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Impact of Resource Conserving Technology on Cropping Pattern in Punjab and Haryana

Rohit Rana[1]

The study examines the changes in cropping patterns in Punjab and Haryana due to the adoption of resource-conserving technologies. It is based on primary data collected from four districts: Karnal and Sonipat in Haryana and Moga and Ludhiana in Punjab. The findings indicate that adopters of RCTs, who typically have larger landholdings, are more likely to engage in mechanized farming and diversify their crops beyond the traditional rice-wheat system. In contrast, non-adopters, often small and marginal farmers, tend to stick to the conventional rice-wheat cropping pattern and are less inclined to take risks with new technologies. The RCTs also help reduce labour costs and increase crop yields, leading to higher profitability for farmers adopting these technologies. Overall, the study highlights the potential of RCTs to transform traditional agricultural practices, particularly in regions where the rice-wheat system dominates, and suggests that wider adoption of these technologies could lead to significant economic and environmental benefits.

Impact of Agricultural Technology Management Agency (ATMA) on Crop Diversification, Employment, and Income of Beneficiary Farmers in Raipur District of Chhattisgarh State

Ajay Gauraha, Shilpa Jangde, M.R. Chandrakar and P. Verma1

Using the data from 200 beneficiary farmers, this study examines the effects of the ATMA scheme on agricultural practices in Raipur, Chhattisgarh. It analysed the changes in cropping patterns, employment, and income among these farmers before and after adopting the ATMA project. There is a significant shift in cropping patterns, with a decrease in the area under paddy cultivation and an increase in the cultivation of maize, pigeon pea, green gram, black gram, and scented rice during the Kharif season. Similar trends were observed in the Rabi and summer seasons, where the area under wheat decreased while the cultivation of crops like chickpea, mustard, finger millet, and small millet increased. The study also reports a notable improvement in farmers' income, with overall net returns rising by 38.84 per cent after the implementation of ATMA. Employment opportunities also grew by 14.38 per cent, with the Rabi season showing the highest increase in employment days. The ATMA scheme has positively impacted crop diversification, income, and employment among beneficiary farmers.

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On the Move: Revolutionizing Supply Chains with the Innovative Mode of Marketing

V. Mathuabhirami[1], C. Karthikeyan[2] and M. Nirmala Devi[2]

The study explores the challenges and responses in agricultural supply chains during the COVID-19 pandemic by using the data collected from 350 farmers in the Coimbatore and Tiruvallur districts of Tamil Nadu. The proposed model emphasizes collaboration among various stakeholders and includes strategies such as 'Uzhavar Santhai' (farmers' markets), mobile vehicle marketing, e-commerce platforms, bulk procurement, and cold storage facilities. These mechanisms aim to ensure fair prices, market stability, and sustainability in the agricultural sector. The study highlights the critical role of extension services in enabling farmers to navigate the disruptions caused by the pandemic. It concludes that a collaborative approach, combining traditional and innovative marketing methods, is essential for building a resilient agricultural supply chain capable of withstanding future crises. The proposed model addresses immediate challenges and provides a framework for long-term growth and sustainability in the agricultural sector.

Comparative Analysis of Financial Inclusion and its Dimensions in the Union Territory of Jammu and Kashmir

Tosib Alam and Naseer Ahmad Hajam[3]

The study uses the Sarma Index to explore the state of financial inclusion across 22 districts of Jammu and Kashmir. It analyses three key dimensions: banking penetration, availability of financial services, and usage. It also utilizes secondary data from the State Level Banking Committee, Census 2011, and the Economic Survey of Jammu and Kashmir (2022-23). It reveals significant disparities in financial inclusion across the districts. Jammu, Srinagar, and Ganderbal emerged as the top performers, driven by urbanization, infrastructure development, and industrialization. These districts benefit from a higher concentration of bank branches and ATMs, critical indicators of financial service penetration and availability. In contrast, many rural and remote districts show low levels of financial inclusion, attributed to challenges like poor infrastructure, low population density, and the higher costs of providing financial services. The study highlights the importance of expanding banking infrastructure, enhancing financial literacy, and ensuring the affordability of financial services to bridge the gap between urban and rural areas. Moreover, the research suggests that policymakers should focus on improving access to financial services in rural areas to promote inclusive growth and reduce poverty.

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Biopesticide Market, Regulations and the Determinants of Farm-Level Use

A. Amarender Reddy[1], Shaikh Mohd. Mouzam[2] and K.V. Praveen[3]

Based on existing literature and secondary data, this study provides an overview of global and national biopesticide markets. It examines trends in the demand and usage of biopesticides in India at national and state levels, identifies the factors influencing spending on them, and reviews the regulatory frameworks in select countries. The findings indicate that the consumption of biopesticides is slow in India; hence, government intervention is needed to promote this sector. As indicated by our analysis, farmer organizations can be a reliable means to promote the farmers' expenditure on biopesticides. India can gain valuable insights from the regulatory systems in other countries, particularly in streamlining the registration process and ensuring compliance with safety and efficacy standards. Biopesticides present an eco-friendly and sustainable alternative to chemical pesticides, helping to reduce pollution and maintain ecological balance in agriculture. Encouraging the development and use of biopesticides is essential for promoting sustainable agricultural practices and minimizing the environmental impact of chemical pesticides.

Cost and Return Analysis of Wheat Crop under Solar Irrigation in Udaipur, Rajasthan

Shivangi Upadhyay and Akash Mhaskey[4]

The study compares the costs and returns of wheat production under solar irrigation with traditional diesel or electric irrigation methods. The research was conducted in Udaipur, where many solar water pumps were installed under the PM-KUSUM scheme, and the primary data for 2022-23 were used. The findings reveal that the total cost of wheat cultivation under solar irrigation in Jhadol tehsil was ₹49,571.55 per hectare, with 64.01 per cent variable costs and 35.99 per cent fixed. In Kotra tehsil, the total cost was slightly higher at ₹50,133.80 per hectare. The cost of production per quintal of wheat was approximately ₹1,443 in Jhadol and ₹1,454 in Kotra. The study concluded that wheat cultivation under solar irrigation systems is economically viable and suggested that transitioning to solar irrigation enhances profitability for farmers and contributes to sustainable development by reducing greenhouse gas emissions and dependency on fossil fuels.

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Shifts in Input Use and Profitability of Major Crops in Punjab and Haryana

Harsh Dagar[1], Jatinder Sachdeva[1], J.M. Singh[1], Jasdev Singh[1] and Inderjit Singh Grewal[2]

The study examines the changes in the cost of cultivation and profitability of paddy and wheat crops in Punjab and Haryana during the past three decades by using secondary data from various sources, including the Commission for Agricultural Costs and Prices (CACP). It shows a significant increase in the total cost of cultivating paddy and wheat in these states. For instance, in Punjab, the total cost of paddy cultivation increased by approximately 333 per cent from 1999-2002 to 2019-2022, while in Haryana, it rose by about 332 per cent. Similarly, the cost of wheat cultivation in Punjab increased by around 220 per cent and in Haryana by approximately 247 per cent during the same period. Despite the rising costs, the study finds that both paddy and wheat have remained profitable, primarily due to the government's minimum support prices (MSP) and input subsidies. Haryana generally shows higher profitability for both crops than Punjab, particularly when considering constant prices. The study also highlights a shift towards mechanization. It concludes by discussing the environmental concerns associated with the extensive cultivation of paddy, particularly groundwater depletion in Punjab.

Impact of International Migration on the Income of Farm Households: Evidence from Punjab, India

Prabhjot Kaur, Amanpreet Kaur and Rajveer Kaur Ritu[3]

The study explores how international migration affects the income of rural farm households in Punjab, focusing on different income sources such as agriculture, livestock, non-farm wages, and self-employment. The research is based on primary data collected from 880 households, including migrant and non-migrant families, across four districts of Punjab: Gurdaspur, Jalandhar, Hoshiarpur, and Ludhiana. The findings reveal that international migration adversely affects agricultural income, as migrant households (MH) tend to own and lease less land and suffer from a loss of family labour, leading to reduced agricultural productivity. In contrast, migration positively influences income from non-farm self-employment, as remittances provide additional financial resources that allow these households to invest in self-employment activities. The impact of migration on livestock income and non-farm wages is found to be insignificant. The study suggests that the decline in agricultural income due to migration underscores the need for systematic changes in the agricultural sector to make it more profitable and sustainable. It also highlights the importance of

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strengthening the rural non-farm sector to provide alternative income opportunities, thereby reducing the need for youth to migrate abroad for better prospects.

Innovations in Agri-Input and Services Market Towards Sustainable Agriculture in India: A Systematic Literature Review

Neelam Singh[1]

The study provides a comprehensive overview of the advancements in agricultural inputs and market services aimed at promoting sustainable agriculture in India. Key innovations discussed in the paper include agroforestry, precision agriculture, climate-smart practices, and digital agricultural extension services. These innovations have demonstrated the potential to improve resource efficiency, increase crop yields, and reduce environmental impacts. The review also identifies various factors influencing the adoption of these innovations, including socio-economic, climatic, structural, institutional, and political aspects. The study underscores the importance of integrating advanced technologies, such as big data analytics and digital platforms, to address the challenges faced by smallholder farmers. Moreover, the paper emphasizes the need for policy support and gender-sensitive approaches to ensure the widespread adoption of sustainable practices. In conclusion, the paper highlights the critical role of collaborative efforts among governments, private sectors, and international organizations in advancing sustainable agriculture in India. It also suggests future research directions, including developing predictive tools, the integration of advanced technologies, and exploring sociocultural and gender-specific factors in agriculture.

Changing Scenario of Tea Economy in India

Kumar Charan Krishna and Aswathy Vijayan[2]

The study analyses the evolution and current state of India's tea economy. It discusses the structural transformation within the tea industry, marked by the rise of Small Tea Growers (STGs), who now contribute nearly 48 per cent of the total tea production, up from 7 per cent in 1991. Favourable tea prices and government assistance programs have driven this shift from large plantations to smaller operations. However, it has also introduced challenges such as fluctuating prices, labour issues, and the impact of climate change. The study highlights the constraints faced by STGs, such as labour shortages, financial difficulties, and inadequate marketing infrastructure. It suggests that innovation, product diversification, and sustainable practices, such as organic cultivation and intercropping with exotic fruit crops, will

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ensure the industry's long-term viability. In conclusion, the study emphasizes the importance of strategic investments in sustainable practices, technological advancements, and global collaborations to enhance India's position in the international tea market and ensure the tea economy's continued success.

The Role of Digital Platforms in Supporting Zero Budget Natural Farming (ZBNF) in Himachal Pradesh

Karan Rana[1]

This study investigates how digital platforms, including social media, e-portals, and mobile applications, facilitate the adoption and success of ZBNF among farmers in the hilly state of Himachal Pradesh. The research highlights the significant role of digital tools in providing crucial information, technical support, and market opportunities to farmers. Platforms like YouTube, Facebook, and Twitter are instrumental in offering self-paced learning materials, sharing success stories, and fostering a community of ZBNF practitioners. Additionally, the state government's initiatives, such as the Cetara Initiative, which provides certification and market linkage for ZBNF products, have been enhanced through digital technologies, enabling farmers to achieve better prices and gain consumer trust. The integration of ZBNF with the e-NAM platform has further expanded market access for farmers, ensuring transparent and efficient trade practices. However, challenges such as digital literacy, network issues due to the mountainous terrain, and the need for more comprehensive training remain. The paper concludes that digital platforms have significantly contributed to the spread and success of ZBNF in Himachal Pradesh, serving as a model for promoting sustainable agriculture through technology.

Farm Mechanisation for Sustainable Punjab Agriculture

Sangeet Ranguwal and Jatinder Sachdeva[2]

Based on data collected from 300 farm households across 30 tehsils in Punjab during 2019-20, this study examines the role of farm mechanization in enhancing agricultural productivity and sustainability in Punjab. About 85 per cent of farmers owned a tractor, though only one-fourth of marginal farmers and half of small farmers owned it. The tractor use is only 450 hours per year—less than half of what is required for economic viability. The use of tractors is higher in the rabi season than in the kharif season. The study suggests that the high cost of production due to underutilized machinery could be alleviated by promoting custom hiring services, particularly for marginal and small farmers. The research emphasizes the need for a paradigm shift in agricultural mechanization, advocating for introducing machinery for un-mechanized operations like sugarcane harvesting, cotton picking, and paddy transplanting. The

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study concludes that sustainable and appropriate mechanization can increase land productivity, reduce labour shortages, and achieve food security while improving farmers' livelihoods.

GM Mustard in India: An Ex-Ante Impact Assessment

Sahin Aktar Munshi, Akriti Sharma, K.V. Praveen, Harbir Singh, P. Anbukkani, M.L. Nithyashree and M. Balasubramanian[1]

The study evaluates the potential economic impacts of adopting the genetically modified (GM) mustard variety, Dhara Mustard Hybrid-11 (DMH-11), in India by using the Economic Surplus Model (ESM) to assess the potential economic benefits from 2024 to 2034. The study estimates a substantial total economic surplus of ₹6.07 lakh million by 2034, with a net present value (NPV) of ₹2.72 lakh million, an internal rate of return (IRR) of 264.29 per cent, and a benefit-cost ratio (BCR) of 353.12, indicating highly favourable returns on investment. The study emphasizes the potential for GM mustard to enhance economic welfare in Indian agriculture, supporting sustainable development and reducing the reliance on costly imports. The paper highlights the importance of continued investment in agricultural biotechnology and the need for evidence-based policy decisions to maximize the benefits of GM crops like DMH-11.

Urea Subsidy in India – Can Nano-Fertilizers Address the Issue

Shalendra[3], Soumitra Das[4] and Sangamesh Angadi[3]

The study examines the growing burden of fertilizer subsidies in India, particularly for urea, and explores whether adopting nano-fertilizers could offer a sustainable solution. The study highlights that traditional urea usage is expensive and inefficient, with up to 50 per cent of the nutrients being lost to the environment. This inefficiency drives up the cost of agriculture and places a heavy financial burden on the government due to the need for continued subsidy support. It suggests that adopting nano-urea could lead to significant savings, with estimates indicating a potential reduction in urea subsidy by more than ₹72,000 crore by 2026-27 if nano-urea replaces conventional urea as planned. The authors also emphasize the need for a comprehensive strategy to ensure the successful adoption of nano-fertilizers. This includes building the necessary infrastructure for production, creating effective extension services to educate farmers, and implementing a robust marketing strategy to ensure widespread availability. Additionally, the study calls for caution when using

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nano-fertilizers, as excessive application could pose risks to human health and the environment.

Bibliometric Analysis of Agricultural Water Management Institutions

S. Harshitha Nayak[1], Shivendra Kumar Srivastava[2] and K.V. Praveen[1]

The study offers a comprehensive review of global research on "water institutions" over the past 30 years using the Scopus database, covering 2,611 articles. The findings highlight significant growth in the annual number of published articles, indicating a rising interest in water management research. The United States, China, and Australia are identified as the leading contributors to this research area. The analysis also reveals that despite substantial advancements in water management research, there is a noticeable gap in studies focusing specifically on "water institutions," particularly in India. It underscores the need for more in-depth research on the role and impact of water institutions in effective water management practices. The authors conclude that while water institutions represent a critical yet under-researched area, addressing this gap is essential for developing comprehensive strategies to support sustainable water use and management. It calls for enhanced research efforts, particularly in countries like India, to better understand the complexities of water governance and to inform policies that ensure equitable and sustainable water resource management.

Determinants of Farm Machinery Ownership Among Farmers in India

S. Rohith[3], Nalini Ranjan Kumar[3], Pramod Kumar[4], Venkatesh[4], Girish Kumar Jha[5] and Roaf Ahmad Parray[5]

The study examines the factors influencing the ownership of farm machinery, such as tractors, power tillers, and threshers, among Indian farmers. The study utilizes cross-sectional data from 44,239 rural households extracted from the All-India Debt and Investment Survey (AIDIS) conducted in the 77th round of the National Sample Survey (NSS). The household characteristics, such as the age and education level of the household head, the number of adults in the household, and the type of household, significantly influence the likelihood of owning farm machinery. Additionally, socio-economic factors, including access to credit, total agricultural and irrigated land ownership, and livestock ownership, play a critical role in determining machinery ownership. The study highlights the importance of economies of scale, as larger households with more resources are better positioned to invest in agricultural equipment. It concludes by suggesting that targeted policy interventions, such as improving access to credit and enhancing educational and training programs for

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farmers, could help increase the ownership of farm machinery, particularly among smaller and less resource-rich households.

Impact of Trade Agreements on India's Plantation Sector

M. Movidha and F. Thasnimol[1]

The study delves into how liberalisation and subsequent trade agreements have exposed India's plantation sector—encompassing crops like tea, coffee, rubber, coconut, cashew, and spices—to heightened global competition, resulting in increased imports and declining domestic prices. It reveals that the ASEAN-India Free Trade Agreement (AIFTA), signed in 2009, negatively impacted the plantation sector. Reducing import tariffs for key plantation crops like tea, coffee, and pepper made Indian products less competitive against the cost-efficient produce from ASEAN countries. This led to a significant increase in imports, particularly from countries like Vietnam and Indonesia, causing a sharp decline in domestic prices and adversely affecting the livelihoods of plantation workers and small farmers. In addition, bilateral trade agreements with countries like Japan and Thailand had mixed effects. While the India-Japan agreement facilitated a large export of cashew nuts, benefiting Indian exporters, the India-Thailand agreement led to a trade deficit for plantation crops due to high imports of low-priced products. The study highlights the need for strategic policy interventions to safeguard the interests of the sector, particularly in the face of evolving international trade dynamics.

Adaptation of New Agricultural Technologies by Women: Pathways to Sustainability

Akansha Jain[2], Neha[2] and Tanya Bhatia[3]

The study delves into the challenges faced by women in the agricultural sector, such as gender disparities in resource access, land ownership, education, and decision-making power. It also examines the potential benefits of empowering women to achieve sustainable development goals (SDGs) through enhanced participation in agriculture. The study highlights that only 13 per cent of rural women own land, directly impacting their economic empowerment and productivity. It also discusses women's barriers to adopting new agricultural technologies, including limited access to resources, information gaps, and socio-cultural constraints. Strategies such as collective action through cooperatives, targeted training, and digital technologies are suggested as effective ways to overcome these challenges. Case studies from Andhra Pradesh and Bihar illustrate successful examples of women adopting new technologies

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like the System of Rice Intensification (SRI) and digital agricultural training, which have led to improved productivity, resource efficiency, and sustainability. The study concludes that empowering women in agriculture is a matter of social justice and a strategic imperative for achieving sustainable development.

Exploring the Future of Aviation with Sustainable Aviation Fuel (SAF) and Benefits in Agriculture Economy

Raj Kumari Sharma[1] and Ashish Sharma[2]

The study explores the potential of Sustainable Aviation Fuel (SAF) as a game-changer for the aviation industry and its positive impact on the agricultural economy. It discusses how adopting SAF is driven by regulatory pressures, environmental goals, and the pursuit of sustainability within the aviation sector. The airlines are pursuing the integration of SAF into their operations through collaborations with biofuel producers, government support, and investments in infrastructure. However, the key barriers are high production costs, limited supply, and the need for technological advancements. The study also emphasizes the benefits of SAF for the agricultural economy. SAF production creates new markets for agricultural products, enabling farmers to diversify their crops and generate additional revenue streams. Establishing SAF production facilities in rural areas can lead to job creation, infrastructure investments, and enhanced rural development. Additionally, using agricultural residues for SAF production promotes sustainable farming practices, improves soil health, and reduces environmental waste. The paper concludes that the integration of SAF into the agricultural economy presents a mutually beneficial relationship, where the agricultural sector supports the aviation industry's sustainability goals while gaining economic and environmental advantages.

A Comparative Study on the Economics of Groundnut Cultivation Among the Adopters and Non-Adopters of Sprinkler Irrigation System

B. Harini and M. Anjugam[3]

The study uses the data from 90 farmers and explores the economic impact of adopting the Sprinkler Irrigation System (SIS) versus the Conventional Irrigation System (CIS) in groundnut cultivation in Tamil Nadu, India. The results revealed that SIS adoption led to a significant reduction in the cost of cultivation, with the most substantial savings observed in irrigation (₹21,257 per hectare), intercultural operations (₹7,963 per hectare), and land preparation (₹1,806 per hectare). Overall, SIS adoption resulted in a cost reduction of ₹30,417 per hectare. There was no significant difference in the gross value of production between the two groups, indicating that the

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profits from groundnut cultivation were primarily driven by cost reductions rather than increased yield. SIS adopters did, however, experience slight improvements in crop yield (an increase of 153 kg/ha) and significant improvements in water and electricity productivity. The study also highlighted several constraints faced by SIS adopters, including low equipment quality, clogging, and high replacement costs, which hinder the broader adoption of this technology.

Evaluation of Extension Methods and Constraints in the Adoption Level of Paddy Straw Management Machinery in Punjab

Vishnu Ji Awasthi [1], Manpreet Singh[1], Rajesh Goyal[1], Arshdeep Singh[1], Rajat Mishra[2], Anoop Kumar Dixit[1] and Manjeet Singh[1]

The study examines the effectiveness of various dissemination methods and the challenges in promoting the adoption of paddy straw management machinery among farmers in Punjab. Using data from a survey of 180 farmers, the findings indicate that the most effective methods were organizing bi-annual kisan melas (farmer fairs) and conducting technology advancement extension activities for rural farmers. On the other hand, the high cost of machinery and the associated risks were the primary barriers, making it difficult for small and marginal farmers to invest in such technologies. A lack of familiarity with the technology and insufficient guidance and training were also highlighted as critical challenges. The study concludes by recommending that the government and agricultural institutions focus on addressing these barriers through effective community mobilization and emphasizing the economic and environmental benefits of straw management machinery.

Assessing the Environmental Impact of Technological Innovation (Technology Capsule) for Controlling Fall Armyworm in Maize Cultivation: A Case Study from Erode District Tamil Nadu

K. Shanmuga Priya[3], T. Samsai[4] and S. Selvam[3]

The study highlights the severe impact of fall armyworm (FAW) on maize production in Tamil Nadu, which has led to a significant decrease in yield since its detection in 2018. It compares the environmental impact of FAW management practices between adopters and non-adopters of the TNAU technology capsule using the Environmental Impact Quotient (EIQ) method. The adopters of the TNAU technology capsule used fewer pesticides, and the frequency and quantity of pesticide applications were lower than non-adopters. The EIQ values indicated that the technology capsule significantly reduced environmental risks. The study concludes that

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the TNAU technology capsule is an ecologically sustainable and effective method for managing FAW, with lower environmental and health risks. It recommends enhancing farmer awareness and promoting the adoption of this technology through extension services, emphasizing its environmental benefits over conventional pesticide practices.

Impact of National Food Security Mission on Cereals Production in India: Growth Instability and Hazell Decomposition Analysis

Sudha Kumari[1]

The study examines the effects of the National Food Security Mission (NFSM) on the growth, instability, and production of cereals in India, particularly rice, wheat, pulses, and coarse cereals like millets, maize, sorghum, and barley. The findings indicate that the NFSM significantly increased rice, wheat, and pulses' production growth rates. For example, the production growth rate of pulses increased from 0.1 per cent to 2.3 per cent. While the area under cultivation for coarse cereals generally decreased, the production and yield rates for crops like maize increased post-NFSM, except for barley, where the area and production rates declined. The study also highlights that changes in mean yield and area are the primary factors influencing average production, with significant contributions from yield improvements due to NFSM interventions. Instability in cereal production, measured by the Cuddy Vella Index, generally decreased for rice and wheat, reflecting greater stability post-NFSM. In conclusion, the NFSM has positively impacted cereal production growth and stability in India, contributing significantly to the nation's food security. The study emphasizes the need for continued technical advancements and inclusive policies to maintain and enhance these gains.

Status and Assessment of National Rural Livelihood Mission in North East Region of India: An Overview

Pushpanjali Saikia and Ram Singh[2]

The study evaluates the implementation and impact of the National Rural Livelihood Mission (NRLM), also known as Deendayal Antyodaya Yojana, in the North East region of India. There has been a significant increase in microfinance activities and SHG formation in the Northeast. The number of SHGs linked with banks and the amount of microfinance savings has shown a consistent upward trend from 2011 to 2023. Despite the overall positive trend, the study reveals low instability in the growth of SHGs linked with banks for microfinance savings, suggesting the need for robust monitoring and evaluation mechanisms to ensure continued progress. The study underscores the importance of NRLM in improving livelihoods, enhancing financial

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inclusion, and empowering women in the rural North East. It recommends revising financial assistance programs and strengthening the support systems to maximize the benefits of NRLM for the targeted beneficiaries.

Assessing the Impact of Climate Change on Agricultural Productivity in India

Aamir Ahmad Teeli[1]

The paper investigates how climate change has influenced agricultural productivity in India, focusing on the period from 1981 to 2019. Using the Autoregressive Distributed Lag (ARDL) bounds test approach, it examines the relationship between key climatic factors—such as rainfall and temperature—and agricultural productivity while considering the effects of employment growth in agriculture and overall economic growth. The study reveals that rainfall positively impacts total factor productivity (TFP) in agriculture, and rising temperatures negatively affect TFP. It also finds that employment growth in agriculture has a negative impact, but overall economic growth positively influences agricultural productivity. The paper suggests that policies should promote the adoption of drought-resistant crops, efficient irrigation systems, and water conservation techniques to sustain agricultural productivity in the face of climate variability. Additionally, encouraging innovation and technology adoption in agriculture and diversifying employment opportunities beyond the agricultural sector could further enhance productivity and contribute to sustainable development in India's agricultural sector.

Economic Viability of Greengram Varieties in North Karnataka

D.B. Hemnath[2], M. Y. Teggi[3], G.N. Kulkarni[2] and S.A. Biradar[4]

The paper investigates the costs and returns of three key varieties of green gram—DGGV-2, BGS-9, and NVL-1—cultivated in the districts of Gadag and Dharwad, Karnataka. A survey of 128 farmers during the 2021–22 agricultural year was conducted to assess the economic performance of these varieties. The findings indicate that DGGV-2 is the most profitable variety, with a net return of ₹42,872 per hectare and a Benefit-Cost (BC) ratio of 1.80. BGS-9 and NVL-1 yielded lower returns of ₹23,793 and ₹34,988 per hectare, respectively, with BC ratios of 1.43 and 1.63. The higher profitability of DGGV-2 is attributed to its superior yield and pest resistance, making it a favourable option for farmers. The study recommends that the government and agricultural bodies promote the DGGV-2 variety through seed distribution and extension activities. By raising awareness and providing access to improved seeds,

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farmers can achieve higher returns, thereby boosting agricultural productivity and income in the region.

Does Bio-inputs Influence Agricultural Output for Sustainable Agriculture

Bibhunandini Das[1]

The paper examines the role of bio-fertilizers, manures, and bio-pesticides in enhancing agricultural productivity compared to synthetic fertilizers and pesticides. Using the data from the 77th round of the National Sample Survey (NSS) covering 2018-2019, it analyzes the expenditure patterns on various agricultural inputs and their impact on farm output. The analysis reveals that Indian farmers predominantly rely on chemical fertilizers, and backward states depend more on chemical inputs than developed states. While chemical fertilizers significantly impact agricultural output, bio-fertilizers and manures also contribute positively, albeit to a lesser extent. Interestingly, bio-pesticides have a higher return on investment compared to chemical pesticides. The paper concludes that while bio-fertilizers and bio-pesticides may not provide the same immediate boost to productivity as chemical inputs, they hold substantial potential for promoting sustainable agriculture in the long term.

Assessing the Sustainability of Farmer Producer Companies (FPCs) in Himachal Pradesh

Akanksha Klate[2], Chandresh Guleria[2] and Pardeep Mahal[3]

The paper evaluates the current status and prospects of FPCs, mainly focusing on their role in promoting sustainable agriculture and achieving Sustainable Development Goals (SDGs). It highlights that 53 per cent of the FPCs in the state are involved in horticultural crops, while 41 per cent engage in agriculture and allied activities. A smaller proportion is active in handicrafts, dairy, fishery, and forestry sectors. The study finds rapid growth in FPCs and attributes it to supportive government policies and initiatives by organizations like the Small Farmers Agribusiness Consortium (SFAC) and the National Bank for Agriculture and Rural Development (NABARD). The paper forecasts that the number of FPCs in Himachal Pradesh could increase to 500 by 2030 if current trends continue. It emphasizes the potential of FPCs to contribute significantly to the SDGs and advocates for continued support and promotion of FPCs to enhance their sustainability and impact.

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Dynamics of Labour Scarcity in U.T. of Puducherry – Markov Chain Approach

E. Thanu Vaishnubharathi, T. Sivasakthi Devi, N. Swaminathan, A. Pouchepparadjou and S. Saravanan[1]

The study explores the impact of labour scarcity on agricultural practices and cropping patterns in Puducherry, India. It reveals that cereals, particularly paddy, have the highest retention probability, indicating their stability in labour shortages. Paddy retained 64 per cent of its cultivation area, making it the most stable crop, while other crops like sugarcane, groundnut, and cotton also showed varying retention levels. It identifies that higher wages in non-agricultural jobs and migration to nearby cities for better-paying opportunities are the primary reasons for the labour shortage. Additionally, the high cost of adopting new farming technologies and a lack of necessary skills among farmers were significant barriers to the adoption of farm mechanization, further exacerbating the labour issue. The study concludes that labour scarcity leads to a shift in cropping patterns towards crops requiring less labour. It suggests policy interventions such as implementing MGNREGA during lean seasons and providing better access to farm machinery at subsidized rates to help farmers cope with labour shortages and maintain agricultural productivity.

Nano Urea: Bridging the Gap Between Efficiency and Sustainability in Farming

Bhaskhar Sahu and Sanjay Kumar Joshi[2]

The paper examines the potential of nano urea as a sustainable alternative to conventional urea fertilizers. It highlights the significant environmental benefits of nano urea, including reduced greenhouse gas emissions and minimized nitrogen pollution, which are major concerns with conventional urea. It also compares the performance of nano urea with conventional urea, showing that it has a higher use efficiency (85-90 per cent compared to 30-40 per cent for conventional urea) and is more cost-effective. Additionally, nano urea's smaller particle size allows for better plant nutrient uptake, improving crop yields while reducing the environmental footprint. The field trials demonstrate the effectiveness of nano urea in increasing crop yields with reduced nitrogen application rates. It concludes that nano urea presents a promising solution for enhancing agricultural productivity and sustainability, with potential benefits for farmers and the environment.

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Application of Cropwater Modelling in Sustainability of Groundwater Agriculture

G. Arun Prasath[1], D. Velmurugan[2], S. Ravichandran[2] and R. Venkataraman[2]

The study uses the CROPWAT 8.0 modelling software developed by the FAO to calculate the crop water requirements for various crops. It also shows a significant imbalance between the water available from groundwater sources and the water required for agriculture, leading to the overexploitation of groundwater. High water-consuming crops like sugarcane, banana, and paddy dominate the irrigated area, contributing to the depletion of groundwater resources. It proposes optimising cropping areas using Sens Multiple Objective Programming, which aims to balance profit maximization with water use minimization. The findings suggest that reducing the cultivation of water-intensive crops and increasing the area under less water-demanding crops like maize, pulses, and gingelly can significantly reduce groundwater use while maintaining or even increasing farm profitability. It concludes that optimizing cropping patterns and adopting water conservation practices at both the macro and micro levels are essential for achieving sustainable groundwater use in agriculture. The study highlights the need for policy interventions to encourage the adoption of sustainable water management practices and the development of artificial groundwater recharge structures to replenish depleted aquifers

Analysing the Impact of Marketing Channels on Paddy Growers' Economic Welfare in India

Vinita Kanwal[3], Bitin Mondal[4], Assem Abu Hatab[5], Jaspal Singh[6] and Arti[4]

The paper investigates the effects of different marketing channels on the economic welfare of paddy growers in India. Using the National Sample Surveys (NSS) data, it examines the determinants influencing farmers' choices among various marketing channels, such as local markets, Agricultural Produce Market Committees (APMCs), cooperatives, government agencies, private processors, and contract farming. It employs a Multivalued Treatment Effect (MVT) model to analyze the impact of these choices on welfare indicators like output quantity, value of output, paddy price, monthly consumption expenditure, and monthly income. The results show that marketing channels like APMC, cooperatives, and government agencies generally offer higher prices and better economic outcomes for paddy growers than local markets and input dealers. Socio-economic factors such as education, access to technical advice, and awareness of MSP play crucial roles in influencing farmers' marketing

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channel choices. The paper concludes with policy recommendations to enhance farmers' access to profitable marketing channels, improve market infrastructure, and increase farmers' awareness of market dynamics and government support mechanisms.

Determinants of Adoption of Paddy Stubble Management Technologies in Punjab

Sanjay Kumar, Laishram Priscilla, Amit Guleria, Kamal Vatta, J.M. Singh, Vinita Kanwal, Rohit Saini, Gurlal Singh and Surbhi Bansal[1]

The present study identifies the key determinants of adopting paddy stubble management technologies in Punjab. The study was conducted across 22 districts, and it sampled 2,100 farmers, including 1,320 adopters and 840 non-adopters of paddy stubble management (PSM) interventions. The findings revealed that villages with a lower dominance of long-duration paddy varieties or a higher dominance of short-duration varieties had greater paddy stubble management. Additionally, the number of training sessions and PSM machines per unit of paddy area positively influenced the extent of paddy stubble management. Over 37 per cent of adopters preferred shallow incorporation, around 27 per cent opted for mulching, and about 20 per cent used traditional machines to manage their paddy stubble, while approximately 20 per cent chose ex-situ management. Factors such as the highest level of education in the family, size of operational holding, crop income, and total household income also positively impacted the adoption of PSM practices. Government training efforts further increased the likelihood of adopting paddy stubble management. The study suggested that cultivating short-duration paddy varieties like PR 126 and PR 121 extends the time window between harvesting and sowing subsequent crops, providing farmers ample time for field management. The influence of farming experience and education on the decision to avoid burning fields was also evident in the study.

Binding the Innovations through Modern Digi-tech Agricultural Extension Services for Farmer's Sustainable Growth

Vandana Kumari and S. Aravindh Kumar[2]

The study highlights how the advent of mobile applications, artificial intelligence (AI), the Internet of Things (IoT), and blockchain has revolutionized the dissemination of agricultural knowledge, improving productivity, sustainability, and inclusivity in farming. Traditionally, agricultural extension services were often limited by geographical constraints and scalability issues. However, digital technologies have overcome these limitations by enabling real-time data access and personalized recommendations through smartphones and other digital platforms. It also discusses

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the benefits of digital tech-enabled agricultural extension services, such as improved access to information, timely and personalized advisory, capacity building, market linkages, and sustainable resource management. These technologies have the potential to empower women and marginalized farmers, promote data-driven decision-making, and enhance resilience against risks like climate change. However, the study acknowledges challenges such as the digital divide, data privacy concerns, and the affordability of technology. Addressing these issues through sustainable funding, policy support, and capacity-building initiatives is crucial for the widespread adoption and success of digital agricultural extension services.

Quantification of Virtual Water Flows for Major Cereals in India

Palnati Naveen Reddy, Baljinder Kaur Sidana, Sunny Kumar and Bilavat Swami Nayak[1]

The paper analyzes the virtual water trade associated with India's export and import of major cereals, namely rice, wheat, and maize, from 2017-18 to 2021-22. It finds that India is a significant net exporter of virtual water through its cereal trade. Rice contributes the largest share of these virtual water exports, followed by wheat and maize. The data shows that 13 per cent of the water used to produce major cereals in India is exported through trade, primarily to South and East Asia, West Asia, and Africa. The study underscores India's critical role in global food security through its cereal exports, which have significant implications for water resource management in the country. The authors call for carefully considering water resource allocation in agricultural policy, particularly in water-stressed regions, to balance food security, export earnings, and sustainable water use. They suggest that policymakers should promote water-efficient crops and irrigation techniques and consider the environmental costs of virtual water trade when making decisions about agricultural exports.

Cost Effectiveness of Millet Production and Impact of Odisha Millet Mission

B. K. Mandal[2], S. N. Mishra[2], R. K. Rout[3], A. Dash[2], S. Das[2] and C. Nayak[2]

The present study was conducted in the year 2022-23 in four districts of Odisha, namely Koraput, Kandhamal, Nuapada and Gajapati. A sample size of 192 farmers was selected randomly by multistage sampling method. Using a pre-tested questionnaire, primary data were collected via the personal interview technique. A partial budgeting technique was adopted for finger millet over upland paddy in which the total net return was Rs. 7092.10 per hectare. On sensitivity analysis, it was found that facilitating & miscellaneous cost was the most important variable driving the contribution margin

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positively. In contrast, imputed family labour cost was the most influential negative contributor to net return. Compared to parboiled rice, finger millet is more nutrient-rich, ensuring nutritional security among growers in the study area. By taking the mandates of OMM in the Likert scale, we found that OMM had impacted to the medium range level (40.62 per cent millet farmers) followed by a high level of impact (34.46 per cent millet farmers). OMM helped dispose of finger millet at MSP, ranked I by respondents in the Likert scale analysis. It was revealed that since the mean score of all domains is greater than three. It indicates the positive impact of OMM in all domains.

Analysing Total Factor Productivity of Chickpea in India: An Application of Malmquist Productivity Index

N. Naresha, Manjeet Kaur and Kashish Arora[1]

The paper explores the trends in chickpea production, input usage, profitability, and Total Factor Productivity (TFP) in India from 1981-82 to 2021-22 by focusing on four major chickpea-producing states of Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh. The results indicate that chickpea cultivation in India has experienced significant growth, particularly in area, production, and productivity. Technological advancements and government initiatives such as the National Food Security Mission (NFSM) and the Accelerated Pulses Programme (A3P) have been instrumental in driving this growth, especially in states like Maharashtra, Rajasthan, and Madhya Pradesh. However, the study also highlights regional disparities. While Madhya Pradesh, Maharashtra, and Rajasthan have shown substantial improvements in TFP and productivity, Uttar Pradesh has struggled with declining cultivation areas and production despite some gains in productivity. The paper emphasizes the importance of continued investment in technology, infrastructure, and targeted support programs to sustain the growth of chickpea production in India.

Impact of NFSM on Crop Yield and Income of Farmers in Tamil Nadu

P. Jagdeshwaran[2], K.R. Ashok[3], A. Vidyavathi[4] and M. Prahadeeswaran[4]

The paper evaluates the impact of the National Food Security Mission (NFSM) on farmers' agricultural productivity and income in Tamil Nadu. The study finds that NFSM beneficiaries had higher yields and net returns than non-beneficiaries. The average yield for beneficiaries was 9.5 quintals per hectare, compared to 8 quintals for non-beneficiaries. Consequently, the net return for beneficiaries was Rs. 15,063 per

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hectare, significantly higher than the Rs. 9,595 per hectare realized by non-beneficiaries. The paper employs the Cobb-Douglas stochastic frontier production function to estimate technical efficiency, revealing that NFSM beneficiaries are more technically efficient, with an average efficiency of 85 per cent, compared to 76 per cent for non-beneficiaries. Factors such as farmyard manure, nitrogenous fertilizers, human labour, and machine labour positively influenced productivity, while increased seed rate and phosphatic fertilizers were associated with reduced yields. The paper concludes that while NFSM has positively impacted crop yield and income for beneficiaries, the scheme's benefits are limited to those with at least one hectare of land, leaving smaller landholders with less access to these advantages.

Rural Innovation through Women's Indigenous Knowledge in Punjab: The Way Forward for Socio-Agri Entrepreneurship

Sandeep Kaur[1], Harpreet Singh[2] and Mankirat Singh[3]

The paper explores the significant role of women's indigenous knowledge in driving rural innovation and socio-agri entrepreneurship in Punjab, India. It highlights the challenges women face in these sectors, such as lack of market access, gender wage gaps, increasing input costs, and limited access to credit. Despite these obstacles, women have utilized their traditional knowledge innovatively, particularly in handicrafts like Phulkari (a traditional Punjabi embroidery) and in agricultural practices like dairy farming and beekeeping. The authors suggest linking government initiatives like the National Rural Livelihood Mission (NRLM) with local self-help groups (SHGs) to enhance women's participation in socio-agri enterprises, thus contributing to their economic empowerment and the sustainability of rural economies. Furthermore, they call for improved infrastructure, better market access, and more targeted training for women in SHGs to overcome existing challenges.

An Innovative Approach to Estimate Varietal Adoption through Breeder Seed Statistics

Biswajit Mondal[3], Jaiprakash Bisen[4], R. P. Saha[3], Sudipta Paul[3], Nitiprasad Jabhulkar[3], G. A. K. Kumar[3], Ankita Kandpal[4] and Rajni Jain[5]

The paper presents a novel method for estimating the area covered by different crop varieties, focusing on rice varieties developed by the ICAR-National Rice Research Institute (NRRI). It discusses the challenges associated with traditional

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methods of varietal area estimation, such as the time, cost, and manpower required. It critiques existing approaches, including proportionate, seed multiplication, and technology adoption methods, which often rely on indirect indicators like seed supply or replacement rates. To address these limitations, the authors propose an improved method incorporating both formal and informal channels of seed dissemination. The refined approach offers more accurate and realistic estimates of the area covered by specific crop varieties. The paper validates this method through a case study and shows that the improved method provides more accurate and reliable estimates, making it a valuable tool for researchers and policymakers. The method's advantages include its cost-effectiveness, minimal data requirements, and the ability to support short-term projections and policy decisions related to resource allocation in agriculture.

From Fields to Finances: Exploring Tenant Farmers' Economic Challenges in Andhra Pradesh

Ghanshyam Pandey[1]

Based on a survey of 240 farmers, the study highlights significant socio-economic disparities between tenant farmers and owner cultivators. Tenant farmers in the region are shown to have lower per capita incomes, higher debt burdens, and limited access to institutional credit compared to owner cultivators. The research reveals that tenant farmers are more dependent on non-institutional sources of credit. In contrast, owner cultivators have better access to formal credit institutions. The study explores the impact of external factors like unseasonable rains, low crop yields, and market uncertainties on the financial stability of tenant farmers. These factors contribute to a cycle of indebtedness, with tenant farmers often facing cascading effects that deepen their financial troubles. Despite their larger operational landholdings, tenant farmers earn significantly less from farm business income than owner cultivators. It recommends relaxing collateral requirements, enhancing access to formal credit, and regulating informal lending practices to protect farmers from debt traps.

Exploring the Relationship between Agricultural Credit and Farmers' Choice to Adopt Modern Sustainable Agrarian Practices: A Comparative Case of Punjab and Bihar

Neha Thureja and Avanindra Nath Thakur[2]

The paper examines how access to agricultural credit influences farmers' decisions to adopt sustainable agricultural practices in Punjab and Bihar. Using a combination of secondary data from the National Sample Survey Office (NSSO) and primary village surveys, the study compares the experiences of farmers in these two states. With its well-developed agricultural infrastructure, Punjab shows better access

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to institutional credit, particularly among larger landholders. In contrast, Bihar, with more small and marginal farmers, displays significant reliance on non-institutional credit sources like moneylenders, especially among smaller landholders. The study highlights the challenges small and marginal farmers face, particularly in Bihar, where socio-political dynamics, land size, and caste limit access to credit. The authors conclude that improving access to institutional credit for small and marginal farmers is crucial for promoting sustainable agriculture. They recommend policy interventions that address the disparities in credit access and encourage adopting environmentally sustainable practices, particularly in states like Bihar, where livelihoods are more precarious.

Analysing the Economic Impact of Paddy Stubble Management: What Can Be Done?

Chandan Rana, Ekta and Sandeep Kaur[1]

The paper investigates the costs and benefits of various paddy stubble management techniques in the Bathinda district of Punjab, India. With stubble burning contributing significantly to environmental pollution, this study assesses two key management methods—ex-situ and in-situ—and their economic viability for farmers. The findings indicate that both techniques lead to higher paddy yields than non-adoption, with In-situ methods generating the highest yield at 7,343 kg per hectare. While ex-situ management incurs lower variable costs, In-situ techniques involving heavy machinery also result in similar financial returns. Regression analysis highlights that awareness of the environmental consequences of stubble burning and the availability of management tools significantly influence the adoption of stubble management practices. The study concludes that although paddy stubble management increases production costs, it reduces labour and input costs like urea and plant protection chemicals while improving yields and economic returns. These techniques offer substantial long-term benefits, particularly in mitigating environmental harm and boosting farmer income.

Impact of COVID-19 on Agribusiness: Challenges and Adaptations in Agricultural Sector of Punjab and Haryana

Himanshu and Sandeep Kaur[2]

The COVID-19 pandemic significantly impacted India's agricultural sector, particularly in Punjab and Haryana. While the overall economy suffered, with GDP growth dropping from 3.7 per cent in 2019 to -6.6 per cent in 2020, agriculture remained relatively resilient, increasing its share of GDP to 18.22 per cent in 2020.

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However, the sector faced numerous challenges due to restrictions. These included labour shortages for harvesting as migrant workers returned home, a lack of harvesting machines due to transport disruptions, and complications in crop procurement. Various agricultural sub-sectors were affected differently: horticulture saw decreased demand due to the closures of hotels and restaurants, the dairy industry experienced a 25-30 per cent reduction in demand nationwide, and the poultry sector suffered from rumours and drastically reduced consumption. The crisis pushed farmers to adopt new technologies like Direct Seeding Rice (DSR) to deal with labour shortages. Despite these challenges, the pandemic also highlighted the need for improvements in the agricultural system. Suggestions for future resilience include creating direct farmer-consumer connections, providing special movement passes for farm vehicles, increasing procurement centres, offering better insurance packages for poultry and dairy sectors, improving agricultural storage infrastructure, and restructuring traditional supply chains. While the pandemic exposed vulnerabilities in the agricultural sector, it also demonstrated its importance to the economy and spurred technological adoption and innovation in farming practices.

Estimation of Crop Water Requirement as a Factor of Production for Sustainable Sugarcane Cultivation in Different Agro-Climatic Zones of Tamil Nadu

K. Mohankrishnan[1], S. Ravichandran[1], C. Aroutselvam[2], R. Venkatraman[1] and S. Santhakumar[1]

The study uses the CROPWAT 8.0 software, based on the FAO Penman-Monteith method, to estimate the CWR for sugarcane. The research findings show that the CWR for Villupuram is 1,372 mm, while Erode requires 1,918.7 mm. The higher CWR in Erode is attributed to higher evapotranspiration rates, necessitating more irrigation compared to Villupuram, which benefits from higher effective rainfall. This indicates that sugarcane cultivation is more sustainable in Villupuram due to lower water demand and a smaller water footprint. The paper also analyzes the water footprint (WF) of sugarcane, which includes both green water (rainwater) and blue water (irrigation water). The study concludes by emphasizing the need to treat CWR as a vital input in agricultural production to optimize water use, reduce costs, and ensure sustainable farming practices. The authors advocate for adopting advanced irrigation techniques and water management practices to minimize water exploitation, particularly in regions like Erode with higher water demands.

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Decoding Decision-Making: Factors Shaping Investments in Chemical Fertilisers for Paddy Cultivation in Kole Lands

Joyal Mathew and P. Indira Devi[1]

The paper investigates the factors influencing farmers' decisions regarding the use of chemical fertilizers in the Kole lands of Kerala. It focuses on how socio-economic variables affect the investment in chemical fertilizers, which has significant implications for soil health, agricultural productivity, and environmental sustainability. A binomial logistic regression model for data from 100 farmers reveals that a farmer's age, education, and family income significantly influence fertilizer investment decisions. The paper also highlights the widespread misuse of fertilizers, with farmers applying far more than the recommended doses, particularly for potassium. The findings emphasize the need for better education and extension services that include farmers and their families to encourage scientifically sound fertilizer practices. Additionally, it advocates using modern technologies such as sensors, remote sensing, and AI to provide real-time soil health data and support informed decision-making.

Bibliometric Analysis of Fertilizers in India

Anurita Kharayat and Chandresh Guleria[2]

The study examines the research landscape on fertilizers in India through a bibliometric approach. It analyzes a substantial dataset of 852 publications from 2015 to 2024, sourced from Dimensions.ai, to identify prolific authors, influential journals, and key research institutions contributing to the discourse on fertilizers in India. The results show a significant increase in publications over the years, with a growth rate of 20.9 per cent, indicating a growing interest and ongoing efforts to address challenges such as soil health degradation, nutrient management, and sustainable agricultural practices. The top-cited article, published in 2019, discusses the greening of the world through land-use management and has been cited 1,838 times. The study also highlights the most productive authors and institutions in this field, with Akbar Hossain leading among individual contributors and the Indian Agricultural Research Institute ranking first among institutions with 38 publications and 1,130 citations.

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Can Farmer Collectives Contribute to Agricultural Sustainability and Rural Development?

B. Navaneetham[1] and K. Mahendran[2]

The study is based on a primary survey of 200 farmers across 20 FPCs, focusing on how these collectives support marginalized farmers by enhancing services such as marketing, financing, and training while committing to sustainable development goals. The research employs Structural Equation Modeling (SEM) to analyze the relationship between various factors such as organic farming promotion, training, ICT facilitation, credit services, and infrastructure development, and their impact on agricultural sustainability and rural development. The results indicate that FPCs have a significant positive influence on promoting sustainable agricultural practices, mainly through organic farming and farmer training programs. These initiatives have contributed to higher agricultural sustainability, which has a direct positive impact on rural development. While credit services and ICT tools provided by FPCs play a role, their contributions to agricultural sustainability and rural development are less pronounced unless combined with other supportive measures like training and infrastructure development. The study suggests that infrastructure development, particularly the creation of market yards and retail outlets, moderately influences rural development but is not as impactful as agricultural sustainability.

The Soil Health Card Scheme: Enhancing Agriculture Productivity Through Judicious Use of Fertilisers

Ravinder Ram[3]

The paper comprehensively analyses the Soil Health Card Scheme (SHCS). By 2021, 140 million Soil Health Cards (SHCs) were distributed and about 25 million soil samples were collected across India. It highlights the significant positive impact of the SHCS on both fertilizer use and crop yields. Farmers who adhered to the recommendations provided in the SHCs reported a 10-20 per cent reduction in the use of chemical fertilizers. This shift towards more sustainable fertilization practices has led to an average increase in crop yields of 8-10 per cent, with notable improvements in key crops such as wheat, rice, and legumes. The paper also discusses the economic benefits of the SHCS, noting that farmers experienced a return of Rs. 3-4 for every rupee invested in the scheme. However, the paper identifies several challenges in implementing the SHCS, including issues related to farmer awareness, accessibility, and the accuracy of soil testing. It concludes with recommendations for enhancing the scheme's effectiveness, such as improving farmer education and expanding access to

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soil testing facilities, to ensure the long-term sustainability of India's agricultural sector.

Agri-E-Market: A Digital Approach towards Sustainable Agriculture

Kanzam Shubhrata Singha[1] and Abujam Anuradha Devi[2]

The study explores the role of digital marketing in promoting sustainable agriculture through e-commerce platforms. It focuses on two prominent online agricultural platforms, AgriBegri and BharatAgri. It emphasizes how these e-commerce platforms help farmers by providing easy access to necessary agricultural products, often at competitive prices, and with the convenience of home delivery. The study also discusses the broader impact of digital marketing on agriculture, noting that virtual marketing channels can significantly increase the customer base, reduce product losses, and enhance communication between sellers and buyers. The authors argue that e-commerce in agriculture is a crucial innovation for promoting sustainable agricultural practices, as it helps streamline the supply chain and reduce waste. However, the paper also acknowledges potential challenges, such as the risk of monopolies in e-commerce platforms, which could reduce customer choice. The study recommends further expansion of digital marketing in agriculture to support sustainability.

Sugarcane Production in India: Probability and Supply

M. Umanath[3], R. Paramasivam[4], V. Saravanakumar[5], S. Ambika[6], K. Mohanraj[7] and P. Alli[4]

The paper investigates various factors influencing the production and supply of sugarcane in India by using the data from the National Sample Survey Organisation (NSSO) for 2012-13. Using the Heckman Sample Selection model, the results reveal that the prices of competitive crops like cotton and paddy negatively influence the choice to cultivate sugarcane. However, factors such as awareness of the Minimum Support Price (MSP), availability of credit, and access to extension services positively influence both the decision to cultivate sugarcane and the level of production. Additionally, access to credit and awareness of MSP enhance production levels by enabling farmers to invest more in inputs and adopt better farming practices. The study also highlights that household and farm characteristics, such as household size, expenditure on labour and irrigation, and crop diversification, significantly affect sugarcane production. Larger households with more labour availability and higher investment in irrigation tend to produce more sugarcane.

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Sustainable Inputs in Cereal Cultivation: Assessing Impacts and Identifying Determinants

Asha Devi, K.V. Praveen, V.R. Renjini and Chiranjit Mazumder[1]

The study examines the adoption of sustainable agricultural inputs such as biofertilizers, biopesticides, and manure in rice and wheat cultivation across India. Using data from the 77th National Sample Survey (NSSO) on agricultural households, the study analyzes the impact of these sustainable inputs on farm productivity and profitability. The regression adjustment model reveals that integrating biofertilizers with chemical inputs significantly enhances crop yield and profits, with rice and wheat showing notable gains. However, biopesticides and manure did not yield higher when used alone, likely due to reduced chemical inputs. The study also employs ordinal probit regression to identify the key factors influencing sustainable input adoption. The results indicate that age, gender, social group, land size, training, and membership in farmer organizations are significant determinants of adoption intensity. The findings emphasize the need for greater awareness and training to encourage adopting sustainable practices, which can lead to improved productivity, environmental sustainability, and long-term farm profitability.

Study of Custom Hiring Centres (CHCs) in Meghalaya: An Economic Analysis

Ipshita Bhuyan, Ningombham Anandkumar Singh and Ram Singh[2]

The paper examines the economic viability and impact of CHCs in Meghalaya, where 81 per cent of the population depends on agriculture. CHCs provide farm machinery to farmers on a rental basis, promoting mechanization at affordable costs. The study focuses on two CHCs in the Ri Bhoi and East Khasi Hills districts, analyzing their financial feasibility using methods such as Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR). The results show that both CHCs are financially viable, with BCR values greater than one and positive NPV. CHC beneficiaries experienced lower cultivation costs than non-beneficiaries, resulting in higher net farm income. Major constraints faced by CHC managers include the non-availability of technical manpower and unused machinery. Beneficiaries reported challenges such as the unavailability of machinery during peak seasons, while non-beneficiaries struggled with a lack of awareness about CHCs. The study concludes that expanding CHCs and providing training programs could enhance farm mechanization and improve agricultural productivity in Meghalaya.

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Change in Consumption Pattern Among Major States: Commodity and Income Wise Analysis

Ankruti Negi and Priyabrata Sahoo[1]

The paper explores shifts in consumption patterns across 19 major Indian states from 2011-12 to 2022-23. Using data from the NSS Household Consumption Expenditure Survey and the Ministry of Statistics and Programme Implementation (MOSPI), the study analyzes commodity and income expenditures. It categorizes expenditures into food and non-food items and examines the impact of rising incomes and regional disparities on consumption behaviour. The study highlights that, as incomes have increased, there has been a significant shift from food to non-food expenditure, especially in urban areas. Regional disparities are evident, with states like Haryana and Karnataka showing higher per capita incomes and consumption while states like Bihar and Uttar Pradesh lag. The analysis underscores the role of economic policies in addressing these disparities and promoting balanced development. The study concludes that improving incomes leads to more diversified consumption patterns, with non-food expenditures increasing as a reflection of rising living standards and changing consumer preferences across Indian states.

Targeting Technologies to Agro-Ecological Zones: Large Scale Demonstration of High Density Planting System to Enhance Cotton Productivity Under Rainfed Conditions

Y. G. Prasad[2], A.S. Tayade[2], R. Jayakumara Vardana[2], G.I. Ramkrushna[2], S.P. Gwande[3], U.G. Thakare[4] and J.R. Katore[5]

The paper analyzes the effectiveness of HDPS in improving cotton yields in rainfed regions of India. Despite the introduction of Bt cotton in 2002, cotton productivity has plateaued at around 450 kg lint per hectare since 2013-14. This study, conducted in five states, including Maharashtra and Telangana, compared HDPS with the Conventional Planting System (CPS) among 2165 farmers. Results showed that HDPS, with a closer planting spacing of 90 × 15 cm, increased yields by an average of 10.03 quintals per acre, a significant 2.08 quintal improvement over CPS. While HDPS raised costs slightly due to higher seed rates and harvesting labour, it also reduced weeding costs. Farmers realized a net income of ₹33,541 per acre under HDPS, compared to ₹23,114 under CPS, with a benefit-cost ratio of 1.91 versus 1.71. The study concludes that HDPS can potentially increase cotton productivity by 28.44 per cent and shift yield distributions toward higher ranges, improving farmer incomes and livelihoods.

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Economic Viability and Cost Effectiveness of Farm Mechanization in Rice Cultivation

A. Pouchepparadjou[1], N. Swaminathan[2] and C. Aroutselvam[3]

The paper evaluates the impact of mechanization on rice farming in the Cauvery Delta region, focusing on its economic benefits and effects on labour requirements. The study used a comparative approach, analyzing 120 farms divided into mechanized and partially mechanized categories. Key findings reveal that fully mechanized farms achieved higher net returns, with an average of ₹21,434 per hectare, compared to ₹14,660 per hectare on partially mechanized farms. The study employed Logit regression to identify significant factors influencing the adoption of mechanization, such as farmer education, access to machinery, and extension services. Regression analysis showed that mechanization reduced labour requirements, mainly through using tractors and inputs, while animal power increased labour needs. The paper also highlights challenges to adopting mechanization, including machine availability, costs, and soil quality concerns. Overall, higher levels of mechanization significantly increased farm profitability and reduced labour dependency, contributing positively to farmers' livelihoods and economic sustainability.

Statistical Evaluation of Inter-State Variation in Agricultural Development of India

Amrit Kaur Mahal, Pritpal Singh, Sunny Kumar and Simranjit Kaur[2]

The present study provides a comparative analysis of inter-state variations in India's agricultural sector. Using secondary data from major agricultural states for 2020-21, the study examines 28 development indicators. Composite indices of development were calculated for four zones—North, East, West, and South—as well as for the overall agricultural states of India. Results show that Punjab (0.32), West Bengal (0.37), Gujarat (0.52), and Kerala (0.58) were ranked first in their respective zones. The overall composite index ranged from 0.47 in Punjab to 0.83 in Odisha. States were classified into four development categories: High (H), High Middle (HM), Low Middle (LM), and Low (L). Punjab, Haryana, Gujarat, and Madhya Pradesh were identified as highly developed agricultural states. Step-wise regression analysis identified key factors influencing agricultural development, including gross irrigated area, mechanization (tubewells), productivity (wheat, maize, and vegetables), input usage (chemical fertilizers), and economic returns from crops like sugarcane. The study suggests that improvements in these areas could enhance farmers' socio-economic conditions, especially in less-developed states that need significant progress in multiple indicators to boost agricultural development.

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Bridging the Gender Gap in Green Energy: An Analysis of the Comparative Perspective from India and Germany

Swati Sharda[1]

The paper explores the intersection of green energy policies and gender inclusion, comparing the approaches of India and Germany. With renewable energy becoming crucial for sustainable development, the study highlights how gender inclusivity can enhance the efficacy of green energy initiatives. Germany, a leader in renewable energy, has embedded gender considerations in its environmental policies, while India, with its growing energy demands, is beginning to address gender-related challenges in its renewable energy sector. The research evaluates policies, such as Germany's *Frauen in der Energiewende* initiative and India's rural electrification and skill development programs, examining their effectiveness in promoting gender equality and economic empowerment. Key insights reveal that gender-inclusive policies foster innovation and economic growth and improve social resilience by addressing energy poverty and enabling women's participation in energy initiatives. The paper concludes that gender-sensitive policies are critical for sustainable development and provides recommendations for integrating gender considerations into energy policies worldwide.

Impact of Pesticide Residues on India-EU Agricultural Trade: Evidence and Implications

V.R. Renjini, S.S. Asha Devi and M Balasubramanian[2]

The study examines the status and trends of agricultural exports from India to the European Union (EU) and the associated issue of pesticide rejections based on secondary data from 2012-13 to 2022-23. India exports approximately 6 per cent of its agricultural products to the EU, with marine products, coffee, and spices being the primary commodities. The export of fresh and processed fruits, processed vegetables, and tea has shown a consistent upward trend, reflecting the EU's growing preference for processed and high-value food products. However, stringent EU product standards are negatively impacting India's exports. Between 2020 and 2023, out of 385 total border rejections, 289 (75 per cent) were due to pesticide residues. The rejection analysis indicated that spices, sesame seeds, basmati rice, fresh vegetables, and shrimp were the products most frequently rejected. The gravity model was used to assess the impact of these border rejections on India's agricultural exports to the EU. The findings reveal that border rejections have a negative effect, with a 1 per cent increase in rejections leading to a 0.006 per cent decrease in exports. It was also observed that while India is over-exporting to the EU, the EU is under-exporting to India, relative to their agriculture trade potential. It is essential to focus on trade facilitation and adopting

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good agricultural practices to reduce border rejections and increase agricultural export earnings from high-value markets like the EU.

Challenges and Opportunities in Implementing Crop Diversification: Case Studies from Punjab and Uttar Pradesh

Guradeeshwar Singh Rangi and Keshav Sharma[1]

This paper examines the agricultural challenges of climate change, focusing on Punjab and Uttar Pradesh in northern India. Both states are renowned for their extensive farming practices, including rice, wheat, and sugarcane cultivation, which require intensive groundwater use. Amidst environmental sustainability challenges, several committees of experts have advocated for crop diversification away from water-guzzling crops. However, the implementation challenges of crop diversification are far more complex regarding the sustainability of farmers' income levels. In this regard, this paper presents two case studies: one from Punjab, where farmers struggle to find markets for diversified crops, leading them to revert to traditional crops, and another from Uttar Pradesh, where despite the potential for profitable crops like Kinnow and Mango, government support remains skewed towards sugarcane due to its assured market. This study underscores the necessity for comprehensive agricultural governance involving government, private sector, and infrastructure support to facilitate crop diversification. It concludes with recommendations for improving market access and infrastructure to support diversified farming, benefitting farmers, the economy, and the environment.

Economic and Environmental Accounting for Energy and Carbon Footprint in Sugarcane Cultivation under Solar Powered Irrigation System – A Study in Villupuram District of Tamil Nadu

V. Nandhini, R. Venkataraman and S. Ravichandran[2]

This study compares the technical, economic, and environmental benefits of solar-powered irrigation (SPI) with electric-powered irrigation (EPI) in sugarcane cultivation. Using multi-stage and snowball sampling methods, 90 farmers from Villupuram district, Tamil Nadu, were surveyed—45 using SPI and 45 using EPI. The study indirectly assessed the cost of irrigation, energy consumption, carbon footprints, and social carbon costs through imputation techniques. Results show that SPI had lower irrigation water costs and higher water output compared to EPI, despite EPI's higher discharge rate due to larger outlets and more powerful motors. However, due to longer pumping hours, SPI required more energy (3393.93 Kwh/Ha) than EPI (2060.83

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Kwh/Ha). Irrigation costs rose in both systems when subsidies were removed, but SPI remained more economical, especially when considering social carbon benefits. Without subsidies, irrigation costs moved to the second-highest expense for EPI, while for SPI, it dropped to the lowest when accounting for social carbon benefits. SPI demonstrated higher net income, with a significant Rs. 18,154.79 difference in favour of SPI after internalizing carbon benefits. This suggests the potential for farmers to claim carbon credits for using solar energy in agriculture, encouraging SPI adoption.

Impact Assessment of Pradhan Mantri Fasal Bima Yojana among paddy growers in the Cauvery Delta Region of Tamil Nadu

T. Priyadharshan, N. Swaminathan, A. Pouchepparadjou, S. Parthasarathi and M. Vinoth[1]

The impact of Pradhan Mantri Fasal Bima Yojana (PMFBY) focused on assessing the performance, awareness among insurers and non-insurers, and perceptions and constraints faced by farmers of the Cauvery Delta region. A multi-stage purposive sampling technique was used, Thiruvarur and Nagapattinam districts were selected. The sample size was 180 farmers (120 insured and 60 non-insured farmers). PMFBY grew 2.52 and 9.98 per cent in the number of insured farmers and gross premiums collected during 2016-23, respectively. However, multiple state withdrawals caused a delay in claims processing and increased premium prices, leading to a 13.89 per cent decrease in farmer benefits and a 5.83 per cent decline in insured area. Perception analysis indicated that in the case of insured farmers, most were aware of the PMFBY and its provisions and were clear about the claim settlements. There was strong disagreement among farmers about the involvement of private insurance companies under PMFBY. Most insured farmers perceived that procedures for availing PMFBY were lengthy and that the claims received were less compared to the actual crop loss incurred. The other constraints were dissatisfaction with the area approach claim assessment loss followed by a lack of awareness about the cut-off dates for enrolment, constraints in loan disbursement, and delay in claim settlements from insurance companies. The study suggested that the implementing agency and the agricultural department conduct crop-cutting experiments as soon as possible and that claims should be settled within one month after receipt of yield data.

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Assessing the Economic Impacts of Climate Change on Cereal Production in Bihar, India: Variations in Yield, Quality, and Cropping Patterns

Ranjeet Ranjan[1], Sachin Rathour[2] and Meera Kumari [1]

Climate change significantly influences crop yield and production, particularly in regions like Bihar. This study aims to assess the impact of climate variables on maize and wheat crop yields, along with the adaptation measures and constraints farmers face in Samastipur district, Bihar. Secondary data on crop yields, climatic variables, cost of cultivation, and minimum support prices were collected for 1999-2019. Additionally, a household survey of farmers was conducted in two blocks, Pusa and Tajpur. Regression analysis was employed to analyze the time series data, revealing a positive relationship between annual rainfall and wheat yields. At the same time, maximum and minimum temperatures had an adverse impact on maize and wheat yields. Findings suggest that soil type, fertility, and farming methods influence crop yields. Income and cultivation costs were not significantly associated with climate variables, indicating that other factors contribute to income fluctuations. Cereal crops, especially those grown in the rabi season, were adversely affected by climate change, while changes in rainfall and temperature also impacted maize and wheat. Farmers with greater experience and access to climate change information were more likely to adopt strategies to mitigate adverse weather effects. Soil and water conservation practices were recommended by farmers to combat climate change-induced soil degradation, particularly in steep slope areas. This study underscores the importance of considering maize and wheat in crop planning to minimize the adverse effects of climate change in Samastipur district.

Reasserting the Development Agenda: A Quantitative Examination of Domestic Support Proposals for Agricultural Negotiation to WTO

Sachin Kumar Sharma, Teesta Lahiri, Talha Akbar Kamal, Suvayan Neogi and Kamalini Mukherjee [3]

Disciplining domestic support to agriculture remains an unfinished agenda in the WTO negotiations due to the different views and positions of members. Developing members have been consistently demanding effective special and differential treatment (S&DT) for themselves, along with a substantial reduction in the trade-distorting support entitlement of developed members. However, members have failed to agree on different aspects, especially coverage and approaches, to determine an overall trade-

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distorting support (OTDS) limit. In this context, this study quantifies and critically examines the implications of various proposals on the policy space to provide trade-distorting support based on floating and fixed reference period models. It estimates trade-distorting entitlements of 9 developed and 16 developing members under the Agreement on Agriculture (AoA) and the selected proposals for 2020 and 2030. These entitlements have been computed in monetary limits and a percentage of the value of production on a per-farmer basis. Results show that many proposals have failed to deliver effective S&DT, as developing members generally have to undertake higher cuts than developed members, highlighting the negotiation asymmetries. The study will help members take an informed position in the agriculture negotiations on domestic support.