop varieties and market requirements influence the choice of bagging materials. Continual evaluation and adaptation of bagging techniques will be necessary to ensure their effectiveness and sustainability in fruit crop production.

Figure 2: Future trust

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