
Insights into Sustainable Food Systems: Learnings from Odisha's Agricultural Officers

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ABSTRACT

Sustainable food systems stand as pivotal pillars in addressing global food security challenges, emphasizing the need for environmentally conscious agricultural practices. Within this context, this research study delves into the realm of sustainable food systems, focusing on the invaluable insights gleaned from the dedicated cadre of Odisha's Agricultural Officers. Their profound expertise and hands-on experience in agriculture form the bedrock of this investigation, offering a comprehensive understanding of sustainable agricultural practices and their implementation within the unique landscape of Odisha. The primary goal of this study is to unravel the intricate tapestry of sustainable agricultural practices through the lens of these proficient Agricultural Officers. Their perceptions, attitudes, and knowledge pertaining to crucial facets of sustainable agriculture-ranging from soil health, water management, integrated pest management, to organic farming and more-serve as fundamental keystones in this exploration. Through a structured methodology that involved pre-assessment questionnaires, exposure to sustainable agriculture concepts, and subsequent post-assessment evaluations, this research uncovers the transformative learnings and evolving perspectives of these esteemed officers. Their wealth of experience and nuanced understanding of sustainable agricultural principles and challenges significantly contributes to the broader discourse on achieving agricultural sustainability. By delving into the unique insights and experiences of Odisha's Agricultural Officers, this study aspires to shed light on actionable strategies and potential pathways to foster sustainable food systems. Ultimately, these findings not only enrich the understanding of sustainable agriculture but also hold the promise of guiding future towards a more sustainable and resilient agricultural landscape in Odisha and beyond.

Keywords: Agricultural Officers, Agricultural practices, Attitudes, Knowledge, Perceptions, and Sustainable food systems

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1. Introduction

In the contemporary world, the global community grapples with an array of interconnected challenges, spanning from environmental crises like climate change and global warming to economic strains, escalating debt, and geopolitical conflicts (World Bank, 2023; Rosegrant & Cline, 2023). These multifaceted issues not only hinder the trajectory of sustainable development but also jeopardize the attainment of critical milestones such as the Sustainable Development Goals (SDGs) set forth by the United Nations (UN) (UNDP, 2023).

Central to these concerns is the food system, an intricate network encompassing production, distribution, consumption, and waste management (World Farmer's Organisation, 2020). This system plays a pivotal role in ensuring human nourishment, health sustainability, and societal well-being. However, amidst these challenges, there remains a pressing global issue: hunger and malnutrition. The UN's SDGs, specifically Goal 2 - Zero Hunger, aim to eradicate hunger by 2030 through sustainable agricultural practices, equitable access to resources for small-scale farmers, and bolstering international cooperation for technological advancements in agriculture (UNDP, 2023; World Farmer's Organisation, 2020).

A critical aspect of addressing global hunger lies in the concept of Sustainable Food Systems (SFS). These systems emphasize the need to feed a burgeoning global population within the confines of environmental sustainability. Yet, prevailing research predominantly focuses on the environmental aspects of food system sustainability while often neglecting the broader scope of the entire food supply chain (Davis et al., 2022; World Farmer's Organisation, 2020).

Recent studies have underscored the shared aspirations of farmers and consumers for sustainable practices, highlighting a growing concern about environmental degradation and a willingness to embrace innovative technologies for enhanced food production (Corteva and Longitude, 2019). Despite this awareness, challenges persist, such as declining crop yields due to insufficient investment in research and deteriorating infrastructures (Rosegrant & Cline, 2023).

This introduction encapsulates the pressing issues surrounding global food security, sustainability and the urgent need for concerted efforts in addressing the multifaceted challenges within the food system, with this aim a training program was initiated by Odisha State Government in collaboration with National Institute of Agricultural Extension Management (MANAGE), Hyderabad. The current study was the outcome from the pre and post evaluation of the trainees.

2. Objectives of the Study

- To evaluate the current perceptions, attitudes, and knowledge of Odisha's Agricultural Officers regarding global food security challenges and the

factors contributing to food insecurity worldwide.

- To measure the familiarity of Agricultural Officers with the principles of sustainable agriculture and identify the principles perceived as most crucial for promoting sustainability in agricultural practices.

Methodology

I. Participant Selection and Recruitment

A purposive sampling method was employed to select participants with expertise in agriculture and working within the Department of Agriculture, Government of Odisha. Participants were identified based on their roles as Agriculture Officers, Engineers and related positions. Contact information, including names, addresses, office phone numbers, email IDs, and mobile numbers, was obtained for each participant. A total of 49 participants were selected for the study, ensuring representation from different districts in Odisha. Participants were provided with a detailed explanation of the study's purpose, procedures, and potential implications. An informed consent form was presented, emphasizing voluntary participation and the right to withdraw at any stage. Written consent was obtained from each participant, acknowledging their understanding and willingness to participate. Participants were assured of the confidentiality of their responses, and their identities were anonymized in the analysis.

II. Data Collection

Pre-assessment and post-assessment questionnaires were developed to gather information on participant's knowledge, perceptions and attitudes related to sustainable food systems. Questionnaires were designed based on scientific principles and previous literature on sustainable agriculture. Initially explained the study's objectives, and arrangements were made for questionnaire distribution and collection at National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India from 25th September to 3rd November, 2023.

A structured questionnaire was designed to assess participants' baseline knowledge, perceptions, and attitudes related to sustainable food systems. The pre-assessment questionnaire covered global challenges, sustainable agriculture principles, soil health, water management, integrated pest management, disease resilience, and organic farming. Following the pre-assessment, participants were exposed to relevant information on sustainable food systems by training where they have learnt with 16 sessions and 2 field visits. Information dissemination was conducted through tailored training to enhance participants' understanding.

After the information exposure phase, participants were provided with

the post-assessment questionnaire, mirroring the pre-assessment questions. Post-assessment responses were collected to analyze changes in participants' knowledge and attitudes. Clear instructions were given, and arrangements were made for the distribution and collection of questionnaires.

III. Data Analysis

Quantitative data from both assessments were subjected to statistical analysis using appropriate tools (e.g., Excel). Open-ended responses from questionnaires underwent thematic analysis to extract qualitative insights. Themes and patterns in participants' perceptions and opinions were identified for a comprehensive understanding.

IV. Ethical Considerations and Confidentiality

Anonymization of participant identities was maintained throughout the study. All collected data were securely stored, and access was restricted to the research team. Participants were provided with a detailed explanation of the study's purpose, procedures, and potential implications. Written informed consent was obtained from each participant, ensuring their voluntary participation and right to withdraw.

Participants were acknowledged for their valuable contributions to the study. Findings were summarized to draw conclusions regarding changes in participants' knowledge and attitudes towards sustainable food systems.

Results and Discussion

The study aimed to investigate the demographic and professional characteristics of respondents working within the Department of Agriculture in the Government of Odisha. A total of 49 individuals participated in this survey, providing valuable insights into their gender distribution, age, professional experience, positions held, organizational affiliation, and expertise areas within agriculture details was given in the table 1.

Table 1 Characteristics of the respondents involved in the study

Characteristics of the respondents n=49	
Gender	29 men, 20 women
Age	On average 38 years (20 years min;58 years max)
Experience	On average 12 years (1 min; 34 max)

Position	Group-A (Rank of Assistant Director and above) - 19 Group-B (Rank below Assistant Directors) - 30
Organization	Department of Agriculture, Government of Odisha
Expertise Area	Agriculture-49

Among the respondents, there were 29 men and 20 women, indicating a slightly higher representation of men within the surveyed population. This observation aligns with broader trends often seen in agricultural sectors, where male participation historically outweighs female involvement. However, this ratio may also reflect the changing dynamics within the Department of Agriculture in Odisha. The average age of the respondents was 38 years, with a range spanning from 20 to 58 years. This diversity in age suggests a mix of experienced professionals and younger individuals contributing to the sector's workforce. The presence of individuals across different age groups could indicate a potentially balanced blend of fresh perspectives and seasoned expertise within the department. Respondents reported an average professional experience of 12 years, with a range from 1 to 34 years. This distribution signifies a considerable breadth of experience among the surveyed individuals. The varied tenure in the field could contribute to a rich knowledge base and diverse skill set within the Department of Agriculture, fostering an environment conducive to innovation and expertise sharing. Regarding professional positions, 19 respondents belonged to Group-A, holding ranks of Assistant Director and above, while the remaining 30 individuals were categorized in Group-B, comprising ranks below Assistant Directors. This distribution indicates a hierarchical diversity within the department, with a significant representation of individuals from both higher and lower professional tiers. All respondents were affiliated with the Department of Agriculture, Government of Odisha, indicating a focused study within a specific governmental body responsible for agricultural development and policy implementation in the region. All 49 respondents were associated with expertise in agriculture, signifying a cohesive focus on the core domain of the department. The unanimity in the expertise area underscores a collective dedication to agricultural development and highlights a shared professional interest among the surveyed individuals.

The survey presents a comprehensive overview of the demographic and professional landscape within the Department of Agriculture, Government of Odisha. The findings reveal a mix of gender representation, a wide age range, diverse professional experiences, hierarchical diversity, and a unanimous

dedication to agriculture among the respondents. These insights are pivotal in understanding the workforce composition and potential dynamics contributing to agricultural policies, innovations, and strategies within the department.

4.1 Pre-evaluation results:

The responses from the 49 respondents shed light on various perceptions regarding multiple factors contributing to the complexity of ensuring adequate and sustainable food supplies for a growing population. These perceptions can be broadly categorized into several key themes:

A. Global Challenges and Food Security:

When posed the question 'What are your current perceptions of global food security challenges', the respondent's opinions were expressed as below:

Climate Change and Environmental Factors: A predominant concern highlighted by respondents was the impact of climate change on agricultural practices and food production. Issues such as erratic weather patterns, water scarcity, land degradation, depletion of soil health, and the destruction of natural resources were frequently mentioned. Climate variability was linked to reduced yields, affecting the availability and quality of food globally. This aligns with scientific consensus that climate change poses significant risks to agricultural productivity and food systems.

Population Growth and Urbanization: The expanding global population and rapid urbanization were recurrently mentioned as factors straining food security. The rising demand for food due to increased population growth, coupled with limited cultivable land and land-use changes (such as conversion of agricultural land for other purposes), pose challenges in meeting the food requirements of a growing populace.

Resource Constraints and Agricultural Practices: Respondents highlighted inadequate irrigation, economic slowdowns, resource constraints, and poor agricultural practices as contributors to food insecurity. Factors such as inefficient nutrient and water management, inadequate pest control, and loss of biodiversity due to chemical use were mentioned. These issues reflect the challenges faced in optimizing agricultural processes to maximize yields sustainably.

Global Economic and Social Factors: Economic crises, high costs, affordability issues, and disparities in income were linked to food availability and accessibility. Modern food systems, food waste, and market inefficiencies were identified as contributors to global food insecurity. Additionally, challenges related to employment, poverty, and inequality were mentioned as interconnected aspects affecting food security.

Health and Nutrition Concerns: Nutrition-related concerns including malnutrition, inadequate access to quality and balanced food, unsafe food due to residual toxicity, and dietary shifts, were highlighted. Respondents recognized the need for access to nutritious food to ensure the health and well-being of populations globally.

Disruptions in Food Chain and Security Concerns: Disruptions in the food chain due to environmental shocks, changes in climatic conditions, and conflicts were mentioned as challenges impacting food security. Perceptions of security risks associated with the global food system were also evident.

The responses gathered from the survey participants for the question ‘Can you identify key factors contributing to food insecurity around the world?’ highlight several key factors contributing to food insecurity around the world.

Key factors contributing to global food insecurity, as identified by respondents, encompass environmental challenges like climate change, leading to erratic weather patterns and land scarcity. Socioeconomic factors such as poverty, income inequality, population growth, and conflicts disrupt food supplies. Unfair trade rules and geopolitical tensions impact food accessibility and prices. Inadequate agricultural practices, including poor post-harvest handling, pesticide misuse, and technological barriers, hinder production. Gender inequality, lack of education, and inefficient food distribution systems also play roles.

These multifaceted challenges require integrated solutions. Strategies should address climate resilience, sustainable agricultural practices, poverty reduction, equitable resource allocation, and education. Collaborative efforts between governments, organizations and communities are vital to ensure access to safe, nutritious food globally. Mitigating these complexities demands policy reforms, technology adoption, and cultural shifts toward sustainable practices, aiming to achieve food security and combat global hunger effectively.

B. Principles of Sustainable Agriculture:

The respondents’ understanding of sustainable agriculture principles varied. Some recognized its essence, focusing on minimal soil disturbance, resource conservation, and ecosystem preservation. They highlighted integrated nutrient management, crop diversification, and efficient use of natural resources for sustainable yields. Several emphasized practices like integrated farming systems, biodiversity conservation, and holistic approaches to meet present needs without compromising future generations. Some acknowledged the importance of environmental stewardship, social responsibility, and economic viability in sustainable agriculture. However, a few admitted unfamiliarity with

these principles. Overall, the responses reflected a spectrum of understanding, showcasing recognition of the need for environmentally conscious, resource-efficient agricultural practices to ensure long-term food security while preserving ecosystems for future generations.

When asked the question ‘What do you believe are the most important principles for promoting sustainability in agriculture?’ The respondents expressed varied views on the key principles for promoting sustainability in agriculture. Many emphasized practices such as crop rotation, intercropping, and organic farming to conserve natural resources and enhance soil health. They highlighted principles like nutrient cycling, soil regeneration, and avoiding environmentally harmful inputs to sustain agricultural ecosystems. Integrated approaches and efficient utilization of resources, including water and soil, were emphasized for sustainability. The importance of biodiversity conservation, ecosystem balance, and reducing off-farm inputs to promote resource efficiency emerged as key principles. Some highlighted the significance of community engagement, economic viability, and climate resilience in sustainable agriculture. However, a few respondents expressed uncertainty or lacked specific insights into these principles. Overall, the responses underscored the importance of adopting eco-friendly practices, enhancing soil health, and conserving resources as fundamental principles for promoting sustainability in agriculture, albeit with varying degrees of understanding and emphasis.

C. Soil Health and Nutrient Management:

The respondents provided insights into soil health and effective nutrient management in agriculture. Soil health was defined as the combined physical, chemical, and biological well-being of the soil, crucial for sustaining plant health, productivity, and ecosystem balance. Its importance lay in supporting crop growth, maintaining biodiversity, and ensuring food quality.

Strategies for effective nutrient management varied, encompassing practices like Integrated Nutrient Management (INM), soil testing, and balanced fertilizer application. The 4 R’s principle (right rate, right source, right time, right place) was highlighted as a guideline for optimized nutrient usage. Other strategies included organic farming, crop rotation, intercropping, and the use of bio-fertilizers to minimize chemical inputs, maintain soil health, and manage nutrient levels effectively.

These strategies aim to optimize nutrient application, minimize environmental impact, and sustain soil fertility. Integrated approaches, soil testing, and precision in nutrient application emerged as common themes among respondents, demonstrating a nuanced understanding of the need for balanced

nutrient management to enhance agricultural productivity while minimizing environmental degradation.

D. Efficient Water Management in Agriculture:

The role of water management in sustainable agriculture was emphasised by the respondents as below:

Importance of Water: Respondents unanimously agreed that water is a fundamental resource for life and crop production. Water scarcity, excessive water, and its proper management significantly impact agricultural productivity.

Sustainability: Water management is considered crucial for sustainable agriculture due to its role in promoting efficient resource allocation, ecosystem preservation, and long-term farming practices. Efficient water utilization, avoiding wastage, and enhancing resource allocation efficiency were recurring themes.

Technological Innovation: Sustainable water management practices were linked to technological advancements, including innovative irrigation methods like drip and sprinkler systems, along with rainwater harvesting structures and farm ponds.

Climate Change Resilience: Given changing climatic conditions, proper water management becomes more critical. Respondents highlighted the need for adaptive practices in response to irregular rainfall patterns and decreased groundwater levels.

Crop Yield and Resource Preservation: Effective water management is essential for optimizing crop yield, ensuring nutrient absorption by plants at the right time, and preventing damage caused by water stress or excess water.

Impact on Ecosystem: Sustainable water management practices were recognized as integral to maintaining the ecosystem and minimizing negative impacts on soil, environment, and overall agricultural productivity.

The perceived techniques for efficient Water Use in Farming by the respondent's is given below:

Irrigation Methods: Drip and sprinkler irrigation were cited as efficient methods for water use, optimizing the application of water directly to crops, thus reducing wastage.

Rainwater Harvesting: Techniques for harvesting rainwater and storing it in farm ponds were highlighted as strategies to conserve water resources.

Soil Moisture Conservation: Practices such as mulching, cover cropping,

contour farming, and precision soil moisture monitoring help retain soil moisture, minimizing evaporation.

Crop Selection and Rotation: Selecting crops suitable for the available water resources and practicing crop rotation to optimize water use for varying plant needs.

Micro Irrigation and Farming Systems: Implementing micro-irrigation systems, using indicator plants, and employing integrated farming systems were suggested for efficient water use.

Technology Integration: Adoption of advanced technologies, such as weather forecasting, nanotechnology, and water budgeting, was highlighted for optimizing water use in farming.

Overall, the responses highlight the consensus on the vital role of water management in sustaining agricultural productivity while preserving natural resources and ecosystems. The diverse range of suggested techniques emphasizes the need for a holistic approach to address water scarcity challenges in farming for a sustainable agricultural future.

E. Integrated Pest Management (IPM):

Understanding of Integrated Pest Management (IPM) was asked through the question 'What is your understanding of integrated pest management (IPM)? The responses reflect a varied comprehension of IPM, with a prevalent notion of employing a combination of different methods for pest control:

Holistic Approach: Many recognize IPM as a holistic strategy encompassing biological, cultural, mechanical, and chemical methods to control pests below economic thresholds, integrating chemical and non-chemical practices.

Ecosystem-Based Strategy: Several respondents perceive IPM as an ecosystem-based approach, aiming for long-term pest prevention through practices like biological control, habitat manipulation, and the use of resistant varieties.

Reduced Dependency on Chemicals: The emphasis on reducing reliance on chemical pesticides and promoting alternative tools and strategies to manage pests is evident across several responses.

Combining Pest Management Methods: It involves combining physical, biological, cultural, and chemical methods of pest control, sometimes applying chemicals only when pest populations exceed economic thresholds.

Environmental Sensitivity: A notable understanding is the emphasis on minimizing environmental risks by utilizing IPM practices that are cost-effective, socially acceptable, and environmentally friendly.

When asked about any encountered IPM practices in agriculture respondents reported various encountered IPM practices, including the use of biological controls (natural predators and enemies), cultural methods (crop rotation, resistant varieties), and physical controls (traps).

Chemical & Non-Chemical Methods: These encounters encompass both chemical (use of pesticides, bio-pesticides) and non-chemical practices (light traps, sticky traps and cultural practices) for pest control.

Specific Pest Management Techniques: Instances include the use of trap crops, border crops, intercropping, and the employment of certain traps like yellow sticky traps, pheromone traps, and light traps.

Preventive Measures: Some practices involve preventive measures like draining fields, using resistant varieties, adopting summer plowing, and employing cultural techniques to reduce pest populations.

Adoption of ITKs (Indigenous Technical Knowledge): Traditional knowledge-based practices like using specific plants, natural predators, and altering cropping patterns were also reported.

E. Integrated Pest Management (IPM):

The respondent's response on 'How do you think farmers can enhance their resilience to agricultural diseases?' was given below:

Use of High-Quality Seeds: Emphasis on using quality seeds and soil treatment methods to enhance disease resilience.

Cultural Practices: Practices like clean cultivation, weeding, and crop rotation, along with optimal plant population, are considered important for disease management.

Reduced Chemical Usage: Encouragement for limited use of inorganic fertilizers, more use of organic products, and lower chemical application for better disease management.

Climate-Resilient Agriculture: Adoption of climate-resilient practices, including indigenous technical knowledge (ITK), crop diversification, intercropping, and changing planting times, to manage diseases effectively.

Integrated Pest Management (IPM): Several responses suggest adopting IPM practices, such as using resistant varieties, employing trap crops, and implementing pest monitoring systems. Wilby, A., et al. (2015) research evaluates the practical implications of integrated pest management (IPM), addressing its environmental and economic impacts, which could complement the study's focus on disease management strategies.

Whereas in this study respondents asked about ‘Are there any specific diseases or challenges you are familiar with in this context?’ the below response was received:

Paddy Diseases: Diseases like blast, bacterial leaf blight (BLB), brown plant hopper (BPH) infestations, stem borers, and sheath blight are commonly reported in paddy fields.

Pulses Challenges: Yellow mosaic virus (YMV) in pulses and various diseases like blast, brown spot, and stem borers are reported in pulse crops.

Other Challenges: Fall armyworm (FAW) in maize, fruit and shoot borers in brinjal, tobacco caterpillars, and bacterial wilt in ginger are other challenges reported by some respondents.

Preventive Measures: Many suggestions revolve around preventive measures like seed treatments, using resistant varieties, and adopting specific cultural practices to combat these diseases.

E. Organic Farming and Agroforestry:

When asked about ‘What do you know about organic farming and agroforestry as sustainable agricultural practices?’ as response received below:

Organic Farming: It involves minimal use of chemical fertilizers and pesticides, focusing more on biological and organic sources for plant nutrients. It promotes the use of natural waste, manures, and compost while avoiding synthetic substances.

Agroforestry: This practice integrates agriculture with trees, utilizing woody perennials alongside crops or animals on the same land units. It generates various products like food, fiber, fuel, and fodder, enhancing biodiversity and ecosystem services.

The Associated Benefits with these Practices perceived by the respondents as:

Organic Farming Benefits: Improved soil health, reduced chemical inputs, healthier food, resilience to climate change, reduced greenhouse gas emissions, and increased biodiversity.

Agroforestry Benefits: Enhanced soil health, increased biodiversity, better erosion control, increased productivity, and diversified income sources for farmers.

Altieri (2018) covers principles and practices of agroecology, emphasizing the importance of ecological processes in agricultural systems, aligning with the study’s focus on sustainable agriculture practices. Food and Agricultural

Organisation (2022) report examines the role of organic agriculture in climate change mitigation, offering insights into how organic farming contributes to reducing greenhouse gas emissions, which could be relevant to the study's exploration of organic farming practices. Ponisio, L. C., et al. (2016) study explores the relationship between fire diversity and avian diversity, offering insights into biodiversity maintenance in agroecosystems, which might relate to the study's investigation of agroforestry practices and their impact on biodiversity.

4.2 Post-evaluation results:

Following the Sustainable Food Systems training, participants showcased an enriched comprehension of global food security challenges and the pivotal role sustainable agricultural practices play in addressing these issues. Their post-evaluation reflections indicate a profound shift in understanding and emphasis on sustainable solutions.

Enhanced Awareness of Challenges: The training enabled participants to delve deeper into the complexities of food security, encompassing aspects like food access, quality, market equilibrium, waste reduction, and post-harvest losses. They now grasp the interconnectedness of these challenges and their impact on global food security more comprehensively.

Hope through Sustainability: An overarching realization emerged post-training that adopting sustainable agricultural practices offers a beacon of hope in mitigating global food security threats. Participants acknowledge sustainable food systems as instrumental in combating challenges, demonstrating a newfound optimism despite the complexities.

Understanding Interconnected Issues: Respondents showcased a more profound understanding of interconnected factors such as climate change, soil health degradation, water scarcity, and market fluctuations and their significant contributions to food insecurity. They now grasp the multifaceted nature of these challenges more thoroughly.

Identifying Additional Factors Contributing to Food Insecurity: Participants recognized and internalized an extended array of factors contributing to global food insecurity beyond their preconceived notions. This included technological barriers, inadequate water supply, socio-economic instability, racial discrimination, and geographical constraints, among others.

Impact of Training: The training significantly augmented participant awareness, cultivating a broader comprehension of the complex interplay between agricultural practices, environmental factors, and socio-economic conditions shaping food security. There's a notable shift in emphasis towards sustainable

agricultural methods to confront food insecurity and establish a more resilient food system for the future.

Emphasis on Soil Health and Nutrient Management: The post-evaluation revealed an acute understanding of the criticality of soil health and nutrient management in sustainable agriculture among respondents. Key takeaways encompassed strategies like soil testing, conservation tillage, nutrient management techniques, biodiversity, organic farming, and integrated approaches, indicating a comprehensive understanding of fostering soil health.

Overall, the post-evaluation showcases a paradigm shift in participant's perspectives, reflecting a deeper comprehension of food security challenges and a strong emphasis on implementing sustainable agricultural practices to address these global issues effectively. Their learnings underscore the imperative nature of balancing environmental conservation, economic viability, and social equity within agricultural practices to ensure long-term food security.

The responses emphasize a growing recognition of the significance of water management in agriculture. Views have evolved, highlighting water's pivotal role in crop growth, sustainability, and food security. Respondents acknowledge the need for improved water management practices, linking it to increased crop yields and reduced environmental degradation.

Specifically, promising water-saving practices emerged, including micro-irrigation methods like drip and sprinkler systems, rainwater harvesting, mulching, and crop rotation. These techniques aim to conserve water, enhance soil moisture, and optimize irrigation schedules, ensuring better crop health and yield while minimizing water wastage.

The shift towards precision in water application, adopting drought-resistant crop varieties, and integrating technology for efficient water use showcases a holistic approach to address water scarcity challenges in agriculture. Additionally, emphasis on using water smart technologies, implementing conservation practices, and choosing appropriate irrigation methods based on local conditions emerged as notable strategies.

The responses highlight a progression in understanding Integrated Pest Management (IPM) in agriculture. Initially, some respondents expressed a basic understanding, emphasizing the need for multiple approaches to control pests. There was recognition of cultural, physical, biological, and chemical methods, though the specific implementation was not always clear. Pre-knowledge centered on methods like summer plowing, trap crops, light traps, and biological controls using predators and bio-pesticides. Some also mentioned the importance of not relying solely on chemical control and the significance of soil

health, ecosystem balance, and the risk of pest resistance to chemicals.

Post-knowledge, respondents showcased a deeper understanding of IPM's holistic approach. There was a more detailed articulation of various IPM techniques, including soil treatment, crop rotation, intercropping, the use of trap plants, bio-pesticides, cultural practices like sanitation and crop diversity, and mechanical controls like hand-picking or trapping. There was a notable shift towards emphasizing sustainable and environmentally friendly practices, reducing reliance on chemical pesticides, and promoting the conservation of natural predators and beneficial organisms.

Overall, the post-knowledge responses reflected a more nuanced understanding of how IPM techniques should be integrated and sequenced, emphasizing the importance of ecological balance, soil health and reducing the environmental impact of pest management practices. This evolution indicates a broader awareness of the interconnectedness of pest control, environmental sustainability and agricultural productivity among respondents.

Post-evaluation, the insights garnered from participant's responses reflect a comprehensive understanding of disease management strategies in agriculture. The knowledge acquired highlights a range of practical approaches encompassing cultural, agronomic, biological and technological methods to combat agricultural diseases and enhance resilience. Participants displayed an increased awareness of disease-resistant crop varieties, crop rotation, soil health management and the adoption of Integrated Pest Management (IPM) practices. Emphasis was placed on the significance of proper sanitation, timely planting and the utilization of organic and biological control measures to mitigate disease occurrences. There is a notable shift towards sustainable practices, including the use of organic inputs, integrated nutrient management and the reduction of chemical pesticides. The responses indicate an elevated preparedness among participants to address agricultural challenges, integrating traditional knowledge (ITK) with modern techniques. However, challenges such as disease identification, changing climate patterns, and the evolving nature of diseases remain pertinent.

Overall, the evaluation reveals a stronger grasp of diverse disease management strategies, emphasizing a holistic and sustainable approach that considers ecological, economic, and social aspects of farming. This knowledge empowers participants to navigate agricultural challenges more effectively while prioritizing environmentally friendly and resilient practices.

The responses from the participants after the training program showcase a more informed understanding of organic farming and agroforestry practices.

There is a heightened recognition of the manifold advantages these practices offer in terms of sustainability, soil health, biodiversity preservation, and overall environmental health. Participants highlighted the benefits of organic farming, emphasizing reduced dependency on agrochemicals, increased soil fertility, improved water retention, and the promotion of healthy produce. The discussions revolved around the advantages of agroforestry, such as erosion control, increased soil organic matter, carbon sequestration and the provision of multiple resources like food, fodder, fuel and medicines. Moreover, respondents outlined the interconnectedness between organic farming and agroforestry, acknowledging how these practices contribute to sustainable food systems, nutritional security and environmental sustainability. They expressed a clearer understanding of how these methods enhance soil health, biodiversity, ecosystem services and climate resilience while offering economic benefits to farmers. Ponisio, L. C., et al. (2015) study investigates the yield benefits of diversification practices in organic agriculture, suggesting reduced yield gaps between organic and conventional farming, which might align with the study's findings on organic farming and yield improvements.

Overall, the knowledge gained post-training reflects a holistic comprehension of how organic farming and agroforestry intertwine to create sustainable agricultural systems that not only ensure food security but also contribute to environmental conservation and socio-economic well-being.

5. Policy Implications and Conclusion

The overarching themes from the study, including Sustainable Agriculture, Climate Change Adaptation, Disease Management, and Organic Farming & Agroforestry, bear significant policy implications and conclusions for agricultural practices and policies:

Sustainable Agriculture: Encouraging and incentivizing farmers to adopt sustainable agricultural practices should be a policy priority. Government policies should support the dissemination of knowledge on sustainable techniques such as conservation agriculture, precision farming, and integrated crop-livestock systems. Investing in research, providing subsidies for eco-friendly inputs, and creating market incentives for sustainable produce can further promote these practices.

Climate Change Adaptation: Policies need to address the impact of climate change on agriculture. Implementation of climate-smart agricultural techniques, promoting drought-resistant crops, efficient irrigation methods, and incentivizing carbon-neutral practices can mitigate climate risks. Integrating indigenous knowledge with modern technology in policy frameworks will enhance adaptation measures.

Disease Management and Resilience: Policymakers must promote Integrated Pest Management (IPM) strategies. Investing in research for disease-resistant crop varieties and promoting diversified cropping systems can reduce dependence on chemical pesticides. Supporting farmer education programs for disease diagnosis and implementing biocontrol methods through incentives and subsidies will be crucial.

Organic Farming and Agroforestry: Policy frameworks should incentivize and support the transition towards organic farming practices and agroforestry. This includes providing financial assistance, technical training, and market access for organic produce. Land use policies should encourage agroforestry systems to enhance biodiversity, soil health, and carbon sequestration.

The study's findings underscore the urgency to reframe agricultural policies and practices towards sustainability, climate resilience, and eco-friendly methodologies. Implementing supportive policies that integrate traditional knowledge with modern techniques is pivotal. Collaborative efforts involving governments, agricultural institutions, and local communities are imperative to achieve a holistic and sustainable transformation in agricultural practices. These policy changes and collective actions will not only ensure food security but also contribute to environmental preservation and the overall well-being of farming communities.

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