



SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

The sustainable development goals (SDGs) contain seventeen goals which have a bearing on multiple issue areas including agriculture. This study sought to develop an SDG Blueprint to inform integrated approaches to sustainable agriculture at the national level in India. It is crucial that the lenses of sustainable development, climate action, value chains, and multi-stakeholder approaches be considered for sustainable agriculture to contribute towards food security, livelihoods, and ecosystem integrity. The scope of the study was to examine the national policy interface of sustainable agriculture with SDGs. Through tools such as stakeholder mapping, systematic literature review, sustainable agriculture metrics, nominal group techniques, key informant interviews, and stakeholder validation, an SDG Blueprint is developed to inform policy and praxis on the issue of sustainable agriculture.

Prepared by:
The Energy and Resources Institute

Supported by:
The Norwegian Ministry of Foreign Affairs

Keywords: sustainable development goals, sustainable agriculture, climate change, national policies

COPYRIGHT

This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes without special permission from the copyright holder provided acknowledgment of the source is made.

ISBN: 978-93-94657-57-1

STUDY TEAM

Authors

Lead Authors: Madhuparna Maiti, Palak Khanna, Shailly Kedia, Shivangi Raj, Manish Anand
Supporting Authors: Rishikaa Sajeev, Aakriti Arora, Deeksha Modgil, Mansi Juneja

Reviewer

Prodipto Ghosh

Advisors

Marit Marie Strand, Vivek Kumar

SUGGESTED CITATION

The Energy and Resources Institute. (2024). *SDG Blueprint for Sustainable Agriculture*. New Delhi: The Energy and Resources Institute.

PUBLISHED BY

The Energy and Resources Institute

FOR MORE INFORMATION

The Energy and Resources Institute (TERI), Darbari Seth Block, India Habitat Centre, Lodhi Road, New Delhi – 110003, India

Tel.: +91 11 2468 2100 or 2468 2111 | Email: pmc@teri.res.in | Web: www.teriin.org

ACKNOWLEDGEMENT

We would like to express our sincere appreciation to everyone whose support and contributions have enabled this study.

We express our gratitude to the Royal Norwegian Embassy for their generous support. This report was prepared in close cooperation with the valued contributions of Ms Marit Marie Strand and Mr Vivek Kumar from the Royal Norwegian Embassy, for which we extend our sincere gratitude to them.

Special thanks to the esteemed experts who participated in the SDG Blueprint expert consultation, contributing invaluable insights. Appreciation is also conveyed to stakeholders from various ministries and departments who generously dedicated their time to share expertise and knowledge through conducted interviews. We express our heartfelt thanks to Dr Vibha Dhawan for institutional support. We would also like to acknowledge Dr Prodipto Ghosh for his continuous guidance throughout the project.

Special thanks to Ms Sonali Mathur and Ms Heena Makhija for their coordination and support within the project. We would also like to acknowledge the Communications Team and Events Team at TERI for their support in outreach activities. Sincere thanks are also extended to Mr John Andrus and Mr Ravi Nair for their substantial contributions to administrative support.

CONTENTS

ACKNOWLEDGEMENT ii

Contents iii

List of Acronyms.....vii

Executive Summaryix

Chapter 1: Sustainable Development Goals and Sustainable Agriculture 1

 Introduction 1

 Research Gaps 3

 Working Definition of Sustainable Agriculture 3

 Rationale.....4

 Research Questions 4

 Scope and Limitations of the Study 5

 Methodology 5

Chapter 2: Sustainable Agriculture in India and Key Indicators9

 Water 9

 Land..... 14

 Energy 21

 Climate Risk..... 23

Chapter 3: National Policy Interface of SDGs and Sustainable Agriculture26

 Goal 1. End poverty in all its forms everywhere..... 26

 National Policy and Stakeholder Mapping26

 Synergies and Trade-offs.....28

 Gaps and Barriers29

 Emerging Policy Solutions29

 Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture..... 30

 National Policy and Stakeholder Mapping32

 Synergies and Trade-offs.....34

 Gaps and Barriers36

 Emerging Policy Solutions36

 Goal 3. Ensure healthy lives and promote well-being for all at all ages..... 39

 National Policy and Stakeholder Mapping40

 Synergies and Trade-offs.....41

 Gaps and Barriers43

 Emerging Policy Solutions43

 Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all44

 National Policy and Stakeholder Mapping44

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Synergies and Trade-offs.....	47
Gaps and Barriers	48
Emerging Policy Solutions	49
Goal 5. Achieve gender equality and empower all women and girls.....	50
National Policy and Stakeholder Mapping.....	51
Synergies and Trade-offs.....	52
Gaps and Barriers	53
Emerging Policy Solutions	54
Goal 6. Ensure availability and sustainable management of water and sanitation for all....	55
National Policy and Stakeholder Mapping.....	56
Synergies and Trade-offs.....	57
Gaps and Barriers	58
Emerging Policy Solutions	59
Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all	60
National Policy and Stakeholder Mapping.....	61
Synergies and Trade-offs.....	63
Gaps and Barriers	64
Emerging Policy Solutions	65
Goal 8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.....	66
National Policy and Stakeholder Mapping.....	67
Synergies and Trade-offs.....	69
Gaps and Barriers	71
Emerging Policy Solutions	71
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.....	74
National Policy and Stakeholder Mapping.....	75
Synergies and Trade-offs.....	77
Gaps and Barriers	78
Emerging Policy Solutions	78
Goal 10. Reduce inequality within and among countries.....	80
National Policy and Stakeholder Mapping.....	80
Synergies and Trade-offs.....	82
Gaps and Barriers	83
Emerging Policy Solutions	83
Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable.....	84
National Policy and Stakeholder Mapping.....	85

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Synergies and Trade-offs.....	86
Gaps and Barriers	87
Emerging Policy Solutions	88
Goal 12. Ensure sustainable consumption and production patterns.....	90
National Policy and Stakeholder Mapping.....	90
Synergies and Trade-offs.....	92
Gaps and Barriers	93
Emerging Policy Solutions	94
Goal 13. Take urgent action to combat climate change and its impacts	95
National Policy and Stakeholder Mapping.....	96
Synergies and Trade-offs.....	97
Gaps and Barriers	98
Emerging Policy Solutions	99
Goal 14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.	103
National Policy and Stakeholder Mapping.....	104
Synergies and Trade-offs.....	104
Gaps and Barriers	106
Emerging Policy Solutions	106
Goal 15. Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss.....	107
Policy and Stakeholder Mapping.....	108
Synergies and Trade-offs.....	110
Gaps and Barriers	112
Emerging Policy Solutions	112
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	114
National Policy and Stakeholder Mapping.....	115
Synergies and Trade-offs.....	116
Gaps and Barriers	117
Emerging Policy Solutions	117
Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development	119
National Policy and Stakeholder Mapping.....	120
Synergies and Trade-off	120
Gaps and Barriers	122

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Emerging Policy Solutions	123
Chapter 4: The Road Ahead	126
Enhancing Synergies and Managing Trade-offs	126
Prioritized SDG-wise Measures	131
Cross-cutting Issues.....	135
References	138
Annexures	173
Annexure 1: English Translations of Key Measures.....	173
Annexure 2: Semi-structured Questionnaire Used in the Study	174
Annexure 3: List of Experts Engaged in the Consultations	175

LIST OF ACRONYMS

ABY	Atal Bhujal Yojna
AFOLU	Agriculture, forestry and other land use
AgDSM	Agriculture Demand side Management
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ASCI	Agriculture Skill Council of India
CCSAMMN	Climate Change and Sustainable Agriculture: Monitoring, Modeling and Networking
CDP	Crop Diversification Programme
CPCB	Central Pollution Control Board
CRZ	Coastal Regulation Zones
CWC	Central Water Commission
EPA	Environment Protection Act
FAO	Food and Agriculture Organization
FICSI	Food Industry Capacity and Skill Initiative
FPOs	Farmers Producers Organisations
GHI	Global Hunger Index
GVA	Gross value added
ICT	Information and Communication Technology
IEC	Information, Education, and Communication
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
M & E	Monitoring and Evaluation
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MHEWS	Multi-Hazard Early Warning System
MSP	Minimum Support Price
NABM	National Agroforestry and Bamboo Mission
NAPCC	National Action Plan on Climate Change
NDMP	National Disaster Management Plan
NGOs	Non-governmental Organizations
NGT	Nominal group technique
NITI	National Institution for Transforming India
NMSA	National Mission for Sustainable Agriculture
NMSKCC	National Mission on Strategic Knowledge for Climate Change
NSDC	National Skill Development Corporation
NSGM	National Smart Grid Mission
PDMC	Per Drop More Crop
PKVY	Paramparagat Krishi Vikas Yojana
PMFBY	Pradhan Mantri Fasal Bima Yojana
PMJVM	Pradhan Mantri Janjatiya Vikas Mission
PMKSY	Pradhan Mantri Krishi Sinchayee Yojan
PMKSY	Pradhan Mantri Kisan Sampada Yojana
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyaan
PSL	Priority Sector Lending
RESCO	Renewable Energy Service Company
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

SCADA	Supervisory Control and Data Acquisition
SDGs	Sustainable Development Goals
SHGs	Self-Help Groups
SMAF	Sub-Mission on Agroforestry
SPS	Sanitary and phytosanitary measures
UN	United Nations

EXECUTIVE SUMMARY

In an era marked by global challenges, the 2030 Agenda for Sustainable Development stands as a beacon, envisioning a world free from the shackles of poverty and hunger, a world where quality education and healthcare are accessible to all, and where gender equality is not just an idea but a reality. At the heart of this ambitious agenda lies the concept of Sustainable Development Goals (SDGs), a set of 169 targets that span a spectrum of social, economic, and environmental dimensions. However, despite the noble aspirations articulated in the agenda, a critical gap persists—one that hampers the practical implementation and integration of the SDGs. The concept of indivisibility, a cornerstone of the 2030 Agenda, remains somewhat elusive in practical terms. The interactions between the myriad SDG targets and the nuanced ways in which they influence each other in real-world scenarios are not thoroughly understood. This gap is not merely academic; it is a chasm that impedes progress towards achieving the comprehensive vision of sustainable development. Existing studies, while valuable in identifying generic interlinkages, fall short of providing a detailed and quantifiable analysis of these connections.

This gap becomes even more pronounced in the realm of sustainable agriculture, a complex system with an extensive value chain encompassing pre-production, production, and post-production stages. Despite its crucial role in the global pursuit of sustainability, the linkages between SDGs and the components of the agricultural value chain are largely unexplored. The prevailing policy frameworks often neglect the intricate connections within the agricultural sector. Focused on crop-based agriculture systems and the associated value chains, the study adopts an exploratory approach, delving into the social, economic, and environmental aspects of the agricultural value chain. What sets this study apart is its commitment to understanding the integrated nature of these linkages and using this knowledge to inform evidence-based decision-making.

The approach of this study leans towards an exploratory exercise to understand the synergies and trade-offs between sustainable agriculture and SDGs and implications for policy and praxis.

This mapping exercise aims to unravel the complex relationships and interdependencies within the subject. Subsequently, the methodology involved stakeholder and policy mapping, illuminating the key players and policy interventions relevant to the nexus between sustainable agriculture and SDGs. Following this, a prioritization activity was undertaken based on specified criteria, adding a layer of strategic focus to the study. The data collection process encompassed a thorough triangulation approach for fact-checking and validation. Stakeholder consultation played a pivotal role, employing the nominal group technique, while key informant interviews, conducted through semi-structured questionnaires, provided rich qualitative insights and validation of the findings. The culmination involved consolidating inputs and conducting a detailed analysis of the findings, ensuring a robust and nuanced exploration of the study's objectives.

This study is not just an academic exercise; it is a clarion call for action. By uncovering the intricate web of connections between sustainable agriculture and the SDGs, the study aspires to guide policymakers towards more informed and effective decisions. It beckons a future where the goals of poverty eradication, food security, environmental sustainability, and other SDGs are not isolated pursuits but interconnected threads weaving the fabric of a truly sustainable world.

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

In the study, to identify synergies and trade-offs between SDGs and sustainable agriculture, all 169 targets were scrutinized based on predefined criteria (Figure A). Synergies are marked in green, trade-offs in red, and SDG targets exhibiting both synergies and trade-offs are highlighted in red and green. This involved assessing the direction of impact, considering both the target’s impact on sustainable agriculture and agriculture’s impact on the target, across the entire value chain—encompassing pre-production, production, and post-production stages. The criteria also delved into studying both immediate and long-term impacts. Through an extensive review of literature, consultations with stakeholders, and validation processes, the study revealed the existence of synergies, trade-offs, and de-links between SDGs and sustainable agriculture. Specifically, 135 synergies were identified, along with 5 targets exhibiting a combination of both synergies and trade-offs (Figure B). Additionally, 29 targets were deemed delinked due to considerations of scope, with assessments based on a working definition of sustainable agriculture and direct environmental impacts on agriculture.

Figure A: Synergies and Trade-offs for SDG Targets

Goals	Targets																		
Goal 1	1.1	1.2	1.3	1.4	1.5	1.a	1.b												
Goal 2	2.1	2.2	2.3	2.4	2.5	2.a	2.b	2.c											
Goal 3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.a	3.b	3.c	3.d						
Goal 4	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.a	4.b	4.c									
Goal 5	5.1	5.2	5.3	5.4	5.5	5.6	5.a	5.b	5.c										
Goal 6	6.1	6.2	6.3	6.4	6.5	6.6	6.a	6.b											
Goal 7	7.1	7.2	7.3	7.a	7.b														
Goal 8	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	8.10	8.a	8.b							
Goal 9	9.1	9.2	9.3	9.4	9.5	9.a	9.b	9.c											
Goal 10	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.a	10.b	10.c									
Goal 11	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.a	11.b	11.c									
Goal 12	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.a	12.b	12.c								
Goal 13	13.1	13.2	13.3	13.a	13.b														
Goal 14	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.a	14.b	14.c									
Goal 15	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	15.a	15.b	15.c							
Goal 16	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	16.10	16.a	16.b							
Goal 17	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	17.10	17.11	17.12	17.13	17.14	17.15	17.16	17.17	17.18	17.19

Figure B: Synergies and Trade-offs for SDGs (Numbers)

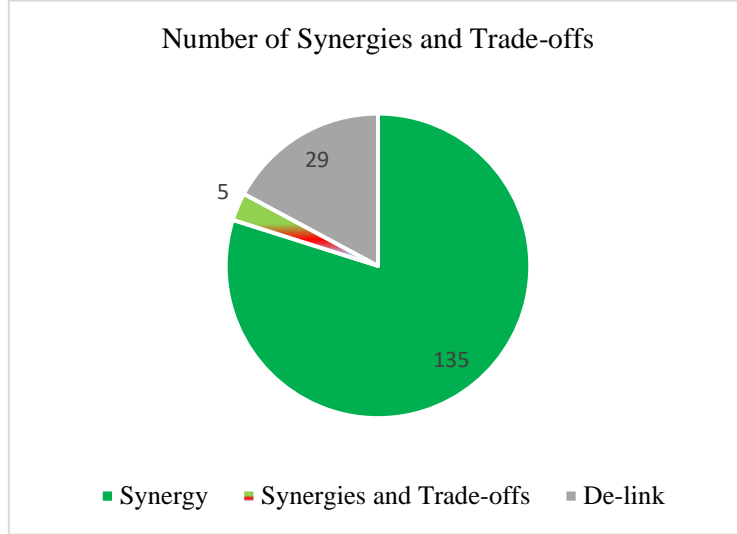


Figure C: Interconnectedness of SDGs and Sustainable Agriculture



SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

In the intricate web of SDGs, the interlinkage reveals complex relationships that go beyond linear relationships (Figure C). However, the pursuit of these goals may also present trade-offs, as interventions to address one goal may inadvertently impact another negatively. Table A depicts the key ministries as stakeholders who are key when it comes to a national policy interface on SDGs and sustainable agriculture. The findings revealed the existence of 34 key stakeholders within the value chain related to SDGs and sustainable agriculture.

This underscores the interconnected nature of stakeholders in the realm of sustainable agriculture, emphasizing the need for a collaborative rather than a siloed approach. The diverse involvement of ministries and departments reflects a convergence on the common issue of agriculture, highlighting the necessity for collaboration. Stakeholder mapping proves instrumental in not only pinpointing the key domains of their work but also identifying potential areas for future collaboration and intervention.

Table A: National Policy Interface on SDGs and Sustainable Agriculture – Stakeholder Mapping

Stakeholders	Sustainable Development Goals																
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6	Goal 7	Goal 8	Goal 9	Goal 10	Goal 11	Goal 12	Goal 13	Goal 14	Goal 15	Goal 16	Goal 17
Ministry of Rural Development	●	●			●			●	●	●		●	●		●	●	
NABARD	●	●						●					●		●		
Ministry of Tribal Affairs	●									●					●		
Ministry of Agriculture and Farmers Welfare	●	●	●	●			●	●	●	●	●	●	●	●	●	●	
Ministry of Power	●						●										
Ministry of Jal Shakti		●				●	●			●	●	●	●	●	●		
Ministry of New and Renewable Energy							●	●		●							
Ministry of Chemicals and Fertilizers		●	●														
Department of Science and Technology		●													●		●
Ministry of Food Processing and Industries		●		●				●	●		●	●	●				
Ministry of Environment, Forests and Climate Change			●			●				●	●	●	●	●	●	●	
Ministry of Education				●													
Ministry of Minority Affairs				●													
Department of Biotechnology				●													
Ministry of Finance	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
NITI Aayog	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ministry of Skill Development and Entrepreneurship				●	●			●									
Ministry of Electronics and Information Technology									●				●			●	
Ministry of Earth Sciences										●			●	●			

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Stakeholders	Sustainable Development Goals																
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6	Goal 7	Goal 8	Goal 9	Goal 10	Goal 11	Goal 12	Goal 13	Goal 14	Goal 15	Goal 16	Goal 17
Ministry of Women and Child Development			●		●			●		●							
Ministry of Panchayati Raj					●					●						●	
Ministry of Social Justice and Empowerment										●						●	
Ministry of Housing and Urban Affairs						●					●						
Ministry of Labour and Employment								●									
Ministry of Development of North-Eastern Region								●									
Ministry of Commerce and Industry								●									●
Ministry of Road Transport and Highways									●								
Ministry of Consumer Affairs, Food and Public Distribution								●		●	●	●				●	
Ministry of Petroleum and Natural Gas											●	●					
Ministry of Home Affairs											●					●	
Ministry of Law and Justice																●	
Ministry of Personnel, Public Grievances and Pensions																●	
Ministry of Health and Family Welfare			●														
Ministry of External Affairs																●	●

SDG 1: It is imperative to further integrate MGNREGS with eco-friendly technologies and sustainable farming practices. Bridging this gap involves incorporating innovative solutions such as solar-powered pumps and energy-efficient machinery into the programme, fostering sustainable infrastructure development. By seamlessly integrating these eco-friendly technologies, MGNREGS can significantly contribute to promoting environmentally conscious practices within the agricultural sector. This holistic approach also ensures a positive impact on both poverty reduction and sustainable development.

SDG 2: To enhance agricultural adaptation and foster crop diversification, it is imperative to emphasize and focus more on the crop diversification programme within the NMSA. This integration should be accompanied by a substantial allocation of funds directed towards robust Research and Development (R&D) initiatives and comprehensive capacity building within the framework of NMSA. Moreover, incentivizing farmers to cultivate a broader spectrum of crops beyond the conventional rice-wheat cycle will play a pivotal role. Creating a market demand for diverse crops and offering incentives to farmers who embrace this diversification will encourage a shift towards cultivating a wider range of crops. This strategic approach will not

only alleviate the pressure on specific crops but also bolster agricultural resilience while fostering market diversity.

SDG 3: It is key to promote environment-friendly and health-friendly inputs through sensitization of farmers to adopting sustainable agricultural methods, which will not only enhance soil health but also contribute to long-term agricultural sustainability. NRHM can also integrate mental health challenges faced by farmers. This approach will facilitate timely intervention and provision of appropriate referrals, thereby ensuring that farmers in distress receive the necessary support and access to mental healthcare services. This integration will acknowledge the holistic well-being of farmers, aligning mental health support with agricultural initiatives for a more sustainable and supportive farming community.

SDG 4: It is imperative to address language barriers hindering effective education, especially in linguistically diverse regions. To overcome this gap, implementing language-specific communication strategies is crucial, ensuring a better understanding and adoption of sustainable farming practices. Additionally, for the Skill India Mission, integrating skill development initiatives with existing agricultural schemes is essential to enhance farmers' income. There can be a larger focus on areas such as water budgeting and sustainable water management practices within the Missions. Furthermore, strengthening collaboration between the Agriculture Skill Council of India (ASCI) and the Food Industry Capacity and Skill Initiative (FICSI) from the planning stage enhances decision-making, outlook, and access to shared resources. To fortify ASCI, incorporating pre-production and post-production stages in training programmes is vital for addressing the entire agricultural value chain and ensuring the effectiveness of training programs.

SDG 5: Mahila Kisan Sashaktikaran Pariyojan (MKSP) can be enhanced by strengthening the components that are aimed at equipping women with sustainable infrastructure and diverse training across various stages of the agricultural value chain. By offering training programmes tailored to different stages of the agricultural value chain, women and women self-help groups (SHGs) can gain vital skills and knowledge necessary for sustainable farming practices, enhanced productivity, and improved access to markets. Furthermore, it is crucial to provide institutional support to women farmers to ensure their access to and manage land/other resources while facilitating the seamless transfer of assets as and when required. This support mechanism within MKSP will empower women to assert their rights, enabling them to secure necessary resources for sustained agricultural endeavours. To better comprehend the impacts of unsustainable farming practices, particularly on women farmers, it is essential to collect gender-disaggregated data. Prioritizing collection and analysis of such data to discern the specific challenges faced by women (such as drudgery and pesticide exposure) in agriculture. This data-driven approach will provide critical insights into the disproportionate impacts of unsustainable practices on women, enabling targeted interventions to mitigate these challenges effectively.

SDG 6: Atal Bhujal Yojana (ABY) can address existing gaps, such as the exclusion of water-stressed states like Punjab and Bihar, where the water tables are rapidly declining. The inclusion of these states within the scheme is essential for comprehensive groundwater management, mitigating depletion concerns. Furthermore, the policy should establish a unified framework to tackle both groundwater issues, treatment, and contamination from agricultural activities, enhancing the prevention of agricultural contamination. Emphasizing integrated management of surface and groundwater resources is crucial for building resilience to changing environmental conditions. Similarly, the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) recognizes water efficiency as a separate component. By including water management under

the NMSA scheme, the policy can elevate the importance of water management in agriculture, including monitoring for improved health assessment of water resources, thereby contributing to the overarching goals of SDG 6.

SDG 7: Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyaan (PM-KUSUM) initiative needs refinement as not all components currently incorporate the Renewable Energy Service Company (RESCO) model, and the exclusive promotion of solar pumps has increased to groundwater depletion concerns. To address this, implementing the RESCO model across all components is crucial, as well as adopting a holistic value-chain approach covering pre-production, production, and post-production stages. Integrating remote monitoring and control systems into solar pumps enhances energy conservation efforts. Meanwhile, the Agriculture Demand Side Management (AgDSM) initiative should extend its focus beyond energy-efficient pumps to encompass various technologies throughout the agricultural value chain, promoting energy conservation comprehensively. Similarly, the National Smart-grid Mission, currently emphasizing agri-solar pumps, should extend its promotion to post-production grids, ensuring a clean energy transition and adopting a whole-of-value-chain approach for sustainable energy practices. These strategic adjustments collectively contribute to cleaner energy transitions and maintain groundwater levels, aligning with the goals of SDG 7.

SDG 8: Priority Sector Lending (PSL) is vital for establishing effective monitoring mechanisms for subsectors and green loan provisions, promoting transparency. Overcoming challenges involves introducing provisions for tagging loans for green activities and implementing RBI-led green credits mapping, encouraging widespread adoption by financial institutions. Integration of crop loans with insurance provides guarantees, addressing regulatory issues. Collaboration with private players, particularly fintech, enhances checks, balances, and recovery processes. To strengthen the limited attention to women farmers, incentivizing women-led agribusinesses and providing training and technology access is crucial. These measures collectively foster improved transparency, informed decision-making, and strengthen the credibility of PSL, encouraging increased investment in green and sustainable agricultural practices while promoting gender mainstreaming in agriculture. Providing farmers with bundled services (including credit, insurance, and benefits from schemes) through a single window will ease access to basic services for farmers.

SDG 9: The enhancement of the Pradhan Mantri Kisan Sampada Yojana (PMKSY) demands strategic adjustments. Prioritizing the inclusion of eco-labels and certifications within PMKSY is essential to encourage sustainable farming practices and informed decision-making. To address the limited adoption of energy-efficient technologies, promoting the use of smart warehouses and renewable energy sources is crucial, facilitating both cost reduction and environmental benefits. Collaboration between PMKSY and the Ministry of Agriculture and Farmers Welfare must be strengthened to ensure synergy in efforts across the entire agricultural value chain. Simultaneously, reinforcing the Cold Storage Infrastructure policy requires a broader focus beyond potatoes to encompass various perishables, ensuring increased availability and mitigating food loss. Additionally, enhancing the user interface of agricultural apps demands the resolution of accessibility issues, prioritizing user-friendly features, language support, and improving connectivity for market information.

SDG 10: The Pradhan Mantri Janjatiya Vikas Mission (PMJVM) necessitates recalibration to address existing gaps. To broaden its impact, there is a critical need to bolster tribal entrepreneurship and livelihood opportunities, incorporating traditional skills and fostering product diversification. This strategic approach not only addresses income disparities but also encourages sustainable practices, thereby optimizing natural resource utilization for tribal communities. Simultaneously, establishing dedicated insurance schemes tailored to the unique

needs of tribal communities, including gender-specific options for women, is imperative. This ensures the mitigation of risks faced by tribal communities, fostering enhanced resilience. Moreover, interventions across the entire agricultural value chain should be integrated, with a specific emphasis on pre-production elements, ensuring the holistic inclusion of tribal communities in sustainable agriculture practices.

SDG 11: To promote urban agriculture and enhance sustainable practices within urban spaces, it is imperative to prioritize the identification and allocation of suitable lands for agricultural purposes. Integrating community-based farms within the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) can be essential to fostering sustainable agricultural practices through community engagement and participation in cities. Hydroponic farming holds potential for enhancing agricultural infrastructure in urban spaces and can be explored for regions where natural ecosystems are not disrupted, such as terraces.

SDG 12: It is imperative to strategically strengthen the National Policy for the Management of Crop Residues by expanding its scope beyond specific states to encompass the entire nation, which is crucial for a comprehensive approach. To foster sustainable agriculture through the *Rashtriya Krishi Vikas Yojana* (RKVY)- Remunerative Approaches for Agriculture and Allied sector Rejuvenation (RAFTAAR) can provide incentives for crop diversification, and the provision of diverse seeds at a single window can be instrumental. Additionally, incorporating ecolabelling within RKVY infrastructure expedites sustainable practices. The focus on commercializing waste under RKVY, including support for startups converting crop wastage, is vital. RKVY-RAFTAAR can also expand its focus to other agricultural crops than just horticultural crops. Simultaneously, within Pradhan Mantri Kisan Sampada Yojana (PMKSY), prioritizing eco-labels and embracing energy-efficient technologies can also promote sustainable practices. Post-harvest waste can be reduced by promoting smart warehouses through enhanced implementation of PMKSY, as also discussed in SDG 9.

SDG 13: Various risk mitigation strategies and adaptation practices that can be adopted include expanding the coverage of crops included in *Pradhan Mantri Fasal Bima Yojana* (PMFBY). Diversifying the list of crops covered will ensure a more comprehensive and inclusive risk mitigation strategy for farmers and encourage them to diversify their crops for cultivation. Also, transitioning from indemnity-based insurance to index-based insurance mechanisms can streamline the claims process, simplifying claim procedures, mitigating inaccuracies in triggering claims for crop losses, reduce administrative overheads, and ensure quicker disbursement of pay-outs to affected farmers. Additionally, integrating a Multi-Hazard Early Warning System (MHEWS) within the National Disaster Management Plan (NDMP) can be essential to provide timely alerts and response mechanisms for various agricultural risks and potential associated effects, thus strengthening disaster risk reduction, as well as climate adaptation. A vulnerability matrix can be developed by Climate Change and Sustainable Agriculture: Monitoring, Modelling and Networking (CCSAMMN) and National Mission on Strategic Knowledge for Climate Change (NMSKCC) to map and track the amount of productivity lost in agriculture due to slow-onset events and devise methods on how international funds can compensate for the loss to the farmers.

SDG 14: To enhance sustainable agricultural practices and minimize environmental impacts on marine systems, it is crucial to implement rigorous monitoring and regulatory mechanisms to manage the rate of runoff from agricultural sources. Introducing comprehensive monitoring systems within Coastal Regulation Zones (CRZ) rules, Water Act, 1971, and Environment Protection Act, 1986 will effectively track and regulate runoff, ensuring minimal agricultural runoff into marine systems. Additionally, within the framework of the Paramparagat Krishi Vikas Yojana (PKVY), water quality monitoring protocols that specifically assess nutrient

export from agricultural fields to adjacent water bodies can be integrated. By embedding robust water quality assessments into PKVY, managing the impact of agricultural activities on water bodies can be assessed.

SDG 15: Emphasizing the post-production component, specifically addressing access to markets, credit, and storage units within Sub-Mission on Agroforestry (SMAF), can help strengthen the agri-value chains and sustainable approach to farming practices. This includes allocating resources towards building storage infrastructure, the post-harvest handling of agroforestry produce, and implementing regulatory frameworks that support marketing prospects for agroforestry produce. This recommendation underscores the significance of focusing on the post-production phase within the SMAF framework. Facilitating access to markets and credit for farmers involved in agroforestry will not only enhance their economic prospects but also incentivize the adoption of sustainable agroforestry practices.

SDG 16: The Model Agricultural Land Leasing Act by NITI Aayog offers a framework to address the complexities of land tenancy scenarios, and it is crucial to encourage each state to adopt this Act. This will help ensure standardized regulations and a structured approach to land leasing, providing clarity and stability to the agricultural sector. This approach will not only address issues related to land tenancy but also foster a more inclusive and sustainable agricultural landscape that benefits all stakeholders involved. Collaborative farming presents a more feasible solution as it allows for a structured framework that safeguards the interests of marginal and tenant farmers. By fostering collaboration among farmers, this approach can lead to increased income opportunities, shared responsibilities, and equitable access to subsidies and support mechanisms. In exploring collaborative farming models, it is essential to acknowledge and address the challenges related to trust, uniformity, accountability, and varying contributions among farmers engaged in land leasing agreements.

SDG 17: Establishing partnerships with international organizations often faces challenges due to the lack of a common knowledge-sharing platform. To address this, there is a pressing need for the development of a comprehensive single-window platform that facilitates improved access to data and knowledge for sustainable agriculture. This platform would serve as a centralized hub, fostering collaboration by providing a shared space for the exchange of information and expertise. By bridging the gaps in knowledge sharing, this initiative aims to enhance cross-sectoral collaboration, particularly in the realms of environment and social protection and ensure sustainability in agriculture with shared resources and knowledge.

Some cross-cutting issues include:

Addressing Data Gaps: The foundation of informed decision-making rests on the availability of reliable data. However, data constraints pose a significant hurdle, hindering the development of policies grounded in real-time insights. Addressing this gap involves a strategic overhaul of data collection mechanisms, leveraging technological solutions, and ensuring comprehensive coverage.

Non-Symmetry between State and Central Mandates: Administrative misalignment can lead to disjointed efforts and a lack of cohesive strategies. Bridging the gap between state and central mandates requires enhanced coordination, shared resources, and a unified vision towards achieving SDGs in the agriculture sector.

Strengthening SDG Index: Niti Aayog's SDG Index and state SDG indicator frameworks can be further strengthened by aligning key agriculture-related indicators such as the crop diversification index.

Inefficient Fund Utilization: The financial backbone of sustainable agriculture initiatives is often hindered by inefficient fund utilization. Rectifying this gap necessitates a meticulous

examination of funding mechanisms, ensuring optimal allocation, and implementing accountability measures to track the impact of financial investments.

Absence of Post-Harvest Data: Post-harvest data is crucial for understanding the efficiency and challenges within the agricultural value chain. The absence of this crucial data impedes the development of targeted interventions. Closing this gap involves implementing comprehensive post-harvest data collection methods and integrating this information into policy formulation.

Market Inaccessibility and Non-adaptability: Market dynamics play a pivotal role in shaping the success of sustainable agriculture. However, market inaccessibility and non-adaptability act as barriers. Addressing this gap calls for strategies that enhance market access for farmers, facilitate adaptation to market trends, and ensure fair returns for sustainable practices.

Shelf Life of Schemes/Projects: The sustainability of agricultural schemes and projects is often compromised by a limited shelf life. Prolonging the impact of these initiatives requires a shift towards long-term planning, community engagement, and adaptive strategies that can withstand the test of time.

Focus on Interlinkages between SDGs: Develop a comprehensive understanding of the interconnected nature of SDGs and their implications for sustainable agriculture. This involves mapping the synergies and trade-offs to inform integrated policy frameworks that transcend siloed approaches.

Improve Sync Between State and Centre Government: Enhance coordination and collaboration between state and central governments to ensure a synchronized approach. This involves aligning mandates, sharing resources, and fostering a cohesive strategy towards achieving SDGs in the agriculture sector.

Robust Information System: Establish a robust information system that integrates data from various sources, providing policymakers with accurate and timely information. This system should be designed to facilitate evidence-based decision-making and monitor the progress of sustainable agriculture initiatives.

Improve Feedback Mechanisms: Implement effective feedback mechanisms that allow for continuous evaluation and adjustment of policies. This iterative process ensures that policies remain responsive to the evolving needs and challenges within the sustainable agriculture landscape.

Collaboration between Stakeholders from the Planning Stage: Foster collaboration between diverse stakeholders, including government bodies, private sectors, civil society, and local communities, right from the planning stage. This inclusive approach ensures a holistic perspective and aligns the efforts of all stakeholders towards common goals.

Strengthen Monitoring and Evaluation (M&E) and Projects Sustainability: Strengthen M&E frameworks to monitor the impact and effectiveness of sustainable agriculture projects. Emphasize sustainability by incorporating long-term planning, resource optimization, and community engagement to ensure enduring positive outcomes.

In conclusion, the gaps in the policy interface between sustainable agriculture and SDGs are not merely challenges but opportunities for transformative change. At the crossroads of identified gaps, the road ahead should be paved with a blueprint that not only acknowledges these challenges but transforms them into opportunities. This study, in its pursuit of understanding the synergies and trade-offs between sustainable agriculture and SDGs, serves as a guide for crafting this blueprint. The road ahead requires a concerted effort to bridge these gaps, backed by a blueprint that understands the intricacies of interlinkages, values

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

comprehensive data, and fosters collaboration among stakeholders. As we navigate this terrain, the study's contribution to identifying synergies and trade-offs becomes the cornerstone of policy recommendations, stakeholder mapping, and a nuanced understanding that will guide the sustainable agriculture landscape towards a resilient and equitable future.

CHAPTER 1: SUSTAINABLE DEVELOPMENT GOALS AND SUSTAINABLE AGRICULTURE

Introduction

In 2015, all 193 member states of the United Nations adopted the Agenda 2030 and Sustainable Development Goals (SDGs), also known as the global goals, as a universal call for action to eradicate poverty, safeguard the environment, and ensure peace and prosperity for all by 2030. The 2030 Agenda has 17 overarching SDGs, 169 targets, and 231 unique indicators to track policy development and progress towards these goals (UN, 2023). It is a shared agenda that requires a collaborative response, with countries charting their own paths to national objectives that will necessitate improved governance practices and institutions.

Ending hunger, increasing food security, boosting nutrition, and promoting sustainable agriculture are embedded in Goal 2 of the SDGs. The number of people suffering from food insecurity has been steadily increasing between 2014 and the onset of the COVID-19 pandemic and increased even further during the pandemic. Additionally, the COVID-19 crisis has made all types of malnutrition worse, especially in children. Further, the Ukraine conflict has affected the global food supply systems. It has pushed up the cost of food, fuel, and fertilizer. Supply chains and international trade have been further disrupted, and the financial markets have been distressed (UN, 2022). The war's impact on volatile, high commodity, and energy costs, which also spurred inflation in many regions of the world, made food shortages worse.

Intergovernmental Panel on Climate Change (IPCC WG II, 2022) estimates that cataclysmic wildfires, floods, droughts, and heatwaves are already harming billions of people worldwide and could cause irreparable harm to the earth's ecosystems. Due to climate change, the resilience, natural adaptive capacity, and seasonal timing of ecosystems have all significantly deteriorated, with negative socio-economic repercussions (IPCC, 2022). The Koronivia Joint-work on Agriculture, adopted by the Conference of the Parties at its 23 session in Bonn in 2017, calls for the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI) to work together to address issues relating to agriculture by taking into account its vulnerabilities and methods for addressing food security through identifying the components: (i) approaches and strategies for evaluating resilience, co-benefits of adaptation, and adaptability; (ii) improved nutrient use and manure management for resilient and sustainable agricultural systems; (iii) improved soil carbon, soil health, and soil fertility under grassland and cropland; (iv) improved livestock management systems; and (v) socio-economic and food security aspects of climate change in the agricultural sector (UNFCCC).

In 2021–22, 45.5% of total workers in India were employed in agriculture, according to the Periodic Labour Force Survey (MOSPI 2023a). For the same period, the agriculture sector also employed 62.9% of the female workforce and 38.1% of the male workforce in India (MOSPI 2023a). The agriculture sector is also a major source of raw materials for a variety of domestic businesses and a significant contributor to foreign exchange. According to the Second Advance Estimates of National Income, MoSPI, the share of gross value added (GVA) of agriculture and allied sectors in the total economy (at current prices) accounts for 18.3% of total gross domestic product (GDP) (at current prices), with a 3.3% increase in GVA (at 2011–12 prices) for the fiscal year 2022–23 (MOSPI, 2023b). Subsidies for fertilizers, pesticides, seeds, water, power, and finance, as well as market support prices, have all contributed to the robust agricultural output rise in the recent decade as per Vision 2030 (MOAFW, n.d.).

Despite significant advancements, there are still concerns about poverty and food insecurity in India. As per the Global Hunger Index (2022), India ranks 107 out of 121 countries. The Food and Agriculture Organization (FAO) estimates that the Food Price Index rose by 30% in 2021–2022. A country’s food security is upheld when there is sufficient food, everyone has the means to purchase food of acceptable quality, and there are no barriers to access. Sustainable agriculture plays a pivotal role in the overall strategy to end hunger, enhance nutrition, and achieve food security.

Agricultural sustainability has emerged as a critical priority within the overall strategy to end hunger, enhance nutrition, and achieve food security. Agriculture in India is at the crossroads of three of the most pressing challenges of the 21st century: *sustaining food and nutrition security, adapting to and mitigating climate change, and ensuring the sustainable use of vital resources such as water, energy, and land* (Vision 2030, MOAFW, n.d.). This will necessitate a fundamental change in our approach to agriculture and shift our approach from incremental change to transformational change.

Agriculture value chains and food systems in developing countries are complex and have pre-production, production, and post-production phases. In India, they serve as one of the most important sources of employment and livelihoods. They are made up of interconnected networks that connect various stakeholders, such as farmers, agricultural workers, input providers, and traders. Sustainable food value chain development employs a holistic strategy incorporating the three key components of sustainable development: economic, social, and environmental. A value chain is considered sustainable in the economic dimension if the activities involved by each stakeholder are commercially viable or feasible. Food value chains also need to be socially acceptable, with equitable distribution of benefits and costs of enhanced value production. Environmental sustainability refers to the ability of value chain actors to generate positive or neutral impacts on the natural environment from their actions.

India’s National Agricultural Policy accords high priority to sustainable agriculture. The Vision 2030 for SDG 2 positions ‘sustainable agriculture’ as a fulcrum in the overall strategy to end hunger, improve nutrition, and achieve food security (MOAFW, n.d.). The National Food Security Act (2013) of India is the world’s largest Right to Food Programme, allocating subsidized cereals at around 90% below the retail price to more than 800 million people. The Vision 2030 document for SDG 2 identifies that the major concerns for food security are the challenges faced by Indian agriculture. Sustainable agriculture, according to Vision 2030 for SDG 2, involves building local capacities, promoting sustainable use of natural resources, ecological protection, and addressing climate change. The National Mission on Sustainable Agriculture, which is one of the eight missions of the National Action Plan on Climate Change (NAPCC), is leading these initiatives, focusing on ten essential dimensions encompassing Indian agriculture, namely, ‘improved crop seeds, livestock and fish cultures’, ‘water-use efficiency’, ‘pest management’, ‘improved farm practices’, ‘nutrient management’, ‘agricultural insurance’, ‘credit support’, ‘markets’, ‘access to information’, and ‘livelihood diversification.’

There is a knowledge gap in terms of examining both synergies and trade-offs across the SDGs when it comes to sustainable agriculture. As a result, initiatives and action plans for sustainable agriculture are largely restricted to specific departments within the Ministry of Agriculture and Farmers Welfare (MoAFW). For integrated approaches to sustainable agriculture that also consider the social, economic, and environmental components in a cogent manner, it is necessary to comprehend the connections between the SDGs. For instance, the National

Mission for Sustainable Agriculture (NMSA) (Ministry of Agriculture and Farmers Welfare) is not integrated with the Skill India Mission (Ministry of Skill Development and Entrepreneurship), which supports the development of the framework for technical and vocational training. The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), which includes activities related to natural resource management (NRM), can contribute to the mandate of NMSA. However, both ministries operate in silos. Thus, there is a need for a comprehensive mapping to inform integrated approaches and how various ministries might cooperate to achieve the shared SDGs. Against this background, the study aims to inform integrated approaches by mapping synergies of sustainable agriculture across SDGs.

Research Gaps

The 2030 Agenda for Sustainable Development envisions a secure world free of poverty and hunger, access to quality education and healthcare, gender equality, and an end to environmental deterioration through the integrated and indivisible concept of SDGs. However, the agenda provides little insight into what indivisibility means in practice and how different SDGs interact with each other in real-world scenarios. Limited information is available on what it means to take an integrated approach towards achieving the SDGs. There is still a need for comprehensive studies on the interactions between the 169 SDG targets.

There is still a lack of literature that comprehensively analyses the identified SDG interlinkages. Most available studies are restricted to the SDG interlinkage analysis by generic identification. They have not conducted a comprehensive assessment of these interactions regarding the quantification of SDGs. The use of SDG interlinkages as a pragmatic source of information to enhance SDG integration and policy coherence in the real policy world is constrained by all these limitations. This gap is linked to the need for policy innovation and integrated monitoring and evaluation of the targets and indicators.

Despite having an exhaustive and complex agricultural value chain in India, the linkages between SDGs and various components in the value chain have not been studied. Currently, the approach in Indian policy on sustainable agriculture does not consider the value chain-based approaches. To develop effective policy frameworks in India, it is important to address these linkages involving diverse groups of actors from the government departments, private sector, and civil society across the value chain.

Working Definition of Sustainable Agriculture

According to FAO, sustainable agriculture is an approach that seeks to improve livelihoods and foster inclusive economic growth while enhancing the resilience of people, communities, and ecosystems (FAO, n.d.). Sustainable agriculture also involves adapting governance structures and practices to address new challenges and promote the sustainable use of natural resources. According to the United States Department of Agriculture (USDA), it involves farming practices that aim to protect natural resources and the environment, maintain and improve soil fertility, and meet human needs for food and fibre (USDA, n.d.). Piñeiro et al. (2021) define sustainable agriculture as involving utilizing natural resources more efficiently, reducing the environmental impact of agriculture, and building resilience to climate change and variability.

India's NMSA aims to advance sustainable agriculture in the country by implementing adaptation measures that focus on ten critical dimensions of Indian agriculture, including improved crop seeds, livestock, and fish cultures; efficient water use and pest management;

better farm practices; nutrient management; agricultural insurance; credit support; market access; and livelihood diversification (NMSA, n.d.).

While the definitions of sustainability highlight crucial factors such as productivity, improving livelihoods, environmental sustainability, and socio-economic aspects, these do not consider the dimension of agricultural value chains.

For the purpose of this study, the working definition of sustainable agriculture is as follows:

Sustainable agriculture involves practices across agricultural value chains that lead to ecosystem integrity, enhanced productivity, economic viability, improved livelihoods, resilience, inclusivity, biodiversity conservation, and food security while reducing negative environmental impacts. It aims to take holistic approaches considering the needs of the present and future generations by recognizing interdependence across sustainable development goals, which include the dimensions of environmental sustainability, social inclusion, and economic growth.

Rationale

The importance of addressing hunger by ensuring food security through sustainable agricultural practices has found resonance in the SDGs. To maintain food security across temporal and spatial dimensions, sustainable agriculture must be viewed through the lenses of climate change, SDGs, value chain, and multi-stakeholder approach. Although the value chain is frequently overlooked in discussions about sustainable agriculture, existing literature suggests that it plays a vital role by affecting sustainable farming practices through the demand and supply cycle and, therefore, must be integrated into the agricultural schemes and policies to ensure sustainability. Additionally, it is important to establish links between the different parts of the value chain to promote sustainable agriculture throughout the value chain. To attain sustainability in agriculture, it is crucial to recognize its linkage with other SDGs and within targets to emphasize the harmonization of efforts and balance trade-offs. Communication channels must be established to encourage collaboration and concrete planning for effective governance and ensure better financial resource allocation. This approach promotes working together rather than in isolation, thereby improving decision-making and resource efficiency.

This study aims to provide insights into the interlinkages between sustainable agriculture and other SDGs in India. It will identify potential synergies and trade-offs. Additionally, the research will map relevant stakeholders and their roles in adopting sustainable practices, which will help inform decision-making in the future. The research has incorporated the potential of value chain components, including pre-production, production, and post-production activities, to ensure the adoption of sustainable agricultural practices across the chain. Finally, the study will identify opportunities for improvement in sustainable agricultural practices in crop-based value chains in India, which can be useful for future research and interventions.

Research Questions

Question 1: What synergies and trade-offs exist between sustainable agriculture and SDGs?

Question 2: Who are the stakeholders involved in the decision-making processes on adopting sustainable agricultural policies and practices in India?

Question 3: What are the policy gaps and how can these be addressed to promote sustainable agriculture across value chains in India?

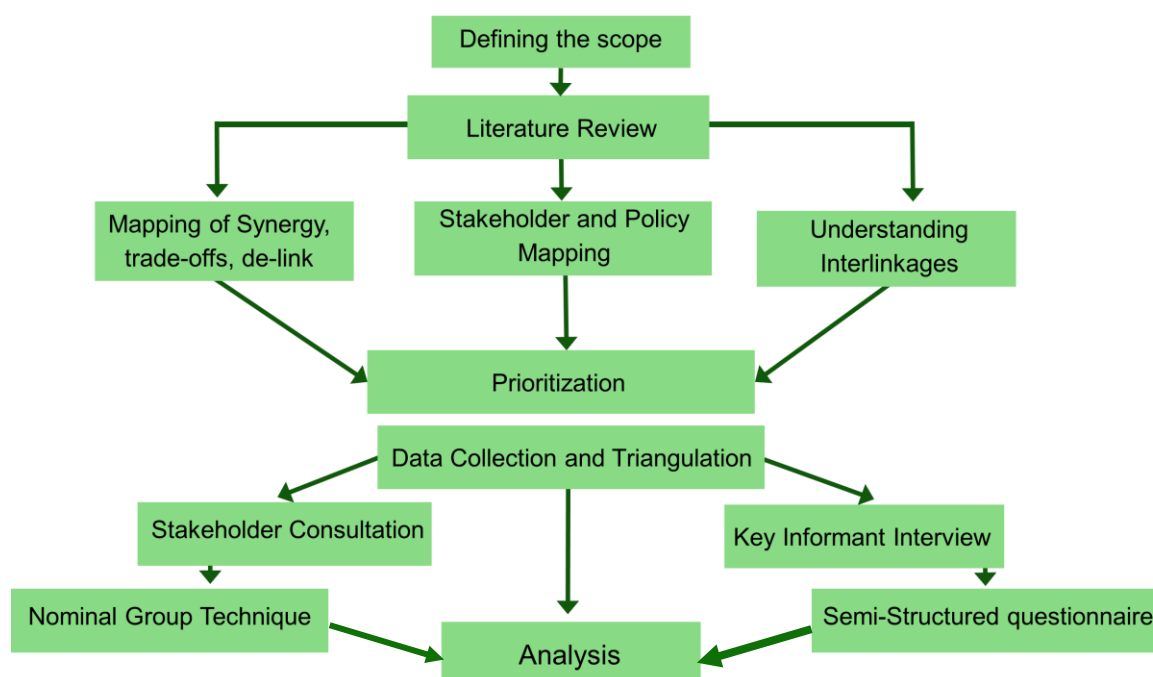
Scope and Limitations of the Study

The study aims to understand synergies and trade-offs between sustainable agriculture and SDGs for informing policies at the national level. It considers crop-based agriculture systems and related value chains, broadly comprising pre-production, production, and post-production stages. However, the study encountered data constraints, especially in the post-harvest stage. This has also been identified as a gap requiring policy intervention.

Methodology

The approach of this study involves an exploratory exercise to understand the synergies and trade-offs between sustainable agriculture and SDGs and the implications for policy and praxis. To achieve this, the study conducted a rigorous literature review using inclusion and exclusion criteria and a meticulous keyword search, providing a solid theoretical framework. The study then progressed to mapping the synergy, trade-offs, and de-linkages inherent in the interface between sustainable agriculture and SDGs. Figure 1.1 illustrates the methodology and the flow of activities followed in this study.

Figure 1.1 Methodology and Flow of Activities



This mapping exercise aimed to unravel the complex relationships and interdependencies within the SDGs. Subsequently, the methodology involved stakeholder and policy mapping, and identifying the key players and policy interventions relevant to the nexus between sustainable agriculture and SDGs. Following this, a prioritization activity was undertaken based on devised criteria, adding a layer of strategic focus to the study. The data collection process encompassed a thorough triangulation approach for fact-checking and validation. Stakeholder consultation played a pivotal role, employing the nominal group technique, while key informant interviews, conducted through semi-structured questionnaires, provided rich qualitative insights and validation of the findings. The culmination involved consolidating inputs and conducting a detailed analysis of the findings, ensuring a robust and nuanced exploration of the study's objectives.

In the prioritization phase, various strategies and criteria were undertaken to discern the most impactful policy interventions at the intersection of sustainable agriculture and the SDGs. The authors used the following criteria in guiding the prioritization process:

Criterion 1-Strong Component of Sustainable Agriculture: Policies emphasizing a robust foundation in sustainable agriculture were given precedence, including the National Mission on Sustainable Agriculture (NMSA). This involves implementing interventions that align closely with the principles of sustainable farming practices. Policies were also prioritized that promote agroecological methods, resource efficiency, and biodiversity conservation as integral components of sustainable agriculture.

Criterion 2-Climate Resilience: Recognizing the imperative to address climate change impacts, interventions that enhance the resilience of agricultural systems in the face of climate variability and extremes were prioritized. The Pradhan Mantri Fasal Bima Yojana (PMFBY) is an example of such an intervention. Policies that deal with climate-smart agriculture practices, such as groundwater depletion, clean energy transitions, and climate-resilient crop varieties, were focused on.

Criterion 3-Value Chain Focus: Acknowledging the significance of the entire agricultural value chain, policies that target improvements at every stage, from production to consumption, were given preference in this study. The Pradhan Mantri Kisan Sampada Yojana (PMKSY) is one such policy that prioritizes interventions that enhance efficiency, reduce waste, and ensure fair returns for all stakeholders in the agricultural value chain.

Criterion 4-Addressing All Components of Working Definition: To ensure a comprehensive approach in the study, policies that address all the components of the working definition of sustainable agriculture, including economic viability, social equity, and environmental stewardship, were prioritized. For instance, the NMSA. In addition, policies promoting the adoption of integrated farming systems that balance economic profitability, social inclusivity, and environmental conservation were also given priority.

Criterion 5-Issue-based and Immediate Address: The study prioritized interventions that address pressing issues in sustainable agriculture and SDGs, focusing on immediate impact and resolution, aiming for quick and tangible improvements such as the NDMP.

Criterion 6-Working on How to Balance Trade-Offs: The study recognized that when making policy decisions, it is important to recognize the inherent trade-offs and prioritize strategies that actively work towards balancing competing interests and minimizing negative consequences such as Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyaan (PM-KUSUM).

The study focused on the linkages between sustainable agriculture and the social, economic, and environmental aspects of agricultural value chains. To ensure that decision-making in sustainable agriculture is evidence-based, the study utilized various tools. It also emphasized the need for integrated approaches in agricultural value chains.

Systematic Literature Review

The study employed a systematic literature review as one of its research methods. This systematic review involved the systematic use of keyword searching, using specific keywords such as sustainable agriculture, climate change, and groundwater depletion, to explore the intersections and trade-offs between sustainable agriculture and policy issues. Additionally, the methodology incorporated the use of Boolean operators to precisely narrow down and yield specific search results during data collection. Some of the search prompts that were used included sustainable agriculture and groundwater depletion, sustainable agriculture and climate change, and sustainable agriculture and pollution or emissions. To gather data for the study, both scholarly journal articles and grey literature sources were consulted.

Stakeholder Mapping

Stakeholder mapping has been used to analyse the interests and influence of key project stakeholders. In this study, stakeholder mapping was done to analyse national policy stakeholders. The aim was to understand their relevance to value chains and SDGs in the context of sustainable agriculture.

Metrics

To understand the overall state of sustainable agriculture in India, a composite index was developed by identifying indicators. The indicators include the percentage of area under the National Agro-Forestry & Bamboo Mission; the percentage of area under organic farming; crop diversification index; consumption of chemical fertilizers including Nitrogen, Phosphorus, Potassium or NPK (in kilograms per hectare); percentage of assessment units with over-exploited groundwater levels; percentage of farmers benefitted in PM Fasal Bima Yojana (crop insurance scheme); percentage of components installed under PM Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana; and percentage of area covered under PM Kisan Sinchayee Yojana (micro-irrigation scheme). The selection of these indicators is based on data availability and relevance to SDGs at the state/union territory levels.

Nominal Group Technique

Expert consultations were held using the nominal group technique (NGT). It is a structured method for group brainstorming that facilitates responses and agreement on the relative importance of issues and subjects. For the study, the exercise involved the following:

- Identification of experts in the fields of agriculture with relevant knowledge of SDGs.
- Creation of groups and stating the question or issue that emerged out of the literature review and preliminary deliberations.
- Recording the discussion of the responses of each team member in turn by the facilitator.
- Prioritization of the recorded ideas in relation to the original question/issue using multi-voting or list reduction supplemented by a collective discussion on the subject.

The study engaged a diverse group of experts working in the field of agriculture and having knowledge of the subject matter. The number of experts consulted for this study was 123, which was based on convenience sampling. The expert consultations commenced with a common brief on the interlinkages between the SDGs and sustainable agriculture. A framing presentation, incorporating the study's objective and approach, was given to provide a foundation for deliberations. Experts were then distributed into breakout groups based on their assigned SDGs. Within these breakout groups, the experts were provided with an initial briefing on policy issues and emerging solutions, with a particular focus on identifying barriers and opportunities based on the study's findings. The NGT data collection tool was employed

with a structured format for group brainstorming that facilitates responses and consensus on the barriers, opportunities, and other ideas related to the subject of discussion. Experts were organized into groups to facilitate a focused discussion. Each group was presented with a specific discussion on their assigned SDGs derived from a literature review and preliminary research findings. A collective discussion was conducted to achieve consensus and agreement on the policy interface discussions. Each expert's response was collected and documented for further analysis. The five expert consultations for SDGs were undertaken as per Table 1.1.

Table 1.1: Expert Consultations for the Study

Date of Consultation	SDGs for Deliberation
22 September 2023	SDG 7, SDG 13, SDG 14
26 September 2023	SDG 1, SDG 3, SDG 4, SDG 5
5 October 2023	SDG 2, SDG 6, SDG 15, SDG 16
10 October 2023	SDG 8 and SDG 17
12 October 2023	SDG 9, SDG 11, SDG 12

Key Informant Interview

A key informant interview (KII) is a helpful tool to understand the respondent's perception, knowledge, and opinion without any literacy requirements. A few selected people were chosen because they possessed information or ideas due to their work or position/involvement. KII is a qualitative interview method that collects needed information, ideas, and insights based on guiding questions. KII is beneficial in understanding the underlying motivations, practices, and attitudes of a target population (policymakers). For this study, policymakers were identified to understand their perception of the interlinkages between SDGs and sustainable agriculture in the context of food security, livelihoods, and ecosystem integrity. The study conducted KIIs with key stakeholders, namely the Ministry of Agriculture and Farmers Welfare (MoAFW), National Bank for Agriculture and Rural Development (NABARD), Ministry of Earth Sciences, Reserve Bank of India, NITI Aayog, and Central Ground Water Board. The interview focused on each department's responsibilities and mandate, leading to policy recommendations derived from SDG analysis and stakeholder consultations.





Stakeholder Validation

The stakeholder validation research method is a process used for gathering feedback and input from various stakeholders on a specific topic or project. It involves identifying and engaging with key stakeholders who have an interest in or are affected by the project or initiative. The stakeholders may include individuals, groups, organizations, and communities with different perspectives, experiences, and knowledge related to the project. In the current study context, the stakeholder validation research method was used to engage agricultural experts, policymakers, and other relevant stakeholders to validate the feasibility, effectiveness, and social, economic, and environmental impacts of different sustainable agricultural practices. This method helped to ensure that the practices were aligned with the needs and priorities of the stakeholders and could be implemented and scaled up effectively. The study's findings were validated on 9 November 2023 through a validation workshop. This workshop fostered cross-sectoral discussions and dialogue among the key stakeholders. The aim was to shape integrated national strategies by identifying links and policy intersections between SDGs and sustainable, climate-sensitive agriculture.

CHAPTER 2: SUSTAINABLE AGRICULTURE IN INDIA AND KEY INDICATORS

To understand the state of sustainable agriculture practices and national schemes, eight indicators were selected based on four themes (Table 2.1). The latest available and accessible data was taken.

Table 2.1: Key Indicators on Themes of Water, Land, Energy, and Climate Risk

Theme	Indicators
Water 	<ul style="list-style-type: none"> Percentage of area covered under Pradhan Mantri Krishi Sinchayee Yojana Percentage of assessment units with overexploited groundwater levels
Land 	<ul style="list-style-type: none"> Percentage of area under organic farming Crop diversification index Consumption of chemical fertilizers (in kilograms per hectare) Fund expenditure under the National Agro-Forestry and Bamboo Mission
Energy 	<ul style="list-style-type: none"> Percentage of components installed under Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana
Climate Risk 	<ul style="list-style-type: none"> Percentage of farmers who benefitted from Pradhan Mantri Fasal Bima Yojana

Water

Micro-irrigation schemes, such as the On Farm Water Management (OFWM) and Per Drop More Crop (PDMC), can serve as significant indicators in promoting efficient and sustainable water use in agriculture, which aligns closely with the various SDGs. Micro-irrigation enhances water efficiency, reducing wastage and pollution of freshwater resources, and contributes to the goal of ensuring clean and sustainable water sources for agriculture and communities. By increasing crop yields, food production, and farmer incomes, these schemes directly contribute to the goal of achieving food security and zero hunger. Efficient water use through micro-irrigation can also mitigate climate change emissions by reducing the carbon footprint of agriculture, thus aligning with the goal of climate adaptation and resilience.

The data provided in Figure 2.1 offers insights into the net irrigated area and the adoption of drip and sprinkler irrigation systems through the OFWM and PDMC schemes in various states for 2020–21.

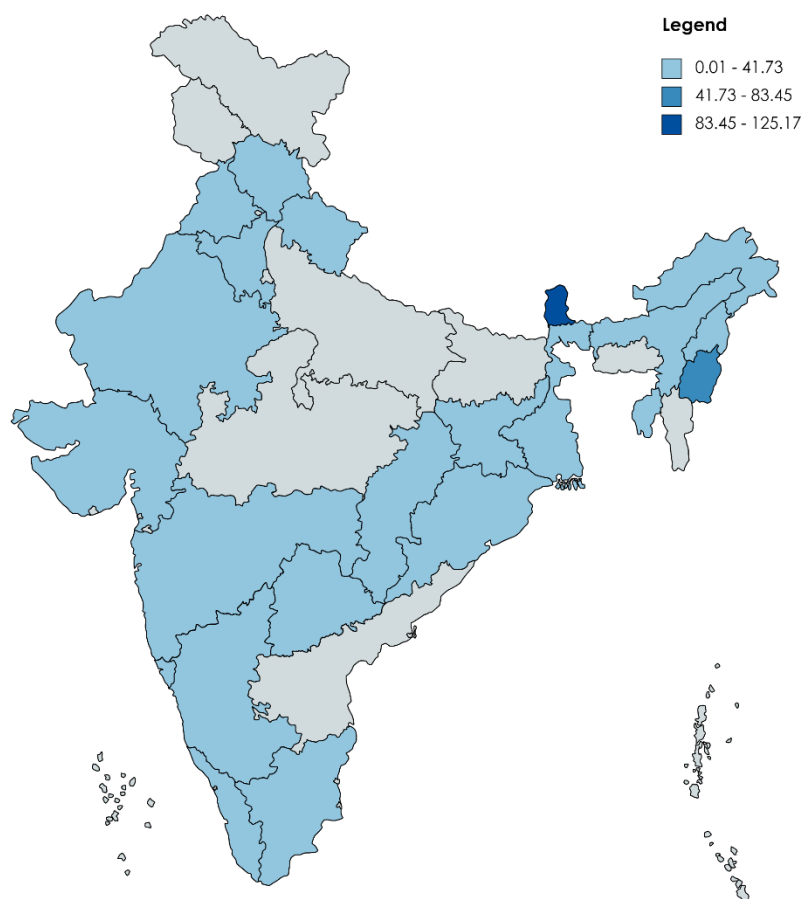
Drip irrigation is widely used in Sikkim, covering an area of 166.58% of the net irrigated area. This indicates that this water-efficient technology is extensively used in the state. Karnataka and Telangana also have notable adoption rates, with 1.33% and 3.53%, respectively, indicating the promotion of water-efficient agriculture in these states.

Sikkim and Manipur have made significant efforts to improve water-use efficiency in their net irrigated areas by adopting sprinkler irrigation systems, covering 19.16% and 6.46% of their net irrigated areas, respectively. This indicates efforts to improve water-use efficiency, particularly in water-scarce regions. However, states like Madhya Pradesh and Meghalaya have reported minimal or nil adoption of drip irrigation systems, suggesting a need for greater

promotion of these technologies. In contrast, Tripura has a relatively high adoption of drip irrigation (8.28%) but nil adoption of sprinkler systems.

The data reveals regional disparities in the adoption of these technologies. States such as Maharashtra, Chhattisgarh, and Gujarat have made significant progress in adopting drip and sprinkler systems, while some northeastern states show low or no adoption. States with low adoption rates have significant potential to enhance their water-use efficiency and agricultural productivity by expanding the use of drip and sprinkler irrigation systems.

Figure 2.1 Micro-irrigation based on OFWM Scheme and PDMC Data for FY 2020-21



Note: For areas in grey, data was not available

States	Net Irrigated Area 2020-21	Area Covered under Drip Irrigation Systems through OFWM and PDMC	Area under Drip Irrigation (in percent)	Area Covered under Sprinkler Irrigation Systems through OFWM and PDMC	Area under Sprinkler Irrigation 2020-21 (percent)
Andhra Pradesh	2,936,000	0	0.00	-	-
Arunachal Pradesh	62,000	3,404	5.49	3,494	5.64
Assam	431,000	1,834	0.43	4,897	7.90
Bihar	3,044,000	1,275	0.04	-	-
Chhattisgarh	1,599,000	3,807	0.24	14,827	23.91
Goa	22,000	50	0.23	82	0.13
Gujarat	557,1000	65,239	1.17	36,090	58.21

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

States	Net Irrigated Area 2020–21	Area Covered under Drip Irrigation Systems through OFWM and PDMC	Area under Drip Irrigation (in percent)	Area Covered under Sprinkler Irrigation Systems through OFWM and PDMC	Area under Sprinkler Irrigation 2020–21 (percent)
Haryana	3,579,000	4,206	0.12	8,240	13.29
Himachal Pradesh	117,000	1,034	0.88	1,017	1.64
Jammu and Kashmir	319,000	605	0.19	415	0.67
Jharkhand	242,000	1,686	0.70	223	0.36
Karnataka	4,931,000	65,803	1.33	255,375	411.90
Kerala	390,000	214	0.05	174	0.28
Madhya Pradesh	12,882,000	-	-	9,564	15.43
Maharashtra	3,114,000	8,154	0.26	14,678	23.67
Manipur	69,000	35,200	51.01	4,455	7.19
Meghalaya	106,000	-	0.00	-	0.00
Mizoram	16,000	-	-	56	0.09
Nagaland	122,000	463	0.38	355	0.57
Odisha	1,200,000	1,165	0.10	10,301	16.61
Punjab	4,126,000	3,291	0.08	351	0.57
Rajasthan	8,778,000	391	0.00	45,870	73.98
Sikkim	14,000	23,321	166.58	2,683	4.33
Tamil Nadu	2,764,000	317	0.01	95,437	153.93
Telangana	3,365,000	118,710	3.53	3,862	6.23
Tripura	90,000	7,448	8.28	-	-
Uttar Pradesh	14,334,000	-	-	49,273	79.47
Uttarakhand	322,000	8,831	2.74	2,356	3.80
West Bengal	3,128,000	1,772	0.06	14,802	23.87

Source: MoAFW (2020)

Sustainable agriculture practices should incorporate water conservation and drought resilience strategies. Therefore, having a comprehensive understanding of groundwater trends is vital for effective planning and adaptation.

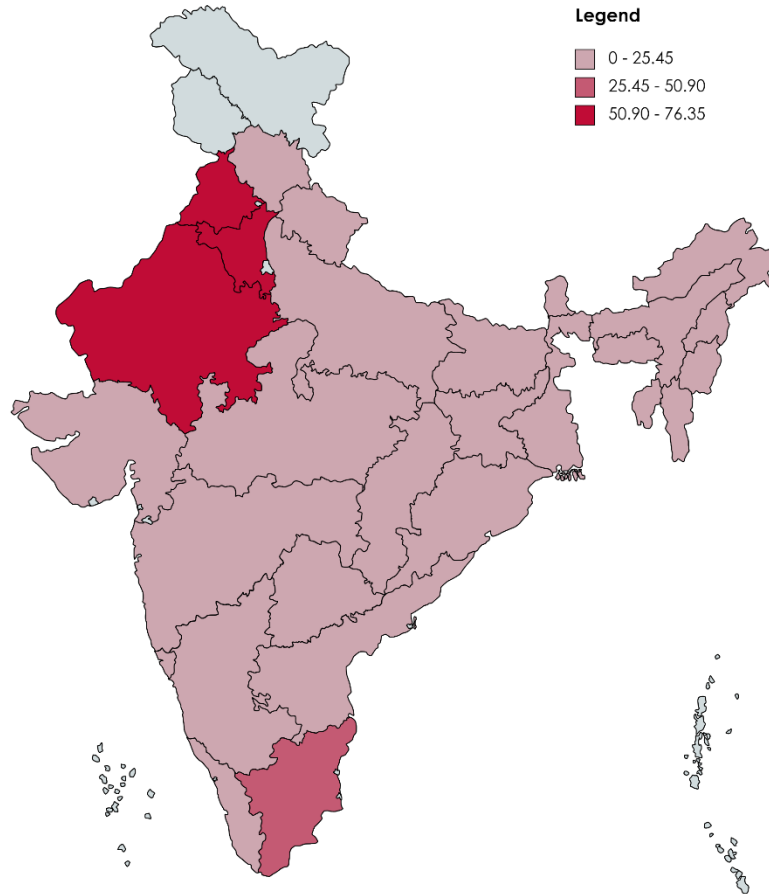
Monitoring and managing groundwater levels is essential for assessing the sustainability of agricultural practices. It serves as a vital indicator for the health and long-term viability of farming. It helps in preventing the overuse of water resources and enables communities and farmers to prepare for and respond to climatic conditions. To understand which regions have the most significant and the least substantial usage of groundwater, it is crucial to evaluate the annual extractable resources (stage of groundwater extraction). This will further help to identify areas with the highest and lowest levels of groundwater utilization.

Groundwater units labelled as ‘overexploited’ are those in which the annual extraction of groundwater substantially exceeds the annually replenishable groundwater recharge. When the extraction falls within the range of 90–100% of replenishment, the units are classified as ‘critical’. Units between 70–90% fall into the ‘semi-critical’ category, while those with extraction below 70% of the annual replenishment are considered ‘safe’ (Figure 2.2).

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

The annual extractable resources vary across states in India. Punjab has the highest number of assessment units falling in the overexploited category (76.35%), followed by Rajasthan (74.85%), Haryana (62.67%), Delhi (45.23%), and Tamil Nadu (27.43%).

Initiatives like Jal Shakti Abhiyan (launched in 2019) aim to improve water availability, including groundwater conditions, in water-stressed regions across India.



Note: For areas in grey, data was not available

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

States	Safe			Semi-Critical		Critical		Over-Exploited	
	Total Annual Extractable Resource of Assessed Units (in mcm)	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
Andhra Pradesh	25,863.17	25,084.22	96.99	492.37	1.9	118.07	0.46	168.51	0.65
Arunachal Pradesh	4,066.15	4,066.15	100						
Assam	21,400.57	21,353.44	99.78	47.14	0.22				
Bihar	30,042.2	27,503.42	91.55	1860.34	6.19	401.65	1.34	276.78	0.92
Chhattisgarh	11,010.29	8,426.53	76.53	2,005.86	18.22	577.9	5.25		
Goa	330.71	330.71	100						
Gujarat	24,581.11	19,980.03	81.28	1,878.92	7.64	702.29	2.86	2,019.87	8.22
Haryana	8,606.22	1,952.4	22.69	713.03	8.28	547.31	6.36	5,393.49	62.67
Himachal Pradesh	938	938	100						
Jharkhand	5,692.32	5,285.92	92.86	215.09	3.78	129.67	2.28	61.64	1.08
Karnataka	16,043.89	9,947.61	62	2,481.16	15.46	680.03	4.24	2,935.09	18.29
Kerala	5,192.77	4,334.83	83.48	714.84	13.77	143.1	2.76		
Madhya Pradesh	32,579.63	22,557.5	69.24	6,068	18.63	536.36	1.65	3,417.77	10.49
Maharashtra	30,447.65	21,887.42	71.89	6,717.16	22.06	795.24	2.61	1,047.83	3.44
Manipur	466.02	466.02	100						
Meghalaya	1,512.99	1,512.99	100						
Mizoram	199.56	199.56	100						
Nagaland	706.94	706.94	100						
Odisha	16,344.68	15,881.29	97.16	463.39	2.84	0	0	0	0
Punjab	17,072.72	2,037.46	11.93	1,327.68	7.78	672.65	3.94	13,034.92	76.35
Rajasthan	10,959.54	1,184.24	10.81	850.48	7.76	721.08	6.58	8,203.74	74.85
Sikkim	244.06	244.06	100						
Tamil Nadu	19,090.2	8,521	44.64	3,949.34	20.69	1,399.73	7.33	5,220.13	27.34
Telangana	19,250.75	17,425.22	90.52	1,578.24	8.2	211.72	1.1	35.56	0.18
Tripura	1,063.57	1,063.57	100						
Uttar Pradesh	65,303.43	45,271.63	69.33	12,632.64	19.34	3,446.56	5.28	3,952.6	6.05
Uttarakhand	1,861.13	1,503.41	80.78	357.72	19.22				
West Bengal	21,417.57	17,152.23	80.08	2,381.7	11.12	1,763.33	8.23		

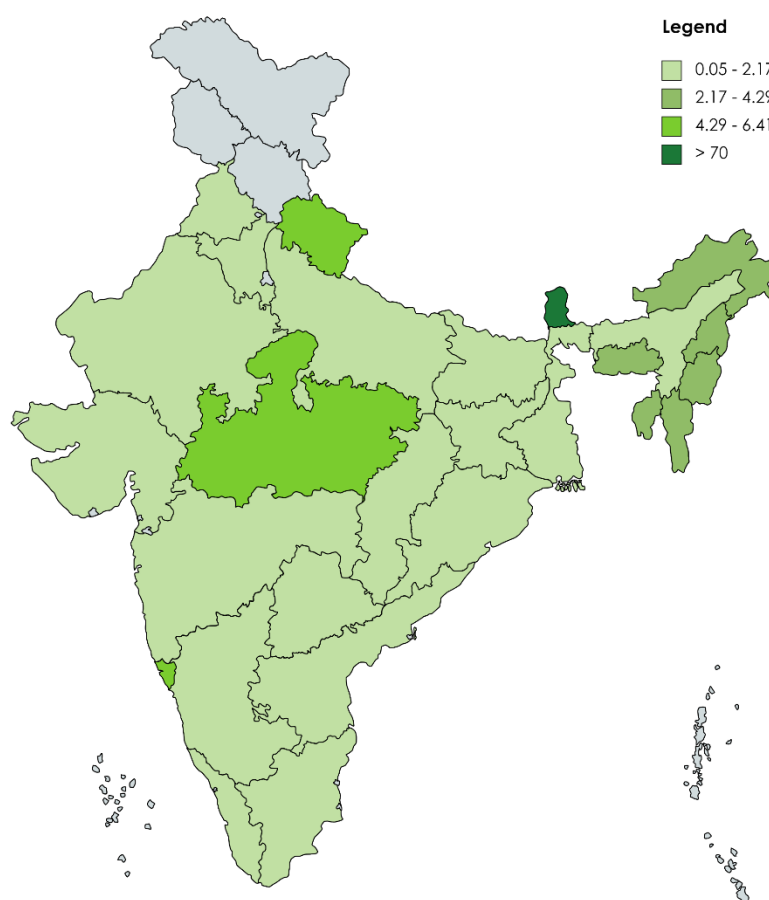
Source: CGWB (2020)

Land

Organic farming promotes the use of natural and organic inputs, which means avoiding the use of synthetic fertilizers and pesticides and prioritizing soil health and biodiversity conservation. In India, the use of organic inputs in agriculture is seen as a means to ensure food security, protect the environment, and improve the livelihoods of farmers.

There are various organic certification bodies that certify farms and products as organic. These certifications help consumers identify genuine organic products and ensure adherence to organic farming standards. In India, two important organic certification systems are the National Programme for Organic Production (NPOP) and the Participatory Guarantee System for Organic (PGS-Organic). Under the NPOP, organic certification is carried out by accredited certification bodies that assess and certify organic farms to ensure they meet the NPOP standards. PGS-Organic is an alternative certification system that involves a decentralized and community-driven approach to certification where local groups of farmers collectively verify and certify the organic status of farms within their community.

For this study, the percentage of area under organic farming as per NPOP certification is used. The data provided gives insights into the area covered under organic farming in 2021 (Figure 2.3). The analysis shows that Sikkim has the highest area under organic farming (78.07%), followed by Goa (6.41%), Madhya Pradesh (5.96%), and Uttarakhand (4.83%). Punjab, Telangana, West Bengal, Haryana, and Uttar Pradesh have the lowest area under organic farming, covering 0.05%, 0.10%, 0.11%, 0.13%, and 0.36%, respectively.



Note: For areas in grey, data was not available

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

States	Area under NPOP Certification (in ha)	Total Agriculture Land in 2018-19 (in ha)	Area under Organic Farming (percent)
Sikkim	75,729.66	97,000	78.07
Goa	12,632.32	197,000	6.41
Madhya Pradesh	1,020,017.98	17,121,000	5.96
Uttarakhand	74,826.4	1,548,000	4.83
Meghalaya	38,376.39	1,011,000	3.80
Mizoram	13,038.89	367,000	3.55
Arunachal Pradesh	13,114.12	424,000	3.09
Manipur	12,724.92	448,000	2.84
Tripura	6,521.31	270,000	2.42
Nagaland	14,790.38	678,000	2.18
Kerala	45,070.38	2,235,000	2.02
Maharashtra	371,722.62	20,719,000	1.79
Himachal Pradesh	11,854	816,000	1.45
Odisha	92,694.81	6,675,000	1.39
Jharkhand	53,261.7	4,319,000	1.23
Rajasthan	298,686.29	25,484,000	1.17
Gujarat	147,866.41	12,661,000	1.17
Karnataka	95,050.08	12,830,000	0.74
Assam	18,470.84	3,305,000	0.56
Bihar	29,902.54	6573000	0.45
Chhattisgarh	23,209.52	5,570,000	0.42
Andhra Pradesh	36,801.36	8,997,000	0.41
Tamil Nadu	31,629.06	8,109,000	0.39
Uttar Pradesh	67,442.61	18,775,000	0.36
Haryana	4,903.06	3,817,000	0.13
West Bengal	6,302.61	5,615,000	0.11
Telangana	6,865.56	6,767,000	0.10
Punjab	2,021.5	4,233,000	0.05

Source: MoAFW (2021)

Crop diversification is a process of introducing new crops or cropping systems to the existing agricultural production on a farm. This process takes into account the various returns from value-added crops. It helps in lowering risks, reducing the likelihood of complete crop failures and economic losses, and maintaining and improving the soil fertility and ecological integrity of a region. Crop diversification is a significant factor in agriculture as it can accelerate and lead to a more sustainable and resilient food production system.

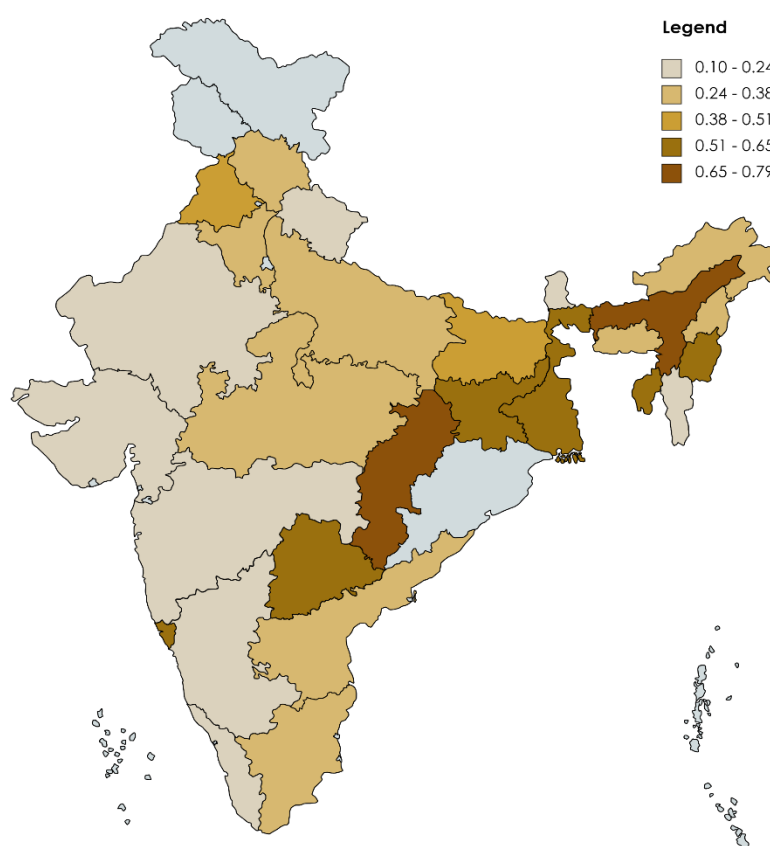
Crop Diversification Index (CDI) is a measure used to assess the extent to which agricultural practices on a farm or a region are diversified by using the Herfindahl–Hirschman Index (HHI) formula:

$$CDI = \sum [(\text{Area of each crop} / \text{Total agricultural area}) ^2]$$

The CDI value is an indicator of the level of crop diversification in the area. A high CDI implies that there is a greater variety of crops being cultivated, indicating a diversified agricultural landscape. On the other hand, a low CDI signifies a higher degree of land allocation to only a few primary crops, indicating a lack of diversification.

For the study, the following crops were considered to calculate CDI: rice, jowar, bajra, maize, ragi/marua, wheat, barley, other cereals and millets, potato, tapioca, sweet potato, onions, black pepper, chillies, ginger, turmeric, cardamom, betelnuts, gram, tur/arhar, other pulses, sugarcane, mango, citrus fruits, banana, grapes, pome fruits, papaya, and apple. The top seven states with high CDI are: Odisha (0.79), Assam (0.67), Chhattisgarh (0.65), Jharkhand (0.59), Telangana (0.57), West Bengal (0.57), and Tripura (0.53) (Figure 2.4).

Figure 2.4: CDI for FY 2020–21



Note: For areas in grey, data was not available

States	CDI
Andhra Pradesh	0.29
Arunachal Pradesh	0.34
Assam	0.67
Bihar	0.39
Chhattisgarh	0.65
Goa	0.51
Gujarat	0.14
Haryana	0.37

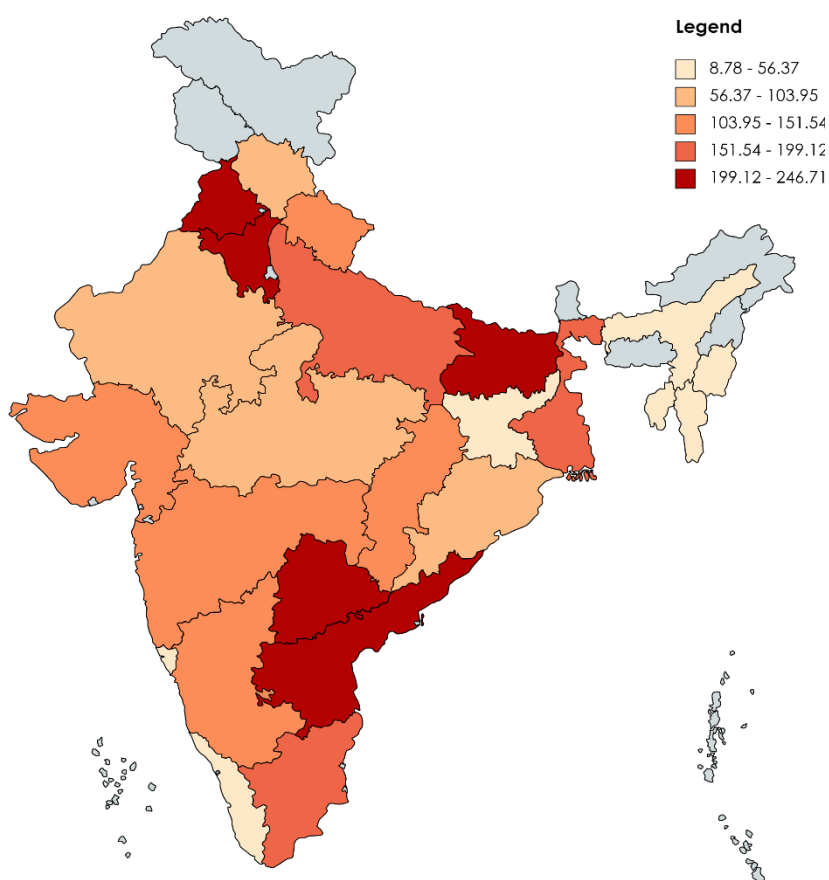
States	CDI
Himachal Pradesh	0.28
Jharkhand	0.59
Karnataka	0.10
Kerala	0.18
Madhya Pradesh	0.29
Maharashtra	0.10
Manipur	0.53
Meghalaya	0.27
Mizoram	0.15
Nagaland	0.36
Odisha	0.79
Punjab	0.46
Rajasthan	0.21
Sikkim	0.18
Tamil Nadu	0.26
Telangana	0.57
Tripura	0.53
Uttar Pradesh	0.28
Uttarakhand	0.21
West Bengal	0.57

Source: India Stat (2021)

Fertilizer consumption (Nitrogen, Phosphorus, Potassium or NPK) levels can be used as an indicator of sustainable farming in a region. This relates to the level of chemical fertilizer used in the production systems. Sustainable agriculture promotes the judicious and balanced use of fertilizers. Farming systems with moderate and well-managed fertilizer consumption indicate a commitment to sustainable practices. However, high and indiscriminate fertilizer use can result in nutrient runoff, water pollution, and soil degradation. This leads to unsustainable practices of agriculture.

State-wise consumption of fertilizers (N, P, K) in kilograms per hectare has been considered for assessing the states with the highest number of fertilizers usage (Figure 2.5). The top five states in terms of fertilizer consumption are Punjab (246.71), Haryana (221.02), Andhra Pradesh (207.64), Bihar (202.83), and Telangana (200.53).

The all-India average consumption of fertilizer (for Indian states) was 118.70 kg per hectare in 2021. This is a significant increase from 89.8 kg per hectare in 2003–04, which was already higher than the preceding year's average of 86.1 kg per hectare. Punjab has the highest usage of fertilizers in the country, primarily to maintain and enhance high crop yields. However, the excessive use of fertilizers has resulted in soil degradation and reduced ecosystem integrity in the region. Persistent, excessive use of chemical fertilizers has led to severe repercussions, and hence, measures need to be taken to discourage farmers from relying heavily on these chemical fertilizers. Per hectare consumption of fertilizers is quite low in Goa, Kerala, Jharkhand, Himachal Pradesh, and Rajasthan, apart from the states in the northeastern region. The data on fertilizer consumption is not available for Arunachal Pradesh, Meghalaya, Nagaland, and Sikkim.

Figure 2.5: Fertilizer Consumption level NPK (kilograms per Hectare) for FY 2020–21

Note: For areas in grey, data was not available

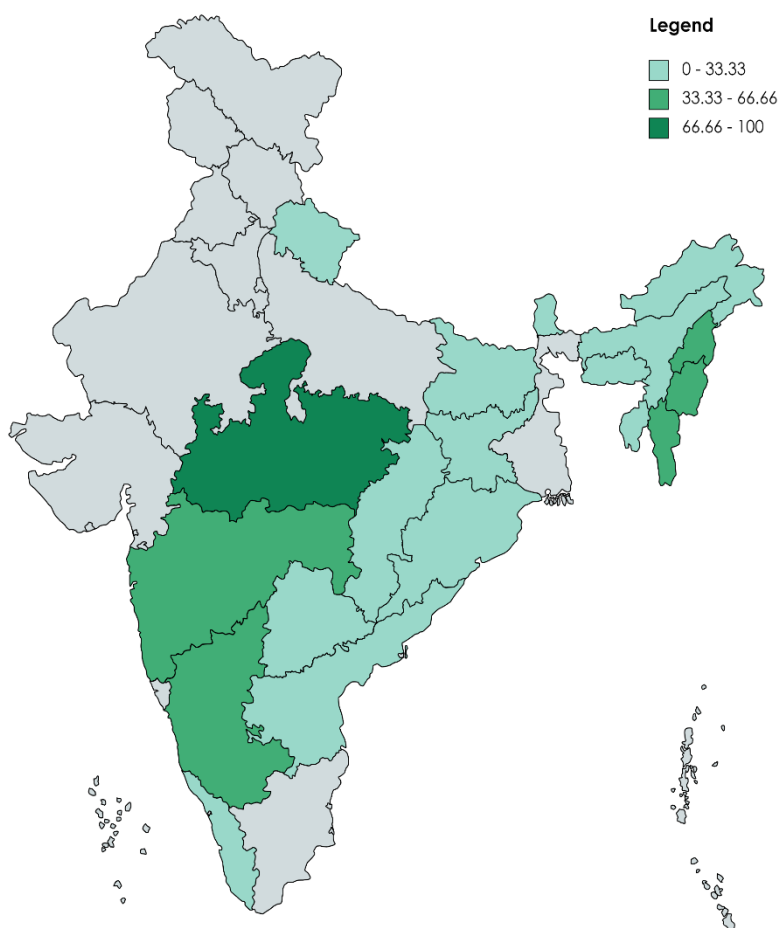
States	N	P	K	Total
Arunachal Pradesh	-	-	-	-
Meghalaya	-	-	-	-
Nagaland	-	-	-	-
Sikkim	-	-	-	-
Punjab	190.81	48.83	7.07	246.71
Haryana	167.05	48.05	5.91	221.02
Andhra Pradesh	116.8	63.49	27.44	207.64
Bihar	136.42	48.61	17.8	202.83
Telangana	129.06	52.36	19.11	200.53
Uttar Pradesh	133.06	47.9	8	188.96
West Bengal	83.93	54.36	43.86	182.15
Tamil Nadu	90.83	37.93	29.12	157.88
Gujarat	99.47	34.7	10.09	144.26
Karnataka	71.91	41.96	21.65	135.52
Delhi	110.46	17.53	2.99	130.98
Uttarakhand	99.39	23.87	6.89	130.15
Chhattisgarh	78.14	40.47	11.09	129.7
Maharashtra	64.33	42.69	22.17	129.19
Madhya Pradesh	75.73	34	4.67	96.40

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

States	N	P	K	Total
Odisha	38.67	19.92	9.47	68.06
Rajasthan	47.17	19.35	0.94	67.46
Himachal Pradesh	41.2	12.28	11.2	64.68
Assam	35.68	11.13	10	56.81
Jharkhand	34.62	13.98	1.37	49.98
Manipur	29.13	6.89	4.37	40.39
Kerala	17.35	7.48	14.79	39.62
Goa	18.12	9.52	9.83	37.47
Tripura	13.82	11.75	4.92	30.5
Mizoram	7.76	1.02	0	8.78

Source: MoAFW (2021)

Figure 2.6: Funds Allocation and Expenditure for Bamboo Production under National Agroforestry and Bamboo Mission 2018–19



Note: For areas in grey, data was not available

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

States	Allocation (in lakhs)	Expenditure (in lakhs)	Expenditure (percent)
Andhra Pradesh	11.84 (1.184 million)	0	0
Arunachal Pradesh	22.55 (2.255 million)	0	0
Assam	23.15 (2.315 million)	0	0
Bihar	9.85 (0.985 million)	0	0
Chhattisgarh	4.56 (0.456 million)	0	0
Goa	-	-	-
Gujarat	0	0	-
Haryana	-	-	-
Himachal Pradesh	0	0	-
Jharkhand	6.42 (0.642 million)	0.65 (0.065 million)	10.12
Karnataka	16.73 (1.673 million)	7.72 (0.772 million)	46.14
Kerala	8.28 (0.828 million)	0	0
Madhya Pradesh	21.08 (2.108 million)	21.08 (2.108 million)	100
Maharashtra	19.88 (1.988 million)	9.65 (0.965)	48.54
Manipur	8.99 (0.899 million)	4.5 (0.45 million)	50.06
Meghalaya	5.82 (0.582 million)	0	0
Mizoram	18.94 (1.894 million)	9.5 (0.95 million)	50.16
Nagaland	12.48 (1.248 million)	6.24 (0.624)	50
Odisha	7.54 (0,754 million)	0	0
Punjab	-	-	-
Rajasthan	0	0	-
Sikkim	6.89 (0.689 million)	0	0
Tamil Nadu	0	0	-
Telangana	6.69 (0.669 million)	0	0
Tripura	24.59 (2.549 million)	7.38 (0.738 million)	30.01
Uttar Pradesh	0	0	-
Uttarakhand	14.39 (1.439 million)	5.57 (0.557 million)	38.70
West Bengal	-	-	-

Source: IndiaStat (2019)

The National Agroforestry and Bamboo Mission can serve as a valuable indicator for the Sustainable Development Goals (SDG) blueprint for sustainable agriculture. The mission is aligned with several key SDG objectives, encouraging the integration of trees and bamboo into agricultural landscapes and promoting sustainable land use while addressing multiple SDG targets. By adopting agroforestry practices that enhance soil fertility and crop yields and diversify income sources for farmers, the mission contributes to SDG 2 (Zero Hunger). Additionally, promoting the cultivation of bamboo supports SDG 1 (No Poverty) as it creates income-generating opportunities for rural communities.

Agroforestry practices under this mission help combat climate change (SDG 13) by sequestering carbon, reducing deforestation, and enhancing resilience to climate-related challenges. Moreover, the cultivation of bamboo, a fast-growing and renewable resource, aligns with SDG 15 (Life on Land) by promoting the sustainable management of forests and biodiversity conservation. Additionally, the mission indirectly contributes to SDG 12

(Responsible Consumption and Production) by promoting sustainable resource utilization and reducing the pressure on natural ecosystems.

The data provided in Figure 2.6 shows the allocation and expenditure of funds for bamboo production under the National Agroforestry and Bamboo Mission for various states in India during the fiscal year 2018–19. According to the data, several states, including Madhya Pradesh, Assam, and Karnataka, were allocated funds for bamboo production. However, the actual expenditure is considerably lower or, in some cases, non-existent (Figure 2.6). This indicates that the allocated funds were not fully utilized in many states.

Madhya Pradesh managed to fully utilize its allocated funds for bamboo production projects, followed by Mizoram and Manipur. The latter two utilized 50.16% and 50.06% of their funds, respectively. This suggests that these states have effectively implemented their bamboo production projects. Other states, such as Maharashtra and Nagaland also achieved relatively high expenditure percentages (above 48%), indicating reasonable utilization of their allocated funds. However, several states, including Andhra Pradesh, Arunachal Pradesh, Bihar, Chhattisgarh, Kerala, Meghalaya, Odisha, Punjab, Rajasthan, Sikkim, Tamil Nadu, Telangana, Uttar Pradesh, and West Bengal, did not report any expenditure during the fiscal year 2018–19. This suggests that either bamboo production projects were not initiated in these states or the implementation was minimal. States such as Tripura and Uttarakhand (30.01% and 38.71%, respectively) recorded partial utilization of the allocated funds, indicating room for improvement in terms of fully utilizing the allocated resources.

The data is incomplete for a few states, including Goa, Gujarat, Haryana, Himachal Pradesh, Jammu Kashmir, and Punjab. This is because there is no information available about their allocation or expenditure. This might be due to a lack of reporting or limited participation in the National Agroforestry and Bamboo Mission during that fiscal year.

Energy

The *Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan* (PM-KUSUM) scheme is a significant initiative that promotes sustainable agricultural practices. It can serve as a significant indicator as it aims to promote sustainable agricultural practices by supporting the installation of solar pumps, reducing reliance on fossil fuels, and enhancing energy efficiency in farming. It also aligns with the SDG 7 objective of ensuring access to affordable, reliable, and clean energy. By reducing energy costs and improving irrigation, PM-KUSUM enhances agricultural productivity, contributing to the goal of zero hunger by ensuring food security through sustainable farming practices. Moreover, the scheme helps to mitigate greenhouse gas emissions by promoting solar energy adoption, fostering climate resilience in agriculture, and reducing the environmental footprint of farming operations.

The provided data presents information on the sanctioned and installed capacities of various components under the PM-KUSUM scheme in different states and union territories of India (Figure 2.7).

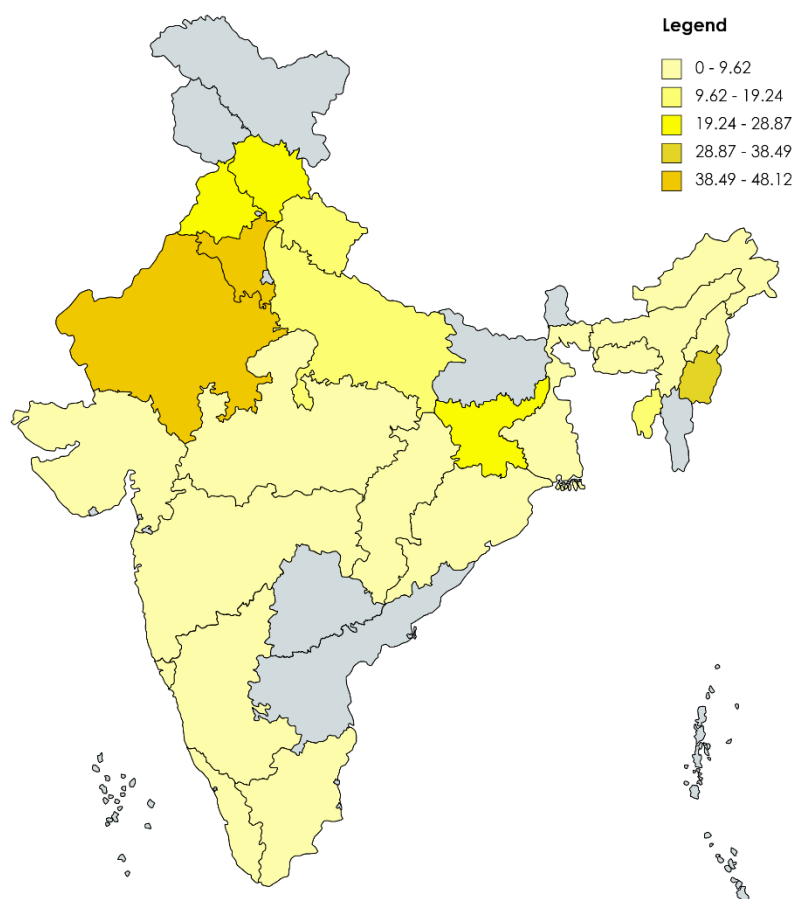
Component-A (MW) and Component-B (Nos): Several states, including Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, and Uttar Pradesh, have received sanctioned capacities for solar power generation (Component-A), but the installed capacities (MW) are significantly lower or non-existent in most of them, indicating that the implementation of solar power generation is yet to be fully realized in these states. The number of solar pump installations (Component-B) varies across states, with some having zero installations while others having substantial numbers.

Component-C (Nos): Many states, including Arunachal Pradesh, Assam, Chhattisgarh, Goa, Karnataka, Kerala, Manipur, Meghalaya, Nagaland, Puducherry, Telangana, Uttarakhand, and West Bengal, have been granted sanctioned capacities for solar water pumps, with individual pump sets (IPS) and family-type lighting systems (FLS) (Component-C). However, the installed capacities in most of these states are either significantly lower or absent. This indicates that these components of the PM-KUSUM scheme are not yet fully operational in these regions.

The data reveals that there are significant regional disparities in the implementation of the PM-KUSUM scheme, with some states, especially in western and northern India, having relatively higher sanctioned capacities and installations. In contrast, other states, particularly in eastern and north-eastern India, have limited or no installations. States such as Gujarat and Maharashtra have relatively high sanctioned capacities and installations, indicating effective implementation of the PM-KUSUM scheme.

On the other hand, states like Jammu and Kashmir, Manipur, Nagaland, and Telangana have received sanctioned capacities but not reported any installations. This highlights the need to ensure that the implementation is carried out in these areas. States with zero installations in all components, such as Goa, Delhi, Ladakh, and West Bengal, may need to explore opportunities for greater utilization of renewable energy through the PM-KUSUM scheme.

Figure 2.7: Status of Sanctioned and Installed Units Components A, B, and C under PM-KUSUM for FY 2021–22



Note: For areas in grey, data was not available

States	Component-A (MW)		Component-B (Nos)		Component-C (Nos)		
	Sanctioned	Installed	Sanctioned	Installed	Sanctioned (IPS)	Sanctioned (FLS)	Installed
Andhra Pradesh	0	0	0	0	0	0	0
Arunachal Pradesh	0	0	50	0	0	0	0
Assam	50	0	1,000	0	603	0	0
Chhattisgarh	30	0	0	0	0	43,265	0
Gujarat	500	0	2,459	459	7,000	39,832	0
Goa	50	0	200	0	11,000	0	0
Haryana	65	2.25	39,326	36,793	0	37,142	0
Himachal Pradesh	30	16	1,180	359	0	0	0
Jharkhand	50	0	16,717	6,717	208	10,000	0
Karnataka	0	0	10,314	314	0	250,000	0
Kerala	40	0	100	0	9,448	2,000	21
Madhya Pradesh	500	0	57,000	7,234	0	187,455	0
Maharashtra	500	0	100,000	5,822	0	250,000	0
Manipur	0	0	78	28	0	0	0
Meghalaya	5	0	35	35	0	10,000	0
Nagaland	0	0	50	0	0	0	0
Odisha	500	0	5,741	997	8,310	1,311	0
Punjab	220	0	12,000	10,131	39	38,111	0
Rajasthan	1,200	38	76,210	44,340	10,764	25,000	1,026
Tamil Nadu	424	0	6,200	1,766	20,000	1,311	0
Telangana	500	0	0	0	0	0	0
Tripura	5	0	3,021	947	2,600	0	0
Uttar Pradesh	225	0	21,842	6,842	0	30,000	0
Uttarakhand	0	0	338	73	200	0	0
West Bengal	0	0	0	0	5,478	0	0

Source: MNRE (2022)

Climate Risk

Pradhan Mantri Fasal Bima Yojana (PMFBY) is a crop insurance scheme sponsored by the Indian government. It aims to help mitigate risks for farmers and promotes sustainable agricultural practices. By providing financial support to farmers affected by natural calamities, the PMFBY helps enhance food security. This contributes to reducing hunger and poverty among rural communities. By safeguarding farmers' income, PMFBY directly addresses the goal of poverty eradication, ensuring that unforeseen losses do not plunge The rural communities further into poverty. The scheme incentivizes farmers to adopt modern agricultural techniques and risk-reduction measures, thereby contributing to land conservation and biodiversity conservation. As climate change poses a significant threat to agriculture, PMFBY helps farmers in dealing with weather-related uncertainties, making it an important tool in climate adaptation and resilience. Additionally, the scheme aims to make crop insurance affordable and accessible to all farmers, thereby reducing income disparities in rural areas.

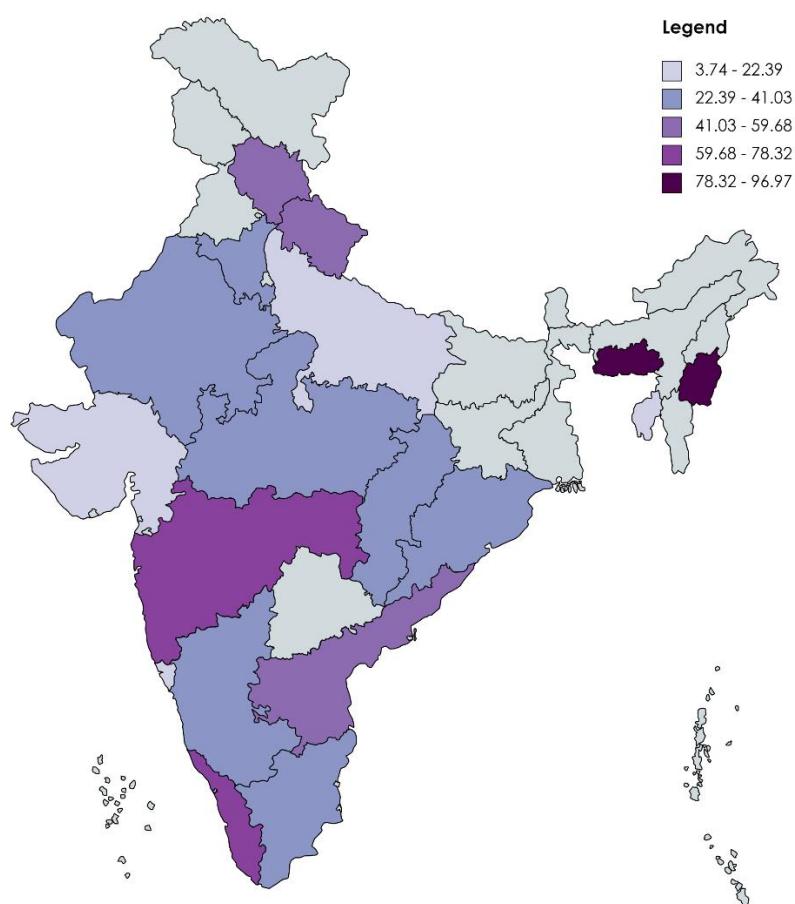
The data provided presents information regarding the number of farmers who applied for crop insurance under the PMFBY, the number of farmers who actually benefited from this scheme,

and the percentage of farmers who benefited in various states (Figure 2.8). In States like Maharashtra and Madhya Pradesh, a relatively high number of farmers apply for crop insurance which indicates a good level of awareness and participation in risk mitigation programmes. However, states like Bihar, Jharkhand, Jammu and Kashmir, and West Bengal do not have any reported data, which could suggest either potential underutilization of the PMFBY scheme or insufficient reporting.

The percentage of farmers who actually benefitted from the PMFBY scheme varies across states. According to the available data, Kerala, Meghalaya, and Manipur have a higher percentage of farmers who benefitted, suggesting effective implementation and support for these farmers. On the other hand, states like Gujarat, Goa, and Uttar Pradesh have relatively lower percentages of farmers who benefitted from the scheme, which may indicate that many applicants did not receive benefits due to various factors, including procedural issues.

States with lower percentages of farmers, such as Gujarat and Goa, may need to improve the effectiveness of the PMFBY scheme to ensure a higher rate of support for their farmers. On the other hand, states with no reported data, such as Bihar, Jharkhand, Jammu and Kashmir, and West Bengal, should consider enhancing reporting and participation to ensure that farmers are aware of and benefit from the scheme.

Figure 2.8: Percent of Farmers Benefitted from PMFBY for FY 2019–20



Note: For areas in grey, data was not available

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

States	Farmers Applications Insured (Lakhs)	Farmer Applications Benefitted (Lakhs)	Farmers Benefitted (in %)
Gujarat	24.81 (2.481 million)	0.927 (0.092 million)	3.74
Goa	0.009 (0.0009 million)	0.001 (0.0001 million)	11.11
Uttar Pradesh	46.947 (4.694 million)	9.343 (0.934 million)	19.90
Tripura	0.364 (0.036 million)	0.077 (0.007 million)	21.15
Odisha	48.769 (4.876 million)	12.078 (1.207 million)	24.77
Rajasthan	85.26 (8.526 million)	25.574 (2.557 million)	30.00
Karnataka	21.316 (2.131 million)	6.869 (0.686 million)	32.22
Haryana	17.111 (1.711 million)	5.552 (0.555 million)	32.45
Tamil Nadu	38.705 (3.870 million)	13.213 (1.321 million)	34.14
Chhattisgarh	40.177 (4.017 million)	15.025 (1.502 million)	37.40
Madhya Pradesh	78.929 (7.892 million)	30.546 (3.054 million)	38.70
Uttarakhand	2.127 (0.2127 million)	0.949 (0.094 million)	44.62
Andhra Pradesh	27.884 (0.2127 million)	13.533 (1.353 million)	48.53
Himachal Pradesh	2.84 (0.284 million)	1.505 (0.150 million)	52.99
Maharashtra	145.642 (14.564 million)	87.895 (8.789 million)	60.35
Kerala	0.581 (0.058 million)	0.457 (0.045 million)	78.66
Meghalaya	0.006 (0.0006 million)	0.005 (0.0005 million)	83.33
Manipur	0.033 (0.0033 million)	0.032 (0.003 million)	96.97
Sikkim	0	-	-
Assam	10.027 (1.0027 million)	-	-
Telangana	10.335 (1.0335 million)	-	-
Jharkhand	10.921 (1.092 million)	-	-
Bihar	-	-	-
West Bengal	-	-	-

Source: MoAFW (2020)

CHAPTER 3: NATIONAL POLICY INTERFACE OF SDGS AND SUSTAINABLE AGRICULTURE

Goal 1. End poverty in all its forms everywhere

Climate-related hazards, both slow-onset shifts and extreme events, are directly affecting vulnerable communities. These hazards are adversely impacting livelihoods, causing losses in agricultural yields, impacting human health and food security, destroying homes, and resulting in loss of income (Connolly-Boutin and Smit, 2016). Agriculture, food systems, and the sustainable use of natural resources are crucial for securing the livelihoods of millions of poor people struggling with poverty worldwide (FAO, 2019). Agricultural development is essential not only for poverty alleviation but also to feed the projected 9.7 billion people by 2050 (The World Bank, n.d.). Growth in the agriculture sector can lead to a two- to four-times increase in income among the poorest compared to other sectors (World Bank, 2023). Farmers who adopt climate adaptation practices experienced higher food security levels (8–13%) and lower levels of poverty (3–6%) than those who did not (Ali and Erenstein, 2017). Achieving agricultural growth through the application of new technologies is one of the most important ways to reduce poverty. However, the impact of such efforts on the rural poor depends on initial conditions, the structure of relevant institutions, and incentives (Khan, 2001). Encouraging farmers to diversify to higher-value commodities will be a significant factor for higher agricultural growth, particularly in rain-fed areas where poverty is high.

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)	<ul style="list-style-type: none"> Ministry of Rural Development 	X	X	X
Pradhan Mantri Gram Sadak Yojana (PMGSY)	<ul style="list-style-type: none"> Ministry of Rural Development 	X		X
Deendayal Antyodaya Yojana (DAY) National Rural Livelihood Mission (NRLM)	<ul style="list-style-type: none"> Ministry of Rural Development National Bank for Agriculture and Rural Development 	X	X	X
Pradhan Mantri Gramodaya Yojana (PMGY)	<ul style="list-style-type: none"> Ministry of Rural Development 	X		
Vanbandhu Kalyan Yojana (VKY)	<ul style="list-style-type: none"> Ministry of Tribal Affairs 	X	X	
National Adaptation Fund for Climate Change (NAFCC)	<ul style="list-style-type: none"> National Bank for Agriculture and Rural Development 	X	X	
Market Intervention Scheme and Price Support Scheme (MIS-PSS)	<ul style="list-style-type: none"> Ministry of Agriculture Cooperation and Farmer's Welfare 			X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)	<ul style="list-style-type: none"> Ministry of Power Rural Electrification Corporation Limited 	X		
Integrated Scheme on Agriculture Marketing	<ul style="list-style-type: none"> Ministry of Agriculture, Cooperation and Farmers' Welfare 			X
<i>Pradhan Mantri Kisan Samman Nidhi</i> (PM-KISAN)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Promotion of Joint Liabilities Groups (JLG's)	<ul style="list-style-type: none"> National Bank for Agriculture and Rural Development 	X	X	X
Pradhan Mantri Fasal Bima Yojana (PMFBY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare Agriculture Insurance Company of India Limited (AICL) 	X	X	X
Rashtriya Krishi Vikas Yojana (RKVY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		X
National Agriculture Market (e-NAM)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
National Mission for Sustainable Agriculture (NMSA)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Pradhan Mantri Kisan Maan-Dhan Yojana (PMKMY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Modified Interest Subvention Scheme (MISS)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Kisan Credit Card (KCC) Scheme	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare National Bank for Agriculture and Rural Development 	X	X	X

Synergies and Trade-offs

Increased agricultural productivity can be beneficial to poor households in various ways. They may gain directly as producers as their income will increase. If the costs decrease more than the prices of the agricultural products, poor households may gain indirectly as consumers through lower prices or as agricultural labourers through increased employment and higher wages (Christiansen and Martin, 2018). Moreover, growth in agricultural productivity not only increases farm incomes but also stimulates linkages to the non-farm rural economy, leading to economic growth and rapid poverty reduction, with the overall growth multipliers almost always significantly greater than one (Hazell and Haggblade, 1993). Well-structured social protection schemes can also play a critical role in reducing poverty. These schemes can minimize the risks of investment in agriculture, benefit agricultural growth more directly, and promote social inclusion, thereby reducing the incidence of poverty (Devereux, 2016). Furthermore, women who own land or have control over assets are better positioned to improve their lives, deal with crises, lower their risk of poverty, and increase food security (LARRDIS, 2023). Therefore, policies to build agricultural resilience in the face of climate change and its impacts should integrate an understanding of gender differences in capacity, needs, and priorities. This will ensure the successful implementation of adaptation actions (Centre for Budget and Governance Accountability, 2021).

On trade-offs, switching crops to sustainable agriculture practices may not be affordable to farmers and may be less profitable than input-intensive agriculture (Kurukulasuriya and Rosenthal, 2003). This is more applicable to small and marginal farmers.

Target	Synergy	Trade-off
Target 1.1: By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.25 a day		
Target 1.2: By 2030, reduce at least by half the proportion of men, women, and children of all ages living in poverty in all its dimensions according to national definitions		
Target 1.3: Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030, achieve substantial coverage of the poor and the vulnerable		
Target 1.4: By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership, and control over land and other forms of property, inheritance, natural resources, appropriate new technology, and financial services, including microfinance		
Target 1.5: By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters		
Target 1.a: Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions		

Target 1.b: Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions		
---	--	--

Gaps and Barriers

The direct linkages between sustainable agriculture, food availability, calorie intake by the poor, and reduction in poverty have been limited (Timmer, 2005). The lack of study and attention on these linkages is a major roadblock to poverty alleviation and agricultural development.

Further, monitoring welfare schemes is of key importance for the success of any programme. It is observed that a major share of resources continues to be absorbed by non-targeted individuals who fall beyond the specified age or income bracket (Asri, 2017).

Due to a lack of data and inadequately utilized methodologies, measuring progress and accountability with respect to governmental assistance remains a challenge (UN DESA, 2009). Additionally, progress towards schemes that focus on women's empowerment and gender equality cannot be accurately tracked owing to under-reporting (Centre for Budget and Governance Accountability, 2021).

Moreover, the SDG India Index captures only three out of seven targets, i.e., Target 1.2, Target 1.3, and Target 1.4. This creates a problem for India as the only metric keeping track of the performance of the SDGs does not cover all the aspects of SDG 1 (Bhambu, 2020). The impacts of sustainable agriculture on multidimensional aspects of poverty remain an area that needs more attention.

Emerging Policy Solutions

Strengthening Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)—Income Diversification and Empowerment: MGNREGA should continue offering alternative income sources to rural households, especially during off-peak seasons. This will allow them to improve livelihood security. Non-farm activities, which provide higher wages, empower farmers to negotiate better terms with buyers, lenders, and other actors in the agricultural value chain, fostering fairer wages.

- **Strengthening agro-ecological practices:** It is important to continue emphasizing water conservation and promoting the construction of water-harvesting structures such as dams and percolation tanks, along with micro-irrigation, under MGNREGA. Additionally, the scheme should encourage agro-ecological practices for sustainable farming, including organic farming and integrated pest management.
- **Sustainable infrastructure and technology:** To improve the effectiveness of MGNREGA projects and promote environmental conservation, the scheme should integrate eco-friendly technologies such as solar-powered pumps and energy-efficient machinery. Additionally, setting up composting systems to recycle organic waste can enhance soil fertility and minimize waste.
- **Sustainable land use:** Encouraging farmers to adopt sustainable land-use practices and diversify crop cultivation is essential to mitigate risks associated with extreme weather events and safeguard crops. This will also enable the farmers to secure their income sources.

- **Equitable resource distribution:** It is critical to address the issue of water availability and ensure equitable access to resources, including water. Strengthening local government capacity for water management through subsidies and grants is vital.
- **Integration with agro-ecological approaches:** MGNREGA should be integrated with agro-ecological measures and incentives for geographical location-based interventions. By enhancing the integration of components of the National Rural Livelihood Mission (NRLM), the impact can be further magnified.
- **Behavioural nudges and awareness:** Strengthening training and capacity building in both NRLM and MGNREGA is essential. Moreover, the promotion of sustainability through village development plans and awareness building can encourage farmers to adopt sustainable practices.
- **Community networks:** To create strong social and community networks for interventions, incentives can be introduced for active self-help groups (SHGs) under NRLM. This will help reduce the influence of middlemen and promote the collective efforts of farmers.

Strengthen Reporting on Metrics for Policy Design and Implementation: Some proposed metrics that could be monitored include the following:

- Percentage of poor farmers and producers who practice sustainable agriculture and who have access to markets.
- Budget allocation for encouraging sustainable agriculture practices in government schemes.
- Market linkage mechanisms for encouraging sustainable agriculture practices among farmers.
- Credit linkage mechanisms for encouraging sustainable agriculture practices among farmers.
- Number of poverty eradication schemes integrating sustainable agriculture through convergence or new components.

Technology Adoption and Synergies: The introduction of technologies such as drones for sustainable livelihoods should be encouraged. Connecting stakeholders, farmer groups, and technologies through existing schemes can be further enhanced by partnering with fintech companies and private sectors that can provide financial incentives.

Market Demand and Climate Resilience through Minimum Support Price: To build resilience among farmers, it is crucial to promote flood-tolerant seeds and increase market demand for livelihood diversification. Minimum Support Price (MSP) can act as an incentive to strengthen the agricultural sector.

Building Trust and Resilience: Addressing liquidity constraints in insurance schemes and promoting trust-building measures, particularly in processing units, can help alleviate issues of distrust among farmers and improve the overall resilience in the agricultural sector.

Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

To ensure food security, agricultural systems must adapt to global influencing factors such as population expansion, shifts in dietary preferences, and the effects of climate change (Hinz et al., 2020). Attaining this objective will entail improving food accessibility and promoting

sustainable farming practices on a large scale. This involves enhancing the efficiency and earnings of small-scale farmers by advocating equitable availability of land, technology, and markets, as well as promoting sustainable methods of food production and resilient agricultural techniques to maintain ecosystem integrity (Department of Economic and Social Affairs, UN, 2016). However, increasing agricultural production and affordability of low-nutrient, energy-rich foods can contribute to macro and micronutrient deficiencies. Farmers have been using fertilizers and pesticides and expanding agricultural land to keep up with the growing population, which has resulted in an increase in agricultural emissions (Hofstra and Vermeulen, 2016).

In India, out of the total net sown area of 139.3 million hectares, rainfed agriculture covers about 69.7 million hectares (Ministry of Agriculture and Farmers Welfare, 2022). This accounts for about 51% of India's net sown area, contributing to nearly 40% of the total food production (Ministry of Agriculture and Farmers Welfare, 2022). This data underscores the vital role that rainfed agriculture plays in ensuring food security in India. However, the condition of rainfed agriculture is precarious as it is highly diverse and prone to various risks. A few of the challenges are low cropping intensity, substantial cost of cultivation, limited adoption of modern technology, unpredictability in crop yields, subpar productivity levels, a rising number of farmer suicides, insufficient access to institutional credit, inadequate public investments, and a high prevalence of rural poverty. Another persistent challenge in Indian agriculture is the practice of monocropping. While India is the second-largest producer of wheat, rice, and groundnuts and also leads in jute production, over 85% of smallholder farmers predominantly engage in monocropping, focusing on crops such as rice, wheat, pulses, spices, vegetables, and various cereals (Mayank, 2021). This heavy reliance on monocropping renders these farmers highly vulnerable to the adverse effects of climate change. Monoculture practices not only affect food production but also contribute to the decline of traditional plant varieties, such as nutrient-rich pulses.

Research conducted under the All India Coordinated Research Project on 'Long Term Fertilizer Experiments' spanning five decades at specific locations has revealed that the exclusive application of nitrogenous fertilizers has adversely affected soil quality and crop yields. This highlights the importance of other essential macro and micronutrients. From 2017 to 2020–21, the utilization of chemical fertilizers (such as Urea and Di-Ammonium Phosphate) in the country amounted to 54.38 million tonnes. Unfortunately, the indiscriminate use of fertilizers and agro-chemicals in agriculture has resulted in the degradation of soil quality, water resources, and biodiversity. As a result, the focus in agriculture is progressively shifting from production to prioritizing the preservation of resources, the restoration of soil health and fertility, and the reduction of negative impacts on both soil and the environment (Ministry of Agriculture and Farmers Welfare, 2023).

The agricultural sector in India has achieved significant success by meeting government-set production targets and establishing new production records for various crop commodities. However, this success has come at a cost as it has led to the degradation of natural resources and adverse environmental impacts. As a result, there has been a decline in overall productivity, depletion of natural resources, stagnant farm incomes, lack of regional ecological approach, diminishing and fragmented landholdings, agricultural trade liberalization challenges, limited job opportunities in non-farm sectors, and the pressing issue of climate change (Singh, 2022). These concerns have emerged as prominent challenges in the growth and development of agriculture in India.

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
National Mission for Sustainable Agriculture (Rainfed Area Development and Soil Health Management)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare Indian Council of Agricultural Research (ICAR) National Centre of Organic Farming (NCOF) Central Fertilizer Quality Control and Training Institute (CFQC&TI) 	X	X	
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Water Resources, River Development and Ganga Rejuvenation Ministry of Rural Development Ministry of Agriculture and Farmers Welfare 	X	X	
Deendayal Antyodaya Yojana (DAY) — National Rural Livelihoods Mission	<ul style="list-style-type: none"> Ministry of Rural Development 	X		
Pradhan Mantri Kisan Sampada Yojna (PMKSY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Paramparagat Krishi Vikas Yojana (PKVY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Rashtriya Krishi Vikas Yojana (RKVY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Pradhan Mantri Kisan Samman Nidhi (PM-KISAN Scheme)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
Development and Strengthening of Infrastructure Facilities for Production and Distribution of Quality Seed	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
National Food Security Mission	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
National Horticulture Mission	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Agri Nutri Garden Project [Initiative under Deendayal Antyodaya Yojana - National Rural Livelihood Mission (DAY-NRLM)]	<ul style="list-style-type: none"> Ministry of Rural Development 		X	
Nutrient-based Subsidy	<ul style="list-style-type: none"> Ministry of Chemicals and Fertilizers 	X		
Urea-based Subsidy	<ul style="list-style-type: none"> Ministry of Chemicals and Fertilizers 	X		
Biotech-Krishi Innovation Science Application Network	<ul style="list-style-type: none"> Department of Science and Technology 		X	
Agriculture Infrastructure Fund	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	X
Crop Diversification Programme [Sub-scheme of Rashtriya Krishi Vikas Yojana (RKVY)]	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
Pradhan Mantri Fasal Bima Yojana (PMFBY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Sub-mission on Agriculture Mechanization under National Mission on Agricultural Extension and Technology	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
Gramin Bhandaran Yojna (GBY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Promotion of National Agriculture Market (NAM)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Integrated Post-Harvest Management – National Horticulture Mission	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare National Horticulture Board 			X
PM Kisan Sampada Yojna (PKSY)	<ul style="list-style-type: none"> Ministry of Food Processing and Industries 			X
National Innovation on Climate Resilient Agriculture	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	

Synergies and Trade-offs

Improving agricultural productivity is critical for addressing both hunger and poverty. It not only increases the amount of food available but also stimulates economic growth by creating jobs, both on- and off-farm. This can raise people's incomes and enable them to purchase food (Uphaus, 2008). Agricultural approaches influence the underlying determinants of various socio-economic and environmental outcomes. They can improve food availability and access, enhance household food security, dietary quality, income, natural resource management, and women's empowerment (Ruel, Quisumbing, and Balagamwala, 2018). Apart from an increase in yield, diversification towards high-value agriculture (fruits, vegetables, fisheries, and livestock) will ensure a diversified food basket, which will also ensure better nutrition (Gulati, Roy, and Saini, 2021). By enhancing technology and capacity-building, agriculture's capacity to adapt to climate change, extreme weather, drought, flooding, and other disasters can also be strengthened (International Council for Science, 2017).

Some of the trade-offs in agriculture are that the government's primary focus is channelled towards maximizing agricultural output, and relatively little attention is devoted to undertaking new research aimed at innovative approaches for efficient utilization of natural resources such as crop diversification and other post-harvest activities such as storage, warehousing, preservation methods, and advancing marketing (Raj, 2018). Additionally, farmers use fertilizers and pesticides, and try to expand agricultural land for agricultural production to keep pace with the growing population, which has resulted in an increase in agricultural emissions as well as depletion of natural resources (Hofstra and Vermeulen, 2016). Further, small and marginal farmers encounter several challenges, primarily stemming from a limited understanding of sustainable farming practices, agro-technologies, and their adoption. The current emphasis on soil carbon sequestration and increased agricultural output, primarily aimed at attracting private investment may have detrimental consequences for small and marginalized farmers in the least developed and developing nations. In countries like India, where most farmers (over 80%) own less than 2 hectares of land, the pursuit of sequestration could result in them forfeiting their land and loss of control over their agricultural output,

freedom of choice, and methods of production to profit-driven private project developers. In terms of agricultural trade, some policies developed to improve food security for the poor, such as price controls, may have perverse impacts, such as depressing farm income (International Council for Science, 2017).

Targets	Synergy	Trade-off
Target 2.1: By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious, and sufficient food all year round		
Target 2.2: By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons		
Target 2.3: By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment		
Target 2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality		
Target 2.5: By 2020, maintain the genetic diversity of seeds, cultivated plants, and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional, and international levels, and promote access to fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed		
Target 2.a: Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries		
Target 2.b: Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round		
Target 2.c: Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility		

Gaps and Barriers

Remote areas often lack access to sufficient or readily available information regarding new seed or plant varieties that farmers require. Farmers are largely unaware of government-supported schemes that support sustainable practices (Alwang et al., 2019; University of Agricultural Science, 2016). Agricultural research, development, and policy continue to place a strong emphasis on increasing production of the three main staple crops (rice, wheat, and maize) while public and private investment in other crops remains low (Grovermann et al., 2018). Furthermore, investment in the agriculture sector continues to be skewed towards the traditional strategy as it primarily focuses on food and fertilizer subsidies and grants (Kumar and Thangaraj, 2022). Although the government is working towards maximizing agricultural production, less emphasis has been given to conducting new research for developing new marketing, storage, warehousing, and preservation techniques (Raj, 2018; Kumar and Thangaraj, 2022). Also, there is an implementation gap in strategies as the framing of targets could lead to a variety of interpretations due to the vagueness of terms such as ‘sustainable’ or ‘fair’. Additionally, there is a lack of specificity regarding the scale of enforcement and monitoring or the boundaries of ‘food systems’ (Gil et al., 2018).

Emerging Policy Solutions

Strengthening the National Mission for Sustainable Agriculture (NMSA) to enhance crop system

- **Integration of Crop Diversification Programme (CDP) in NMSA:** Highlighting the CDP within the NMSA will lead the government to prioritize and focus on it, as NMSA falls under the purview of the National Action Plan for Climate Change.
- **Adequate focus on research and development and capacity building in NMSA:** Allocation of significant funds and emphasis on research and development (R&D) and capacity-building within NMSA will help address issues related to adaptation and implementing coping strategies for crop production systems.

Strengthen Reporting on Metrics for Policy Design and Implementation: Some proposed metrics that could be monitored include:

- Crop diversification index in areas of monoculture.
- Percentage of agricultural policies in India that have a component of sustainable agriculture.
- Percent of budget allocated for sustainable agriculture.
- Number of beneficiaries who participate in the schemes dedicated to sustainable agriculture.

Incentivizing Farmers for Sustainable Agricultural Practices

- **Higher MSP for other crops:** By providing higher MSPs for a broader range of crops, farmers can be incentivized to cultivate a more diverse set and, thus, move away from the rice–wheat cycle and address the market demand as well.
- **Addressing budget constraints:** Budget constraints pose a significant barrier to farmers adopting sustainable agriculture practices. Farmers adopting sustainable agricultural practices, especially when these practices are linked to **subsidies**, should be provided greater incentives.
- **Challenges with insurance schemes and loans:** Farmers often do not support insurance schemes that are provided along with loans. Many farmers are unaware of these schemes and struggle to understand how to access or claim the insurance benefits.
- **Enhancing markets for non-chemical farming practices:** Chemical-based agricultural methods are often more profitable, which discourages farmers from embracing organic farming. It must be ensured that incentives and markets are directed towards farmers who use non-chemical-based inputs.
- **Inclusion of smallholder and tenant farmers:** The plight of smallholder farmers, who lack support to survive market competition, underscores the necessity of incentive mechanisms and equitable distribution. It is crucial to define and recognize farmers, including tenant farmers, who often remain invisible in policy discussions.
- **Information asymmetry:** Policymakers should prioritize rationalizing existing schemes and assessing the impacts on farmers' lives. Empowering district officers and promoting convergence among different departments are potential solutions.
- **Contextualizing policies:** Examples of empowering district officers to directly address the needs of the poorest of the poor demonstrate the potential for more effective, ground-level policy implementation. Long-term policies should aim to converge different departments, creating a one-window approach for farmers. State governments should have the discretion to adapt policies to their specific contexts.
- **Challenges in data consistency:** Data consistency is a significant challenge. For policy synergy, it is crucial to identify the entitlements the farmers receive from different SDG policies and recognize the trade-offs impacting farmers' lives. Agricultural policies should acknowledge local realities.
- **Decentralization in implementing policies:** There is a need to establish more decentralized policies that offer farmers a range of options to choose from rather than rigidly controlling schemes at the state and central levels. The current policies involve subsidies and MSPs, which incentivize specific actions. It is crucial to question whether these policy constraints are in line with the preferences and needs of farmers, both politically and economically.
- **Policy piloting:** Evaluating the effectiveness of existing institutional structure in realizing the SDGs is crucial, along with identifying and addressing potential policy obstacles. The process of policy piloting is essential and initiatives like those undertaken by the Indian Council of Agricultural Research (ICAR) can help promote agricultural systems related to crop diversification plans.
- **Highlighting ecosystem services:** There is a growing need to shift from the traditional focus on yield per hectare and instead emphasize mainstreaming ecosystem services in agriculture, thereby strengthening the agricultural value chain. Policymakers are encouraged to move beyond productivity-focused debates and consider broader, farmer-centric solutions that address economic well-being. It is important to take into account the diverse cultures and farming practices and ensure inclusivity and sustainability.

Promoting Community-led Practices for Efficient Implementation of Sustainable Farming Activities

- **Issues in landholdings:** Fragmentation of land is another issue that poses a challenge for farmers to engage in sustainable farming practices. Hence, aggregating farmers and encouraging community-led adaptation of farming practices can help address the issue of small landholdings.
- **Non-uniformity in farmers' income levels:** Addressing the issue of disproportionate land sizes and different crop diversification programmes should prioritize farmers based on their income levels. For example, affluent farmers in states like Punjab and Haryana may have different needs.
- **Recognizing women in farming operations:** Recognizing the joint household nature of farming and the contributions of women in agriculture can inform policy formulation that better serves communities. Thus, efforts should be made to aggregate small women farmers and engage them in community-led adoption of sustainable farming practices. This can be actively promoted and encouraged by SHGs and women's empowerment through initiatives like 'Mahila Sashaktikaran'.
- **Promotion of agro-forestry:** Approximately 86% of the farmers in India are small and marginal farmers. Hence, leveraging community-led initiatives like Gram Sabha, which sells non-timber forest products (NTFP), can also be applied to agricultural products. This brings the promotion of agro-forestry as a promising agricultural practice.
- **Misalignment between crop choices in comprehensive development plans:** Agro-forestry should be incorporated into comprehensive development plans and involve community participation. Since there is a misalignment between crop choices in comprehensive development plans and the agro-ecological conditions, the challenge is to reconfigure agricultural practices to ensure food security is not compromised.

Capacity-Building and Awareness Campaigns for Ensuring Last-Mile Implementation of Well-Informed Practices

- **Limited farmer awareness:** Farmers often lack awareness of government provisions and learning programmes, necessitating capacity-building and awareness campaigns that encompass policy-related information.
- **Substantial representation of farmers in policy discussions:** It is crucial that farmers become aware of sustainable practices and the importance of profitability in policies. The importance of integrating SDG indicators into policies considering ecology and economy are intertwined, along with information dissemination and market access for farmers will help in the effective implementation of policies.
- **Leveraging initiatives like KISAN Mela:** Farmers often lack awareness of policy provisions and available resources. There is a strong call for awareness campaigns that focus not only on agro-technical aspects but also on policy benefits and learning programmes. *KISAN Mela* is an example of effective government efforts.
- **Platforms to increase awareness amongst farmers:** Farmers involved in Agricultural Technology Management Agency (ATMA) programmes from different states can benefit, ensuring that every village reaps the advantages of government policies. For example, in Rajasthan active farmer WhatsApp groups are utilized to disseminate information to farmers. Thus, community-led approaches, such as *Gram Sabhas* and farmer WhatsApp groups, can play a significant role in disseminating information, promoting sustainability, and aggregating smallholder farmers.

NMSA for Tailor-made Solutions to Farmers

- **Bridging the gap between theory and practice:** The true benefits of NMSA policies will materialize when they are implemented in the field with clear information. Geographical factors and farmers' preferences should be considered in policy design.
- **Focus on crop diversification in NMSA:** The focus on crop diversification should be strengthened in NMSA, which can lead to wider adoption of crop diversification by farmers.

Intake of Technology in Agriculture

- **Adoption of technology-enabled services:** Mere delivery of technology-enabled services will not solve all the problems of farmers. It is also important to ensure that farmers adopt these services. This calls for capacity building, which should be viewed from the farmers' perspective and not merely from the supply side.
- **Accurate dissemination of information:** Utilizing technology for capacity building is vital, and advertising weather forecasts on television can increase farmers' awareness of weather conditions. It is crucial to provide accurate weather information to farmers so that they are able to make informed decisions.

Shifting Focus from Farm Economy to Farmers' Economy

- **Emphasis on choice of crops:** When designing policies, it is essential to consider their impact not just on the overall farm economy but also on individual farmers. Policymakers should evaluate how these policies benefit farmers, what incentives they provide for crop cultivation, and why farmers would choose to grow particular crops.
- **Balance in ecology and economy:** For any policy solution to be delivered, it must align with the economic interests of farmers. It is crucial to strike a balance between ecology and the economy, with a primary focus on the well-being of farmers.

Goal 3. Ensure healthy lives and promote well-being for all at all ages

Agriculture supports health by providing food and nutrition for the people and generating income that can be spent on healthcare. The potential impacts of agricultural activities on the health and nutrition of farmers comprise various channels. Agricultural activities lead to broader economic impacts, including the increase of government revenues for financing healthcare, infrastructure, and nutrition intervention initiatives (Fan, 2015).

Despite experiencing significant economic growth in the past decade, a substantial portion of India's population continues to suffer from hunger and undernourishment. About two-thirds of the country's population is estimated to be micronutrient deficient (NITI Aayog, 2022). In the 2018 Global Hunger Index (GHI) by the International Food Policy Research Institute (IFPRI), India ranked 103 out of 119 countries. It has the largest population of malnourished individuals globally, comprising approximately a quarter of the world's total (IFPRI, 2018). Furthermore, the adverse effects of climate change and global conflicts have far-reaching implications for India's food and nutrition security. Additionally, insufficient investments in the social sector pose a challenge, leaving the economically disadvantaged susceptible to market fluctuations in areas such as healthcare.

Unsustainable agricultural production and food consumption also increase the risks of water-related diseases and foodborne diseases—as well as health hazards linked with specific

agricultural systems and practices, such as infectious animal diseases (avian flu, brucellosis), pesticide poisoning, and aflatoxicosis (World Bank, 2008). For instance, farmers who are exposed to chemicals used in agriculture are at a higher risk of developing asthma and other immune-related ailments in India. They are also prone to farmer's lung, which is an inflammation of the lungs triggered by fungal spores found in mouldy grains or hay (Fernandes, 2020). Furthermore, farm workers are at risk of contracting zoonotic diseases, highlighting the urgent need for interventions in the agrarian community to address these health challenges (Fernandes, 2020).

Mental health disorders have emerged as a significant contributing factor to suicide attempts within the farming community. Over 70% of suicide cases among farmers are linked to those involved in cash crop cultivation, grappling with issues such as debt, hyper-commercialization, rising input costs, and price fluctuations (Sarat, 2023). In 2021, the National Crime Records Bureau reported 5563 suicides among agricultural labourers, marking a 9% increase from 2020 and a large 29% rise from 2019. The total number of suicides within the agricultural sector, including both farmers/cultivators and agricultural labourers, amounted to 10,881 in 2021, representing 6.6% of the overall suicide victims (164,033) in the country. Among the 5318 farmer/cultivator suicides, 5107 were male and 211 were female (National Crime Records Bureau, 2021).

Workers in poor health in the agricultural population face difficulties in carrying out their work, which leads to decreased productivity and income, ultimately resulting in a downwards spiral into ill health and poverty. This situation further jeopardizes food security and economic development for the wider population (IFPRI, 2006) as agriculture plays a vital role in transforming landscapes and influencing livelihoods, changing both the conditions in which human diseases emerge and spread, and the capacity of communities to protect themselves (CGIAR, 2016).

National Policy and Stakeholder Mapping

Policies/schemes	Stakeholders	Pre-production	Production	Post-production
National Food Security Mission	Ministry of Agriculture and Farmers Welfare	X	X	X
National Rural Health Mission	Ministry of Health and Family Welfare	X	X	X
Ayushman Bharat - Health and Wellness Centres and Pradhan Mantri Jan Arogya Yojana (PMJAY)	Ministry of Health and Family Welfare	X	X	X
Pradhan Mantri Matru Vandana Yojana (PMMVY)	Ministry of Women and Child Development	X	X	
National AIDS Control Programme (NACP)	Ministry of Health and Family Welfare		X	X

	National AIDS Control Organization			
Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP)	Ministry of Chemicals and Fertilizers		X	X
Soil Health Card Scheme under Rashtriya Krishi Vikas Yojana (RKVY)	Ministry of Agriculture and Farmers Welfare	X	X	
Environment (Protection) Act, 1986	Ministry of Environment, Forest and Climate Change	X	X	X
Air (Prevention and Control of Pollution) Act, 1981	Ministry of Environment, Forest and Climate Change		X	X
The Water (Prevention and Control of Pollution) Act, 1974	Ministry of Environment, Forest and Climate Change	X	X	X

Synergies and Trade-offs

Improving agricultural productivity and increasing the incomes of small-scale producers will improve access to food and economic resources, which supports the health of mothers, newborns, and children (Howden-Chapman, et al., 2023). Additionally, improved production can result in indirect health benefits by enhancing the economic well-being of agrarian communities (Howden-Chapman, et al., 2023). When farmers have higher incomes, they can cover their health insurance premiums and other out-of-pocket health care expenses (Frimpong and Vermund, 2022). Health and agriculture are synergistic and complementary in the sense that poor health (of farmers) reduces agricultural productivity, and likewise, certain agricultural practices contribute to health problems.

Adopting sustainable agriculture practices can address health issues stemming from air, soil, and water. Substances such as insecticides, pesticides, and fertilizers can pose a threat to human well-being, whether through contaminated food and water or via occupational contact. The increased use of chemicals in agriculture has raised concerns regarding their effects on human well-being. In recent decades, the use of fertilizers and pesticides has increased the exposure of farmers, farm labourers, and the general public to these substances (Dhankar and Kumar, 2023). Exposure to pesticides can occur through skin contact, ingestion, or inhalation. Pesticides have been associated with various adverse health effects, including but not limited to issues related to the skin, gastrointestinal system, nervous system, carcinogenicity, respiratory system, reproductive system, and endocrine system (Stamati et al., 2016; Aktar, Sengupta, D., and Chowdhury, 2019; Dhankar and Kumar, 2023). Pesticide and fertilizer contamination contribute significantly to environmental hazards, affecting biotic and abiotic components, including humans and organisms such as beneficial soil microorganisms, insects, plants, fish, and birds, thus disrupting the entire ecosystem.

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

One of the trade-offs in agricultural productivity and farmers' health is that while cultivating more cash crops increases market prices of food items and raises the income levels of farmers, it can also affect local production by farmers, impacting their traditional healthy diets (Achterbosch, van Berkum, and Meijerink, 2014).

Targets	Synergy	Trade-off
Target 3.1: By 2030, reduce the global maternal mortality ratio to less than 70 per 1,00,000 live births		
Target 3.2: By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under-5 mortality to at least as low as 25 per 1000 live births		
Target 3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases		
Target 3.4: By 2030, reduce by one-third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being		
Target 3.5: Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol		
Target 3.6: By 2020, halve the number of global deaths and injuries from road traffic accidents		
Target 3.7: By 2030, ensure universal access to sexual and reproductive healthcare services, including family planning, information and education, and the integration of reproductive health into national strategies and programmes		
Target 3.8: Achieve universal health coverage, including financial risk protection, access to quality essential healthcare services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all		
Target 3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination		
Target 3.a: Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate		
Target 3.b: Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS agreement and public health, which affirms the right of developing countries to use to the full the provisions in the agreement on trade-related aspects of intellectual property rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all		
Target 3.c: Substantially increase health financing and the recruitment, development, training, and retention of the health workforce in developing countries, especially in least developed countries and small island developing states		
Target 3.d: Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction, and management of national and global health risks		

Gaps and Barriers

Frequently, farmers or farming collectives lack the opportunity to consult occupational health doctors or other professionals specializing in occupational stress-related concerns (Donham and Thelin, 2016). Unlike the general population or the rural population, objective and comprehensive information on the mortality and health status of the relatively small farm population is not available. Therefore, there is no simple summary conclusion to be drawn about the health status of the farm population (Ahearn and Mishra, 2009).

Emerging Policy Solutions

Integrated Approach to Agriculture and Health under National Rural Health Mission (NRHM)

- **Tailored health scheme for farmers:** Incorporating a health scheme under NRHM to address farmers' specific health risks associated with agricultural work.
- **Promotion of sustainable practices:** Strengthening regulations on pesticide usage and promoting sustainable agriculture practices can protect the environment and farmers' health. Through schemes like NRHM, encouraging procurement of nutritional food within available resources can address food insecurity and promote health.
- **Awareness campaigns and workshops:** Conducting awareness campaigns and workshops to encourage organic and sustainable farming practices to minimize health risks. This can be supported by working extensively with agricultural extension service providers to promote climate-smart agricultural practices that mitigate health risks from extreme weather events.
- **Cross-cutting:** Implementing insurance schemes can provide financial security to farmers in the case of crop failure, while crisis helplines can address extreme situations quickly. Promoting multi-sectoral collaboration between ministries and enhancing health infrastructure can lead to more effective healthcare delivery. MSP of nutritional crops like millet can be increased so that it will help the shift from rice and wheat cultivation.

Strengthen reporting on metrics for policy design and implementation: Some proposed metrics that could be monitored include the following:

- Monitoring of pollutants from agriculture
- Malnutrition among farmers

Addressing Mental Health of Farmers to Promote Well-being of Farmers

- **Engagement of mental health professionals:** Capacity building in farming communities should include access to mental health support for farmers. Raising awareness about mental health through community meetings, media, and traditional cultural practices can help reduce stigma and promote well-being.
- **Counselling and telemedicine:** Farmers often hesitate to consult mental health counsellors due to the stigma associated with mental health issues. Improving access to mental healthcare, such as telemedicine, is important. This also includes addressing challenges like limited internet connectivity in rural areas. Proposing telemedicine and digital education requires assessing the availability of necessary infrastructure, such as Wi-Fi and mobile phones, among farmers.

- **Efficient access to agri-inputs:** Ensuring access to loans, seeds, infrastructure, and tools can alleviate financial stress among farmers and reduce mental health issues. Enhancing farmers’ access to markets, knowledge about seeds, and sustainable techniques can improve the agricultural practices and livelihoods of farmers.
- **Community engagement for health system setup:** The community, both at the individual and institutional levels, should harness community assets to develop solutions. Co-creation with the farming community is vital. This aligns with the principle of community engagement for the effective implementation of sustainable development initiatives.

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Education is an essential element of efforts to reduce malnutrition and hunger (UNESCO, 2013). According to FAO (2014), agricultural education and training increase agricultural productivity by building ‘capacities, encouraging the development of people’s skills and competencies for innovation, and creating human capital for research and advisory services, along with raising incomes. It is crucial that farmers attain more advanced levels of education to make use of new information and communications technology (ICT)-based information sources and technical advice and to respond to new market opportunities and environmental changes. The Indian Agriculture Research Institute (IARI) studies show that extension (45%) and research (36%) are the primary drivers of total factor productivity growth, while literacy (10.5%), infrastructure (8%), and urbanization (1.5%) play smaller roles. Investment in extension needs significant improvement (Dubey, 2015).

Barriers to agricultural education are more acute for women than for men (UNFPA, 2014). Mobile phone usage can significantly lower information access costs and provide timely information for various agricultural and non-agricultural needs (Sayed, 2018). Challenges in the agricultural extension system also include limited inter-university collaboration and scientist mobility, inadequate veterinary expertise and infrastructure in Krishi Vikas Kendra (KVKs), absence of comprehensive farmer data, restricted farmer interaction, minimal research by field extension scientists, and limited impact assessment by State Agricultural Universities (SAUs).

SAUs can support rural development and uplift living standards by adopting villages, fostering agripreneurship and gender mainstreaming, and promoting technology transfer (Lalitha, et al., 2022).

National Policy and Stakeholder Mapping

Policies/Scheme	Stakeholders	Pre-Production	Production	Post-Production
National Education Policy 2020	<ul style="list-style-type: none"> • Ministry of Education • Department of School Education and Literacy • Central Advisory Board of Education • Central Board of Secondary Education • Central Institute of Educational Technology • Department of Science and Technology 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

	<ul style="list-style-type: none"> • Department of Atomic Energy • Department of Biotechnology • Indian Council of Agriculture Research • Indian Council of Medical Research • Indian Council of Historical Research • University Grants Commission 			
Multi-Sectoral Development Programme for Minorities	<ul style="list-style-type: none"> • Ministry of Minority Affairs • Department of Finance • Department of Planning 	X		X
Pradhan Mantri Kaushal Vikas Yojna (PMKVY)	<ul style="list-style-type: none"> • Ministry of Skill Development and Entrepreneurship • National Skill Development Council • Sector Skill Councils • National Institute for Entrepreneurship and Small Business Development • Indian Institute of Entrepreneurship • National Council for Vocational Education and Training • National Skill Development Corporation • Krishi Vikas Kendra • State Agricultural Universities • Department of Expenditure 	X	X	X
National Policy for Farmers 2007	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Department of Agriculture and Cooperation • <i>Krishi Vigyan Kendras</i> • Indian Council of Agricultural Research (ICAR) • Department of Information Technology 	X	X	X
National Project on Organic Farming	<ul style="list-style-type: none"> • Ministry of Agriculture • Department of Agriculture and Cooperation • Indian Council of Agricultural Research (ICAR) 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

	<ul style="list-style-type: none"> • Krishi Vikas Kendra • All India Network Programme on Organic Farming • Agricultural Technology Management Agency 			
AGRISNET	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Indian Council of Agricultural Research • Agricultural Technology Management Agency 	X	X	
Rastriya Krishi Vikash Yojna (RKVY)	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Indian Council of Agricultural Research • Agricultural Technology Management Agency • Agricultural Technology Application Research Institute (ATARI) 	X	X	X
Mera Gaon Mera Gaurav (MGMG)	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • ICAR-Indian Agricultural Research Institute • Agricultural Technology Management Agency 	X	X	
Sub-Mission on Agricultural Extension (SMAE)	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Indian Council of Agricultural Research • Agricultural Technology Management Agency • University of Agricultural Sciences, Bangalore • Assam Agricultural University (AAU) 	X	X	X
Farm Business School Initiative	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Kerala Agricultural University • Indian Council of Agricultural Research 	X		
Farmer's Interest Group (FIGs)	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Indian Council of Agriculture Research • Agricultural Technology Management Agency 		X	X

India Skill Development Mission	<ul style="list-style-type: none"> • Ministry of Skill Development and Entrepreneurship • National Skill Development Council • Sector Skill Councils • National Institute for Entrepreneurship and Small Business Development • Indian Institute of Entrepreneurship • National Council for Vocational Education and Training • National Council for Vocational Training • National Skill Development Corporation • Krishi Vikas Kendras • Agriculture Skill Council of India (ASCI) • Food Industry Capacity and Skill Initiative 		X	X
---------------------------------	---	--	---	---

Synergies and Trade-offs

Education, one of the key dimensions of human capital, is of paramount importance to positively impact economic growth and boost the transition to sustainable agriculture (Maini, et al., 2021). By promoting education of both farmers and scientists can increase agricultural productivity as well as long-term sustainability (Brodt, et al., 2011). Sustainable agriculture should penetrate the agricultural education curriculum to enhance agricultural education with wide-based science foundations and their implementation (Sameipour, 2017). It was asserted that there is a requirement to improve education and teaching skills for managing agricultural chemicals. Information and communication technology systems, in turn, play a remarkable role in generating sustainable land-use information and sharing knowledge and innovations for adoption by farmers and service providers (Ommani, 2011).

Targets	Synergy	Trade-off
Target 4.1: By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes		
Target 4.2: By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education		
Target 4.3: By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university		
Target 4.4: By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship		

Target 4.5: By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations		
Target 4.6: By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy		
Target 4.7: By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity, and of culture's contribution to sustainable development		
Target 4.a: Build and upgrade education facilities that are child, disability, and gender sensitive and provide safe, non-violent, inclusive, and effective learning environments for all		
Target 4.b: By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing states and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries		
Target 4.c By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing states		

Gaps and Barriers

Challenges in agricultural education encompass outdated curricula, urban-centric student dominance, limited rural access to quality education, inadequate faculty development, insufficient post-harvest focus, high costs, and neglect of self-development skills (Devi, et al., 2021; Chitoor and Mishra, 2014; FAO, 1997; UNCC, n.d.; Bisheko and Rejikumar, 2023; Sameipour, 2017). Budget constraints due to reduced government spending and economic crises have strained institutions (Chitoor and Mishra, 2014).

However, opportunities exist for improvement. Providing faculty with on-the-job training, exposure to modern teaching methods, and collaboration with national and international seminars can enhance teaching quality (Devi, et al., 2021; Chitoor and Mishra, 2014). Partnerships with industry, sustainable agriculture centres, and private companies can foster technological advancements and knowledge dissemination (Chitoor and Mishra, 2014). Ensuring the representation of rural youth in agricultural education policies and offering education access to economically disadvantaged students is crucial (Chitoor and Mishra, 2014). Leveraging information technologies for collaboration, curriculum development, and distance education can keep institutions abreast of evolving science and technology (Chitoor and Mishra, 2014). Additionally, technological interventions like new plant breeding techniques

can boost sustainable production (IPCC, 2019). These steps can empower youth, promote sustainable agriculture, and address the challenges faced by the sector (Aduroja, 2021).

Emerging Policy Solutions

Improving Existing Educational Infrastructure for Farmers

- **Effective educational initiatives:** Developing impactful educational programmes involves combining awareness-building with capacity-building efforts. Using audio-visual educational materials can make learning more engaging and accessible for farmers. Aligning formal education with market realities, access to technology, and industry partnerships ensures practicality.
- **Enhancing accessibility and awareness:** To make education more accessible to farmers, it is essential to upgrade infrastructure and provide better access to educational institutions. Simultaneously, efforts should be directed towards raising awareness among farmers about available government schemes and the benefits of livelihood diversification. These efforts will, in turn, strengthen the economic prospects of farmers.
- **Gender equality and education:** To achieve gender equality in agriculture and education, it is crucial to challenge and overcome deep-rooted social norms and stereotypes. Promoting gender equality aligns with SDGs 4 and 5, driving progress towards a more inclusive agricultural sector.
- **Strengthening the education ecosystem:** An effective educational ecosystem can be created by integrating vocational training with formal education, fostering innovation, and promoting sustainability in farming. It is critical to engage farmers as key stakeholders and incentivize their participation in this process.
- **Alignment with policy and community:** To align educational efforts with broader policies, they should be integrated with national strategies such as State Action Plans on Climate Change (SAPCC). To overcome trust issues, it is important to enhance skill development by addressing income aspirations and regional needs while collaborating with non-governmental organizations (NGOs) and grassroots organizations. Additionally, engaging with young farmers to overcome hesitancy and promoting robust research is essential to ensure the effective transfer of technology and skills. Assessing needs and improving resource mobilization can further enhance the success of educational programmes.
- **Strengthening farmers' formal education:** The current education system must align with practical agricultural knowledge and skills, covering topics such as soil quality and water management. It should also cater to farmers' income aspirations, ensuring higher revenues through sustainable agriculture. Language barriers, prevalent in linguistically diverse regions, need to be addressed to facilitate effective communication.

Collaboration between SAUs and KVKs on sustainable agriculture: Enhancing the effectiveness of KVKs requires collaboration, resource-sharing, and partnerships with SAUs. This coordination can consider farming calendars and seasonal variations. KVKs, often resource-constrained, need to pool and efficiently utilize resources. Engaging farmers and developing a national database can aid in effective policy formulation.

Tailored technology adoption: Customizing technology for specific regions and ecosystems improves adoption. KVK staff should receive training in the latest advancements to enhance their effectiveness. Technology transfer should follow rigorous research to ensure its benefits.

Strengthening India's Skill India Mission: Integrating skill development initiatives with other schemes can significantly increase farmers' income. The use of innovative ICT tools, such as community radio, can widen the reach and enhance the effectiveness of agricultural education. Gender-sensitive training promotes gender equality. Water budgeting and sustainable water management practices contribute to SDG 6 (Clean Water and Sanitation).

Strengthening the role of ASCI and FICSI: Skill development programmes can be designed to enhance income and reduce poverty. Collaborating with financial institutions can provide access to credit for sustainable farming practices. Adequate funding and practical, hands-on learning are critical to the success of these programmes. It is important to raise awareness among the youth about the opportunities in agriculture and foster collaboration with industries. Tailored educational programmes and linking education with livelihood generation create holistic skill development. Continuous impact assessment and feedback loops improve programme effectiveness over time.

The Agriculture Skill Council of India (ASCI), which operates under the Ministry of Skill Development & Entrepreneurship (MSDE), focuses on capacity-building in the agriculture sector. It aims to upgrade the skills of individuals working in various agricultural sectors, including farmers, wage workers, and extension workers. ASCI covers areas such as farm mechanization, poultry farm management, and watershed management. To ensure a more integrated approach, ASCI modules can include groundwater management as well.

Complementing ASCI's efforts, the FICSI, promoted by the National Skill Development Corporation (NSDC) and FICCI, works to enhance the food processing industry's growth and productivity. FICSI can help farmers capture better value from their produce by addressing issues such as food loss prevention and pre-processing techniques. Collaboratively, ASCI and FICSI aim to promote sustainable development in agriculture and food processing. However, it is crucial to include pre-production and post-production stages in their training programmes to ensure a holistic approach throughout the agricultural value chain. This includes sustainable labelling practices.

Strengthen reporting on metrics for policy design and implementation: Some proposed metrics that could be monitored include the following:

- Modules and farmers' field schools on sustainable agriculture offered in SAUs and through Skill India Mission covering all stages of agriculture value chains
- Number of farmers who have been beneficiaries of Information, Education, and Communication (IEC) activities on sustainable agriculture

Goal 5. Achieve gender equality and empower all women and girls

Promoting sustainability in agriculture necessitates addressing gender disparities. Women farmers in numerous developing nations face significant challenges due to their limited rights to inherit, access, and utilize land and other productive resources, resulting in 20–30% lower production compared to men (FAO, 2020). In developing countries, only 16% of landholders are women, compared to 21% in developed economies (UNCC, 2019). Countries characterized by high-income inequality tend to exhibit lower levels of land productivity and are more susceptible to unsustainable agriculture and food insecurity.

In India, approximately 62.9% of women are engaged in agriculture (Ministry of Labour and Employment, 2023), but land ownership is heavily imbalanced in favour of men, with women

representing just 14% of all landowners (Vasavada, 2022). While recurrent climate-related disruptions impact everyone, there are distinct gendered experiences, with women facing a disproportionate burden because of disparities in societal norms and power dynamics. The situation is exacerbated when funds for crop-related climate risk mitigation are directly deposited into bank accounts. Given the gender-biased distribution of land ownership, it is predominantly men who possess the land and consequently receive the funds in their bank accounts. This, in turn, restricts women from accessing the compensation or participating in decisions regarding its utilization. In several instances, women may not even be aware that the compensation has been transferred. Thus, land ownership by women serves as a protective barrier for them, enabling them access to government climate initiatives and relief programmes designed for the farming sector.

A significant part of women's agricultural labour involves working long hours doing tedious tasks. A study conducted by Singh et al. (2022) compared the drudgery levels of farmers during paddy harvesting in Odisha, India, when using serrated sickles versus a power tiller reaper. The study revealed a 26.61% reduction in drudgery levels when employing the power tiller reaper, as indicated by measured ergonomic parameters, compared to using serrated sickles.

Women working in India's agricultural sector often encounter a lack of recognition, resulting in limited entitlements. Even when women have legal ownership of land, they typically lack control over it as it is usually managed by a male figure, such as a husband or father. Acknowledging and supporting the contributions of women in farming and natural resource management can lead to more environmentally sustainable, socially equitable, and economically viable agricultural practices.

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
Mission for Protection and Empowerment of Women	Ministry of Women and Child Development	X	X	X
Support to Training and Employment Programme	Ministry of Women and Child Development	X	X	X
Rashtriya Gram Swaraj Abhiyan (RGSA)	Ministry of Panchayati Raj	X	X	X
National Rural Livelihood Mission (NRLM)	Ministry of Rural Development	X	X	X
Pradhan Mantri Jan Dhan Yojana (PMJDY)	Ministry of Finance	X	X	X
Pradhan Mantri Kaushal Vikas Yojana (PMKVY)	Ministry of Skill Development and Entrepreneurship	X	X	X
Gender Budgeting	Ministry of Women and Child Development, Ministry of Social Justice and Empowerment	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

National Policy for Farmers 2007	Ministry of Agriculture and Farmers' Welfare	X	X	X
Mahila Kisan Sashaktikaran Pariyojana (MKSP) under NRLM	Ministry of Rural Development	X	X	X
Mission Shakti	Ministry of Women and Child Development		X	X

Synergies and Trade-offs

The agricultural sector, as well as society, may avail many of the tangible and intangible benefits by addressing the gender gap. If women had equal access to productive resources as males, they could boost farm production by 20–30%, leading to a potential 2.5–4% increase in global agricultural output in developing nations (FAO, 2016).

Targets	Synergy	Trade-off
Target 5.1: End all forms of discrimination against all women and girls everywhere		
Target 5.2: Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation		
Target 5.3: Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation		
Target 5.4: Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate		
Target 5.5: Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life		
Target 5.6: Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences		
Target 5.a: Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws		
Target 5.b: Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women		

Target 5.c: Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels		
--	--	--

Women who work in agriculture often face drudgery and are at risk of gender-based violence, including sexual harassment, assault, and exploitation. Tackling gender-based violence in agricultural settings is crucial for safeguarding women's human rights, ensuring their safety and well-being, and enabling them to participate in agricultural development (Corona, 2023). In situations where land ownership rights are predominantly exercised by men, women are excluded from decision-making spaces, lacking a voice or vote in decisions related to agricultural practices, potentially leading to the adoption of unsustainable farming methods (OECD, 2021). Closing the gender gap in access to productive resources, services, rural institutions, and decision-making processes can enhance the well-being of women and their households. This includes involving women and indigenous communities in making decisions about farming policies and practices, given their roles as custodians of natural resources and their representation in the agricultural sector. Their traditional knowledge can help identify local challenges and provide alternative solutions. In emerging regions, agroforestry has been shown to effectively empower women. Women are typically heavily involved in the food production process, working in the fields, and selling the crops harvested. Including them in such practices will not only promote sustainable agriculture but also empower them.

Recognizing and supporting the role of women in farming and natural resource management can lead to more environmentally sustainable, socially equitable, and economically viable agricultural practices. When women enter agricultural markets, they become integral to building a more sustainable agricultural system. Market engagement encourages women to adopt environmentally friendly practices such as organic farming, agroecology, and reduced chemical usage. These practices prioritize soil health, biodiversity, and resource efficiency, contributing to resilient ecosystems and preserving natural resources for future generations.

Gender-sensitive policies that promote healthy diets can have a positive impact on the transition towards more sustainable agricultural practices. A healthy diet not only helps prevent many non-communicable diseases but also creates synergies for reducing environmental pressure on agricultural systems. This is achieved by decreasing the demand for and consumption of organic products (FAO, 2020). This synergy benefits not only women individually but also contributes to the overall well-being of communities, reinforcing the vital link between sustainability and women's economic empowerment.

Gaps and Barriers

Even though there has been extensive research over the years on violence against women, effective monitoring is hindered due to the absence of data for the same. Many farmers, especially women, lack the financial resources, capacity, and expertise necessary to invest in relevant agricultural technologies and better agricultural practices. Gender-based violence and limited access to education, training, land ownership, finance, technology, and markets are some of the obstacles to achieving equitable access to resources for women. Because of the disparity in access, female farmers face an increasing knowledge gap (Chitoor and Mishra, 2012; ActionAid, 2017; Ignaciuk and Chit Tun, 2019).

There are some agricultural education institutions that have gender-sensitive admittance policies in place but due to traditional barriers, female students continue to have problems when it comes to finding employment in agriculture (Chitoor and Mishra, 2012). Women's contribution to agriculture is often unpaid and undervalued, and they frequently face the

dilemma of leaving school to take on household responsibilities and assist with other family tasks. This situation makes it challenging to recognize the unremunerated contributions of women, leaving them disproportionately burdened. This perpetuates a harmful cycle of discrimination and gender inequality that affects future generations (ActionAid, 2017). The scarcity of women in roles such as extension workers, researchers, and other agricultural professionals can be attributed, in part, to the limited number of female graduates emerging from intermediate and higher-level agricultural education institutions (Chitoor and Mishra, 2012).

Emerging Policy Solutions

Enabling Institutional Structures and Governance for Uplifting Women in Agriculture

- **Legal and cultural barriers:** Women often face barriers in accessing and inheriting land, which can restrict their participation in agriculture. Deep-rooted social norms and legal obstacles, such as those related to inheritance, can hinder women's land rights. Registering women as farmers can empower them by recognizing their role and contributions to agriculture.
- **Institutional support through Mahila Kisan Sashaktikaran Pariyojana (MKSP):** Considering complexities in land transfers due to recent changes like Aadhar requirements, the institutional support and access of resources to women should be strengthened through MKSP. To achieve this, MKSP can be leveraged to equip women with proper sustainable infrastructure and training on various stages of the agricultural value chain.
- **Access and ownership of land:** Mere ownership does not guarantee that women will have access to it and vice versa. For instance, when large landholdings are prevalent, women's participation in agriculture tends to decrease since they primarily manage the land without owning it. Likewise, post-marriage, women typically move to their husband's homes, making it difficult for them to access their own land.
- **Gender-disaggregated data:** The absence of gender-disaggregated data hinders policymakers from recognizing gender-related barriers in agriculture. Gender-disaggregated data is crucial for understanding and addressing challenges faced by women in agriculture effectively.
- **Resource management:** Implementation of schemes such as 'Pokra' in Maharashtra can be challenging when large landholders transfer land to females for various benefits. Limited data connectivity and lack of access to mobile phones can hinder women's access to information and resources. To overcome this challenge, initiatives like *Krishi Tai* need to ensure that women join with interest and receive proper remuneration.
- **Acknowledging women's contributions:** Before data collection to determine focus areas, it is important to recognize and acknowledge the work done by women in agriculture. In regions like Punjab, women are often categorized as labourers rather than farmers due to landholding patterns.
- **Policies and concessions:** Promoting policies that provide concessions to women, such as Kisan Credit Cards, incentivizing land transfers and empowering them. Practices like 'Padyali' in Uttarakhand show that a substantial percentage of women are actively engaged in sustainable agriculture.

Support and Opportunities for Women Can Empower Them to Pursue Sustainable Agriculture

- **Asset transfer to women:** Transferring assets to women is an important step towards gender equality. Men often dominate marketing activities, making it difficult for women to sell their produce directly. Initiatives by Krishi Vigyan Kendras to enable farmers to sell their produce in markets should be promoted. Direct payments to women for selling produce, as seen in Gujarat, can empower them economically.
- **Leveraging technology:** Biometric verification is a useful tool to enhance security in property registration and reduce the chances of fraudulent land transfers. Women's digital literacy and access to information can be improved by setting up internet access centres. Leveraging technology for financial inclusion and knowledge dissemination can uplift women in agriculture.
- **Education and awareness:** Education in local dialects and promoting experiential learning can bridge educational barriers. Promotion of gender-neutral intervention in vernacular languages is needed.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include the following:

- Percentage of women engaged in sustainable agriculture practices.
- Percentage of women in rural areas who have access to agricultural information and resources through ICT platforms.
- Government budget allocated to programmes and initiatives focused on promoting gender equality and women's empowerment in agriculture.

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Agriculture is both a major contributor to and a victim of water scarcity. On average, 70% of the world's freshwater withdrawals are used for agriculture. By 2050, the FAO estimates that irrigated food production will have increased by more than 50%, but agricultural water withdrawals will only have increased by 10%, assuming better irrigation techniques and higher yields (FAO, 2017). As the primary cause of inland and coastal eutrophication, agricultural pollution from the use of nitrogen and phosphorus, insecticides, herbicides, fungicides, and bactericides has surpassed contamination brought on by cities and industry in many industrialized countries. As a result, there are toxic algal blooms, habitat degradation, biodiversity loss, and long-term decrease or loss in fish catches. Farm and agro-processing chemicals runoff into surface streams and seepage into aquifers, which pose threats to the environment and human health by groundwater contamination. According to research, globally, farmers apply around 115 million tonnes of nitrogen to their crops every year. Only around 35% of this is used by crops, meaning 75 million tonnes of nitrogen run off into our rivers, lakes, and natural environments (Ritchie, 2021).

India is the world's largest user of groundwater, with over 60% of irrigated agriculture and 85% of drinking water depending on this resource. The quality of groundwater is also influenced by the excessive use of fertilizers and pesticides for agricultural production and industrial activity (CBWG, 2021; World Bank, 2012). About 89% of total annual groundwater extraction, i.e., 217.61 bcm, is for irrigation use (CBWG, 2021). Recently, groundwater monitoring has shown elevated levels of uranium in several community water systems and private wells. As a result of subsidized/free electricity for pumping groundwater to support smallholder farmers, groundwater depletion has become a widespread issue (Mishra, et al.,

2018). Groundwater depletion is a significant issue in Andhra Pradesh, Gujarat, Punjab, Karnataka, and Haryana (Devineni, Perveen, and Lall, 2022).

National Policy and Stakeholder Mapping

Policies	Stakeholders	Pre-Production	Production	Post-production
Jal Jeevan Mission (JJM)	<ul style="list-style-type: none"> Ministry of Jal Shakti Department of Drinking Water and Sanitation Public Health and Engineering Department (PHED) Anganwadi Centres Village Water and Sanitation Committee 	X	X	X
Swachhta Action Plan	<ul style="list-style-type: none"> Ministry of Environment, Forest and Climate Change Department of Drinking Water and Sanitation (rural) Ministry of Jal Shakti (rural) Ministry of Housing and Urban Affairs (urban) 	X	X	X
Namami Gange Programme	<ul style="list-style-type: none"> Ministry of Environment, Forest and Climate Change National Ganga River Basin Authority Central Water Commission Central Public Health Environmental Engineering Organisation Public Health Engineering Department 	X		
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare Department of Agriculture and Cooperation Agriculture Technology Management Agency Indian Council of Agricultural Research National Rainfed Area Authority 	X	X	
National Water Mission	<ul style="list-style-type: none"> Ministry of Jal Shakti Department of Water Resources River Development and Ganga Rejuvenation 	X	X	X
Atal Bhujal Yojana (Atal Jal)	<ul style="list-style-type: none"> Ministry of Jal Shakti 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

	<ul style="list-style-type: none"> • Department of Water Resources • River Development and Ganga Rejuvenation • Central Ground Water Board • India Meteorological Department • National Water Informatics Centre • State Ground Water Resource Centre • Water Management Committee • Village Water and Sanitation Committee 			
--	---	--	--	--

Synergies and Trade-offs

Targets	Synergy	Trade-off
Target 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all		
Target 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations		
Target 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally		
Target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity		
Target 6.5: By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate		
Target 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes		
Target 6.a: By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling, and reuse technologies		
Target 6.b: Support and strengthen the participation of local communities in improving water and sanitation management		

Through activities such as groundwater recharge and water purification, agriculture can positively impact the hydrological cycle (OECD, 2010). Sustainable agriculture can greatly aid in sustainable water management. By implementing practices such as drip irrigation and micro-irrigation, water conservation practices can be promoted in the agriculture sector. Moreover, sustainable agriculture practices promote the usage of bio-fertilizers and bio-pesticides that can have a huge impact on the prevention of underground and surface water

contamination. Reducing synthetic fertilizer use has been linked with improved overall water quality, less eutrophication, and lower levels of surface water contamination. Furthermore, using organic wastes as fertilizers can increase the sustainability of fertilizers and reduce pollution (Bose, 2023).

Farmers can play a crucial role in expanding the world's food supply while preserving and enhancing natural resources, particularly water, in a sustainable manner. It is essential to encourage and guide farmers to conserve natural ecosystems and biodiversity while reducing the harmful environmental impacts of agriculture by implementing appropriate governance practices and incentives. Farmers are at the centre of any process of change involving natural resources (FAO, 2017).

A well-functioning international trade system would encourage nations to export or import items based on their endowment of natural resources. For instance, nations with limited access to water and land would be net importers of agricultural products provided by countries with abundant water resources. Such a system would be more likely to achieve an optimal utilization of both land and water resources (Nkonya, et al., 2023).

Gaps and Barriers

Water managers in arid regions globally, including the western United States, face significant challenges due to insufficient and inconsistent data on evapotranspiration and water use in irrigated agriculture (Melton, et al., 2021). The increasing demand for land and water resources driven by factors such as biofuels, urbanization, and industrialization, often crossing national borders through globalization, are further straining the availability and quality of these resources for food production (Nkonya, et al., 2023).

Policies that regulate the use of on-farm water resources, particularly groundwater, typically involve licenses and regulations. However, these policies are not always enforced due to high transaction costs, leading to issues like groundwater degradation and illicit pumping (OECD, 2010). Climate change and variability pose threats to water supply reliability, flood risk, agriculture, energy, and ecosystems, with current water management practices potentially insufficient to address these challenges. Some countries have been slow to revise their agriculture and water policies to ensure sustainable resource management (OECD, 2010). With over 1.5 billion people living in areas where water resources are already over-allocated across various sectors, including agriculture, environment, urban, and industrial uses, and land and soil degradation are ongoing, regions like the North China Plains and Central Asia, which lack additional water for agriculture, face the challenge of enhancing land and water efficiency while preserving ecosystem resilience (Nkonya, et al., 2023).

To address the growing challenge of diminishing water resources for irrigation, there is a pressing need for effective technological advancements and resource management practices. These include adopting efficient irrigation systems and improved water utilization strategies (Sehgal Foundation, 2021). Given the intricate nature of agricultural water resource management, it is essential to strengthen institutional frameworks and property rights related to water management. Also, it is crucial to ensure that water supply costs are adequately reflected in charges and that policies spanning agriculture, water, energy, and the environment are aligned (OECD, 2010). G20 members can contribute by supporting international organizations that promote sustainable agricultural technologies. They can also increase awareness and adoption of these technologies to ensure a sustainable water supply for agriculture (FAO, 2017).

Furthermore, efforts should be directed towards assisting developing countries in water and sanitation programmes, especially by offering financial resources, capacity-building, and technology transfer, particularly in areas such as water-use efficiency, modern irrigation systems, wastewater treatment, and desalination for agricultural and industrial purposes. Policymakers should also focus on enhancing the resilience of the agricultural sector to water-related challenges, minimizing its impact on freshwater resources and improving the overall water-use efficiency. The OECD recommends a range of policy responses tailored to specific water resource systems.

Emerging Policy Solutions

Strengthening Atal Bhujal Yojna (ABY): One of the major contradictions in the policy is that it is committed to groundwater issues in water-stressed regions but leaves out states like Punjab and Bihar, where the water table is declining rapidly. As per a report by the Central Ground Water Board (CGWB), Punjab is one of the major contributors to both groundwater depletion and contamination. Hence, to tackle the problems of groundwater, it is crucial to add such states under the purview of the scheme.

On the front of groundwater contamination, Atal Bhujal Yojana undertakes ‘six-monthly’ monitoring of contaminants such as fertilizers, pesticides, and other toxic elements in recharging water, soil, or treated municipal wastewater that could be used for irrigation. There is also a provision for an independent audit of the scheme’s environmental performance. However, the scheme does not emphasize the treatment of contamination of groundwater by agricultural activities, which is one of the major sources of groundwater contamination. It would be more effective to create a unified framework that addresses both issues simultaneously rather than treating them in isolation.

Comprehensive Water Management Strategies: To effectively manage water resources, it is imperative to implement inclusive approaches that involve all stakeholders. These strategies should prioritize sustainable practices such as agroforestry and animal husbandry while addressing water management challenges with innovative solutions. To prevent water blockages and environmental degradation, eco-friendly alternatives must be promoted. The focus should be on the promotion of integrated management of both surface and groundwater resources while also incorporating climate-resilient practices to adapt to changing environmental conditions.

Empowering Farmers: Empowering farmers is crucial for ensuring their interests are at the forefront of water management projects. This entails building trust through transparent communication and active community involvement. Farmers should have an active role in decision-making processes, and water management strategies need to be customized to address regional and local needs. Capacity-building and training programmes are essential to empower farmers and government staff. It is also crucial to equip farmers with the knowledge and tools they need to access markets and receive fair prices for their produce.

Efficient Resource Allocation: Efficient resource allocation can be achieved by retrofitting and upgrading existing infrastructure to ensure cost-effectiveness. Providing financial incentives and green credit facilities can motivate the adoption of sustainable practices. It is important to identify and support local leaders to drive community engagement. Proper utilization of allocated funds is essential for achieving water management project goals. Implementing metering and spatial science technology can aid in better resource allocation.

Community Engagement and Knowledge Sharing: Community engagement and knowledge sharing are crucial for successful water management initiatives. Sharing success stories and

best practices not only inspires stakeholders but also guides them in the right direction. It is essential to create centralized platforms for data sharing and access can streamline information exchange among stakeholders. Maintaining coordination between relevant agencies and the Central Pollution Control Board (CPCB) is also vital. Additionally, promoting allied activities such as pisciculture, horticulture, and sericulture alongside traditional farming can enhance the overall income and resource use efficiency.

Climate-Resilient Practices: Given the challenges posed by climate change, it is imperative to incorporate climate-resilient practices into water management schemes. This involves taking into account the effects of climate change on water resources and ecosystems. ICT and IEC campaigns can raise awareness and promote climate-resilient practices. It is important to maintain regular coordination and updates between various agencies involved in water management to ensure effective adaptation to climate change.

Market Access and Income Diversification: To make agriculture sustainable, it is important to equip farmers with the skills and resources needed to sell their produce in the market and receive fair prices. This involves providing them with the necessary knowledge and tools. Promoting income diversification through activities such as agroforestry, animal husbandry, and non-farm ventures can improve overall economic stability and resource utilization.

Exploring Collaboration: Collaboration with civil society, local NGOs, and the Central Water Commission (CWC) can help mobilize resources, expertise, and community engagement for sustainable water management. Repairing and improving canal infrastructure is essential for efficient water distribution to farms and mitigating water loss due to leakage and evaporation. Ensuring a consistent and efficient project cycle is crucial for the timely and effective implementation of water management projects.

The objective of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)'s Per Drop More Crop (PDMC) is to improve water-use efficiency on farms through micro irrigation via drip and sprinkler irrigation systems. However, attaining water efficiency can be identified as a separate component/mission under the NMSA scheme, which enables the government to give it more importance. The distribution uniformity parameter can be used to assess the evenness of water distribution across an irrigated field. Installation of soil moisture sensors can help farmers monitor soil moisture levels and irrigate only when necessary. This can help prevent overwatering and reduce water wastage. Monitoring the quality and quantity of water can also be included in the scheme and engaging farmers to identify water health can also be enhanced.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Convergence of schemes related to groundwater (in numbers)
- Budgetary allocation for schemes related to groundwater conservation (INR crores)
- Water-use efficiency in agriculture (litres/cubic metres/tonnes)
- Number of groundwater quality monitoring stations

Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all

Agriculture is a significant consumer of energy, with modern farming practices relying heavily on fossil fuels and chemical inputs. This leads to greenhouse gas emissions and environmental damage. Around 30% of the world's energy is consumed by agri-food systems (IRENA and FAO, 2021). From 2000 to 2018, global energy consumption in agri-food systems rose by over 20%, driven mainly by mechanization in Asia, such as irrigation pumps, farm machinery, processing equipment, and fertilizers. The production and distribution of food, along with post-

harvest stages, contribute to this energy usage and emissions profile (FAO, 2011). Food systems and energy systems are interlinked and measures related to clean energy can reduce its environmental impact, while also improving efficiency and productivity (IRENA and FAO, 2021). There are also opportunities for clean energy in agricultural processes, such as decentralized energy applications (for example, in cold storage), solar-powered irrigation systems, energy-efficient agriculture implements, and the generation of bioenergy from agri-food residues.

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
The National Smart Grid Mission (NSGM)	<ul style="list-style-type: none"> Ministry of Power Central Electricity Regulatory Commission Central Electricity Authority Power Finance Corporation Energy Efficiency Services Limited (EESL) 	X	X	X
Programme on Energy from Urban, Industrial, Agricultural Wastes/Residues and Municipal Solid Waste	<ul style="list-style-type: none"> Ministry of New and Renewable Energy 	X		
GOBARdhan Scheme	<ul style="list-style-type: none"> Ministry of Jal Shakti 			X
Standards and Labelling	<ul style="list-style-type: none"> Ministry of Power Bureau of Energy Efficiency 	X		
Perform, Achieve and Trade (PAT)	<ul style="list-style-type: none"> Ministry of Power Bureau of Energy Efficiency 	X		
Sahaj Bijli Har Ghar Yojana (Urban) - Saubhagya (SBHGY)	<ul style="list-style-type: none"> Ministry of Power Rural Electrification Corporation Limited 	X	X	X
Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)	<ul style="list-style-type: none"> Ministry of Power Rural Electrification Corporation Limited 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Manufacturing of Pellets and Briquettes and Promotion of Biomass Cogeneration in Industries	<ul style="list-style-type: none"> Ministry of New and Renewable Energy 			X
Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM)	<ul style="list-style-type: none"> Ministry of New and Renewable Energy Solar Energy Corporation of India Ltd (SECI) 		X	
The Grid-Connected Solar Rooftop Programme	<ul style="list-style-type: none"> Ministry of New and Renewable Energy Solar Energy Corporation of India Ltd (SECI) 	X	X	X
National Wind-Solar Hybrid Policy	<ul style="list-style-type: none"> Ministry of New and Renewable Energy 	X	X	X
Development of Solar Parks and Ultra-mega Solar Power Projects	<ul style="list-style-type: none"> Ministry of New and Renewable Energy Solar Energy Corporation of India Ltd (SECI) 	X	X	X
Small Hydropower	<ul style="list-style-type: none"> Ministry of New and Renewable Energy 	X	X	X
Programme on Energy from Urban, Industrial, Agricultural Wastes/Residues and Municipal Solid Waste	<ul style="list-style-type: none"> Ministry of New and Renewable Energy 			X
Biogas Power Generation (off-grid) and Thermal Energy Application Programme	<ul style="list-style-type: none"> Ministry of New and Renewable Energy 			X
Pradhanmantri Krishi Sinchayee Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmer's Welfare 		X	
Demand Side Management (DSM) Scheme	<ul style="list-style-type: none"> Ministry of Power Bureau of Energy Efficiency 	X	X	X

	<ul style="list-style-type: none"> • Indian Council on Agricultural Research (ICAR) • Energy Efficiency Services Limited (EESL) 			
Integrated Power Development Scheme (IPDS)	<ul style="list-style-type: none"> • Ministry of Power • Rural Electrification Corporation Limited • Power Finance Corporation 	X	X	X
Sub-mission on Agricultural Mechanization (under National Mission on Agricultural Extension and Technology)	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmer's Welfare 			X

Synergies and Trade-offs

The energy and environmental aspects of the agriculture value chain have been extensively studied. Wu, et al. (2021) advocated using bioenergy over solar power to enhance food and energy self-sufficiency along with life cycle considerations. Addressing the heavy reliance on fossil fuels in the agricultural food supply chain (AFSC) is the key to climate mitigation (Gorjian, et al., 2022). Electricity feeds irrigation, mechanization, and storage in agriculture and is pivotal in boosting agricultural productivity, income, and food security (World Bank, 2008). Other applications of clean energy include cost-effective options such as solar dryers (Kawuma, 2022) and off-grid solar refrigeration (Kumari, 2022) to aid post-production activities. Organic farming has been highlighted for its energy savings, CO₂ reduction potential, and other benefits (Smith, Williams, and Pearce, 2015). Energy efficiency improvements are also linked to input use (Swanton, et al., 1996). Inputs in agriculture, such as pesticides and fertilizers, have a highly energy-intensive production process (Khan, Ali, and Ashfaq, 2018).

Targets	Synergy	Trade-off
Target 7.1: By 2030, ensure universal access to affordable, reliable, and modern energy services		
Target 7.2: By 2030, increase substantially the share of renewable energy in the global energy mix		
Target 7.3: By 2030, double the global rate of improvement in energy efficiency		
Target 7.a: By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency, and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology		

Target 7.b: By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing states, and landlocked developing countries, in accordance with their respective programmes of support		
--	--	--

Literature has also examined trade-offs between hunger alleviation and energy production, particularly in biofuel-reliant countries (Mainali, et al., 2018). While small renewable energy plants have a minimal environmental impact, their limited energy generation and potential farmland diversion pose challenges (Choobchian, et al., 2018). The volatility of global energy prices influences land use for the choice of food crops (Steinbuks and Hertel, 2013). The issue of solar panel waste generation may also pose a challenge in the future (Wu, et al., 2021).

The profitability of photovoltaic systems is influenced by geographical factors and local considerations (Sacchelli, et al., 2016). Water-stressed regions adopting alternative resources like wastewater treatment and desalination experience increased energy demands, impacting water efficiency and emissions in agriculture (Rodríguez-Díaz, 2012). The distance in agriculture value chains influences the energy footprint in food distribution systems (Halberg, et al., 2005). The indiscriminate use of agriculture pumps can exacerbate groundwater depletion, especially in water-stressed regions. While solar pumps enable farmers to access groundwater for irrigation, their unchecked use can lead to over-extraction of water resources. This can result in declining water tables, reduced aquifer recharge, and, ultimately, the depletion of vital groundwater reserves (Garg, et al., 2017; Kumar, et al., 2007). The adoption of energy-efficient and renewable energy technologies, especially for smallholder farmers with limited resources, raises questions about the affordability and accessibility of these technologies.

Gaps and Barriers

Several obstacles hinder the adoption of renewable energy technologies in agriculture. One major obstacle is the lack of knowledge and awareness about these technologies, particularly among those who own agricultural lands (Kumar and Majid, 2020). People are hesitant to give up their cultivated lands for renewable power plants due to a lack of understanding about these technologies. Additionally, the dependence of renewable energy on varying climate conditions contributes to lower popularity among the general public (Kumar and Majid, 2020). To enhance renewable energy capacity in agriculture, it is crucial to address several key factors, such as increasing awareness, bolstering the capacity of financial institutions, providing supplier support, promoting gender equality, and offering training. Moreover, factors such as cost, social acceptance, policy support, and local conditions must be considered (Gorjian, et al., 2022). Another challenge is the inadequate baseline data on energy efficiency in agriculture. Addressing this lack of data is essential for driving investments in renewable energy systems, enabling better technological design and cost-benefit analysis, and creating awareness of the benefits, including increased incomes, job creation, productivity, food and energy security, and emission reductions (Garg, et al., 2017). Policy evaluation is vital, especially for emerging renewable energy technologies. Governments play a critical role in reducing investment risks and facilitating progress through well-crafted policies in the financial sector (Gorjian, et al., 2022).

Furthermore, the low energy efficiency of agricultural pump sets in India, partly due to electricity subsidies provided to farmers, highlights the need for technical enhancements, cost reductions, and government incentives to implement sustainable renewable solutions in

agriculture and food production (Bhattacharya and Cropper, 2003). It is crucial to manage residues for renewable energy generation, compost preparation, and livestock feed. Collaborative efforts among ICAR institutes and organizations, such as the National Institute of Bio-Energy (NIBE), are needed to formulate policy guidelines for proper management (Gorjian, et al., 2022).

Cost reductions in sensors, control units, and photovoltaic (PV) modules are essential for adopting solar-powered robots and tractors in farming. These machines can significantly contribute to the renewable energy transition in agriculture (Kumari, 2022). Lastly, transitioning to renewables in agriculture requires a restructuring of mechanization processes to replace fossil fuel-based vehicles with electric ones. There are opportunities to set up decentralized cold storage facilities in rural areas powered by solar PV or other forms of decentralized renewable energy. This can reduce operating costs compared to using fossil energy sources (Gorjian, et al., 2022).

Emerging Policy Solutions

Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) can be strengthened by incorporating the RESCO (Renewable Energy Service Company) model in all its components:

- **Social factors in agriculture technology adoption:** Addressing land sharing and diversion issues is crucial. Building trust with small farmers, identifying local champions, and involving decentralized organizations such as SELCO can facilitate community involvement and adoption of innovative agro-technologies.
- **Challenges of agro-voltaic systems:** Small farmers face challenges with agro-voltaic systems due to land pressure and crop diversification issues. Trade-offs between renewable energy and agriculture also need to be considered.
- **Innovative approaches to machinery:** Innovative methods such as installing solar PV plants on canals and utilizing floatovoltaics can save the land and enhance income. Selling surplus water from solar pumps to maintain solar panels can provide additional revenue sources. Additionally, solar pumps can also be equipped with variable speed control mechanisms, allowing farmers to adjust the pump's output to match the actual water requirements of their crops.
- **Challenges in implementing government schemes:** Schemes such as PM-KUSUM hold promise, but face issues related to trust, long-term contracts, capital constraints, and procedural hurdles. Ensuring accessibility through vernacular information, training, and awareness campaigns is essential.
- **The whole value chain approach:** Currently, PM-KUSUM is skewed towards the production stage; there is immense potential to include a pre-production focus by including industries powered by renewables and a post-production focus by including solar dryers and food processing systems.

Agriculture demand-side management (AgDSM) needs to go beyond solar pumps and offer integrated energy solutions across agricultural implements through ESCO models:

- The integration of energy-efficient solutions across agriculture implements such as tractors and harvesters through the ESCO model can promote energy efficiency.

National Smart Grid Mission's Integration with RESCO Model

- **National Smart Grid Mission (NSGM):** NSGM presents both challenges and opportunities in addressing grid failures and grid management. Behavioural economics, AI, and machine learning can improve data collection through a user-friendly interface and analysis. Integrating NSGM with the RESCO model can improve technology utilization.

Persistent grid failures and issues such as grid choking require effective solutions, including grid management through systems like SCADA.

- **Maintenance with subscription models:** Implementing subscription models for maintenance can help ensure the longevity and sustainability of mechanized systems. In addition, solar-powered cooling systems can leverage post-production activities and other valuable techniques such as solar-powered devices emitting ultrasonic or sonic vibrations to repel pests from agricultural fields and further reduce the reliance on pesticide industries at the production stage.

Cross-Cutting

- **Tailored technology for small farmers:** Small farmers require technology suited to their scale, as larger landowners often have access to advanced machinery. Overcoming barriers like land diversity and geography is crucial for successful adoption.
- **Support and continuous handholding:** Providing ongoing support and continuous guidance throughout the adoption process is essential to help small farmers make the most of agricultural technology.
- **Engaging civil society and grassroots organizations:** Involving civil society and grassroots organizations is vital to bridging the community engagement gap and gaining a deep understanding of local dynamics. These intermediaries can connect with farmers on the ground and facilitate technology adoption.
- **Local champions for innovation:** Identifying and empowering local champions can accelerate the adoption of innovative solutions among farmers. These champions can provide continuous demonstrations and share success stories, shedding light on the current realities and power dynamics within their respective areas.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Frequency and duration of electricity outages in rural agricultural areas
- Performance indicators of PM-KUSUM for all three components
- Percentage of renewable energy use in agriculture (off-grid and on-grid)
- Percentage of renewable energy in cold storage
- Energy productivity in agriculture
- Energy efficiency policies extending to agriculture implements such as tractors and harvesters

Goal 8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

Sustainable development, which can lead to better living conditions for people all over the world, requires sustained and inclusive economic growth. Economic expansion can create more lucrative job possibilities and boost financial stability for all. In India, the main source of employment is in agriculture and its allied sectors. About 70% of rural households in the country still make their living mostly from agriculture. However, according to the Second Advance Estimates of National Income, 2022–23, released by the Ministry of Statistics and Programme Implementation (MoSPI), the share of gross value added (GVA) of agriculture and allied sectors in the total economy for the year 2021–22 has reduced to 19.0% and as per the annual Periodic Labour Force Survey (PLFS) report 2021–22, the estimated percentage distribution of workers is about 45.5%.

The protection of the natural resource base is essential for sustainable agriculture. It should secure the livelihood and well-being of agricultural workers and their families, avert the degradation of water and land, preserve biodiversity, promote the economic and social well-being of everyone, and ensure a safe and high-quality availability of agricultural goods. However, agriculture must be financially feasible in the long run to be sustainable. Long-term economic risk is greater for conventional agriculture than for sustainable agriculture (Hans and Coalco, 2019). Further, access to the formal credit system is crucial to ‘promote sustained, inclusive and sustainable economic growth’ of farmers and also for them to invest in sustainable agriculture practices.

The primary objective of implementing the eco-efficiency idea as a new paradigm for agriculture is to increase the production of high-quality goods while decreasing the use of soil, water, energy, labour, and capital.

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
Priority Sector Lending (PSL)	Reserve Bank of India NABARD	X	X	X
Rashtriya Krishi Vikas Yojana (RKVY) – Remunerative Approaches for Agriculture and Allied Sectors Rejuvenation (RAFTAAR)	Ministry of Agriculture and Farmers Welfare	X		X
Kisan Credit Card (KCC) scheme	Ministry of Agriculture and Farmers Welfare NABARD	X	X	X
Pradhan Mantri Kisan Samman Nidhi (PM-KISAN)	Ministry of Agriculture and Farmers Welfare	X	X	X
Deendayal Antyodaya Yojana – National Rural Livelihoods Mission (NRLM)	Ministry of Rural Development	X	X	X
The Trafficking in Persons (Prevention, Care and Rehabilitation) Bill, 2021	Ministry of Women and Child Development	X	X	
Draft National Migrant Labour Policy	NITI Aayog Ministry of Labour and Employment	X		
Pradhan Mantri Fasal Bima Yojana (PMFBY)	Ministry of Agriculture and Farmers Welfare	X	X	X
Weather-Based Crop Insurance Scheme (WBCIS)	Ministry of Agriculture and Farmers Welfare	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

National Policy on Skill Development and Entrepreneurship 2015	Ministry of Skill Development and Entrepreneurship		X	X
Project UNNATI	Ministry of Rural Development		X	
National Solar Mission	Ministry of New and Renewable Energy		X	
Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyaan (PM-KUSUM)	Ministry of New and Renewable Energy		X	
Deen Dayal Antyodaya Yojana – National Rural Livelihoods Mission (NRLM)	Ministry of Rural Development	X	X	X
Mahila Kisan Sashaktikaran Pariyojana (MKSP) under Deendayal Antyodaya Yojana- National Rural Livelihood Mission (DAY- NRLM)	Ministry of Rural Development	X	X	X
Pradhan Mantri Gram Sadak Yojana (PMGSY)	Ministry of Rural Development	X		X
Pradhan Mantri Kaushal Vikas Yojana (PMKVY)	Ministry of Skill Development and Entrepreneurship	X	X	X
Pradhan Mantri Krishi Sinhchayee Yojana (PMKSY)	Ministry of Agriculture and Farmers Welfare		X	
National Agricultural Market (eNAM)	Ministry of Agriculture and Farmers Welfare			X
National Policy for Farmers 2007	Ministry of Agriculture and Farmers Welfare	X	X	X
Initiative for Development of Entrepreneurs in Agriculture	Ministry of Development of North Eastern Region			X
Innovation and Agri-Entrepreneurship Development (Under RKVY)	Ministry of Agriculture and Farmers Welfare Department for Promotion of Industry and Internal Trade			X
Private Entrepreneurs Guarantee (PEG)	Ministry of Consumer Affairs, Food and Public Distribution			X

Gramin Bhandaran Yojana (GBY)	Ministry of Food Processing			X
Draft National Migrant Labour Policy	NITI Aayog, Ministry of Labour and Employment	X		
Agri Tourism Policy	Maharashtra Agri Tourism Development Committee	X	X	X
Agricultural Trade Policy	Ministry of Commerce and Industry			X
Pradhan Mantri Jan Dhan Yojana (PMJDY)	Ministry of Finance	X	X	X

Synergies and Trade-offs

SDG 8 aims to promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all. Its targets range from economic upliftment to decent work, from gender parity to employment of youth. It also targets abuse and trafficking and deals with providing a decent livelihood. It involves access to credit flow and technologies and focuses on the importance of technological advancement to achieve the goal. Since a major part of the population of India is involved in the agriculture sector, Goal 8 has direct synergies with agriculture and, in turn, with the promotion of sustainable agriculture.

Many aspects of agriculture are impacted by technology, including seed technologies, pesticides, and fertilizers. Tilling, harvesting, and physical work have all become more efficient due to mechanization (Sehgal Foundation, 2023). By substituting more exploitative methods and concentrating production systems on regenerative agriculture, diversification can help improve climate resilience and preserve natural resources (soil, water, and biodiversity) (Paroda, 2022). New forms of cooperation between farmers, wholesalers, local governments, and others are allowing innovations to emerge (Potent, 2016). Efficiency in input utilization without jeopardizing the resource base has emerged as key to sustaining growth (Bera, 2021).

Moreover, easy, and efficient access to loans or credit for farmers, especially for small and marginal farmers, can enable them to create a sustained source of livelihood through agriculture. Further, with proper training and capacity-building of farmers, credit flow can encourage them to undertake sustainable agricultural practices as well.

Achieving sustainability in agriculture requires addressing gender inequity, too. It is more difficult to improve production and decrease hunger and poverty where inequality persists (Ignaciuk and Chit Tun, 2019). Further, it is crucial to ignite the interest in agriculture among the country's youth, as over time, the youth have become disillusioned by the inefficiency of agriculture as a livelihood. Youth provides new perspectives, creative ideas, and a willingness to adopt new technologies, which can help the agriculture sector expand and modernize (FSII, n.d.).

Analysing the trade-off between SDG 8 and the agriculture sector, farmers in general and small and marginal farmers in particular have been at the receiving end of the ill effects of globalization. Indian agriculture has seen the share of agriculture in the national income decline from over 50% in the 1950s to around 20% today (Singh, 2011). Specialization and mechanization trends can boost 'efficiency' but also reduce jobs on the land. These issues are

helped by sustainable agriculture, which emphasizes small-scale, labour-intensive performance.

Further, before the Green Revolution, agriculture was more sustainable and diversified in terms of both crops and livestock, with agroforestry and silvopastoral farming systems collaborating with animal-based farming systems (Paroda, 2019). A move towards a few crops with the potential to yield more and generate greater revenue resulted from scientific improvements, opportunities for enhanced varieties, and the development of new crops. Such a strategy gradually increased reliance on just a few crops, such as wheat, rice, maize, and sugarcane (Paroda, 2022). Crop diversification, a component of sustainable agriculture, might be one of the most ‘economically sensible, environmentally sound, and logical strategies’ to lessen agricultural uncertainty—especially for smallholder farmers (Joshi 2005) and promote sustainability. Increasing resilience, agronomical stability, and geographical and temporal biodiversity in farms are all benefits of crop diversification (Holling 1973; Joshi 2005).

Targets	Synergy	Trade-off
Target 8.1: Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7% gross domestic product growth per annum in the least developed countries		
Target 8.2: Achieve higher levels of economic productivity through diversification, technological upgrading, and innovation, including through a focus on high-value-added and labour-intensive sectors		
Target 8.3: Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro, small- and medium-sized enterprises, including through access to financial services		
Target 8.4: Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead		
Target 8.5: By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value		
Target 8.6: By 2020, substantially reduce the proportion of youth not in employment, education or training		
Target 8.7: Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking, and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms		
Target 8.8: Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment		
Target 8.9: By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products		
Target 8.10: Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance, and financial services for all		

Target 8.a: Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to least developed countries		
Target 8.b: By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization		

Gaps and Barriers

Indian farmers depend more on land, labour, and animal inputs to cultivate crops than technology. As per the Agriculture Census (2015–16), around 86% of Indian farmers are marginal and small farmers with less than 2 hectares of land. They lack the resources to learn about technology. Lacking knowledge concerning new methods and technologies pushes farmers into the cycle of poverty and debt. Also, the proportion of agricultural employees in the total workforce is predicted to decrease from 58.2% in 2001 to 25.7% by 2050. In India, major factors affecting the agriculture sector are ageing farmers and rural youth showing a decline in enthusiasm in this sector (Bailey, 2020).

In India, there are regions that have very low entrepreneurship cultures. A gap in the emergence of an entrepreneurial culture among rural residents is caused by a lack of education and awareness. Due to the extremely poor infrastructure and facilities, including a lack of opportunities for employment, skill development, specialization, and talent utilization, people from rural areas are moving to urban centres. This exodus is causing a talent gap in rural areas (Chand, n.d.).

Moreover, it is important to have alternative plans or organized employment opportunities in place since employment in the agricultural industry is only available seasonally. Although farming requires year-round labour, such as harvesting and ploughing, money can only be earned during a specific season. People are more likely to fall into debt if they are afflicted by climate disasters and crop failure.

Covering the aspects of women upliftment, even though women labour more hours per year than men do globally, female farmers significantly underperform their male counterparts in terms of agricultural production and earnings. Farms run by women typically produce 20–30% less than farms run by men. The FAO claims that the gender-specific barriers are the only thing to blame for this ‘crop gap’, which has nothing to do with a person’s aptitude for farming (Duckett, n.d.). Further, children, especially those from low-income families, are more susceptible to slavery than adults because they can be duped or deceived more easily. They are manageable and unlikely to ask for greater pay or working conditions. Child abuse nearly always results from child trafficking, which is linked to child labour (Kaur and Gulati, 2022).

Emerging Policy Solutions

Strengthening Priority Sector Lending

Priority Sector Lending (PSL) is a policy of the Reserve Bank of India (RBI) that obliges banks to lend a specific percentage of their credit to certain sectors of the economy, including agriculture, micro, small, and medium enterprises (MSMEs), education, social infrastructure, and renewable energy. The latest revision of the PSL guidelines includes financing for green activities such as the installation of solar power plants and compressed biogas facilities. The updated guidelines aim to encourage and support environmentally conscious lending strategies to contribute to achieving the SDGs (RBI, 2020).

The policy demands that commercial, foreign banks allocate 40% of their total lending for PSL, while the regional rural banks and small financial banks are expected to set aside 75% of their loans for PSL. Of this, 18% is for the agriculture sector (in the case of foreign banks, applicable only if there are more than 20 branches in India). A further 10% is lent to small and marginal farmers only.

The PSL scheme for the agriculture sector provides loans for different stages of the sustainable value chain. Farmers can avail of loans for green activities, including installing stand-alone solar agricultural pumps, seed production, bio-fertilizers, soil conservation, construction of storage facilities, and setting up compressed biogas plants (RBI, 2020).

The following recommendations can further strengthen PSL to contribute to sustainable agriculture.

- **Monitoring data on the positive outcomes of the subsectors and the green provisions of the loans**

Consolidated data on the agricultural loans provided by the banks is available through RBI and NABARD. The banks have mostly crossed the targets annually set by the Government of India (Budget), known as Ground Level Credit. However, there is currently a lack of monitoring mechanisms for measuring the positive outcomes of the subsectors and green provisions of the loans. It is important to have access to monitored data to ensure the scheme's effectiveness.

- **Introducing the provision of tagging the loans for green activity can strengthen the credibility of the PSL for sustainable practices**

Introducing the provision of tagging the loans for green activity can strengthen the credibility of the PSL for sustainable practices. An emphasis on green credits and loans by an institution like RBI could set precedents for other financial institutions of the country to invest significantly in promoting green, sustainable agriculture practices.

- **Create awareness and amplify the provisions for those seeking loans for sustainable agriculture**

One way to increase awareness about the provisions of PSL in rural areas is to hold gram sabha meetings, rallies, demonstrations, and door-to-door campaigns in rural households. However, language barriers can be a hindrance to creating awareness. Providing information in the local language can be an effective way to reach the target audience that may not necessarily understand the original language of information. It is crucial to focus on strengthening, modernization, and enhancing state-led agricultural institutions such as the ICAR, KVKs, and the Kisan Call Centre. These institutions play a pivotal role in disseminating knowledge and expertise to farmers. It is important to upgrade these institutions, especially in terms of technology adoption, in alignment with the ground realities of Indian agriculture. This would ensure that the latest innovations and practices are accessible to farmers in a way that can be effectively implemented.

- **Regulate and monitor the flow of credits from banks to the beneficiaries and ensure the implementation of the activity for which the credit was allocated**

It is essential to regulate and monitor the flow of bank credits to ensure that they reach the intended beneficiaries and are used for the purpose for which they were allocated. Some critical issues that need to be addressed include the non-availability of guarantees or collateral for loans, a lack of awareness about provisions, dependence on environmental, climatic conditions for agricultural output, and lack of last-mile reach. Connecting crop loans with crop insurance may resolve the barrier of guarantee.

Private players (excluding NBFC and banks) can assume the role of service provider. For example, banks can partner with fintech for checks, balances, and recovery processes. The

player with greater access to farmers can create awareness and facilitate credit and other services. To enforce sustainable agriculture, a system can be put in place where banks give loans to farmers and, in return, receive carbon credits from the yield. Further, to promote the generation of carbon credits, transparency is key, particularly in transferring these credits and the associated monetary benefits to farmers.

- **Ensuring easy access to credit for women farmers is an imperative component for gender mainstreaming—incentivize women-led agribusinesses, start-ups, and entrepreneurial initiatives**

The PSL policy in India has included women beneficiaries from the weaker sections; however, it has not focused on women farmers of India whose labour is often disguised. Providing women farmers with easy access to credit is an imperative component of gender mainstreaming. Further, PSL can also incentivize women-led agribusinesses, start-ups, and entrepreneurial initiatives.

Small and marginal farmers, especially women farmers, often face difficulties in terms of collective bargaining power and visibility. It is important to provide training to address these challenges and leverage information technology to connect with and support farmers. Additionally, providing training to women-led agricultural start-ups and entrepreneurial activities is also important. The efforts should be focused on promoting women's participation in agriculture, addressing the lack of credit history for women, and implementing technology to provide credit.

Cross-cutting Recommendations

- **Banks can help impose a sustainable framework:** For instance, they may come up with provisions where they would provide loans or credits if the receiver does not employ child labour, employs women farmers, or implements crop diversification. To incentivize farmers, they could be offered lower interest rates.
- **Creating an integrated dashboard:** Provides real-time updates on vulnerable areas is essential. This tool can track budget allocations and expenditures in these regions, enhancing transparency and accountability. Integrated dashboards can offer valuable insights into the effectiveness of existing schemes and monitor the progress of new ones. This approach ensures that policies do not become overly focused on yield-specific calculations but instead consider holistic and sustainable outcomes.
- **Health of soil is fundamental for identifying vulnerable areas:** Collaboration between the government and data collected from sources like GIS and remote sensing can help pinpoint areas and groups that need special attention.
- **Implementing green budgeting:** In Bihar and Puducherry, where separate budgeting can be allocated for these vulnerable areas and their populations, can further aid their development and resilience.
- **Baseline data collection:** It is a critical component of identifying vulnerable groups. This data provides an accurate picture of the situation and supports further studies using secondary data sources.
- **Policy coherence and integration:** Various agricultural schemes offered by both state and central governments is another area of importance. Coordinating these schemes can reduce redundancies, optimize resource allocation, and streamline the support provided to farmers.
- **A one-size-fits-all approach is not viable for Indian agriculture:** Given the diverse landholding capacities in different regions, tailoring policies to the specific needs of

each region can ensure that they genuinely benefit the intended communities. Policy convergence, for schemes like MGNREGA and activities like water security plans, water usage, and water users' associations, would help with sustainable resource management in agriculture.

- The absence of a clear and comprehensive definition for 'farmers' exacerbates the problem. It is crucial to establish well-defined classifications and policies that can ensure farmers are included within the social security net. Landless farmers, tenants, and sharecroppers need to be brought under the definition of farmers and build their resilience.
- For sustainability, no one organization can be there working forever. The government needs to step in and take action.

It is crucial to implement a comprehensive agricultural reform not only to transition to climate-resilient agriculture but also to address nutrition concerns. The Green Revolution, while contributing to development, has led to a monoculture of crops. Reforms in this context are essential.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Number of farmers with access to formal credit mechanisms for sustainable agriculture practices
- Number of female farmers with access to a formal credit system for sustainable agriculture practices
- Number of credit schemes on sustainable agriculture under PSL that are monitored regularly, and data is made available to the public

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

Rural infrastructure has the potential to enhance agricultural productivity, leading to an increase in agricultural wages and job opportunities. This, in turn, can stimulate growth in rural areas (Llanto, 2012). Additionally, the availability of mobile phones can reduce the dispersion of agricultural products' prices by improving coordination between producers and traders (Foster, et al., 2023).

Transporting water via open channels and furrows is an inefficient irrigation method due to significant water loss through evaporation before it reaches the root zone, a common issue in traditional irrigation methods (OECD, 2001). Manual irrigation pumps can be physically demanding and costly due to recurring fuel expenses. Green infrastructure, such as water harvesting infrastructures to collect rainwater in agricultural areas or cultivating forests to safeguard the soil and aid in replenishing groundwater, are some examples of creating a more sustainable water-food-energy nexus and a 'greener' economy (UN Water, 2021).

With the increase in population, there is a continuous rise in the implementation of advancements and technologies aimed at enhancing efficiency, economic viability, and the assurance of food supply (Frontiers in Nutrition, n.d.). India is using digital innovations to improve market-led crop insurance schemes, such as the usage of geotagging, satellite data, and drone technology to verify crop-cutting experiments and improve intelligence on the area insured (Boettiger and Sanghvi, 2019).

India incurs losses amounting to Rs 92,651 crores (926.51 billion) in post-harvest processes, resulting in a staggering 40% loss of the country's total produce. This makes India one of the

countries with notably high post-harvest losses, despite government spending on food distribution accounting for just around 1% of the country's gross domestic product (GDP) (MOFPI, 2022).

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholder	Production	Pre-Production	Post Production
Pradhan Mantri Gram Sadak Yojana (PMGSY)	<ul style="list-style-type: none"> Ministry of Rural Development National Rural Infrastructure Development Agency (NRIDA) 	X		
Shyama Prasad Mukherji Rurban Mission (SPMTM)	<ul style="list-style-type: none"> Ministry of Rural Development 	X		
Bharatmala Pariyojana (BP)	<ul style="list-style-type: none"> Ministry of Road Transport and Highways National Highways and Infrastructure Development Corporation Limited 	X		
Digital India	<ul style="list-style-type: none"> Ministry of Electronics and Information Technology National Institute of Electronics and Information Technology (NIELIT) National e-Governance Division National Centre for Geo Informatics Centre For Railway Information Systems (CRIS) Department of Agriculture Cooperation and Farmers Welfare (DAC&FW) Small Farmers Agribusiness Consortium (SFAC) Department of Science and Technology (DST) Open Government Data Platform India 	X		X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

<p>Integrated Scheme for Agriculture Marketing (ISAM)</p> <p>Agricultural Marketing Infrastructure (AMI)</p> <p>Agricultural Marketing Information Network (AGMARKNET)</p>	<ul style="list-style-type: none"> • Ministry of Agriculture • NABARD • Small Farmers' Agribusiness Consortium (SFAC) • Directorate of Marketing and Inspection (DMI), Department of Agriculture and Cooperation, Ministry of Agriculture • National Institute for Agricultural Extension Management • National Institute of Agricultural Marketing • National Consumers Cooperative Federation Ltd. • National Cooperative Development Corporation 			X
<p>Research and Development in Processed Food</p>	<ul style="list-style-type: none"> • Ministry of Food Processing Industries 			X
<p>Venture Capital Assistance Scheme</p>	<ul style="list-style-type: none"> • Ministry of Agriculture • Small Farmers' Agribusiness Consortium (SFAC) 			X
<p>Agro Processing Cluster Scheme</p>	<ul style="list-style-type: none"> • Ministry of Food Processing Industries • Project Execution Agency (PEA) 			X
<p>PM Kisan SAMPADA Yojana (PKSY)</p>	<ul style="list-style-type: none"> • Ministry of Food Processing Industries • Project Execution Agency (PEA) 			X
<p>Scheme for Technology Upgradation/Establishment/Modernization for Food Processing Industries</p>	<ul style="list-style-type: none"> • Ministry of Food Processing Industries 			X
<p>Rashtriya Krishi Vikas Yojna (RKVY)</p>	<ul style="list-style-type: none"> • Ministry of Agriculture 	X	X	X

Synergies and Trade-offs

Target	Synergy	Trade-off
Target 9.1: Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all		
Target 9.2: Promote inclusive and sustainable industrialization and, by 2030, significantly raise the industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries		
Target 9.3: Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets		
Target 9.4: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities		
Target 9.5: Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending		
Target 9.a: Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological, and technical support to African countries, least developed countries, landlocked developing countries, and small island developing states		
Target 9.b: Support domestic technology development, research, and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities		
Target 9.c: Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020		

Durable all-weather roads in agriculture drive crop diversification, modernize farming, boost employment, and promote agricultural commercialization (Shamdasani, 2021). Strong market infrastructure is vital for healthy agricultural production (Bhatia, 1999), and infrastructure expansion benefits both agriculture and economic growth. Clean energy adoption in rural areas

enhances ecological conditions, alleviates energy constraints, and reduces electricity costs for agriculture (Liu. et al., 2018). Government-supported technology-driven innovations have been pivotal in Indian agriculture since the Green Revolution (Singh, 2004), while mobile phones improve connectivity and market information access for farmers (Chhachhar, et al., 2014).

However, opening labour markets outside of villages may lead to a shift away from labour-intensive crops and technologies due to increased labour costs (Asher and Novosad, 2020). To optimize agricultural development, a synergy is needed between infrastructure development, technological innovation, and market access while addressing labour cost trade-offs (Shamdasani, 2021; Bhatia, 1999; Liu, et al., 2018; Singh, 2004; Chhachhar, et al., 2014; Asher and Novosad, 2020).

Gaps and Barriers

Barriers to sustainable development in clean technologies include limited consideration of sustainability dimensions and a narrow focus on specific technologies (Scharfy, Boccali, and Stucki, 2017). Regulatory uncertainty and ex-post expropriation have caused delays and cancellations of projects (Holcomb, 2018). High transaction costs hinder marketing, particularly for producers lacking market access, transport, and post-harvest infrastructure (Rao, Birthal, and Joshi, 2006). Constraints such as high transaction costs, rural credit deficiencies, and farmers' limited assets hinder investment in agriculture (Golait, 2007). The reluctance of insurance companies and Microfinance Institutions (MFIs) to serve rural areas is driven by agricultural production uncertainty (World Bank, 2003). The transition to sustainable farming lacks support for initial income loss and capacity development (Gupta, et al., 2021). While ICT use by farmers can improve market access, the lack of internet access and incentives remains a challenge (Rodrigues and Rodríguez, 2013). Underfunding of rural infrastructure and the need for equitable market access and a transparent regulatory regime are additional hurdles (Samanta, 2015; Holcomb, 2018). Microcredit institutions and government departments can facilitate extension services and marketing support for small farmers (Tenaw and Islam, 2009). Mobile broadband and innovative funding methods like annuity payments and public-private partnerships (PPPs) offer opportunities to address connectivity and infrastructure deficits (Rodrigues and Rodríguez, 2013; Samanta, 2015). Policies should be put in place to promote ICT adoption and access improvements (Rodrigues and Rodríguez, 2013).

Approximately 96% of cold storage facilities in India are privately operated, while government bodies, institutions, and cooperatives manage the remainder. Significantly, about 75% of these cold stores are primarily dedicated to potatoes, indicating a lack of diversity in storage options while underscoring the importance of potatoes in the Indian market. Notably, around 5000 older cold storage units lack integrated pack houses or ancillary units, posing challenges for food storage. Many of these facilities are situated close to production hubs and rely heavily on transportation to reach consumers (NABARD, 2021).

Emerging Policy Solutions

Improving the Technological Infrastructure for the User Interface

- **Inclusive App Development:** Incorporate native languages in agricultural applications to reach rural farmers more effectively. The applications should have user-friendly features, language support, and accessibility for all, including those with limited literacy and disabilities. Rural farmers who are more comfortable with regional languages or dialects might not be well-versed in either of the languages. Advisory services can provide guidance on sustainable farming methods, crop diversification, and risk management. Weather advisories can help farmers prepare for extreme weather events, reducing crop losses. Real-

time information, such as market prices, helps farmers make timely decisions on crop sales and investments. It also aids in predicting and responding to disease outbreaks and pest infestations promptly. Due to the app not being accessible through the Google Play Store and the QR code given on the website not working, it prevents the farmers from using apps such as AgriMart effectively.

- **Improved Internet Access:** Expand rural internet access and enhance network connectivity for real-time communication, market information, and educational resources. Prioritize user-friendly features, language support, and assistive technologies.
- **Incentivization Models:** To shift from a subscription model to a freemium model that has no cost attached to it and farmers can access the applications without paying any sum will require collaboration with mobile service providers for free access, and ensure data security, transparency, and data sharing to encourage farmer participation.
- **Use of advanced technology:** For optimal resource utilization and sustainability, use modern technologies, cleaner fuels, and renewable energy sources. Foster public-private partnerships (PPPs) for large-scale infrastructure projects. Incentivize innovation and resource retrofitting.

Access to Finance: Tailor microcredit and insurance products to farmers' needs. Promote financial literacy, trust-building between farmers and banks, and technology-driven remote transactions for faster loan approvals.

Research and Development: Encourage collaborative research on sustainable practices, drought-resistant crops, and pest management. Incentivize farmers adopting sustainable methods with premium discounts. Invest in climate-resilient seeds and efficient machinery.

Market Adaptability: Promote farming as a respectable profession, reduce transportation costs with on-site processing centres, and develop new agricultural products. Ensure cooperative models for credit sharing and align R&D with market demand.

Collaboration for Shared Resources: To accelerate innovation in the field of agriculture, it is important to promote collaboration among industry players, universities, and research institutions. Converge existing schemes to create a unified framework for agricultural development. Collaborate closely with the Ministry of Agriculture and Farmers Welfare (MoAFW) to synergize efforts and leverage expertise and resources.

Strengthen the Pradhan Mantri Kisan Sampada Yojana (PMKSY) with portable post-harvest technology, seed research, and location-specific market information. Enable direct procurement from farmers, energy-efficient technologies, and inclusivity for small farmers. Retrofit older units, invest in transportation infrastructure, incentivize private investments, and address power supply challenges for more accessible and efficient cold storage facilities nationwide.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Number of marketplaces, mandis, and collection centres where farmers can sell their sustainable agricultural produce and access market information
- Share of public expenditure that focuses on the promotion of usage of cleaner technologies in the agriculture sector
- Percentage reduction in post-harvest losses over the previous year

Goal 10. Reduce inequality within and among countries

Reducing inequalities and ensuring no one is left behind are integral to achieving sustainable development goals. According to a report by the UN, one in six people worldwide has experienced discrimination in some form. Women and people with disabilities are disproportionately affected (UN, 2023). Regions and people with considerable development constraints have a high vulnerability to climatic hazards, which is further exacerbated by inequity due to gender disparities, ethnicity, low incomes, informal settlements, disability, age, and historical and ongoing patterns of inequity (IPCC, 2023). Inequality in agriculture arises when marginalized farmers, women, and youth engaged in agriculture are not able to specialize in sustainable production due to resource constraints (FAO, et al., 2022). Agricultural development is considered unsustainable if it fails to include all communities and benefit those whose livelihoods depend upon it. Therefore, sustainable agriculture can be promoted by increasing access to resources and assets for marginalized communities, increasing their participation in markets, and creating more job opportunities (FAO, 2014).

For instance, women's empowerment is not only a key part of achieving the SDGs by 2030 but is also crucial for collective well-being. *The Status of Women in Agrifood Systems* report suggests that while women have gained more access to resources such as digital technology and financial services over the past decade, the gaps are yet to be filled in rural areas (FAO, 2023). Insights from agriculture suggest that closing the gender gap in farm productivity and the wage gap in agrifood-system employment would increase global GDP by 1% (or nearly \$ 1 trillion). This would reduce global food insecurity by about 2 percentage points, reducing the number of food-insecure people by 45 million (FAO, 2023).

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
National Policy for Farmers	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Mission Organic Value Chain Development for North-eastern Region 2018 (MOVCDNER)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare Integrated Nutrient Management Division 	X		X
Bringing Green Revolution to Eastern India	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Deendayal Antyodaya Yojana (DAY) -National Rural Livelihood Mission (NRLM)	<ul style="list-style-type: none"> Ministry of Rural Development 	X	X	X
New Generation Watershed Development Projects under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Rural Development Department of Land Resources National Rainfed Area Authority Ministry of Agriculture and Farmers Welfare 		X	
National Food Security Mission (NFSM)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare Ministry of Finance 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

	<ul style="list-style-type: none"> • Ministry of Consumer Affairs, Food and Public Distribution • Ministry of Panchayati Raj • Ministry of Tribal Affairs • Ministry of Social Justice and Empowerment • Ministry of Women and Child Development 			
National Agroforestry Policy	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Ministry of Environment, Forest and Climate Change • Ministry of Rural Development • NABARD • Ministry of New and Renewable Energy (MNRE) • International Centre for Research in Agroforestry (ICRAF, South Asia Office) 		X	X
Sub-Mission on Agroforestry (SMAF) under the National Mission for Sustainable Agriculture	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Council of Scientific and Industrial Research • Indian Council of Agricultural Research (ICAR) 	X	X	
Repair, Renovation and Restoration (RRR) of Water Bodies	<ul style="list-style-type: none"> • Ministry of Jal Shakti 		X	
Paramparagat Krishi Vikas Yojana (PKVY)	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare 	X	X	
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) – Har Khet Ko Pani (HKKP)	<ul style="list-style-type: none"> • Ministry of Jal Shakti • Ministry of Rural Development • Ministry of Jal Shakti • Inter-Ministerial National Steering Committee (NSC) 		X	
National Action Programme to Combat Desertification	<ul style="list-style-type: none"> • Ministry of Environment, Forest, and Climate Change 	X		
Pradhan Mantri Janjatiya Vikas Mission (PMJVM)	<ul style="list-style-type: none"> • Ministry of Tribal Affairs • Tribal Cooperative Marketing Development Federation of India (TRIFED) 		X	X
Pradhan Mantri Fasal Bima Yojana (PMFBY)	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare • Agriculture Insurance Company of India Ltd. 	X		
Rashtriya Krishi Vikas Yojana	<ul style="list-style-type: none"> • Ministry of Agriculture and Farmers Welfare 	X	X	X

Synergies and Trade-offs

Targets	Synergy	Trade-off
Target 10.1: By 2030, progressively achieve and sustain income growth of the bottom 40% of the population at a rate higher than the national average		
Target 10.2: By 2030, empower and promote the social, economic, and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion, or economic or other status		
Target 10.3: Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies, and action in this regard		
Target 10.4: Adopt policies, especially fiscal, wage, and social protection policies, and progressively achieve greater equality		
Target 10.5: Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations		
Target 10.6: Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable, and legitimate institutions		
Target 10.7: Facilitate orderly, safe, regular, and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies		
Target 10.a: Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements		
Target 10.b: Encourage official development assistance and financial flows, including foreign direct investment, to states where the need is greatest, in particular least developed countries, African countries, small island developing states, and landlocked developing countries, in accordance with their national plans and programmes		
Target 10.c: By 2030, reduce to less than 3% the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5%		

The promotion of inclusivity and the development of sustainable agriculture involve multiple synergetic levels. The implementation of crucial SAPs (Sustainable Agricultural Practices), such as the use of improved seed, organic fertilizer, and soil and water conservation and SLM (Sustainable Land Management) technologies can increase agriculture outcomes. This, in turn, can improve the income inclusivity of farmers (Setsoafia, Ma, and Renwick, 2022; Branca, et al., 2011; Muhie, 2022). To promote sustainable agriculture, it is essential to assess the differential access to agricultural resources by different stakeholders involved. This ensures equal engagement and empowerment (Grabowski, et al., 2020; Kusnandar, Brazier, and Van Kooten, 2019). Inclusivity promotes climate-smart agriculture, allowing for the identification of responses based on the differing needs of marginalized farmers (Hariharan, et al., 2018).

Increasing foreign investment can lead to better job growth and better income opportunities through infrastructure development and other financial assistance, which can have a positive impact on agriculture development (Karlsson, 2014; Budiasa, 2020; Adhana, 2017). Sustainable agriculture growth also provides investment opportunities by addressing climate change gaps in agriculture, which can generate more job opportunities (Benjamin, 2015). From the lens of migration, sustainable agriculture can help in tackling climate change, which in turn

has the potential to reduce migration issues in climate-sensitive regions (Falco, Donzelli, and Olper, 2018).

There is a trade-off between inclusive growth and sustainable agriculture despite the potential synergies. With the rise in income, the demand for agricultural products increases putting pressure on agricultural land, thus posing a risk to sustainable methods employed in them (Balasubramanian, 2010). In theory, sustainable agriculture and economic development should work together, but in practice there exists a trade-off between them, especially in the developing economies. For instance, when the Green Revolution was launched in India, it promoted the use of fertilizers and input subsidies, which did increase food production and promote inclusivity, but at the expense of the sustainability of agriculture (Reddy, 1995).

Gaps and Barriers

Discriminatory land and property ownership rights, undervaluation of women's labour inputs in agriculture, and limited educational opportunities for women and girls obstruct inclusivity, equality, and equal participation in agriculture (Squire, 2003). The unavailability of infrastructure and restricted ability to use integrated farming techniques can also hamper equal participation in agriculture and negatively impact the use of technology in sustainable agriculture, which ultimately affects agricultural production (Muhie, 2022; Adenle, Manning, and Azadi, 2017).

Investment in agriculture by global institutions and organizations can be hampered by a lack of data on sustainable agriculture practices (Havemann, Negra, and Werneck, 2022). Further, an unsupportive or unpredictable policy environment for global financial investments also negatively affects investment in sustainable agriculture (Havemann, Negra, and Werneck, 2022). Limited funding for infrastructure development significantly reduces participation in agriculture and creates less scope for agricultural development (Zulu, Djenontin, and Grabowski, 2021; Abraham and Pingali, 2020; Havemann, Negra, and Werneck, 2022). Other key barriers to promoting inclusivity and equality in sustainable agriculture include lower participation in decision-making and a lack of youth participation (Zulu, Djenontin, and Grabowski, 2021; Abraham and Pingali, 2020; Havemann, Negra, and Werneck, 2022).

Emerging Policy Solutions

Inclusive Development for Sustainability: Prioritizing the development and empowerment of marginalized communities, including women, tribals, and small-scale farmers, is a foundational element for achieving sustainable agriculture. Policies and programmes should aim to reduce inequalities and promote social and economic inclusion.

Strengthening Pradhan Mantri Janjatiya Vikas Mission (PMJVM): PMJVM, which operates under the Ministry of Tribal Affairs, plays a pivotal role in bolstering tribal entrepreneurship and creating livelihood opportunities. It focuses on post-production value chain development by incorporating traditional skills and fostering product diversification. This approach not only addresses income disparities but also advances sustainable practices that optimize natural resource utilization and support agriculture, NTFP, and non-farm enterprises.

NABARD Watershed Development Project: The NABARD Watershed Development Project primarily targets areas that have a significant Scheduled Castes/Scheduled Tribes population, emphasizing infrastructure development within the pre-production value chain. Additionally, it fosters capacity-building through SHGs. By doing so, the project aims to address inequalities at the grassroots level by improving the foundation upon which agricultural activities depend.

Interventions Across the Value Chain: It is important to recognize that to ensure the holistic inclusion of tribal communities into the sustainable agriculture system and drive income growth, interventions should span the entire agricultural value chain. PMJVM, being a critical facilitator, should integrate these interventions, particularly focusing on pre-production elements such as watershed development, irrigation infrastructure, and the provision of high-quality seeds for sustainable agriculture. Furthermore, it should emphasize the promotion of organic farming, thereby enhancing local communities' opportunities and well-being. These efforts can be achieved through a combination of awareness and training programmes supplemented by institutional funding from the government.

Addressing Wage Disparities: It is essential to comprehensively address wage disparities among marginalized communities by ensuring fair, appropriate, and equal wage structures for all. This is fundamental to fostering inclusive development and reducing income inequalities within the agricultural sector.

Climate Resilience and Disaster Management: It is important to acknowledge the vulnerability of tribal communities to global warming, climate change, and natural disasters. These factors can greatly undermine the resilience of their agricultural systems. To address this issue, comprehensive interventions must be implemented. This includes investing in early warning systems, distributing drought-resistant seeds, and conducting extensive awareness campaigns. These actions will fortify the communities' ability to adapt to climate challenges and manage disasters effectively, ultimately contributing to sustainable agriculture.

Dedicated Insurance Schemes: It is recommended to create dedicated insurance schemes tailored to the unique needs of tribal communities. These plans should include gender-specific insurance options designed to protect livelihoods and enhance employability for women within these communities. The primary aim of these plans is to mitigate the risks tribal communities face and ensure their full participation in sustainable agriculture initiatives.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Tribal labour force participation rate in agriculture
- Schemes on sustainable agriculture oriented towards small and marginal farmers
- Farmers category-wise having access to credit and markets

Fiscal and Social Protection: Fiscal and social protection mechanisms are crucial to support vulnerable tribal communities. By safeguarding their economic well-being and ensuring their social security, these communities can better partake in sustainable agricultural activities. Additionally, providing financial and social safety nets serves to bridge the gap in income and opportunities.

Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable

According to the current projections, the world population is expected to increase from 7.4 billion in 2016 to over 9.7 billion by 2050 (UN, 2019). More than half of the world's population resides in urban areas and consumes about 70% of the total food supply (FAO, 2019). Urban sprawl exerts stress on land and natural resources, leading to unfavourable consequences, while cities are responsible for 70% of greenhouse gas emissions and constitute two-thirds of global energy consumption (World Bank, 2023). Moreover, rising global warming, climate change, and urbanization are expected to enhance warming in cities and lead to urban heat islands. To combat this, urban and peri-urban agriculture can serve as a mitigation and adaptation solution, with co-benefits for food security and reduced soil-water-air pollution (IPCC, 2019). With the increasing scope of investments in infrastructure and other services in developing nations,

along with rapid urbanization and population growth, the opportunity for urban agriculture supported by food-friendly infrastructure has increased. Urban agriculture holds the potential to increase food security and reduce the pressure of land degradation in rural areas. Urban agriculture is practiced in many ways such as rooftop gardening, backyard gardening, allotments, urban-fringe/peri-urban agriculture, aquaponics, hydroponics, livestock grazing in open spaces, and vertical farming (IPCC, 2019).

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
National Hydrology Project	<ul style="list-style-type: none"> Ministry of Jal Shakti Indian Meteorological Department (IMD) Central Water Commission (CWC) 	X		
Atal Mission for Rejuvenation and Urban Transformation (AMRUT)	<ul style="list-style-type: none"> Ministry of Housing and Urban Affairs 			X
Disaster Management Policy	<ul style="list-style-type: none"> Ministry of Home Affairs National Institute of Disaster Management (NIDM) 	X		
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
National Mission of Clean Ganga (NMCG)	<ul style="list-style-type: none"> Ministry of Jal Shakti 		X	
Soil Health Management (SHM) under National Mission for Sustainable Agriculture (NMSA)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
National Policy on Handling, Storage and Transportation of Foodgrains	<ul style="list-style-type: none"> Ministry of Consumer Affairs, Food and Public Distribution 			X
Pradhan Mantri Kisan Sampada Yojana	<ul style="list-style-type: none"> Ministry of Food Processing Industries 			X
Mission Organic Value Chain Development for Northeastern Region (MOVCDNER)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Sustainable Alternative Towards Affordable Transportation	<ul style="list-style-type: none"> Ministry of Petroleum and Natural Gas 			X
Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue	<ul style="list-style-type: none"> Ministry of Environment, Forest and Climate Change 			X

Agriculture Infrastructure Fund	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Disaster Management Policy	<ul style="list-style-type: none"> Ministry of Home Affairs National Institute of Disaster Management (NIDM) 		X	X
Flood Forecasting	<ul style="list-style-type: none"> Ministry of Jal Shakti 		X	X
Capital Investment Subsidy Scheme (CISS) under Soil Health Management Scheme	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Rashtriya Krishi Vikas Yojana	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Mahatma Gandhi National Rural Employment Guarantee Scheme	<ul style="list-style-type: none"> Ministry of Rural Development 			X

Synergies and Trade-offs

The literature for linkages between sustainable agriculture and SDG 11 highlights various synergistic relationships that suggest incorporating urban agriculture into urban designs can improve the quality of life, food security, environmental conditions, green spaces, and community resilience (Ghazy, 2022; Sarker, Bornman, and Marinova, 2019). In addition, urban farming holds an opportunity to build up the productivity of economic enterprises and reduce unemployment in urban settlements and slums, thus adding value to the population settlements in these areas (Surya, et al., 2020). Promoting safe and resilient transportation in urban areas creates vital linkages between all agricultural supply chains (Gray, 2020). Besides that, agriculture with the development and conservation of natural heritages can highlight efficient resource management practices and thus promote the agricultural heritage system (Daugstad, Rønningen, and Skar, 2006; Min and Zhang, 2019). Sustainable farming practices play a crucial role in disaster management by harnessing resource management techniques that simultaneously reduce the extremity of disasters in urban spaces (Wall and Smit, 2005). Thus, urban agriculture might be an opportunity to expand the amount of urban green spaces in urban spaces (Contesse, Van Vliet, and Lenhart, 2018).

The agricultural heritage system is a new concept that combines an intertwined natural and cultural inheritance with a separate intangible cultural inheritance; it is also a traditional agricultural production system linking farm, farmer, farm employment, and rural revitalization (Min and Zhang, 2019). Urban agriculture can contribute to feeding city dwellers and improving metropolitan environments by providing more green space (Sarker, Bornman, and Marinova, 2019). Peri-urban ecosystems, especially peri-urban agriculture, play an important part in multiple dimensions of both rural and urban sustainability and resilience (Chen, et al., 2023).

Access to water for households is a basic requirement in the urban settlement; it acts as a trade-off with the irrigation water requirements for crop cultivation (Hinz, et al., 2020). However, building resilient and sustainable settlements and promoting agriculture in urban areas brings forward trade-offs related to water allocation and its distribution between agriculture fields (to

support sustainable agriculture) and urban housing (to promote basic services to the urban people) (Hinz, et al., 2020).

Targets	Synergy	Trade-off
Target 11.1: By 2030, ensure access for all to adequate, safe, and affordable housing and basic services and upgrade slums		
Target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons		
Target 11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries		
Target 11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage		
Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations		
Target 11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management		
Target 11.7: By 2030, provide universal access to safe, inclusive and accessible, green, and public spaces, in particular for women and children, older persons, and persons with disabilities		
Target 11.a: Support positive economic, social, and environmental links between urban, peri-urban, and rural areas by strengthening national and regional development planning		
Target 11.b: By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation, and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels		
Target 11.c: Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials		

Gaps and Barriers

Due to the lack of education in peri-urban spaces and slums, many people are unaccustomed to sustainable agriculture practices (Kukreja, n.d.). Many slums are informal settlements, which means they lack formal recognition and secure land tenure. In addition, government agencies responsible for slum development may lack the capacity, resources, and expertise needed to implement sustainable urban design solutions (Ghazy, 2022). The availability of land that influences and affects capital investment, crop selection, and market access in urban areas is a major constraint to urban agriculture development. Lack of policies or poor policy framework is another constraint for the lack of promotion of agriculture in urban areas (Sarker, Bornman, and Marinova, 2019; Contesse, Van Vliet, and Lenhart, 2018; Tsuchiya Hara, and Thaitakoo, 2015). Moreover, slums and urban areas often lack access to monetary and funding services, which is a constraint in expanding agriculture practices in these areas (Ghazy, 2022; Contesse, Van Vliet, and Lenhart, 2018).

Adaptation and mitigation cost in the prevention of water-related disasters is expensive and, therefore, low funding is one such constraint (Mishra, Bruno, and Zilberman, 2021). Also, the policy frameworks of agricultural landscapes, giving a limited focus on heritage values and sites, are major barriers (Mitchell and Barrett, 2015).

Emerging Policy Solutions

Inclusion of Urban Agriculture in Atal Mission for Rejuvenation and Urban Transformation (AMRUT) Development Plans

- Incorporating urban agriculture as a central component of Atal Mission for Rejuvenation and Urban Transformation (AMRUT) development plans by identifying suitable areas within urban settings for farming, including vacant lots, rooftops, and public spaces, and allocating them for agricultural purposes.
- Encouraging and incentivizing rooftop gardening through subsidies, technical support, and information dissemination in AMRUT to residents, especially in densely populated areas with limited ground space and promoting sustainable farming in cities.
- Developing community-based farms as shared spaces for urban residents to engage in local food production to promote a sense of community and self-sufficiency.

Promotion of Behavioural Change towards Sustainability

- Incentivization and educational campaigns to encourage residents to engage in self-sustainable practices, such as food cultivation in residential complexes, can shift the practices of urban households. For instance, the utilization of synthetic turf on terraces or backyard spaces can be avoided as it makes it difficult for water to seep into the ground.
- It is important to transfer the responsibility for waste management and composting from municipalities to residents as the latter can be actively engaged in reducing organic waste at their homes and enriching soil quality through composting.

Addressing Water Scarcity and Ecological Implications of Concretization

- While constructing infrastructure in urban settings, it is important to consider the ecological consequences of urban concretization, including challenges related to water seepage, biodiversity loss, and vulnerability to natural disasters.
- Promotion of sustainable and holistic urban designs that facilitate water access and soil preservation can benefit urban trees and the overall environmental quality, contributing to the inclusive infrastructures in urban spaces.
- One way to address the issues related to water scarcity can be through regulations and incentives for rainwater harvesting systems in residential households. This may include encouraging retrofitting of existing buildings with rainwater harvesting systems and enhancing awareness campaigns on water conservation and efficient water use within complexes.

Balancing Soilless Farming Methods such as Hydroponics with Environmental Concerns

- The potential ecological consequences of soil-less farming methods like hydroponics and aquaponics should be recognized and challenges related to initial setup costs, water wastage, nutrient management, and adaptability to different climates should be addressed.

- There is a need to emphasize the need for careful management of such soil-less technologies to minimize ecological repercussions and disruptions to the natural environment.

Integration of Sustainable Agriculture into Education

- There is a need to integrate agriculture into the curriculum of students in schools, which emphasizes a long-term investment in cultivating sustainable practices and environmental consciousness among future generations.
- Through demonstration and hands-on farming activities in schools, environmental responsibility and sustainability values in students can be instilled.

Cross-cutting Solutions

- A robust monitoring and evaluation system for urban governance and sustainable development should be established to consistently measure and review the outcomes of environmental initiatives within regions.
- Investment in training and capacity-building for urban planners and policymakers as well as providing education and training in urban sustainability, including agriculture-related activities, in schools and universities, will inculcate ideas for sustainable agriculture.
- Urban planners and students should be equipped with the knowledge and tools needed to design and implement holistic urban solutions.
- Implementation of efficient land-use planning and responsible water management practices in urban parks and open spaces can lead to the conservation of natural habitats, protection of biodiversity, and sustainable resource use in urban environments.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Number of integrated sustainable agriculture projects in urban and peri-urban areas.
- Produce coming from hydroponic farming and sustainable agriculture in urban and peri-urban areas.

Goal 12. Ensure sustainable consumption and production patterns

India is facing a significant challenge with the annual generation of 500 million tonnes of crop residue (MoAFW, 2022). The conventional practice of burning this crop residue not only results in the loss of vital nutrients and resources but also leads to the emission of various harmful air pollutants that negatively impact the ambient air quality. Notably, rice residue contributes substantially to these issues, elevating global warming potential through the release of greenhouse gases such as CH₄, N₂O, and CO₂ equivalents (CO₂-eq). In this context, it becomes crucial to understand the perspective put forth by Smil (1999), which emphasizes that crop residues should be viewed as valuable providers of essential environmental services for sustaining productive agro-ecosystems (Kumar, et al., 2023).

In 2022, India's bioeconomy reached over \$80 billion, showing a remarkable growth of 14.1% from 2020's figure of \$70.2 billion, as revealed in the *Releasing India's Bioeconomy Report 2022*. This trajectory of growth suggests that the bioeconomy sector is poised to touch \$150 billion by 2025 and over \$300 billion by 2030, underlining its significance in the country's economic landscape (BIRAC, 2022).

The agricultural bioeconomy approach to crop residue management offers a sustainable, scalable, crop- and region-specific, socially inclusive, environmentally friendly, and technically robust solution. It plays a pivotal role in transitioning from input-intensive agriculture to multifunctional agriculture, where crop wastes are effectively recycled and repurposed to benefit the agroecosystem. This approach not only addresses the challenges posed by crop residue but also contributes to the broader goal of achieving a sustainable and environmentally responsible agricultural system in India (Venkatramanan, et al., 2020).

India incurs losses amounting to Rs 92,651 crores in post-harvest processes, resulting in a staggering 40% loss of the country's total produce. This makes India one of the countries with notably high post-harvest losses, despite government spending on food distribution accounting for just around 1% of the country's GDP (MOFPI, 2022).

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
GOBARdhan Scheme	<ul style="list-style-type: none"> Ministry of Jal Shakti 	X	X	
Monitoring of Pesticide Residues at National Level Scheme (MPRNL) 2018 (under Sub-Mission on Plant Protection)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
National Water Mission under National Action Plan on Climate Change	<ul style="list-style-type: none"> Ministry of Jal Shakti 	X		
Bringing Green Revolution to Eastern India (under Rashtriya Krishi Vikas Yojna)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
National Policy for Farmers	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Large Area Certification Scheme of the Participatory Guarantee System Certification Programme	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

National Project on Organic Farming	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Capital Investment Subsidy Scheme for Vegetable and Fruit Market Waste Compost and Biofertilizers – Biopesticides Production Units (under National Project of Organic Farming)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
New Generation Watershed Development Projects under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Rural Development 	X		
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
Pradhan Mantri Kisan Samman Nidhi Scheme (PM-Kisan) 2020	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
Sub-Mission on Agricultural Mechanization (SMAM) of National Mission on Agricultural Extension and Technology (NMAET)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
Soil Health Management (SHM) under National Mission for Sustainable Agriculture (NMSA)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Targeting Rice Fallow Areas (TRFA)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	X
Bhartiya Prakritik Krishi Paddhati (BPKP) Programme under Paramparagat Krishi Vikas Yojana (PKVY) under National Mission on Sustainable Agriculture (NMSA)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
National Policy for Management of Crop Residues (NPMCR)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Repair, Renovation and Restoration (RRR) of Water Bodies	<ul style="list-style-type: none"> Ministry of Jal Shakti 	X	X	X
National Agroforestry Policy	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Sub-Mission on Agroforestry (SMAF) under National Mission for Sustainable Agriculture (NMSA)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Climate Change and Sustainable Agriculture: Monitoring, Modeling and Networking (CCSAMN) under National Mission for	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Sustainable Agriculture (NMSA)				
Deendayal Antyodaya Yojana – National Rural Livelihoods Mission	<ul style="list-style-type: none"> Ministry of Rural Development 	X	X	X
Rashtriya Krishi Vikas Yojana - Remunerative Approaches for Agriculture and Allied Sector Rejuvenation (RKVY-RAFTAAR)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		X
Paramparagat Krishi Vikas Yojana (PKVY), National Mission for Sustainable Agriculture	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
National Policy on Handling, Storage and Transportation of Foodgrains	<ul style="list-style-type: none"> Ministry of Consumer Affairs, Food and Public Distribution 			X
Sustainable Alternative Towards Affordable Transportation	<ul style="list-style-type: none"> Ministry of Petroleum and Natural Gas 			X
Pradhan Mantri Kisan SAMPADA Yojana	<ul style="list-style-type: none"> Ministry of Food Processing Industries 			X
Central Sector Scheme of Financing facility under Agriculture Infrastructure Fund 2020	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue	<ul style="list-style-type: none"> Ministry of Environment, Forest and Climate Change 			X

Synergies and Trade-offs

Sustainable production and consumption patterns define and shape sustainable agriculture practices. Due to the increasing pressure on natural resources, it is essential to reassess the current agricultural practices and shift towards more sustainable approaches (Piñeiro, et al., 2020; Pennsylvania Envirothon, 2019; Singh, Pandey, and Singh, 2011). The shift from inorganic to organic farming/sustainable farming has evolved over the years because of increased awareness (Santhoshkumar, Reddy, and Sangwan, 2017), growth in advanced and sustainable technologies (Khan, et al., 2021), and growing opportunities in other sectors such as tourism (Berno, 2006). Rotating crops and embracing diversity, planting cover crops, no-till systems (or reduced till), integrated pest management, integration between livestock and crops, agroforestry practices, and precision farming are some steps that ensure sustainable agriculture (Piñeiro, et al., 2020). Practices such as downscaling the agricultural subsidies can help improve sustainable production in agriculture by boosting the transition from fossil fuel-based production to organic production (Heyl, et al., 2022). Depending upon the policy structure of the country, sustainable agriculture can also be promoted through green or organic public food procurements that define the source of food and type of food purchased (Swensson and Tartanac, 2020). Sustainable practices such that minimizing the negative impacts on health and social capital and the use of external farming that would not change soils and ecosystems lead to sustainable agriculture (Adenle, et al., 2017).

Targets	Synergy	Trade-off
Target 12.1: Implement the 10-Year Framework of programmes on sustainable consumption and production patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries		
Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources		
Target 12.3: By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses		
Target 12.4: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water, and soil to minimize their adverse impacts on human health and the environment		
Target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse		
Target 12.6: Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle		
Target 12.7: Promote public procurement practices that are sustainable, in accordance with national policies and priorities		
Target 12.8: By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature		
Target 12.a: Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production		
Target 12.b: Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products		
Target 12.c: Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities		

Gaps and Barriers

Promoting sustainable agriculture offers various promising avenues for improvement. These include investments in agricultural education and research (Grover and Gruver, 2017), the adoption of renewable technologies and on-farm practices such as no-till farming and crop rotation (Piñeiro, et al., 2020; Panwar, Kaushik, and Kothari, 2011), and the implementation of IoT-based food grain monitoring systems to reduce waste (Devi, et al., 2021). Agro-tourism and sustainable cuisine (Pan, et al., 2018; Berno, 2006) provide opportunities to merge agriculture and tourism, boosting sustainability. Collaboration through PPPs and joint initiatives (Smith, 2007) is crucial, and financial support can further promote sustainable farming methods (Klerkx, and Jansen, 2010). Adequate policies (Garcia-Herrero, et al., 2018) and the establishment of post-harvest review groups (Kitinoja, et al., 2011) can also contribute to sustainable agriculture. In contrast, several barriers hinder progress, including the high dependence on pesticides, inadequate infrastructure, organizational inertia, and coordination issues between stakeholders (Jacquet, et al., 2022; Parsons and Barling, 2022; Shrivastava,

1995; Smith, 2007). Financial constraints and weak national policies can limit the adoption and planning of sustainable practices (Mangla, Govindan, and Luthra, 2017; Adenle, Azadi, and Manning, 2017), while the unavailability of well-constructed infrastructure and high transaction costs in policies act as further obstacles (Heyl, et al., 2022). Inadequate storage facilities also contribute to food loss (Priyadarshini and Abhilash, 2020).

Emerging Policy Solutions

Improving Cold-Storage Infrastructure: It is crucial to diversify existing cold storage units, retrofit older facilities, and address power supply issues to cater to a wider range of agricultural products and reduce post-harvest losses. Strategic location planning and incentives for private investments can improve accessibility and functionality. It is important to resolve power supply challenges, especially in remote areas, to enhance cold storage efficiency.

- Practical implementation and accountability are crucial for successful sustainability efforts. It is important to operationalize emerging policy solutions and ensure accountability. Making a business case for sustainability and creating demand for sustainable practices should be a priority. Focusing on post-harvest infrastructure and addressing resource and circular economies can lead to effective policy implementation.
- It is crucial to increase the production of biofuels, biofertilizers, and organic fertilizers. Leveraging digital platforms to connect farmers with stakeholders can enhance the agricultural supply chain. Additionally, ensuring adequate food storage infrastructure and addressing post-harvest food waste are vital.

Strengthening Provisions of Rashtriya Krishi Vikas Yojana (RKVY) for Sustainable Agriculture: RKVY works on pre- and post-production infrastructure to make farming a profitable activity and focuses on risk mitigation and promoting agri-business entrepreneurship. Its emphasis on sustainable agriculture is crucial and can have a widespread impact across states.

- RKVY works on the creation of seed storage and processing facilities. Crop diversification is an important component of sustainable agriculture and RKVY can provide incentives to farmers for opting for crop diversification. It can also provide diverse seeds at a single window. This can be furthered by providing information to the farmers regarding the benefits of crop diversification on their earnings, soil, and environment.
- Ecolabelling is an important information tool that nudges consumers to opt for organic produce. It also empowers the farmers by accelerating sustainable agriculture practices. RKVY provides infrastructure for collecting, sorting, and packing. By adding the provision of ecolabelling, it can significantly expedite sustainable agriculture practices.
- Commercializing waste is another key area that can be focused on under RKVY. There are infrastructural provisions for assessing crop loss, but it does not talk about the usage or disposal of the crop loss. RKVY can be strengthened by adding infrastructure support for channeling the crop wastage and commercializing it. Supporting start-ups working on converting crop wastage in products such as manure, paper, and sanitary napkins can also be provisioned under RKVY.
- The current focus of the scheme is limited to horticultural crops. However, the mandate can be explored for other crops, such as food grains.

Transition from Biomass to Solar Power: The transition from biomass to solar power faces economic challenges, and addressing population growth, unemployment, and labour disparities is vital. Aligning prices with the MGNREGA rates can ensure equitable pricing.

Challenges in Livestock Farming and Slurry Management: The large livestock population poses challenges, and resolving land encroachment and soil microorganism decline is critical. Emphasizing the role of extension services, indigenous farming knowledge, and accountability in implementation is essential.

Organic Farming and Sustainable Practices: Recognizing the time required for yield recovery in organic farming and compensating for sustainable practices are essential. Balancing *in-situ* and *ex-situ* management practices is key to sustainable agriculture. Acknowledging the need for support and compensation for land degradation due to conventional farming practices can drive sustainable agriculture.

Knowledge Dissemination and Quality Inputs: Spreading agricultural knowledge and improving input quality are vital components of sustainable farming. Addressing post-harvest challenges and converting crop residue into valuable products like manure can reduce waste. Embracing precision agriculture and diversifying income sources are crucial for agricultural sustainability.

Women's Training Programmes and Holistic Approach: Empowering women in disseminating agricultural knowledge through training programmes can promote inclusivity. Coherent policies across different sectors should align to comprehensively address sustainability. Acknowledging the social and economic equity aspects of sustainability is essential.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Total share in public expenditure that is allocated to the development of post-harvest storage infrastructure (Rs crores)
- Percentage decrease in incidences of stubble burning from the previous year
- Total allocation of funds towards research in bioeconomy in agriculture (Rs crores)
- Crop diversification index for Punjab, Haryana, and Western Uttar Pradesh

Goal 13. Take urgent action to combat climate change and its impacts

Climate change affects how food is produced and distributed, thus posing problems for the agriculture sector worldwide. According to the IPCC's *Special Report on Climate Change and Land* (SRCCL), climate change has adversely impacted food security and terrestrial ecosystems as well as contributed to desertification and land degradation in many regions (IPCC, 2019). The SRCCL paper examined the linkages between land use, sustainable land management, and climate change and highlighted that climate change has a detrimental impact on agricultural yields and food security. As per IPCC Working Group II AR6, extreme weather has reduced the productivity of crops, including losses in crops, such as the global decline in wheat output in 2012, 2016, and 2018 (IPCC, 2022). It has exacerbated the food security of millions of people, putting their nutrition and livelihoods at risk across regions because of droughts, floods, wildfires, and maritime heatwaves. This impact has become more detrimental

as agriculture is highly sensitive to climate change. Extreme temperature increase and heat waves lead to an increase in the frequency and severity of natural disasters, including floods, cyclones, droughts, and unseasonal rain, which severely damage crops and the agro-rural economy.

There is a major need to shift the much-needed attention to agricultural adaptation to climate change. As the world will need to produce almost 70% more food by 2050 to feed an estimated 9 billion people, the challenges of agriculture productivity and food security will only get worse overtime (World Bank, 2021). In response to these challenges, several action plans and strategies are often considered and discussed. Between 2016 and 2021, India lost a crop area of 5.04 million hectares to natural disasters and about 36 million hectares of agricultural land were adversely affected by hydro-meteorological catastrophes (Mahapatra, 2021). Farmers have suffered repeated losses, particularly the small and marginal farmers, who make up more than 85% of total farmers in the country. These farmers are facing increasingly challenging circumstances as climate change disrupts various aspects of agriculture, ranging from planting operations to harvesting.

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-Production	Production	Post-Production
National Adaptation Fund	<ul style="list-style-type: none"> National Bank for Agriculture and Rural Development (NABARD) 	X	X	
National Action Programme to Combat Desertification	<ul style="list-style-type: none"> Ministry of Environment, Forest and Climate Change 	X		
Weather and Climate Services Upgradation of Forecast System	<ul style="list-style-type: none"> Ministry of Earth Sciences India Meteorological Department FASAL 	X	X	X
Disaster Management Policy and Plan	<ul style="list-style-type: none"> National Disaster Management Authority 	X	X	X
Rural Innovation Fund and Farm Innovation and Promotion Fund	<ul style="list-style-type: none"> National Bank for Agriculture and Rural Development (NABARD) 	X	X	
Paramparagat Krishi Vikas Yojana (PKVY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare (MoAFW) 		X	
National Mission on Strategic Knowledge for Climate Change (NMSKCC)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Rashtriya Krishi Vikas Yojana	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Pradhan Mantri Fasal Bima Yojana (PMFBY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare Agriculture Insurance Company of India Limited (AICL) 	X	X	X
National Digital Communications Policy-2018	<ul style="list-style-type: none"> Ministry of Communications 	X	X	X
Climate Change and Sustainable Agriculture: Monitoring, Modeling and Networking (CCSAMMN) under NMSA	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Mission For Integrated Development of Horticulture	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	X
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
Mahatma Gandhi National Rural Employment Guarantee Scheme	<ul style="list-style-type: none"> Ministry of Rural Development 	X	X	
Flood Management Programme and Forecasting	<ul style="list-style-type: none"> Ministry of Jal Shakti 	X	X	
National Mission of Clean Ganga (NMCG)	<ul style="list-style-type: none"> Ministry of Jal Shakti 		X	
National Agriculture Disaster Management Plan	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Pradhan Mantri Kisan SAMPADA Yojana (PMKSY)	<ul style="list-style-type: none"> Ministry of Food Processing Industries 			X
Mission Organic Value Chain Development for Northeastern Region (MOVCDNER)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
Capital Investment Subsidy Scheme (CISS) under Soil Health Management Scheme	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	

Synergies and Trade-offs

Climate change and agriculture interact in a synergistic relation as natural resources such as water, land, and oceans and associated risks are influenced by the effects of climate change, which affect agriculture and the sustainability of food systems. This also impacts equality, infrastructure, economics, health, and gender relations (Bruce, et al., 2018; Schneider, Rebetez,

and Rasmann, 2022; de Jong, et al., 2019). Smallholders and vulnerable farmers are at higher risk of being affected by climatic calamities such as flooding and droughts, which can have adverse effects on their livelihoods. However, climate resilience measures, such as sustainable agricultural practices, crop diversification, and participation in market exchanges, as well as investments in education and migration, can help reduce these risks (Agrawal, 2008). Climate change is anticipated to be one of the key drivers of change in crop-pest interactions globally, along with agricultural intensification because it affects both plants and insects in a variety of ways (Schneider, Rebetez, and Rasmann, 2022).

However, the literature also indicates trade-offs to building climate resilience. For example, activities such as forest restoration and building dams for managing floods and irrigation purposes can potentially result in lock-in and maladaptation, including redistributing vulnerability from one ecosystem to another, thereby reducing agricultural output, nutrition, and incomes (Orchard, et al., 2020; Louman, et al., 2019;). For instance, insurance programmes make farmers prefer insured cash crops over drought-tolerant crops or intercropping.

Targets	Synergy	Trade-off
Target 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries		
Target 13.2: Integrate climate change measures into national policies, strategies, and planning		
Target 13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning		
Target 13.a: Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible		
Target 13.b: Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth, and local and marginalized communities		

Gaps and Barriers

There are several obstacles that prevent the effective implementation of climate change strategies. One of the biggest challenges is the lack of socio-economic and land-use data necessary to evaluate climate hazards. This includes a lack of knowledge about the hydrology of river basins, meteorological information on rainfall patterns, and information about local communities and their land-use practices, including agricultural cropping patterns, which pose production challenges (G, et al., 2023). Even though India has insurance programmes that help farmers mitigate and adapt to the agricultural losses due to climate change, there are various challenges in their implementation, leading to inaccuracies and delays in processing and confirming insurance claims to the farmers. Numerous institutional barriers also exist, such as the inability of local government actors to use climate data to develop climate action plans. This creates obstacles during the pre-production, production, and post-production processes. Effective planning for national-level budgeting on climate change has been hampered by the lack of national-level climate information (extreme climatic events, loss and damages, and adaptation costs), influencing how climate funds are allocated to various national missions and

federal states. Also, there is a lack of functional coordination and a unified approach when addressing loss and damage in the agriculture sector at the national level, which hinders the implementation of climate-related policies (Bahinipati and Gupta, 2022).

Emerging Policy Solutions

Climate-specific planning for agricultural systems for effective implementation of climate policies and instruments are as follows:

- **District-level planning:** There is a need to emphasize district-level plans and sub-district climate risk analyses. This will help address the issue of scant district-level data collection and management and provide insights into localized vulnerabilities, enabling tailored adaptation strategies.
- **Management information systems and monitoring systems:** To effectively manage climate change and its impacts, robust management information systems (MIS) and monitoring systems are essential. These systems play a crucial role in collecting data and predicting climate-related events, allowing for proactive measures to be taken.
- **Efficient data collection:** Climate information systems need to be context specific. Bridging the gap between climate data at the district level is a critical step in enhancing climate change adaptation efforts. To overcome this data gap, it is important to synthesize information from different agricultural systems and agro-economic and ecological zones. This could involve mapping agriculture based on watershed variances or climatic zones, which provide a more holistic way of collecting data beyond existing governance structures.
- **Effective implementation in the National Mission for Sustainable Agriculture (NMSA):** NMSA should provide clear guidelines that emphasize framing climate resilience strategies at the sub-national and local levels. This shift in focus from national to local action plans is crucial for tailoring strategies to the specific needs and conditions of different regions.

Enhancing the efficiency of insurance programmes such as PMFBY will help mitigate and adapt to climate-related risks in agriculture.

- **Expanding crop list:** Many states are opting out of insurance programmes because the crops they produce are not covered by these schemes. Thus, it is necessary that the crop list under the PMFBY is expanded so that it can also promote crop diversification.
- **Enhancing awareness and education:** There is a lack of awareness among farmers regarding the availability of insurance options. Thus, insurance education can be integrated into various training programmes that are focused on risk management. Motivating farmers through KVKs and introducing remote sensing technology for accurate assessment can help revitalize and improve the effectiveness of PMFBY.
- **Challenges in creditworthiness among local farmers:** Many farmers lack the financial history or collateral needed to access these funds, creating a barrier to their ability to invest in climate-resilient agricultural practices.
- **Issues in trigger claims:** Another critical issue linked to insurance programmes is the occurrence of both underclaiming and overclaiming, which can lead to imbalances in the dispersion of claims. To tackle this problem, leveraging technological advancements, including remote sensing, satellite data, and machine learning, can significantly enhance the accuracy of assessing agricultural losses. This would ensure that compensation is distributed fairly and aligns with the actual losses incurred by farmers.
- **Integrating index-based insurance into PMFBY:** Index-based insurance that relies on predetermined meteorological benchmarks could be a partial solution to address the

inaccuracies in trigger claims for crop losses. Implementing parametric insurance effectively would require a public-dominated model within a PPP framework.

- **Enhancing market linkages:** Enhancing market linkages and addressing challenges in crop insurance schemes such as PMFBY are vital steps towards building resilience in agriculture.

Translation of National Agriculture Disaster Management Plan (NADMP) into Concrete Scheme

- As mandated by Sections 36/37 of the Disaster Management (DM) Act, 2005, the Ministry of Agriculture and Farmers Welfare (MoAFW) has prepared a NADMP to include key aspects of disaster risk reduction for climate change adaptation and for realizing the SDGs. However, MoAFW does not yet have a proposal for the creation of a dedicated scheme around National Agriculture Disaster Management. An integrated and comprehensive scheme can be designed by MoAFW, which can then be implemented by state governments.

Devising Tools and Mechanisms for Climate-resilient Agriculture

- **Loss and Damage (L&D) in agriculture:** Adaptation to climate change is a critical component of resilience building, and it often involves responding to the impacts and losses that have already occurred due to climate-related events. L&D reduces vulnerability and enhances resilience to future challenges. Pro-resilience insurance can be instrumental in mitigating the impacts of these stressors.
- **Upscaling NABARD initiatives:** Drought-proofing strategies are regarded as one of the most reliable methods for mitigating the impacts of climate change on agriculture. NABARD's successful schemes offer valuable insights into promoting climate-resilient agriculture in India. Replicating and upscaling these initiatives, including capital subsidies, bank credit, Corporate Social Responsibility (CSR) funding, and solar irrigation, can contribute to sustainable agricultural practices.
- **Shifting focus to resilience building:** In addressing climate change in agriculture, it is crucial to make the 'invisibles of the agriculture visible'. There is a need to shift the focus from reporting solely on traditional metrics like yield per hectare to examining the intangible benefits of agriculture, such as the resilience building of farmers.
- **Circular economy integration:** Intercrop mixed agriculture methods and circular economy integration, such as the utilization of bamboo agriculture, are needed for more competitive market structures. Circular economy principles, such as utilizing bamboo and converting waste into wealth, can make agriculture more cost-competitive and sustainable. Creating an economic case for various aspects of agriculture and making projections based on this data are crucial step in observing the impacts of major schemes.
- **Crop diversification:** Crop diversification can be an approach to shift the focus from food security to nutrition security. However, it is essential not only to consider the supply side but also the demand side, as well as water usage and land use.
- **Crop sustainability analysis:** Crop sustainability analysis is a vital tool that needs to be employed more widely to inform agricultural practices. It helps identify suitable crops and practices based on local conditions and climate considerations.
- **Vulnerability assessments of crops:** Farmers require support and guidance to transition effectively into diversified cropping systems. This includes vulnerability assessments and indexes to evaluate damage to crops due to extreme as well as slow-onset events. This can help determine suitable crop choices for specific regions. Agro-

climate mapping using GIS technology, as exemplified in Punjab through the Integrated Mission for Sustainable Agriculture (IMRM), is a valuable tool for informed decision-making.

Tapping Market Linkages and Building Economic Cases for Sustainable Agriculture

- **Creating market for organic farming and horticulture:** Schemes related to organic farming and horticulture need to address market linkage challenges to ensure profitability for farmers.
- **Strengthening agroforestry:** Agroforestry presents an opportunity to address land degradation and promote mixed cropping systems in India. However, this requires the allocation of resources and the establishment of governance structures for skill development and capacity building. The issue of land degradation requires financial support. Combining agroforestry with efforts to combat land degradation can make projects more appealing to financiers looking for sustainability.
- **Cost parity for MSP:** Addressing market linkage is a challenge, especially when consumer demand is not consistently strong. Many farmers still rely on government procurement systems and MSP. Collaborating with state governments to ensure cost parity for MSP and developing sustainable procurement policies for private players can help bridge this gap.
- **Strengthening bank credit:** Access to bank credit has been pivotal in enabling farmers to invest in climate-resilient practices. Expanding access to credit and making it more affordable can be a powerful tool for promoting sustainable agriculture.

Holistic and Innovative Approaches to Climate for Informed Investments in Climate-Resilient Agriculture

- **Investing in blended finance:** There is a growing recognition of the need for blended finance, which combines public and private resources to fund both mitigation and adaptation efforts. While mitigation programmes often come with well-defined business plans, adaptation projects often lack such business models, and fewer funds are allocated towards adaptation. Additionally, mobilizing finance for climate-smart agriculture (CSA) or climate resilience is challenging, as it is difficult to attract private finance without clear, tangible benefits for the private sector.
- **Co-benefits for resilience building:** Climate finance can be closely linked to co-benefits, ensuring that investments in resilience also contribute to broader development objectives and sustainability. Furthermore, there is a need to leverage co-benefits from mitigation efforts, which often receive a larger share of finance. Adaptation schemes should incorporate mitigation co-benefits, or vice versa, to create a more balanced approach to climate financing.
- **Integration of development and climate initiatives:** India's Climate Change Development Report (CDDR) underscores the importance of integrating development and climate initiatives. A collaborative approach involving solution providers and financiers is essential to scale up climate financing. Result-based financing and pre-financing for farmers' databases can facilitate effective implementation.
- **Private sector for climate-sensitive agriculture:** Increasing private sector involvement in adaptation is crucial as the expanding demand for funding in this area cannot be adequately met through public funding alone. Private enterprises play a pivotal role in funding, constructing, and sustaining essential infrastructure, supply chains, and markets. Therefore, it is imperative that they incorporate climate resilience

considerations into their investment choices and explore creative financial tools to enhance partnerships with the public sector in crucial domains.

- **Tapping CSR:** CSR funding is another avenue that can be tapped to support agricultural initiatives. Private companies can contribute significantly to climate-resilient agriculture.
- **Political will for climate finance:** Climate finance is inherently linked to the political sector, and it is imperative that states disburse funds effectively for climate resilience projects. Ensuring that financial resources reach the grassroots level and are used efficiently is a complex challenge that requires political will, commitment, and coordination.

Leveraging Green Finance Mechanisms: Stabilizing elementary financing through mechanisms like green credit and establishing a minimum carbon price can provide stability and incentives for climate-resilient agricultural practices.

- **PPP for sustainable agriculture:** There is a growing trend of PPP in the realm of sustainability and climate change adaptation. The private sector is increasingly becoming involved in initiatives such as sustainability-based green bonds that are designed to generate funds for climate adaptation and mitigation efforts. Some bonds, such as catastrophe bonds and impact/outcome-based bonds, are being used to funnel resources into climate adaptation initiatives.
- **Climate lens to agriculture:** Ensuring that value chain operators and farmer-produce organizations (FPOs) have access to finance is critical for the success of green initiatives. Applying a climate lens to agriculture can enhance the resilience of farming communities.

Improving Government Infrastructure for Efficient Implementation

- **Coordination between the central and state governments:** Implementing climate-resilient agricultural programmes requires a clear understanding of roles and responsibilities, as well as effective coordination between the central and the state governments. While programmes are in place, the key question often revolves around who will execute them and how. The willingness of states to collaborate and actively participate is crucial for the success of such programmes.
- **Defining climate-smart agriculture:** There is a need for a clear and practical definition of CSA that goes beyond academic and research spaces. This definition should reach farmers in the field and inform policymakers, focusing on how CSA can generate green credit and be seen as a profitable measure.
- **Decentralized approach:** Governance challenges in climate-smart agriculture persist, as many states find policies and schemes confusing. A decentralized approach is essential to address the variability of climate impacts. There should be more efforts to streamline and merge schemes. There is a potential for cross-sectoral collaboration to overcome information gaps and establish robust governance structures.

Sustainability of Policies: Many strategies are project based, and there is a need to devise ways to sustain these initiatives beyond their life cycles. Understanding how these projects intersect and build upon each other is vital for long-term success and impact assessment.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include the following:

- Total loss of crop or crop damage due to natural disaster annually (in tonnes)

- Percentage of farmers having access to climate services
- Percentage of farmers having access to crop insurance scheme
- Budget allocation for climate adaptation in agriculture (Rs crores)
- Number of agriculture policies and schemes with climate component in India
- Funds allocation and utilization for information education and communication-related activities for farming communities (Rs crores)
- Number of KVKs conducting training programmes on climate for agriculture
- Amount allocated for climate finance in India (US\$ million)

Goal 14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

The ocean and seas cover 70% of the Earth's surface area, host the largest connected ecosystem, and play a central role in climate stability, oxygen generation, nutrient cycling, food production, and coastal protection. Marine and coastal areas are most vulnerable to pollution from both land- and marine-based activities (UNEP, 2010). Agricultural runoffs cause pollutants and nutrients such as nitrogen and sulphur to enter coastal waters, which removes, alters or destroys natural coastal ecosystems (Hilmi, et al., 2015). Excess use of fertilizers and pesticides in agricultural fields gets washed down to the rivers during heavy rainfall, ultimately reaching the oceans and seas and damaging the marine ecosystem (UN Environment Programme, 2022). The release of sulphur and nitrogen into the atmosphere through agricultural activities such as residue burning and excess use of fertilizers and pesticides also contribute to ocean acidification (Oceanus, 2008). Climate change impacts increase in storm surges and sea-level rise, which can cause to saltwater infiltration in freshwater aquifers, leading to soil salinization and, hence, reducing agricultural productivity.

India is one of the major pesticide-producing countries in Asia, with an annual production of 90,000 tonnes, and it stands in the twelfth position in the world in manufacturing pesticides (Khan, Zia, and Qasim 2010). In India, 52,466 MT of chemical pesticides were used by different states and union territories during FY 2022–23 (Directorate of Plant Protection, Quarantine & Storage, 2023).

National Policy and Stakeholder Mapping

Policies	Stakeholders	Pre-Production	Production	Post-Production
Integrated Coastal Zone Management	Ministry of Environment, Forest and Climate Change	X	X	
Ocean Services, Technology, Observations, Resources Modelling and Science	Ministry of Earth Sciences	X		
Swachh Bharat Abhiyan, 2014	Ministry of Jal Shakti	X	X	
Coastal Regulation Zone Notification	Ministry of Environment, Forest and Climate Change	X	X	
Coastal and Marine Spatial Planning (CMSP)	Ministry of Environment, Forest and Climate Change	X		
Conservation of Natural Resources and Ecosystems	Ministry of Environment, Forest and Climate Change		X	
Paramparagat Krishi Vikas Yojana	Ministry of Agriculture and Farmers Welfare	X	X	
The Water (Prevention and Control of Pollution) Act, 1974 and associated rules	Ministry of Environment, Forest and Climate Change	X		X
The Water (Prevention and Control of Pollution) Cess Act, 1977 and Associated Rules	Ministry of Environment, Forest and Climate Change	X		X
Environment (Protection) Act was enacted, 1986 and Associated Rules	Ministry of Environment, Forest and Climate Change	X		X
National River Conservation Program	Ministry of Jal Shakti	X		X

Synergies and Trade-offs

Land-based anthropogenic activities contribute to coastal ecosystem damage because of excessive use of fertilizers, pesticides, coastal development projects, and pollution (Blanc, Freire, and Vierros, 2017). In 2020, nearly 200 million tonnes of nitrogen fertilizers were used globally. At the same time, nitrogen fertilizers accounted for around 56% of the total global consumption, and phosphate and potash fertilizers held shares of 24 and 20%, respectively (Statista, 2023). In 2019, globally approximately 2 million tonnes of pesticides were utilized, of which 47.5% comprised herbicides, 29.5% insecticides, 17.5% fungicides, and 5.5% other pesticides (De, et al., 2014). Excess use of fertilizers and pesticides in agricultural fields also makes agriculture unsustainable in the long term. Chemicals from agricultural activities ultimately reach oceans and seas, contributing to eutrophication and subsequent de-oxygenation (Hilmi, et al., 2015; UN Environment Programme, 2022). In water, excess

pollutants promote the growth of algae, which trigger toxic blooms that can kill fish and nitrate in drinking water harms human health.

Targets	Synergy	Trade-off
Target 14.1: Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution		
Target 14.2: Sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans		
Target 14.3: Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels		
Target 14.4: Effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics		
Target 14.5: Conserve at least 10% of coastal and marine areas, consistent with national and international law and based on the best available scientific information		
Target 14.6: Prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation		
Target 14.7: Increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism		
Target 14.a: Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular Small Island developing States and least developed countries		
Target 14.b: Provide access for small-scale artisanal fishers to marine resources and markets indicators		
Target 14.c: Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of 'The future we want'		

Gaps and Barriers

A critical issue is the insufficient understanding of the threats and pressures related to sustainable coastal management (UN Environment Programme, 2021). Poor implementation of policies and laws across multiple governance levels is also a significant challenge due to a lack of interest and knowledge amongst stakeholders (UN Ocean Conference, 2022). Furthermore, the lack of infrastructure and technology for addressing marine pollution from land-based activities hampers effective mitigation efforts (UN Environment Programme, 2021). Cross-institutional cooperation across sectors and jurisdictions remain weak (Paul, 2021). Insufficient investment and funding for coastal blue carbon ecosystems further hinder the overall development and resilience (UN Ocean Conference, 2022). Area-based conservation measures and management tools, such as marine spatial planning and marine protected areas, can promote ecosystem-based approaches (Blanc, Freire, and Vierros, 2017).

A solution-oriented integrated ocean science agenda can provide innovative ideas and fundamental knowledge to enhance sustainable development and human–ocean interactions (Visbeck, 2018). Additionally, investing in developing resources for farmers and communities in coastal areas through training and good practice validation can support local communities (UNEP, 2018). Community-based management and co-management with transparency and local benefit-sharing are important (Govan, et al., 2009). The interface between land-based agricultural run-off and marine ecosystems can be strengthened in policy and programmatic mandates.

Emerging Policy Solutions

Legislative Frameworks such as Coastal Regulation Zone (CRZ) Rules, the Water Act (1971), and the Environment Protection Act (EPA) to Manage Agricultural Runoff

- **Incorporating, strengthening, and integrating CRZ rules, the Water Act, and EPA to manage agriculture runoff:** Agriculture contributes to soil erosion and nutrient runoff that have detrimental effects on marine ecosystems. CRZ rules primarily focus on regulating coastal activities rather than land-based agricultural activities, limiting their applicability in managing agricultural runoff. By incorporating land-based agricultural rules into CRZ, it can address the issue of runoff to marine bodies.
- **Quantification of runoff through the Water Act:** The Water Act plays a crucial role in monitoring and regulating the rate of runoff from agricultural sources. However, accurately quantifying runoff and its impact remains an under-examined aspect.
- **Integration of measures in EPA to regulate impact on marine systems:** Sustainable agriculture requires examining land-use conversions in protected or coastal areas and finding a balance between environmental protection and agricultural practices. Existing regulations in the EPA can include the applicability of land-based agriculture in coastal areas.
- **Integration of regulatory measures:** Addressing agricultural runoff necessitates an integration of regulatory measures and soft rules/guidelines, which can incorporate the impact of agricultural runoff by involving stakeholder consultations and encouraging the participation of the public and industries that are involved in marine-related activities.

Cross-cutting Mechanisms for Focus on Marine Systems

- **Spatial planning:** Coastal and marine spatial planning, predominantly at the state and district levels, can offer a platform for multi-sector stakeholder discussions for holistic and innovative solutions.
- **Education and awareness raising:** Awareness levels need to be increased in farmers about the harmful impacts of excessive fertilizer and pesticide use on marine ecosystems. Effective communication and coordination between government agencies responsible for agriculture and marine conservation will promote integrated management efforts. Upscaling clusters that promote reduced fertilizer and nutrient usage can mitigate nutrient runoff.
- **Expanding the definition of agriculture:** Expanding the definition of agriculture to include diverse aspects of coastal agriculture will help in sustainable land use. Not only are oceans impacted by agricultural operations, but coastal agriculture is also impacted by the oceans as an environment, with sea-level rise, saltwater intrusion, and cyclones impacting coastal areas. Agricultural practices like deforestation and land reclamation can exacerbate coastal erosion.
- **Resilience building for coastal agriculture:** Creating resilience strategies for coastal agriculture requires a deep understanding of the specific challenges posed by the coastal environment. This includes finding alternative livelihoods for people living in coastal areas affected by saltwater intrusion and sea-level rise. Converting natural coastal habitats into agricultural land disrupts the delicate balance of these ecosystems.

Paramparagat Krishi Vikas Yojana (PKVY) for Strengthening Water Quality Monitoring Mechanisms

- **Integrating monitoring systems in PKVY:** Within programmes like PKVY, incorporating water quality monitoring and assessing the nutrient export from agricultural fields to water bodies can provide valuable insights. It is essential factor in the economic value of ecosystem services, nutrient loss, and soil erosion associated with agricultural practices.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Number of monitoring systems for agriculture run-offs
- Percentage of marine pollution caused due to land-based agriculture
- Allocation of budget for ocean-based research, including study of the implications of sea-level rise and saltwater intrusion on agriculture and monitoring of agricultural run-off

Goal 15. Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss

Terrestrial ecosystems play a crucial role in providing goods, raw materials for construction, energy, and food for living. Additionally, they offer various ecosystem services such as carbon capture, maintenance of soil quality, provision of habitat for biodiversity, maintenance of water quality, as well as regulation of water flow and erosion control. By doing so, they reduce the risks of natural disasters such as floods and landslides, regulate local and regional climatic

conditions, and maintain the productivity of agricultural systems (United Nations Environment Programme, 2017).

Agriculture, forestry and other land use (AFOLU) is a significant net source of greenhouse gas emissions, contributing to about 23% of anthropogenic emissions of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) combined, as CO₂ equivalents, in 2007–16. Further increases in climate change and urbanization in the coming times will enhance the warming of cities and their surroundings, causing the urban heat island effect, especially during heat waves and droughts (IPCC, 2019). Between 1990 and 2015, the world's total forest cover diminished from 31.7% to 30.7% of the world's total land mass. This loss was mainly due to the conversion of forest land for other purposes, such as agriculture, settlement, and infrastructure development. In 2014, 15.2% of the world's terrestrial and freshwater ecosystems were covered by protected areas, which are recognized, dedicated, and managed to achieve the long-term conservation of nature (United Nations Statistics Division, 2023). This goal aims to ensure that the benefits of land-based ecosystems, such as forests, freshwater ecosystems, mountains, and sustainable livelihood opportunities, must be enjoyed for generations to come.

Policy and Stakeholder Mapping

Policies	Stakeholders	Pre-production	Production	Post-production
National Agriculture Policy, 2000	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
National Watershed Development Project for Rainfed Areas 1990	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
Sub-Mission on Agroforestry (SMAF) under National Mission for Sustainable Agriculture	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare Council of Scientific and Industrial Research Indian Council of Agricultural Research (ICAR) 	X	X	
National Agroforestry Policy 2014	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare Ministry of Environment, Forest and Climate Change Ministry of Rural Development NABARD International Centre for Research in Agroforestry (ICRAF, South Asia Office) 	X	X	X
National Mission on Agricultural Extension and Technology 2014	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
National Policy for Management of Crop Residues 2014	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	X
National Innovations in Climate Resilient Agriculture 2011	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
Large Area Certification (LAC) Scheme, 2014	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		
National Mission for Sustaining the Himalayan	<ul style="list-style-type: none"> Department of Science and Technology 	X		

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Eco-system under National Action Plan on Climate Change 2010				
Saansad Adarsh Gram Yojana Guidelines 2014	<ul style="list-style-type: none"> Ministry of Rural Development 	X	X	X
Sub-Mission on Plant Protection and Plant Quarantine	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	X
National Adaptation Fund for Climate Change 2015	<ul style="list-style-type: none"> Ministry of Environment, Forest and Climate Change 	X	X	
Central Assistance for Command Area Development Works in Prioritized AIBP (Accelerated Irrigation Benefitted Programme) Funded Irrigation Projects 2017	<ul style="list-style-type: none"> Ministry of Jal Shakti 		X	
Soil Health Card (SHC)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
Mahatma Gandhi National Rural Employment Guarantee Act	<ul style="list-style-type: none"> Ministry of Rural Development 		X	
Per Drop More Crop Component of PMKSY 2021	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
Bhartiya Prakritik Krishi Padhati Programme 2020 under Paramparagat Krishi Vikas Yojana (PKVY)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
National Water Policy 2012	<ul style="list-style-type: none"> Ministry of Jal Shakti 		X	
National Afforestation Programme 2002	<ul style="list-style-type: none"> Ministry of Environment, Forest, and Climate Change 			
New Generation Watershed Development Projects (WDC-PMKSY 2.0) 2021	<ul style="list-style-type: none"> Ministry of Rural Development 		X	
National Action Programme to Combat Desertification 2001	<ul style="list-style-type: none"> Ministry of Environment, Forest, and Climate Change 		X	
National Policy for Farmers	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Monitoring of Pesticide Residues at National Level Scheme, 2018	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Long-Term Irrigation Fund 2016	<ul style="list-style-type: none"> Ministry of Jal Shakti 		X	
National Project on Organic Farming, 2010	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
Bringing Green Revolution to Eastern India	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Pradhan Mantri Janjatiya Vikas Mission	<ul style="list-style-type: none"> Ministry of Tribal Affairs NITI Aayog 	X	X	X

Sub-Mission on Seed and Planting Material under National Mission on Agricultural Extension and Technology 2014	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
Paramparagat Krishi Vikas Yojana	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	
National Agriculture Disaster Management Plan 2020	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Mission Organic Value Chain Development for Northeastern Region 2018	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X		X
National Seed Policy 2002	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
National Policy for Farmers	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Monitoring of Pesticide Residues at National Level Scheme 2018	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) 2015	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 		X	
Rashtriya Krishi Vikas Yojana – Remunerative Approaches for Agriculture and Allied Sector Rejuvenation	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Scheme Guidelines for Central Sector Scheme of Financing facility under Agriculture Infrastructure Fund 2020	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X

Synergies and Trade-offs

Agriculture impacts the well-being of terrestrial ecosystems (sustainable food production system and agriculture practices) and should reinforce the maintenance of terrestrial ecosystems and the prevention of land and biodiversity erosion (International Science Council, 2019). Without healthy biodiversity and ecosystems in well-functioning watersheds, river catchments, basins, and mosaic landscapes, the infrastructure built for irrigation, hydropower, or municipal water supply may not function sustainably (Subedi, Karki, and Panday, 2020).

Sustainable and resilient agriculture practices aligned to ecosystem protection can reinforce conservation, restoration, and sustainable use of terrestrial ecosystems, sustainable forestry and arresting deforestation, and contribute to the restoration of degraded land and soils, as well as combat desertification (International Science Council, 2019). One such practice of ‘agroforestry’ helps claim degraded/wasteland under a tree-based system. It identifies the right species that befit the degraded ecology in the wastelands and enables reclamation and restoration for sustainability.

One trade-off that needs to be addressed is that the extension of agricultural fields for sustainable agriculture while increasing the agricultural income of the farmers can also increase deforestation globally (International Science Council, 2019).

Growing input-intensive cash crops has helped farmers to raise agriculture income but also led to unsustainable water mining because the increased commercialization with high return possibility encourages farmers to invest in groundwater pumping, making agriculture unsustainable in nature (Subedi, Karki, and Panday, 2020). Land is a scarce resource in India, even though the country has a land area of about 328 million hectares, the seventh largest land area in the world. India is burdened with overpopulation and overconsumption of resources (Ramamurthy, Singh, and Chattara, 2016). While up-scaling agroforestry and identifying potential land is crucial to fighting food insecurity in the nation, bringing available wasteland into the ambit of tree-based ecosystems must be undertaken (Arunachalam, Sundaram, and Handa, 2021).

Targets	Synergy	Trade-off
Target 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements		
Target 15.2: By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally		
Target 15.3: By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world		
Target 15.4: By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development		
Target 15.5: Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species		
Target 15.6: Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed		
Target 15.7: Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products		
Target 15.8: By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species		
Target 15.9: By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts		
Target 15.a: Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems		
Target 15.b: Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation		
Target 15.c: Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities		

Gaps and Barriers

Clearing forest land and practicing shifting agriculture has a huge environmental impact on regional hydrology, carbon stock, forest fires, and other ecological benefits (NITI Aayog, 2018; Kumar, et al., 2016; Metzger, 2003). The leaching of nutrients and organic carbon from slash burnt agriculture down the soil causes harm to the land, and many farmers are not aware of the damages (Ritse, et al., 2020)

Currently, global production is focused on homogenous crops, including wheat, rice, maize, potato, soybean, sunflower oil, and palm oil (CGIAR, 2014). Efforts to reduce yield gaps may become increasingly difficult due to climate change (Zhao, et al. 2017), low resilience, and poor agricultural biodiversity (Biodiversity International, CGIAR, Clarmondial, 2017).

Land tenure and rights over it make the implementation of sustainable forest management even more challenging. Access to land is granted on rights to use, control, and transfer land, responsibilities, and restraints to someone else. Such rights include the right to use the land for grazing, growing subsistence crops, and gathering minor forestry products (FAO, 2002). Moreover, due to the existing patriarchal gender norms in society, women hold less control than men over the lands and other resources for their livelihoods and well-being (Bansard and Schröder, 2021). Indigenous people, women, and marginalized people often struggle to have their rights recognized and are excluded from decision-making processes related to land and resources (UN Women, 2020).

The rise in international investment treaties causes power differences. While fostering commercialization and privatization of land and prioritizing investors' rights and interests over the rights of local peoples, they often neglect public-interest policies and public access to remedial action (Cotula, 2015, 2016).

One of the major challenges for financing sustainable agriculture communities includes the unavailability of an efficient and effective impact monitoring system of social and environmental performance, testing of new investment strategies, and cultivation of appropriate structures and intermediaries (Havemann, et al., 2020). Furthermore, biodiversity projects lack cash flows, which is crucial to attracting private-sector financing. Biodiversity and ecosystem services are often referred to as public goods whose true value cannot be reflected in any economic transactions or market.

Lastly, poor collaboration and cooperation between research, academia, and extension with the government and private sector also act as a major barrier to SDG 15 and sustainable agriculture (Subedi, Karki, and Panday, 2020). Decreasing food diversity and low awareness of the need to address food and nutrition security, along with high costs of production and soaring food prices, are due to a lack of access to data and knowledge (Subedi, Karki, and Panday, 2020).

Emerging Policy Solutions

Collective Farming and Land Leasing for Inclusive Farming Systems

- **Promotion of collective farming:** While collective marketing is seen as beneficial, collective production is viewed as challenging due to issues related to uniformity, accountability, and varying contributions among farmers. Trust among farmers is considered crucial. Instead of land pooling, collective farming is more feasible.
- **Challenges in collective farming:** Talking about 'common land', for the purpose of collective farming, the issues pointed out were the identification of beneficiaries, controller of land, and allocation of benefits. Common land should be earmarked for public goods and not private goods.

Strengthening Governance and Market Dynamics

- **Clarity and convergence among systems:** The lack of clarity in terminology, such as organic farming, sustainable agriculture, natural farming, and regenerative agriculture, is noted as a challenge. The need for alignment and convergence among these different agricultural methods is emphasized. KVK promotes natural farming through demonstration but for its effective adoption among farmers, it requires clarity and convergence.
- **Transparent price discovery:** Market dynamics are characterized by a distorted pricing mechanism, where producers receive a small fraction of what consumers pay. Transparent price discovery is seen as essential to establish a stronger connection between consumers and farmers.
- **Issue in policy contradiction:** Governance is viewed as the key to achieving equity in product distribution, as markets tend to exploit farmers. Policy contradictions and the lack of a well-defined land-use policy are identified as challenges that need addressing.
- **Focus on localized solutions:** The importance of localized solutions and farmer-centric policies is highlighted. Policymaking should prioritize the welfare of farmers, ensuring that policies are feasible and beneficial for them.
- **Data integration:** The creation of foundational data is deemed essential for effective governance. Reliable and extensive data can inform decisions that benefit farmers and promote agricultural sustainability. Additionally, the discussion underscores the importance of circularity in policies, with a focus on how goods are transferred to the market within the value chain.

Strengthening of Sub-Mission on Agroforestry (SMAF) to Promote Agroforestry

- **Focus of post-production in SMAF:** There is another challenge of a broken supply chain; it is related to how the farmers will be guaranteed that their produce will be safeguarded and sold after completing the gestation period of as long as 20 years. Limited land holding among farmers also discourages agroforestry. Thus, SMAF can be strengthened by promoting an efficient supply chain through agroforestry.
- **Inclusion of strong financial mechanisms in SMAF:** There is a lack of financial mechanisms for agroforestry. For carbon credits, people opt for fast carbon-growing species that destroy the local resources faster. Also, there is no evidence that farmers have received incentives for voluntary marketing. Hence, financial support and a market for agroforestry produce should be ensured.

Viewing the Ecosystem from a Holistic Lens

- **Ecosystem as a whole:** There is a need to view land as an integral part of a larger landscape, emphasizing the importance of common land, such as community pastures, within the context of agriculture. It is important to recognize that agriculture cannot be isolated from the broader ecosystem. There is an interconnectedness between land and agriculture, including nutrient transfer, soil moisture, and coordination.
- **Preservation of common land:** Common lands should be acknowledged as vital for wildlife conservation, providing habitat for many species. The common land should be preserved for the benefit of the planet and its biodiversity, keeping it free from agricultural or other human activities.
- **Systemic approach for institutional functions:** A systemic approach is advocated to link institutional functions that focus on the responsible use of resources for the benefit of farmers. The productivity of private land is seen as dependent on resources such as water,

which often originates from common land. Thus, the relationship between private and common land is highlighted as a critical connection.

- **Common land for irrigation:** In regions lacking irrigation infrastructure, common land is identified as a strategic asset that can significantly enhance agricultural productivity.
- **Tailoring solutions to ecosystem:** Local crops, beyond demand-driven varieties, are seen as vital to preserving local ecosystems. Adopting a holistic approach that considers local species, soil health, and water management is significant. Different regions and areas require tailored interventions to address their unique challenges and opportunities. Therefore, contextualizing solutions to local conditions is considered essential.
- **Addressing both supply and demand sides:** Alignment of interests and subsidies is considered crucial. The state and individual farmers need to share responsibility, addressing both the supply and demand sides of agriculture comprehensively.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Budget allocation for agroforestry schemes
- Schemes covering post-production aspects to promote agroforestry
- Land brought under trees outside the forest (acres)
- Carbon sinks created because of agroforestry

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Sustainable development is based on peace and justice and institutions that are efficient, responsible, and inclusive. Due to inadequate institutions, inaccessibility to justice, information, and other essential freedoms, many countries continue to experience extended armed conflict and violence, and an excessive number of people continue to struggle (UNOOSA, n.d). The biggest and most damaging threat to globalization, prosperity, well-being, and the very life of nations is violence and inequity.

Since the middle of the 20th century, the agriculture industry has expanded phenomenally all over the world. However, this growth is hindered by the issue of inequality and inaccessibility, which threatens its sustainability. A sense of social injustice is fuelled by disparities between the ‘haves’ and ‘have-nots’ among those who feel abandoned and shut out of development prospects, as well as from better-off allies. As a result, political dissent and even violence are encouraged (Council for Social Justice and Peace, Goa, 2011). Good governance through digital public infrastructure needs to benefit agricultural communities.

Providing a safe and peaceful environment is essential for the growth of agriculture and farmers. Sustainable agriculture requires new methods to be adopted and disseminated. Availability and unhindered accessibility of land are of key importance for the upliftment of our farmers and agriculture sector.

National Policy and Stakeholder Mapping

Policies	Stakeholders	Pre-production	Production	Post-production
Model Agricultural Land Leasing Act, 2016	<ul style="list-style-type: none"> NITI Aayog 	X	X	X
Pradhan Mantri Kisan Samman Nidhi (PM-KISAN)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
National Policy for Farmers	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
National Rehabilitation and Resettlement Policy	<ul style="list-style-type: none"> Ministry of Rural Development, Department of Land Resources 	X	X	X
Section 352 in The Indian Penal Code	<ul style="list-style-type: none"> Ministry of Law and Justice 	X	X	X
The Trafficking in Persons (Prevention, Care and Rehabilitation) Bill, 2021	<ul style="list-style-type: none"> Ministry of Women and Child Development 	X	X	X
Article 14 of the Constitution of India reads as follows: 'The State shall not deny to any person equality before the law or the equal protection of the laws within the territory of India.'	<ul style="list-style-type: none"> Ministry of Home Affairs Ministry of Law and Justice 	X		
Article 13 of the Indian Constitution ensures that parliament and state legislatures are prevented from making such laws that may infringe or take away the fundamental rights, guaranteed by the constitution itself.	<ul style="list-style-type: none"> Ministry of Home Affairs Ministry of Law and Justice 	X		
Prevention of Corruption Act, 1988	<ul style="list-style-type: none"> Ministry of Personnel, Public Grievances and Pensions 	X	X	X
Right to Information Act, 2005	<ul style="list-style-type: none"> Ministry of Personnel, Public Grievances, and Pensions 	X	X	X
Digital India	<ul style="list-style-type: none"> Ministry of Electronics and Information Technology 	X	X	X
Essential Commodities Act (ECA)	<ul style="list-style-type: none"> Ministry of Consumer Affairs, Food and Public Distribution 			X
Discussions on Climate and Sustainability under the aegis of the Intergovernmental forum G20	<ul style="list-style-type: none"> Ministry of Environment, Forest and Climate Change of India 	X	X	X
Article 19 of the Indian Constitution ensures Freedom of Speech and Expression and the Right to Protest Peacefully.	<ul style="list-style-type: none"> Ministry of Home Affairs Ministry of External Affairs 	X	X	X
Protection to Farmers Against PPV&FR (Protection of Plant Varieties and Farmers' Rights Act, 2001)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 	X	X	X
Indian Penal Code, 1860 (Section 153 A)	<ul style="list-style-type: none"> Ministry of Home Affairs 	X		
Scheduled Caste and Scheduled Tribe (Prevention of Atrocities) Act, 1989	<ul style="list-style-type: none"> Ministry of Social Justice and Empowerment 	X	X	X
Indian Penal Code, 1860 Indian Evidence Act, 1872 Code of Criminal Procedure, 1973	<ul style="list-style-type: none"> Ministry of Law and Justice 	X		
73rd Amendment Act, 1992	<ul style="list-style-type: none"> Ministry of Panchayati Raj 	X	X	X

Synergies and Trade-offs

To establish sustainable agricultural systems, it is crucial to improve equality, justice, well-being, and dignity for everyone involved in the food and agricultural supply chain, including farm owners, tenants, and workers in both rural and urban areas (FAO, 2018). In areas where the rule of law is weak, individuals and firms may be influenced by the fear of crime, which can impact their production decisions. For farmers, this could mean selecting crops with a lower risk of theft or devoting more time to security to protect crops rather than other useful tasks. It can also affect farmers' crop decisions, time management, investments in land upgrades, and agricultural production (Dyer, 2020).

The use of sustainable farming methods can be hampered by corruption (Tacconi and Williams, 2020). Corruption risks can arise at various stages of agribusiness, including packaging, distribution, and even storage stages, such as obtaining licenses and permissions for storage, transportation, and actual processing of raw/unfinished agricultural products (Fink, 2002). It is common knowledge that 'middlemen' or intermediaries often pay farmers very low prices for their products while charging high prices to consumers or secondary processors (Rahman, et al., 2021). Also, during the storage and delivery of agricultural goods, theft and embezzlement can be frequent problems (Rahman, et al., 2021). In India, the inaccessibility of land to farmers because of their economic or social backwardness is one of the major hindrances that directly impact their livelihood, income source, and eligibility for various government welfare schemes. Further, small and marginal farmers with small landholdings cannot significantly contribute to sustainable agriculture. Hence, establishing effective and efficient mechanisms for ensuring equity and anti-corruption measures is imperative for sustainable agriculture.

For any community, the next generation is its cornerstone. Ending child labour and trafficking would allow the development of children. Well-nourished, educated children would become the youth that would support sustainable agriculture. Moreover, achieving sustainability in agriculture requires addressing gender inequity. It is more difficult to improve production, decrease hunger and poverty, and focus on sustainability when inequality is high (Ignaciuk and Chit Tun, 2019). SDG 16 also emphasizes human rights. Human rights and sustainable food systems are interrelated. The human rights of farmers include job security, crop insurance, and land rights, among others. Sustainable food systems include sustainable agriculture or agroecology. Agroecology enhances the quality of the air, land, and water, lowers greenhouse gas emissions, and enhances the lives of small-scale farmers (Boyd, n.d).

Targets	Synergy	Trade-off
Target 16.1: Significantly reduce all forms of violence and related death rates everywhere		
Target 16.2: End abuse, exploitation, trafficking and all forms of violence against and torture of children		
Target 16.3: Promote the rule of law at the national and international levels and ensure equal access to justice for all		
Target 16.4: By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime		
Target 16.5: Substantially reduce corruption and bribery in all their forms		
Target 16.6: Develop effective, accountable, and transparent institutions at all levels		
Target 16.7: Ensure responsive, inclusive, participatory, and representative decision-making at all levels		

Target 16.8: Broaden and strengthen the participation of developing countries in the institutions of global governance		
Target 16.9: By 2030, provide legal identity for all, including birth registration		
Target 16.10: Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements		
Target 16.a: Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime		
Target 16.b: Promote and enforce non-discriminatory laws and policies for sustainable development		

Gaps and Barriers

In developed markets, landowners in the agricultural sector have historically taken advantage of farm workers, denied land and agricultural financing to minority and underserved groups, restricted access to healthy food for low-income and minority communities, and polluted rural area's water and air (GIIN, n.d.). Small-scale farmers in rural areas often run the risk of falling victim to corruption with respect to 'land, title, and tenure', which restrains them from increasing their production and level of food security. Because there are so many small-scale landholders in developing nations, many of whom are extremely poor, the effects of corruption in the agricultural sector are amplified (Rahman, et al., 2021). Corruption and inequity in agriculture and related fields hold back these farmers from the opportunities for their upliftment and prosperity.

The Agriculture Census 2015-16 indicates that only 13.9% of operational landholders are female, while men make up 85.8%. Due to their low rates of property ownership, women are often not viewed as farmers and agricultural heirs. As per Oxfam, only 2.3% of women participate in government committees and the implementation of agricultural programmes (Meshram, n.d.). Further, there is a prevalence of Sarpanch Pati in rural India where male family members frequently push the women in their families to run for office so that, if they succeed (through the women quota), the men can influence and dominate the Panchayati Raj Institutions (PRI) through the women from their family. Women continue to be mainly underrepresented in the PRI and local governance systems despite women reservations. Many women sarpanch have had to endure serious violence for questioning established power centres in their villages, where 'proxy politics', 'power brokering', and 'gender-based discrimination' are still prevalent (NIRDPR and CORD, n.d.).

Children, especially those from low-income families, are more susceptible to slavery than adults because they can be duped or deceived more easily. Children are manageable and are less likely to complain about pay or working conditions. Child abuse nearly always results from child trafficking, which is linked to child labour (Kaur and Gulati, 2022). Further, agriculture is perceived as one of the riskiest professions in the world. In certain nations, agriculture has twice as many fatal accidents as the average for all other industries (ILO, 2000). In India, the number of suicides in the industry increased in 2020 compared to 2019, with an 18% increase in the share of victims who were agricultural labourers (Mohan, 2021).

Emerging Policy Solutions

Implementation of Model Land Leasing Act, 2016, Proposed by NITI Aayog to Curb the Barriers to Land Leasing in Indian states

- The national policy suggestions led to different tenancy reform laws in each state, as land is the subject of the state list. Many state governments have either formally outlawed or

placed limitations on the leasing of agricultural land. For instance, Kerala and Jammu and Kashmir have imposed bans on land tenancy while others like Bihar, Karnataka, and Uttar Pradesh only allow certain sections such as widows, people suffering from physical or mental ailment, and seamen to have leasing rights. In Punjab, the tenants acquire purchasing rights of the land, and in Gujarat and Maharashtra, the tenancy of the tenants from the Scheduled Castes/Scheduled Tribes category cannot be terminated (NITI Aayog, 2016).

- Land leasing regulations that are too rigid have made tenancy informal, unstable, and ineffective. Informal tenants are the least secure and productive since they lack legal protection, institutional credit, insurance, and other support services.
- Furthermore, regulations on land renting have restricted the occupational mobility of landowners who desire to pursue careers outside of agriculture but are compelled to remain in it out of concern that they will lose their land if they lease out and leave (NITI Aayog, 2016). For example, in Punjab, 55% of landowners live abroad. This presents an opportunity to address this gap in land leasing.

Benefits of the Model Act for Landowners and Tenants

- The Model Agricultural Land Leasing Act, 2016, put forward by NITI Aayog, aims to tackle the tenancy issues in rural India by legalizing and regularizing leasing with the motive of increasing agricultural efficiency and promoting poverty alleviation and equity. It also proposes to do away with the states' land laws related to adverse ownership of land since it obstructs the free operation of the land lease market.
- The Act makes it easier for all tenants, including sharecroppers, to receive bank credit secured by pledges of anticipated output and insurance credit. Legalizing land tenancy would guarantee farmers access to formal credit, insurance, and inputs like fertilizers.
- The Act strategically tackles the issues of the land tenancy scenario of India and encourages each state to adopt the Act. It is important that all the states incorporate the tenets of the Model Agricultural Land Leasing Act and formulate a lease-friendly policy for the farmers (including landless farmers and sharecroppers).

Making Tenants Eligible for Welfare Schemes

- Most welfare schemes in agriculture are dedicated to registered farmers who own land. It is important to extend the ambit of farmers' definition to include landless farmers, sharecroppers, collective farmers, and tenants.
- The welfare scheme will add to their upliftment, socially and economically. Further, it will significantly boost their performance and incentivize their efforts. It shall also aid the promotion and adoption of sustainable farming practices.

Policy Coherence and Convergence

- Establish convergence in land leasing policies by different states to promote the availability of land among landless, small, marginal, and women farmers.
- Integration and coherence in land-related policies, especially related to leasing and other agricultural activities, are deemed necessary for efficient outcomes.

Strengthen Reporting on Metrics for Policy Design and Implementation

Some proposed metrics that could be monitored include:

- Number of sharecroppers and tenant farmers who benefit from agriculture welfare schemes

- Number of schemes that promote collective farming, including through land pooling
- Policies and regulations that bring reform in land tenancy in agriculture

Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Agriculture, severely impacted by climate change, requires significant focus to ensure food security, preserve the environment, and stabilize economies. The effects of climate change transcend national boundaries and demand significant resources for sustainable agriculture. Global collaboration allows nations to combine their resources for investment in sustainable agricultural practices, research, development, and infrastructure enhancements (Sustainable Agriculture Network, 2019). International collaboration enables the consolidation of knowledge, skills, and cutting-edge research across diverse regions and fields.

As per the Technology and Innovation report by UNCTAD (2023), there is a clear gap in R&D expenditure between developed and developing countries. Several European Union countries allocate around 3% of their GDP to R&D, whereas leading global performers invest approximately 5%. In developing countries, the percentages are considerably lower. On average, lower-middle-income countries invest around 0.53% on R&D (UNCTAD, 2023). Countries with varying socio-economic statuses and ecological landscapes prioritize different areas within their policy and R&D agendas. For instance, in developed countries, where food availability is no longer a concern, R&D in the agricultural sector has decreased. In contrast, middle-income nations experiencing population growth and rising incomes require agricultural R&D to enhance productivity. The global community can bridge these priority gaps by transitioning research for green innovations from national to multinational level.

Research organizations can foster new skills and capabilities by forging partnerships between unconventional collaborators. For instance, connecting agricultural scientists with technology firms creates innovative ‘technology ecosystems’ that drive development (Shepherd, et al., 2018). Knowledge sharing at the multinational level enables efficient natural resource management and coordinated farming practices by operating on scales better suited to the spatial scope of ecological processes across the globe, going beyond the conventional focus on field or farm scales (Velten, et al., 2021). Global partnerships enable the consolidation of knowledge, skills, and cutting-edge research across diverse regions and fields. South–South and triangular cooperation in agriculture enable interactions between countries with similar agro-ecological systems, amplified by the support of an even greater number of actors, creating a unique potential for improving coordination and sharing experiences. Through the exchange of information, effective farming methods, and technological progress, farmers gain access to enhanced crop varieties, inventive agricultural approaches, and climate-specific adaptive measures.

International cooperation allows nations to establish unified policies and standards for sustainable agriculture and environmentally conscious practices. When regulations are aligned, it can streamline market entry for agricultural goods, fostering equitable trade and bolstering the economies of involved countries. Additionally, international alliances can fortify resilience against market fluctuations caused by climate influences, thereby ensuring a more stable and secure food supply chain (Sustainable Agriculture Network, 2019).

National Policy and Stakeholder Mapping

Policies/Schemes	Stakeholders	Pre-production	Production	Post-production
Foreign Direct Investment (FDI) Policy	<ul style="list-style-type: none"> Ministry of Commerce and Industry 	X	X	X
India – Australia Bilateral Economic Partnership	<ul style="list-style-type: none"> NITI Aayog 	X		
Foreign Trade Policy 2023	<ul style="list-style-type: none"> Ministry of Commerce and Industry 			X
International Treaty on Plant Genetic Resources for Food and Agriculture	<ul style="list-style-type: none"> United Nations 	X	X	
WTO Agreement on Agriculture	<ul style="list-style-type: none"> World Trade Organization 			X
Carbon Border Adjustment Mechanism (CBAM)	<ul style="list-style-type: none"> European Union 	X	X	X
e-National Agriculture Market (e-NAM)	<ul style="list-style-type: none"> Ministry of Agriculture and Farmers Welfare 			X
International Fund for Agricultural Development	<ul style="list-style-type: none"> United Nations 	X	X	X

Synergies and Trade-off

Foreign investments in the agricultural sector can bring in advanced technologies, best practices, and knowledge that contribute to improved agricultural productivity, resource efficiency, and sustainable land management. Efficient channelizing of agriculture finance through international partnerships can empower poor farmers to increase their income and help to provide market-based financial services, and fund long-term and green investments to support sustainable agriculture and agri-food value chains (World Bank, 2022). Investing in agriculture and food systems in a responsible manner has a positive impact on food security and nutrition. This is achieved by increasing sustainable production and productivity of safe, nutritious, diverse, and culturally acceptable food. Responsible investment also helps in reducing food loss and waste. It prevents and minimizes negative impacts on air, land, soil, water, forests, and biodiversity. Furthermore, it improves the management of agricultural inputs and outputs. This leads to enhanced production efficiency and minimizes potential threats to the environment and to plant, animal, and human health, including occupational hazards (CFS, 2014).

Research into agricultural varieties and techniques, such as biotechnologies, holds significant promise in aiding developing nations to achieve food security and rural development by overcoming limitations in crop yield. These advancements can be instrumental in developing crop varieties resilient to conditions like salinity and alkalinity, thereby supporting the growth of low-input agriculture—a crucial factor for countries with a substantial population of small

and marginalized farmers (Kumar, 2009). Additionally, looking at successful instances in countries like Brazil, China, and India, the industrialization of integrated food-energy systems stands as a viable model that could be emulated elsewhere. (Kumar, 2009). To enhance this progress, collaborative efforts among developing nations through South-South cooperation can involve joint research, knowledge exchange, higher education partnerships, and the establishment of standards concerning food systems.

Targets	Synergy	Trade-off
Target 17.1: Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection		
Target 17.2: Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7% of gross national income for official development assistance (ODA/ GNI) to developing countries and 0.15 to 0.20% of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20% of ODA/GNI to least developed countries		
Target 17.3: Mobilize additional financial resources for developing countries from multiple sources		
Target 17.4: Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress		
Target 17.5: Adopt and implement investment promotion regimes for least developed countries		
Target 17.6: Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism		
Target 17.7: Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed		
Target 17.8: Fully operationalize the technology bank and science, technology and innovation capacity building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology		
Target 17.9: Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation		
Target 17.10: Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda		

Target 17.11: Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020		
Target 17.12: Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access		
Target 17.13: Enhance global macroeconomic stability, including through policy coordination and policy coherence		
Target 17.14: Enhance policy coherence for sustainable development		
Target 17.15: Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development		
Target 17.16: Enhance the Global Partnership for Sustainable Development, complemented by multistakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries		
Target 17.17: Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships		
Target 17.18: By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts		
Target 17.19: By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries		

Gaps and Barriers

Due to a lack of data and inadequately utilized methodologies, measuring progress and accountability with respect to governmental assistance remains a challenge (UN, 2009). As a result of under-reporting, the progress of schemes focusing on women empowerment and gender equality also cannot be tracked (Centre for Budget and Governance Accountability, 2021). Moreover, the SDG India Index captures only three out of seven targets, i.e., Target 1.2, Target 1.3, and Target 1.4. This creates a problem for India as the only metric for keeping track of the performance of the SDGs does not cover all the aspects of SDG 1 (Bhambu, 2020). The impacts of sustainable agriculture on multidimensional aspects of poverty are an area that needs more attention.

Unfortunately, most of the existing sovereign debt restructuring programmes do not incorporate climate-change risk and biodiversity loss, even if they are potential risks to macroeconomic and financial stability, which may not cover all the aspects of sustainable agriculture (Jena, 2023).

The dissemination of agricultural technology is influenced by the speed and impact of the technologies. Currently, developing countries are putting more effort into innovating single

agriculture technologies while having relatively few supporting technical achievements and lacking effective technological support (Wang, et al., 2020). The success of agricultural, innovative, or environmental policies may be hampered by incoherence, which can be caused by a lack of coordination or inadequate ex-ante and ex-post assessments in some circumstances (OECD, 2019).

There are inherent challenges in South–South cooperation, including a lack of adequate funding and institutional capacity, different regional conditions, and vulnerability to economic and political shocks (United Nations, 2009). This hinders the stability of the smooth flow of sustainable practices at all value chains.

Emerging Policy Solutions

To bolster sustainable agriculture and align it with the objectives of SDG 17, a comprehensive policy framework must include finance, capacity-building, technology, and multi-stakeholder partnerships.

Finance and investment: The policy adopted by direct investment (FDI) focuses on the back-end infrastructure of the agricultural value chain. To further enhance its impact, it could introduce tax incentives, streamlined permit processes, and regulatory support to attract more FDI. Additionally, the policy might include provisions to encourage FDI in R&D related to sustainable agriculture, thus fostering innovation in the sector. Furthermore, it should promote the adoption of agroecological approaches and biodiversity-friendly farming practices through grants, subsidies, and extension services, ensuring that these practices are accessible to all farmers.

Ensuring policy coherence and coordination: In terms of policy coherence, the creation of an inter-ministerial committee is a positive step, but it should be empowered to enforce policy alignment. Regular assessments and stocktaking should be mandatory, and mechanisms to resolve conflicts among policies must be established. A central repository for policy documents and data sharing could further improve coordination among government agencies. While India has engaged in bilateral and multilateral partnerships in agriculture, there is room for improvement in harnessing the full potential of North-South, South-South, and triangular cooperation. Existing efforts tend to be fragmented, with limited coordination among various ministries and agencies responsible for agriculture, international cooperation, and development.

Developing and strengthening global partnerships: India can formulate a comprehensive national strategy that outlines clear objectives, targets, and timelines for North-South, South-South, and triangular cooperation in agriculture. This strategy should involve stakeholders from multiple ministries, research institutions, and the private sector. It is important to partner with international research institutions to develop innovative, science-based schemes that align with SDG 17 for sustainable agriculture. It is also recommended to encourage land tenure reforms in collaboration with international organizations to promote secure land ownership, which can boost investment in sustainable agriculture.

One way to improve India's agricultural sector is by facilitating the transfer of agricultural technology and expertise from developed countries. This can be achieved by establishing joint research and development projects, technology-sharing agreements, and capacity-building programmes for Indian farmers and agricultural scientists. India can take a leadership role in

South-South cooperation by sharing its successful agricultural practices with other developing countries facing similar challenges. This could include knowledge-sharing platforms, joint research initiatives, and technical assistance programmes. Collaboration with international organizations like the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD), and the World Bank to facilitate triangular cooperation. These organizations can help mobilize resources and expertise for sustainable agriculture projects. India can actively engage in international platforms and initiatives that promote sustainable agriculture, such as the UN Food Systems Summit as part of its commitment to the global partnership for sustainable development.

Strengthening e-NAM: Existing practices in India's agricultural value chain, such as the Kisan Credit Card scheme and eNAM, have begun to streamline processes and enhance transparency. However, there is an opportunity to prioritize sustainability within value chains. Policies can incentivize the adoption of sustainable practices by offering premium prices for sustainably produced goods and facilitating the certification and labelling of such products. e-NAM primarily focuses on staple crops, and there is a need to broaden its coverage to include a wider range of agricultural commodities. This would ensure that farmers producing diverse crops can equally benefit from the platform. However, there are challenges in achieving seamless integration between e-NAM and existing Agricultural Produce Market Committee (APMC) systems. This lack of interoperability can result in inefficiencies, as data exchange and communication between different platforms may not be smooth. In some regions, inadequate infrastructure, including transportation and storage facilities, poses challenges in efficiently moving and storing agricultural produce. Addressing these bottlenecks is vital for the smooth functioning of e-NAM. Harmonizing and standardizing agricultural marketing laws and regulations across states is essential. Inconsistent regulatory frameworks can create obstacles to the seamless operation of e-NAM on a national scale.

Robust monitoring and evaluation: Establish a monitoring and evaluation framework to track the progress and impact of international cooperation initiatives in agriculture. Regular assessments should be conducted to ensure that the partnerships are achieving their intended objectives and making a meaningful contribution to sustainable agriculture and SDG 17.

Collaboration and partnerships: Transboundary cooperation is critical in regions like the Indo-Gangetic Plain shared with neighbouring countries. While existing agreements exist, such as the Indo-Nepal Agriculture Cooperation Plan, there is potential for deeper collaboration. A policy entry point could be strengthening and updating existing agreements to promote sustainable land and water management practices, which would benefit all countries involved.

India has taken steps to collaborate with Nepal on various aspects of agriculture, including seed exchange, joint research, and training programmes. However, the focus has primarily been on improving productivity and addressing food security. To enhance transboundary cooperation, India can initiate discussions with Nepal and other neighbouring countries to update existing agreements to prioritize sustainability. This may involve joint efforts in sustainable water resource management, including irrigation efficiency, reducing water pollution, and protecting shared ecosystems. Collaboration on climate-resilient agriculture practices, crop diversification, and pest management can also be explored. Establishing a shared database for monitoring and managing water resources and crop health could facilitate this cooperation. Additionally, cross-border farmer exchange programmes and knowledge sharing can foster a more integrated approach to sustainable agriculture in the region. India's engagement in international partnerships like the Coalition of African, Asian, and Latin American Countries

(COMESA) and the International Fund for Agricultural Development (IFAD) demonstrates its commitment to global cooperation. To enhance this engagement, India could consider expanding its support to international research and development initiatives in agriculture, further aligning its efforts with global sustainability goals.

India has been involved in several international initiatives through IFAD, supporting projects related to rural development, climate resilience, and agricultural productivity in developing countries. However, these initiatives have often been focused on individual countries or regions rather than a broader global partnership for sustainable agriculture. To enhance global partnerships for sustainable development, India can consider expanding its support to international research and development initiatives in agriculture. This could involve increasing contributions to organizations such as IFAD and participating in collaborative research projects that address global agricultural challenges. India can also advocate for and contribute to the development of international frameworks that promote sustainable agriculture, including those related to climate change mitigation and adaptation in agriculture.

Boosting trade and its regime: India's trade regulations can sometimes be complex and cumbersome, leading to delays and trade barriers. This could involve simplifying documentation requirements and reducing redundant administrative procedures. One potential solution is to establish a Single Window System for trade, where all trade-related documentation and clearances are available in one place. This would reduce paperwork, improve transparency, and expedite the trade process. Developing and implementing trade facilitation measures such as advance rulings, customs automation, and expedited clearance procedures can minimize trade barriers.

Compliance with sanitary and phytosanitary measures (SPS) can be strengthened. To accomplish this, it is necessary to invest in capacity-building programmes for farmers, producers, and food processing units. Training should cover the safe handling, storage, and processing of agricultural products. Testing laboratories should be upgraded to meet international standards to conduct accurate and timely inspections. This includes equipping labs with the latest technology for food safety testing. A robust risk assessment system should be developed that evaluates and manages risks associated with agricultural products. This can help prioritize inspections and resources more effectively. It is also important to allocate funds for the modernization and expansion of inspection and testing facilities, particularly in regions with high agricultural production. Trade policies can prioritize fair and equitable trade agreements that benefit small-scale farmers and promote the export of sustainably produced agricultural products. This can contribute to economic growth and international cooperation.

Technology advancements: India can upgrade border inspection points to meet international standards for product testing and quarantine measures and strengthen the cold chain infrastructure to ensure the safe transportation and storage of perishable agricultural products. It can also explore the use of blockchain technology and other AI tools for supply chain transparency and traceability. This can enhance trust in the safety of agricultural products.

Capacity-building: Lastly, to bolster capacity-building and research, the policy should allocate dedicated funds for farmer education and training programmes and prioritize research that addresses local agricultural challenges. By strengthening the educational and research aspects, the policy can help ensure that sustainable agricultural practices are well understood and widely adopted.

CHAPTER 4: THE ROAD AHEAD

In an era marked by global challenges, the 2030 Agenda for Sustainable Development stands as a beacon, envisioning a world free from the shackles of poverty and hunger, a world where quality education and healthcare are accessible to all, and where gender equality is not just an ideal but a reality. At the heart of this ambitious agenda lies the concept of SDGs, a set of 169 targets that span a spectrum of social, economic, and environmental dimensions. However, despite the noble aspirations articulated in the agenda, a critical gap persists—one that hampers the practical implementation and integration of the SDGs. The concept of indivisibility, which is central to the 2030 Agenda, remains somewhat elusive in practical terms. The interactions between the myriad SDG targets and the nuanced ways in which they influence each other in real-world scenarios are not thoroughly understood. This gap is not merely academic; it is a chasm that impedes progress towards achieving the comprehensive vision of sustainable development. Existing studies, while valuable in identifying generic interlinkages, fall short of providing a detailed and quantifiable analysis of these connections.

This gap becomes even more pronounced in the realm of sustainable agriculture, a complex system with an extensive value chain encompassing pre-production, production, and post-production stages. Despite its crucial role in the global pursuit of sustainability, the linkages between SDGs and the components of the agricultural value chain are largely unexplored. The prevailing policy frameworks often neglect the intricate connections within the agricultural sector.

This study focused on crop-based agriculture systems and the associated value chains. It adopted an exploratory approach, delving into the social, economic, and environmental aspects of the agricultural value chain. What sets this study apart is its commitment to understanding the integrated nature of these linkages and using this knowledge to inform evidence-based decision-making.

The study's relevance in contemporary times cannot be overstated. As the global community grapples with pressing issues, such as climate change, food security, and social equity, the need for a nuanced understanding of sustainable development becomes paramount. The study focuses on the national level, recognizing the importance of local policies in the global pursuit of the SDGs. By bringing attention to the often-neglected linkages within the agricultural value chain, the study aims to catalyse a paradigm shift in policy formulation, urging policymakers to adopt a more holistic and integrated approach.

Furthermore, the study's focus on the Indian context is both timely and crucial. With a burgeoning population and a significant agrarian economy, India stands at the crossroads of sustainable development. In essence, this study is not just an academic exercise but a clarion call for action. By uncovering the intricate web of connections between sustainable agriculture and the SDGs, the study aspires to guide policymakers toward more informed and effective decisions. It beckons a future where the goals of poverty eradication, food security, and environmental sustainability and other SDGs are not isolated pursuits but interconnected threads weaving the fabric of a truly sustainable world.

Enhancing Synergies and Managing Trade-offs

The identification and understanding of synergies and trade-offs within the context of sustainable agriculture and the SDGs are pivotal for crafting effective and holistic strategies. Synergies, where the pursuit of one goal positively influences the achievement of another, are crucial for optimizing resource use and avoiding duplicative efforts. For instance, promoting sustainable agricultural practices (SDG 2) not only contributes to zero hunger but also enhances environmental sustainability (SDG 13) through reduced land degradation and responsible resource management.

On the other hand, recognizing trade-offs is equally important to navigate potential conflicts between goals. The widespread promotion of solar pumps, while contributing to clean energy access (SDG 7), may lead to unintended consequences such as groundwater depletion, which creates tension between agricultural productivity and sustainable water management. In the realm of sustainable agriculture, a careful balance is essential. For instance, the adoption of agroecological approaches may showcase a synergy by promoting biodiversity (SDG 15) while simultaneously improving soil health for increased agricultural productivity. Conversely, decisions like promoting unchecked use of certain technologies may present trade-offs, such as groundwater depletion, highlighting the need for a nuanced and balanced approach to sustainable agriculture.

Figure 4.1: Synergies and Trade-offs for SDG Targets

Goals	Targets																		
Goal 1	1.1	1.2	1.3	1.4	1.5	1.a	1.b												
Goal 2	2.1	2.2	2.3	2.4	2.5	2.a	2.b	2.c											
Goal 3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.a	3.b	3.c	3.d						
Goal 4	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.a	4.b	4.c									
Goal 5	5.1	5.2	5.3	5.4	5.5	5.6	5.a	5.b	5.c										
Goal 6	6.1	6.2	6.3	6.4	6.5	6.6	6.a	6.b											
Goal 7	7.1	7.2	7.3	7.a	7.b														
Goal 8	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	8.a	8.b	8.c							
Goal 9	9.1	9.2	9.3	9.4	9.a	9.b	9.c												
Goal 10	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.a	10.b	10.c									
Goal 11	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.a	11.b	11.c									
Goal 12	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.a	12.b	12.c								
Goal 13	13.1	13.2	13.3	13.a	13.b														
Goal 14	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.a	14.b	14.c									
Goal 15	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	15.a	15.b	15.c							
Goal 16	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	16.10	16.a	16.b							
Goal 17	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	17.10	17.11	17.12	17.13	17.14	17.15	17.16	17.17	17.18	17.19

In the study, to identify synergies and trade-offs between SDGs and sustainable agriculture, all 169 targets were scrutinized based on predefined criteria (Figure 4.1). This involved assessing the impact direction, considering both the target’s impact on sustainable agriculture and agriculture’s impact on the target across the entire value chain—encompassing pre-production, production, post-production, and post-production stages. The criteria also delved into studying both immediate and long-term impacts. Through an extensive review of literature, consultations with stakeholders, and validation processes, the study revealed the existence of synergies, trade-offs, and de-links between SDGs and sustainable agriculture. Specifically, 135 synergies were identified, along with 5 targets exhibiting a combination of both synergies and trade-offs (Figure 4.2). Additionally, 29 targets were deemed delinked due to considerations of scope, with assessments based on a working definition of sustainable agriculture and direct environmental impacts on agriculture.

Figure 4.2: Synergies and Trade-offs for SDGs

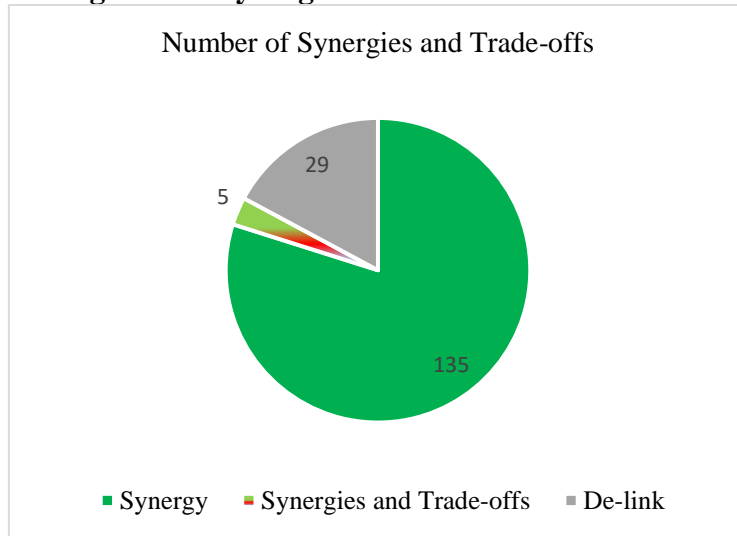


Figure 4.3: Interconnectedness of SDGs and Sustainable Agriculture



In the intricate web of SDGs, the interconnectedness reveals complex relationships that goes beyond linear relationships (Figure 4.3). However, the pursuit of these goals may also present trade-offs, as interventions to address one goal may inadvertently impact another. Table 4.1 depicts the key ministries as stakeholders who are key when it comes to a national policy interface on SDGs and sustainable agriculture. The findings revealed the existence of 34 key stakeholders within the value chain related to SDGs and sustainable agriculture. This underscores the interconnected nature of stakeholders in the realm of sustainable agriculture,

emphasizing the need for a collaborative rather than a siloed approach. The diverse involvement of ministries and departments reflects a convergence on the common issue of agriculture, highlighting the necessity for collaboration. Stakeholder mapping proves instrumental in not only pinpointing the key domains of their work but also identifying potential areas for future collaboration and intervention.

In discussions with the stakeholders at the Ministry of Agriculture and Farmers Welfare, several existing agricultural schemes were discussed, focusing on sustainable practices and ecosystem-based approaches. These policy measures are designed to cater to farmers’ needs and enhance their income, aligning with the aim of meeting farmers’ requirements and aligning with SDG targets.

Through the interaction with stakeholders at the Ministry of Earth Sciences, the possibility of using advisory services at the block level was discussed. The Agromet Advisory Service (AAS) network was suggested to be expanded by establishing District Agro-Met Units (DAMUs) at the sub-district or block level through the Gramin Krishi Mausam Seva (GKMS) scheme. This service provides weather information twice a week, along with special bulletins addressing extreme weather events as and when necessary. The importance of historical weather information was also emphasized, as it is a valuable resource for farmers in strategic crop planning and optimizing agricultural practices. This information can help them identify the optimal planting and harvesting periods, fine-tune irrigation schedules, forecast potential pest infestations, and develop predictive models for anticipating crop yields, which further adds to their sustainable agriculture practices.

During discussions with stakeholders at NITI Aayog, the emphasis was on the organization’s proactive approach to anticipating the impending challenges of climate change and recognizing the intricate connections between sustainable agriculture and the SDGs. NITI Aayog’s policy framework is strategically designed to navigate trade-offs effectively and foster synergies. A key initiative involves the State Support Mission, which aims to broaden the planning scope within each state, ensuring seamless policy implementation and coherence between state and central levels. NITI Aayog recognizes the pivotal role of data and actively maintains databases like the India Climate and Energy Dashboard to bolster planning processes and promote transparency. The organization is actively engaged in collaborative efforts with various departments, aiming to break down silos and enhance resource mobilization.

Table 4.1: National Policy Interface on SDGs and Sustainable Agriculture – Stakeholder Mapping

Stakeholders	Sustainable Development Goals																
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6	Goal 7	Goal 8	Goal 9	Goal 10	Goal 11	Goal 12	Goal 13	Goal 14	Goal 15	Goal 16	Goal 17
Ministry of Rural Development	●	●			●			●	●	●		●	●		●	●	
NABARD	●	●						●					●		●		
Ministry of Tribal Affairs	●									●					●		
Ministry of Agriculture and Farmers Welfare	●	●	●	●			●	●	●	●	●	●	●	●	●	●	
Ministry of Power	●						●										
Ministry of Jal Shakti		●				●	●			●	●	●	●	●	●		
Ministry of New and Renewable Energy							●	●		●							

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Stakeholders	Sustainable Development Goals																
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6	Goal 7	Goal 8	Goal 9	Goal 10	Goal 11	Goal 12	Goal 13	Goal 14	Goal 15	Goal 16	Goal 17
Ministry of Chemicals and Fertilizers		●	●														
Department of Science and Technology		●													●		●
Ministry of Food Processing and Industries		●		●				●	●		●	●	●				
Ministry of Environment, Forests and Climate Change			●			●				●	●	●	●	●	●	●	
Ministry of Education				●													
Ministry of Minority Affairs				●													
Department of Biotechnology				●													
Ministry of Finance	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
NITI Aayog	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ministry of Skill Development and Entrepreneurship				●	●			●									
Ministry of Electronics and Information Technology									●				●			●	
Ministry of Earth Sciences										●			●	●			
Ministry of Women and Child Development			●		●			●		●							
Ministry of Panchayati Raj					●					●						●	
Ministry of Social Justice and Empowerment										●						●	
Ministry of Housing and Urban Affairs						●					●						
Ministry of Labour and Employment								●									
Ministry of Development of North-Eastern Region								●									
Ministry of Commerce and Industry								●									●
Ministry of Road Transport and Highways									●								
Ministry of Consumer Affairs, Food and Public Distribution								●		●	●	●				●	
Ministry of Petroleum and Natural Gas											●	●					
Ministry of Home Affairs											●					●	
Ministry of Law and Justice																●	

Stakeholders	Sustainable Development Goals																	
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6	Goal 7	Goal 8	Goal 9	Goal 10	Goal 11	Goal 12	Goal 13	Goal 14	Goal 15	Goal 16	Goal 17	
Ministry of Personnel, Public Grievances and Pensions																	●	
Ministry of Health and Family Welfare			●															
Ministry of External Affairs																	●	●

Prioritized SDG-wise Measures

SDG 1: It is imperative to further integrate MGNREGS with eco-friendly technologies and sustainable farming practices. Bridging this gap involves incorporating innovative solutions such as solar-powered pumps and energy-efficient machinery into the programme, which will help foster sustainable infrastructure development. By seamlessly integrating these eco-friendly technologies, MGNREGS can significantly contribute to promoting environmentally conscious practices within the agricultural sector. This holistic approach will also ensure a positive impact on both poverty reduction and sustainable development.

SDG 2: To enhance agricultural adaptation and foster crop diversification, it is imperative to emphasize and focus more on the crop diversification programme within the NMSA. This integration should be accompanied by a substantial allocation of funds directed towards robust initiatives and comprehensive capacity-building within the framework of NMSA. Moreover, incentivizing farmers to cultivate a broader spectrum of crops beyond the conventional rice-wheat cycle will play a pivotal role. By creating a market demand for diverse crops and offering incentives to farmers who embrace this diversification, they can be encouraged a shift towards cultivating a wider range of crops. This strategic approach will not only alleviate the pressure on specific crops but also bolster agricultural resilience while fostering market diversity.

SDG 3: It is key to promote environment-friendly and health-friendly inputs through sensitization of farmers to adopt sustainable agricultural methods, which will not only enhance soil health but also contribute to long-term agricultural sustainability. Additionally, NRHM can also integrate mental health challenges faced by farmers. This approach will facilitate timely intervention and provision of appropriate referrals, thereby ensuring that farmers in distress receive the necessary support and access to mental healthcare services. This integration will acknowledge the holistic well-being of farmers, aligning mental health support with agricultural initiatives for a more sustainable and supportive farming community.

SDG 4: It is imperative to address language barriers hindering effective education, especially in linguistically diverse regions. To overcome this gap, implementing language-specific communication strategies is crucial to ensure a better understanding and adoption of sustainable farming practices. Additionally, for the Skill India Mission, it is essential to integrate skill development initiatives with existing agricultural schemes to enhance farmers’ income. There can be a greater focus on areas such as water budgeting and sustainable water management practices within the mission. Furthermore, strengthening collaboration between ASCI and FICSI from the planning stage enhances decision-making, outlook, and access to shared resources. To fortify ASCI, it is vital to incorporate pre-production and post-production stages in training programmes to address the entire agricultural value chain, ensuring the effectiveness of training programmes.

SDG 5: MKSP can be made more effective by strengthening the components that are aimed at equipping women with sustainable infrastructure and diverse training across various stages of the agricultural value chain. By offering training programmes tailored to different stages of the

agricultural value chain, women and women SHGs can gain vital skills and knowledge necessary for sustainable farming practices. This support mechanism within MKSP will empower women to assert their rights and enable them to secure necessary resources for sustained agricultural endeavours. To better comprehend the impacts of unsustainable farming practices, particularly on women farmers, it is essential to collect gender-disaggregated data. Collection and analysis of such data should be prioritized as it will enable discerning the specific challenges faced by women (such as drudgery and pesticide exposure) in agriculture. This data-driven approach will provide critical insights into the disproportionate impacts of unsustainable practices on women, enabling targeted interventions to mitigate these challenges effectively.

SDG 6: Atal Bhujal Yojna can address existing gaps in groundwater management. Currently, water-stressed states like Punjab and Bihar are excluded from the scheme, even though their water tables are rapidly declining. Including these states within the scheme is essential for comprehensive groundwater management, which will help mitigate depletion concerns. Furthermore, the policy should establish a unified framework to tackle groundwater issues, such as treatment and contamination from agricultural activities, and enhancing the prevention of agricultural contamination. Emphasizing integrated management of surface and groundwater resources is crucial for building resilience to changing environmental conditions. Similarly, for the Pradhan Mantri Krishi Sinchayee Yojana, recognizing water efficiency as a separate component is important. By including water management under the NMSA scheme, the policy can elevate the importance of water management in agriculture. This includes monitoring for improved health assessment of water resources, thereby contributing to the overarching goals of SDG 6.

SDG 7: PM-KUSUM initiative needs refinement as not all components currently incorporate the RESCO model. Additionally, the exclusive promotion of solar pumps has increased groundwater depletion concerns. To address this, it is crucial to implement the RESCO model across all components and adopt a holistic value-chain approach that covers pre-production, production, and post-production stages. By integrating remote monitoring and control systems into solar pumps, energy conservation efforts can be improved. Moreover, initiatives such as the AgDSM and ESCO models should extend their focus beyond energy-efficient pumps and encompass various implements (including tractors) and promote energy conservation comprehensively. Similarly, the National Smart-grid Mission, currently emphasizing agri-solar pumps, should promote post-production grids, ensuring a clean energy transition and adopting a whole-of-value-chain approach for sustainable energy practices. These strategic adjustments collectively contribute to cleaner energy transitions and maintain groundwater levels, aligning with SDG 7.

SDG 8: It is vital to establish effective monitoring mechanisms for subsectors and green loan provisions in PSL. This will promote transparency and help overcome challenges. To encourage widespread adoption by financial institutions, provisions for tagging loans for green activities and implementing RBI-led green credit mapping need to be introduced. Integration of crop loans with insurance will provide guarantees and address regulatory issues. Collaboration with private players, particularly fintech, will enhance checks, balances, and recovery processes. To strengthen the limited attention to women farmers, incentivizing women-led agribusinesses and providing training and technology access are crucial. These measures collectively foster improved transparency informed decision-making and strengthen the credibility of PSL. They encourage increased investment in green and sustainable agricultural practices while promoting gender mainstreaming in agriculture. Providing farmers

with bundled services (including credit, insurance, and benefits from schemes) through a single window will ease access to basic services for farmers.

SDG 9: The enhancement of the Pradhan Mantri Kisan Sampada Yojana (PMKSY) demands strategic adjustments. Prioritizing the inclusion of eco-labels and certifications within PMKSY are essential to encourage sustainable farming practices and informed decision-making. To address the limited adoption of energy-efficient technologies, it is crucial to promote the use of smart warehouses and renewable energy sources, which can facilitate both cost reduction and environmental benefits. Collaboration between PMKSY and the Ministry of Agriculture and Farmers Welfare must be strengthened to ensure synergy in efforts across the entire agricultural value chain. Simultaneously, reinforcing the cold storage infrastructure policy requires a broader focus beyond potatoes to encompass various perishables, ensuring increased availability, and mitigating food loss. Additionally, enhancing the user interface of agricultural apps needs to be enhanced by resolving accessibility issues, prioritizing user-friendly features, language support, and improving connectivity for market information.

SDG 10: The Pradhan Mantri Janjatiya Vikas Mission necessitates recalibration to address existing gaps. To broaden its impact, tribal entrepreneurship and livelihood opportunities need to be bolstered, incorporating traditional skills and fostering product diversification. This strategic approach not only addresses income disparities but also encourages sustainable practices, optimizing natural resource utilization for tribal communities. Simultaneously, it is imperative to establish dedicated insurance schemes tailored to the unique needs of tribal communities, including gender-specific options for women. This ensures the mitigation of risks faced by tribal communities, fostering enhanced resilience. Moreover, interventions across the entire agricultural value chain should be integrated with a specific emphasis on pre-production elements, ensuring the inclusive participation of tribal communities in sustainable agriculture practices.

SDG 11: To promote urban agriculture and enhance sustainable practices within urban spaces, it is imperative to prioritize the identification and allocation of suitable lands for agricultural purposes. Integrating community-based farms within AMRUT can be crucial to fostering sustainable agricultural practices through community engagement and participation in cities. Hydroponic farming holds the potential in terms of enhancing agriculture infrastructure in urban spaces and can be explored for regions where natural ecosystems are not disrupted, such as on terraces.

SDG 12: It is crucial to strategically strengthen the National Policy for the Management of Crop Residues beyond specific states to encompass the entire nation in a strategic manner. This will provide a comprehensive approach to foster sustainable agriculture through the Rashtriya Krishi Vikas Yojana (RKVY)-Remunerative Approaches for Agriculture and Allied sector Rejuvenation (RAFTAAR) can provide incentives for crop diversification, and the provision of diverse seeds at a single window can be instrumental. Additionally, incorporating ecolabelling within RKVY infrastructure can expedite sustainable practices. It is vital to focus on commercializing waste under RKVY, including support for startups converting crop wastage. RKVY-RAFTAAR can also expand its focus to other agricultural crops than just horticultural crops. Simultaneously, within Pradhan Mantri Kisan Sampada Yojana (PMKSY), prioritizing eco-labels and embracing energy-efficient technologies can also promote sustainable practices. Post-harvest waste can be reduced by promoting smart warehouses through enhanced implementation of PMKSY as also discussed in SDG 9.

SDG 13: To mitigate risks and adapt to changing situations, farmers can adopt various strategies. One such strategy is to expand the crop coverage under the PMFBY scheme. Diversifying the list of crops covered will ensure a more comprehensive and inclusive risk

mitigation strategy for farmers. It will also encourage them to diversify their crops for cultivation. Instead of indemnity-based insurance, farmers can opt for index-based insurance mechanisms. This will streamline the claims process, simplifying claim procedures, mitigate inaccuracies in trigger claims for crop losses, reduce administrative overheads, and ensure quicker disbursement of pay-outs to affected farmers. To strengthen disaster risk reduction and climate adaptation, a Multi-Hazard Early Warning System (MHEWS) can be integrated into the NDMP. This will provide timely alerts and response mechanisms for various agricultural risks and potential associated effects, thus strengthening disaster risk reduction as well as climate adaptation. A vulnerability matrix can be developed by CCSAMMN and NMSKCC to map and track the loss of agricultural productivity due to slow-onset events. This will help devise methods on how international funds can compensate for the loss to the farmers.

SDG 14: To enhance sustainable agricultural practices and minimize environmental impacts on marine systems, it is crucial to implement rigorous monitoring and regulatory mechanisms to manage the rate of runoffs from agricultural sources. One effective approach is introducing comprehensive monitoring systems within CRZ rules, the Water Act (1971) and EPA, which can effectively track and regulate runoffs, ensuring minimal agricultural runoff into marine systems. Additionally, within the framework of the PKVY, water quality monitoring protocols can be integrated, which specifically assess nutrient export from agricultural fields to adjacent water bodies. By embedding robust water quality assessments into PKVY, the impact of agricultural activities on water bodies can be assessed.

SDG 15: To strengthen the agri-value chains and sustainable approach to farming practices, it is recommended to focus on the post-production component, specifically addressing access to markets, credit, and storage units within SMAF. This includes allocating resources to build storage infrastructure, the post-harvest handling of agroforestry produce, and implementing regulatory frameworks that support the marketing prospects for agroforestry produce. This recommendation underscores the significance of focusing on the post-production phase within the SMAF framework. Facilitating access to markets and credit for farmers involved in agroforestry will not only enhance their economic prospects but also incentivize the adoption of sustainable agroforestry practices.

SDG 16: The Model Agricultural Land Leasing Act by NITI Aayog provides a framework to address the complexities of land tenancy scenarios, and it is crucial to encourage each state to adopt this Act. Doing so will help ensure standardized regulations and a structured approach to land leasing, providing clarity and stability to the agricultural sector. This approach will not only address issues related to land tenancy but also foster a more inclusive and sustainable agricultural landscape that benefits all stakeholders involved. Collective farming presents a more feasible solution as it allows for a structured framework that safeguards the interests of marginal and tenant farmers. By fostering collaboration among farmers, this approach can lead to increased income opportunities, shared responsibilities, and equitable access to subsidies and support mechanisms. In exploring collective farming models, it is essential to acknowledge and address the challenges related to trust, uniformity, accountability, and varying contributions among farmers engaged in land leasing agreements.

SDG 17: It is crucial to establish partnerships with international organizations that often face challenges due to the lack of a common knowledge-sharing platform. To address this, there is a pressing need for the development of a comprehensive single-window platform that facilitates improved access to data and knowledge for sustainable agriculture. This platform would serve as a centralized hub, fostering collaboration by providing a shared space for the exchange of information and expertise. By bridging the gaps in knowledge sharing, this initiative aims to

enhance cross-sectoral collaboration, particularly in the realms of environment and social protection and ensure sustainability in agriculture with shared resources and knowledge.

Cross-cutting Issues

In the intricate tapestry of sustainable agriculture and the SDGs, there exist gaps that demand astute attention and strategic intervention. These gaps, akin to chasms in the policy interface, present challenges that, if left unaddressed, could impede the journey towards a sustainable and equitable agricultural landscape. This report explores these gaps, which include data constraints, administrative asymmetry, funding inefficiencies, and the pressing need for comprehensive post-harvest data and market accessibility. These gaps, like fault lines, underscore the urgency for a transformative approach, a blueprint that not only identifies these crevices but also lays the groundwork for a resilient and responsive policy framework.

Data Constraints: The foundation of informed decision-making rests on the availability of reliable data. However, data constraints pose a significant hurdle, hindering the development of policies grounded in real-time insights. To address this issue, we need a strategic overhaul of data collection mechanisms, leveraging technological solutions, and ensuring comprehensive coverage.

Non-Symmetry between State and Central Mandates: Administrative misalignment can result in disjointed efforts and a lack of cohesive strategies. Bridging the gap between state and central mandates requires enhanced coordination, shared resources, and a unified vision towards achieving SDGs in the agriculture sector.

Strengthening SDG Index: NITI Aayog's SDG Index and state SDG indicator frameworks can be further strengthened by aligning key agriculture-related indicators such as the crop diversification index.

Inefficient Fund Utilization: The financial backbone of sustainable agriculture initiatives is often hindered by inefficient fund utilization. To rectify this gap, it is crucial to meticulously examine funding mechanisms, ensure optimal allocation, and implement accountability measures to track the impact of financial investments.

Absence of Post-Harvest Data: Collecting data on the post-harvest process is crucial for understanding how efficient and effective the agricultural value chain is, as well as identifying any challenges that may exist. The absence of this crucial data point impedes the development of targeted interventions. Closing this gap involves implementing comprehensive post-harvest data collection methods and integrating this information into policy formulation.

Market Inaccessibility and Inadaptability: Market dynamics are critical in determining the success of sustainable agriculture. However, market inaccessibility and inadaptability act as barriers. Addressing this gap calls for strategies that enhance market access for farmers, facilitate adaptation to market trends, and ensure fair returns for sustainable practices.

Shelf Life of Schemes/Projects: The limited lifespan of agricultural projects undermines their sustainability. Prolonging the impact of these initiatives requires a shift towards long-term planning, community engagement, and adaptive strategies that can withstand the test of time.

Focus on Interlinkages between SDGs: It is important to develop a comprehensive understanding of the interconnected nature of SDGs and their implications for sustainable agriculture. This involves mapping the synergies and trade-offs to inform integrated policy frameworks that transcend siloed approaches.

Addressing Data Gaps: It is important to invest in robust data collection mechanisms to address data constraints. This includes leveraging technology for real-time data, ensuring

comprehensive coverage, and addressing disparities in data availability to build a foundation of informed decision-making.

Improve Sync between State and Centre Governments: It is important to enhance coordination and collaboration between state and central governments to ensure a synchronized approach. This involves aligning mandates, sharing resources, and fostering a cohesive strategy towards achieving SDGs in the agriculture sector.

Robust Information System: It is important to establish a robust information system that integrates data from various sources and provides policymakers with accurate and timely information. This system should be designed to facilitate evidence-based decision-making and monitor the progress of sustainable agriculture initiatives.

Improve Feedback Mechanisms: It is necessary to implement effective feedback mechanisms that allow for continuous evaluation and adjustment of policies. This iterative process ensures that policies remain responsive to the evolving needs and challenges within the sustainable agriculture landscape.

Collaboration between Stakeholders from the Planning Stage: It is important to foster collaboration between diverse stakeholders, including government bodies, private sectors, civil society, and local communities, right from the planning stage. This inclusive approach ensures a holistic perspective and aligns the efforts of all stakeholders towards common goals.

Strengthening the Role of FPOs, Cooperatives, NGOs, and Civil Society: Collaboration with a grassroots organization is pivotal in enhancing farmers' capacity and facilitating their active participation in programme implementation. Leveraging the familiarity and relatability that farmers have with these organizations is crucial, as it fosters a sense of trust and openness. The proximity of these organizations to the farmers' centres, coupled with their awareness of regional structures and prevalent practices, makes them a valuable resource for farmers seeking assistance. When government programmes or agricultural schemes are introduced, the organization becomes a bridge between the authorities and the farmers. This collaborative approach strengthens the capacity of farmers and promotes a more inclusive and locally relevant implementation of initiatives.

Systems Perspectives and Ecosystem-based Approaches: It is important to view agriculture holistically, recognizing it as a multifaceted system that comprises complex systems involving soil health, water resources, biodiversity, climate, and socio-economic factors. Emphasizing systems perspectives is fundamental for sustainable agriculture, underlining the interconnectedness of various elements within an agricultural system. Ecosystem approaches foster resilient agricultural systems and are crucial for building systems that can adapt to changes, whether environmental (climate, pests) or societal (market demands, regulations). These approaches prioritize efficiently using resources like land, water, soil nutrients, and energy. Diverse ecosystems can better withstand climatic shocks and stresses, ensuring more stable yields over time. Furthermore, preserving and promoting biodiversity within agricultural systems contributes to essential ecosystem services. Ecosystem-based approaches can be enhanced by employing techniques such as crop rotation, cover cropping, and minimal soil disturbance. These methods improve soil structure, fertility, and microbial activity. Such holistic strategies promote a more harmonious relationship between agriculture and the environment, ensuring food security and environmental health for the future.

Multiple Policies with Similar Objectives: A comprehensive strategy should be devised by the government to achieve common goals, replacing the multitude of existing schemes and policies. This unified policy should be customized for different regions, taking into account

their specific needs and geographical considerations. Such an approach would minimize the risk of fund misallocation and redundant efforts, ultimately enhancing effectiveness.

Strengthen Monitoring and Evaluation (M&E) and Projects Sustainability: It is important strengthen M&E frameworks to monitor the impact and effectiveness of sustainable agriculture projects. Emphasizing on sustainability by incorporating long-term planning, resource optimization, and community engagement can ensure enduring positive outcomes.

In conclusion, the gaps in the policy interface between sustainable agriculture and SDGs are not merely challenges but opportunities for transformative change. At the crossroads of identified gaps, the road ahead should be paved with a blueprint that not only acknowledges these challenges but transforms them into opportunities. The study, in its pursuit of understanding the synergies and trade-offs between sustainable agriculture and SDGs, serves as a guide for crafting this blueprint. The road ahead requires a concerted effort to bridge these gaps, backed by a blueprint that understands the intricacies of interlinkages, values comprehensive data, and fosters collaboration among stakeholders. As we navigate this terrain, the study's contribution to identifying synergies and trade-offs becomes the cornerstone of policy recommendations, stakeholder mapping, and a nuanced understanding that will guide the sustainable agriculture landscape towards a resilient and equitable future.

REFERENCES

Chapter 1

- Acharya, S. S. (2006). Sustainable Agriculture and Rural Livelihoods. *Agricultural Economics Research Review*, 205-217. Retrieved from <https://core.ac.uk/download/pdf/6332859.pdf>
- Barua, P., and Rahman, S. H. (2021). Sustainable management of agriculture products value chain in responses to climate change for South-Eastern coast of Bangladesh. Retrieved from <https://www.emerald.com/insight/content/doi/10.1108/MSGRA-07-2020-0020/full/pdf>
- Bennich, T., Weitz, N., and Carlsen, H. (2020). Deciphering the scientific literature on SDG interactions: A review and reading guide. *Science of The Total Environment*.
- Bhavani, R., and Rampal, P. (2020). *Harnessing Agriculture for Achieving the SDGs on Poverty and Zero Hunger*. Observer Research Foundation.
- Blanc, D. (2015). *Towards integration at last?* Department of Economic & Social Affairs.
- Caiado, R., Filho, W., Quelhas, O., Nascimento, D., and Ávila, L. (2018). A literature-based review on potentials and constraints in the implementation of the sustainable development goals. *Journal of Cleaner Production*, 1276-1288.
- Choudhuri, S. (2021). Research on Sustainable Development. *International Journal of Recent Technology and Engineering*.
- El Bilali, H., Callenius, C., Strassner, C., and Probst, L. (2019). Food and nutrition security and sustainability transitions in food systems. *Food and Energy Security*, 8(2), e00154. doi: <https://doi.org/10.1002/fes3.154>
- Food and Agriculture Organisation of the United Nations. (n.d.). *Sustainable Food and Agriculture*. Retrieved from Food and Agriculture Organisation of the United Nations: <https://www.fao.org/sustainability/background/en/>
- Food and Agriculture Organisation. (2016). *The State of Food and Agriculture*. The Food and Agriculture Organisation. Retrieved from <https://www.fao.org/3/i6030e/i6030e.pdf>
- Food and Agriculture Organisation of the United States. (2019). *The State of Food and Agriculture*. Retrieved from <https://www.fao.org/3/ca6030en/ca6030en.pdf>
- Food and Agriculture Organisation of the United States. (2023). *World Food Situation*. Retrieved from <https://www.fao.org/worldfoodsituation/foodpricesindex/en/>
- Food and Agriculture Organization of the UN (FAO); International Fund for Agricultural Development ; International Labour Office (ILO). (2010). Agricultural value chain development: Threat or opportunity for women's employment? Retrieved from https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_150833.pdf
- Global Hunger Index. (2022). *Food Systems Transformation and Local Governance*. Retrieved from <https://www.globalhungerindex.org/pdf/en/2022.pdf>
- Godfray, H. C. (2010). Food security: The challenge of feeding 9 billion people. *Science*, 327(5967), 812– 818.
- Hernandez, J. E., Kacprzyk, J., and Panetto, H. (2017). Challenges and solutions for enhancing agriculture value chain decision-making. a short review. Retrieved from https://link.springer.com/chapter/10.1007/978-3-319-65151-4_68

- Intergovernmental Panel on Climate Change, Working Group II. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Intergovernmental Panel on Climate Change.
- IPCC. (2019). *Special Report on Climate Change and Land*. Intergovernmental Panel on Climate Change.
- Kaplinsky, R., and Morris, M. (2001). *Handbook for Value Chain Research*. Retrieved from https://www.researchgate.net/publication/42791981_A_Handbook_for_Value_Chain_Research
- MOSPI (Ministry of Statistics and Programme Implementation). (2023). *Periodic Labour Force Survey (PLFS) (July 2021-June 2022)*. New Delhi: Ministry of Statistics and Programme Implementation.
- Ministry of Consumer Affairs. (2013). *National Food Security Act*. New Delhi: Ministry of Consumer Affairs, Food and Public Distribution
- National Institute of Food and Agriculture, United States Department of Agriculture. (n.d.). *Sustainable Agriculture*. Retrieved from The National Institute of Food and Agriculture, USDA: <https://www.nifa.usda.gov/>
- National Mission For Sustainable Agriculture. (n.d.). *National Mission For Sustainable Agriculture*. Retrieved from National Mission For Sustainable Agriculture: <https://nmsa.dac.gov.in/>
- Nilsson, M., Griggs, D., Visbeck, M., Ringler, C., and McCollum, D. (2017). *A Guide to SDG Interactions: From Science to Implementation*. International Council for Science
- NITI. (2021). *SDG India Index & Dashboard 2020-21*. New Delhi: NITI Aayog, Government of India.
- Pegler, L. (2015). Peasant inclusion in global value chains: economic upgrading but social downgrading in labour processes? *Journal of Peasant Study*. Retrieved from https://www.researchgate.net/publication/281317051_Peasant_inclusion_in_global_value_chains_economic_upgrading_but_social_downgrading_in_labour_processes
- Piñero, V., Arias, J., Elverdin, P., Ibáñez, A. M., Morales Opazo, C., Prager, S., and Torero, M. (2021). *Achieving Sustainable Agricultural Practices: From Incentives to Adoption and Outcomes*. International Food Policy Research Institute. doi:10.1038/s41893-020-00617-y
- Pradhan, P., Costa, L., Rybski, D., Lucht, W., and Kropp, J. P. (2017). A systematic study of Sustainable Development Goal (SDG) interactions. *Earth's Future*, 5(11), 1169-1179. doi:<https://doi.org/10.1002/2017EF000632>
- Priyadarshini, P., and Abhilash, P. C. (2020). Policy recommendations for enabling transition towards sustainable agriculture in India. *Land Use Policy*, 96, 104718. doi: <https://doi.org/10.1016/j.landusepol.2020.104718>
- Suresh, A., Krishnan, P., Jha, G. K., and Reddy, A. A. (2022). Agricultural sustainability and its trends in India: A macro-level index-based empirical evaluation. *Sustainability*, 14(5), 2540. doi:10.3390/su14052540
- Sustainable Agriculture Research & Education Program. (n.d.). *Values-based Supply Chains*. Retrieved from Sustainable Agriculture Research & Education Program: <https://sarep.ucdavis.edu/sustainable-ag/values-based-supply-chains>

- Sustainable Agriculture Research & Education Program. (n.d.). *What is Sustainable Agriculture?* Retrieved from Sustainable Agriculture Research & Education Program: <https://sarep.ucdavis.edu/sustainable-ag>
- Tosun, J. and Leininger, J. (2017). *Governing the Interlinkages between the Sustainable Development Goals: Approaches to Attain Policy Integration*. Retrieved from Wiley Online Library: <https://onlinelibrary.wiley.com/doi/full/10.1002/gch2.201700036>
- Trienekens, J. H. (2011). Agricultural value chains in developing countries. *International Food and Agribusiness Management Review*. Retrieved from <https://edepot.wur.nl/189057>
- UN (United Nations). (2023). *Tier Classification for Global SDG Indicators (Version: 31st March 2023)*. New York: United Nations.
- UN-DESA. (2022). *The Sustainable Development Goals Report 2022*. New York: United Nations.
- United Nations Statistics Division. (2020). *The Sustainable Development Goals Report*. Retrieved from <https://unstats.un.org/sdgs/>
- van Soest, H. L. et al. (2019). Analysing interactions among Sustainable Development Goals with Integrated Assessment Models. *Global Transitions*, 1, 210-225. doi: <https://doi.org/10.1016/j.glt.2019.10.004>
- Vision 2030. n.d. *Sustainability Framework for Realising SDG*. New Delhi: Department of Agriculture Cooperation and Farmers Welfare
- Vorley, V., Macgregor, J., and Lundy, M. (2012). Agricultural value chain finance strategy and design. Retrieved from <https://www.ifad.org/documents/38714170/39144386/Agricultural+value+chain+finance+strategy+and+design.pdf/1ae68ed6-4c3c-44f4-8958-436e469553bb>

Chapter 2

- CGWB. (2020). *Assessment of Groundwater Level (Annual Extractable Resource of Assessment Units) for FY 2021-22*. New Delhi: Central Ground Water Board. Ministry of Jal Shakti
- IndiaStat. (2019). *Funds Allocation and Expenditure for Bamboo Production under National Agroforestry and Bamboo Mission (NABM)*. Retrieved from <https://www.indiastat.com/data/agriculture/national-agroforestry-and-bamboo-mission-nabm>
- IndiaStat. (2021). *State-wise area of crops (in hectares)*. Retrieved from <https://www.indiastat.com/Home/DataSearch?Keyword=Crops%20in%20India>
- MNRE (2022). *Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan*. New Delhi: Ministry of New and Renewable Energy
- MoAFW (2021). *Area Covered Under Organic Farming (NPOP)*. New Delhi: Ministry of Agriculture and Farmers Welfare
- MoAFW. (2019). *Pradhan Mantri Fasal Bima Yojana*. New Delhi: Ministry of Agriculture and Farmers Welfare
- MoAFW. (2020). *Pradhan Mantri Krishi Sinchayee Yojana*. New Delhi: Ministry of Agriculture and Farmers Welfare

MoAFW. (2021). *Agricultural Statistics at a Glance. State-wise Fertilizer Consumption*. New Delhi: Ministry of Agriculture and Farmers Welfare

Chapter 3

SDG 1

- Ahmed, N., Marriott, A., Dabi, N., Lowthers, M., Lawson, M., and Mugehera, L. (2022). *Inequality Kills: The Unparalleled Action Needed to Combat Unprecedented Inequality in the Wake of COVID-19*. Oxford: Oxfam International. doi: 10.21201/2022.8465
- Ali, A. and Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management*. 16(2):183–194. doi: 10.1016/j.crm.2016.12.001
- Asri, V. (2017). Targeting social transfers: are India's elderly poor left behind? *ADB Working Paper*.
- Bhambu, K. (2020). Can India achieve SDG-1 by 2030: An empirical investigation of potentials. *Alochana Chakra Journal*, IX(IV), 5056–5068
- Bhavani, R. and Rampal, P. (2020). Harnessing agriculture for achieving the SDGs on poverty and zero hunger. *ORF Issue Brief* (407), 2-10.
- Christiansen, L. and Martin, W. (2018). Agriculture, structural transformation and poverty reduction: Eight new insights. *World Development*, 109.
- Connolly-Boutin, L. and Smit, B. (2016). Climate change, food security, and livelihoods in sub-Saharan Africa. *Regional Environmental Change*, 16, 385–399.
- Daidone, S., Rossi, N. W., and Soares, F. V. (2018). Synergies between social protection and agriculture. In A. S. Fleur Wouterse, *Boosting Growth to End Hunger by 2025: The Role of Social Protection* (pp. 5-15). Washington, DC: International Food Policy Research Institute (IFPRI). doi: https://doi.org/10.2499/9780896295988_02
- Dev, S. M. (2017). SDG Goal 1 On Poverty: Challenges for India. *BusinessWorld*.
- Devereux, S. (2016). *Social Protection for Rural Poverty Reduction and Rural Transformations*. Rome: International Fund for Agricultural Development. [https://www.un.org/development/desa/dspd/2021/05/social-protection-in-rural-areas/#:~:text=A%20key%20policy%20area%20to,\(United%20Nations%2C%20201\)](https://www.un.org/development/desa/dspd/2021/05/social-protection-in-rural-areas/#:~:text=A%20key%20policy%20area%20to,(United%20Nations%2C%20201))
- Fan, S., Gulati, A., and Thorat, S. (2007). Investment, subsidies, and pro-poor growth in rural India. *IFPRI Discussion Paper*.
- FAO. (2011). *FAO in the 21st Century: Ensuring food security in a changing world*. Rome: FAO.
- FAO. (2019). The role of agriculture and rural development in achieving SDG 1.1. *Paper for presentation at the United Nations Expert Group Meeting on Eradicating Rural Poverty to Implement the 2030 Agenda for Sustainable Development*, 27 February to 1 March 2019, UNECACC-AA.
- Gómez, M., Barrett, C., Raney, T., et al. (2013). Post-Green Revolution food systems and the triple burden of malnutrition. *ESA Working Paper*, 129-138.
- Hanjra, M. and Qureshi, M. (2010). Global water crisis and future food security in an era of climate change. *Food Policy*, 35(5), 365-377. doi: <https://doi.org/10.1016/j.foodpol.2010.05.006>

- Hazell, P. and Haggblade, S. (1993). Farm-nonfarm growth linkages and the welfare of the poor. *Including the Poor: Proceedings of a Symposium Organized by the World Bank and the International Food Policy Research Institute*. Washington: The World Bank.
- Hussain, I. and Hanjra, M. A. (2004). Irrigation and poverty alleviation: review of the empirical evidence. *Irrigation and Drainage*, 53(1). doi: <https://doi.org/10.1002/ird.114>
- Khan, M. H. (2001). *Rural Poverty in Developing Countries: Implications for Public Policy*. (26). International Monetary Fund. <https://www.imf.org/external/pubs/ft/issues/issues26/>
- Kumar, D. (2017 5). Institutional intervention and the feminization of farm sector: lessons of experiments with KDMS and MKSP in Kerala. *Munich Personal RePEc Archive*.
- Kurukulasuriya, Pradeep and Rosenthal, Shane. (2013). Climate change and agriculture: a review of impacts and adaptations. *Climate Change Series 91*, Environment Department Papers, World Bank, Washington, D.C.
- LARRDIS. (2023). *Gender equality for Agriculture and Food Security: A pathway towards sustainable development goal*. Parliament Library and Reference, Research, Documentation and. Information Service.
- Madhusudan, G. (2017). Infrastructure and development in rural India. *Margin - The Journal of Applied Economic Research*, 3(3). <https://journals.sagepub.com/doi/abs/10.1177/0973801017703499>
- Nayak, R., Saxena, N., and Farrington, J. (2002). Reaching the poor: the influence of policy and administrative processes on the implementation of government poverty schemes in India. *Overseas Development Institute*.
- Patel, D. and Sethi, D. (2021). *Rural Women: Key to New India's Agrarian Revolution*. New Delhi: NITI Aayog.
- Rao, C. H. (1998). Agricultural growth, sustainability and poverty alleviation: recent trends and major issues of reform. *Economic and Political Weekly* 33(29-30).
- Sinha, S. (2012). Govt-sponsored schemes: meant for poor, but beyond their reach. *Economic Times*.
- Sreeramulu, G. and Ramanna, P. (2010). Implementation of poverty eradication programmes in two states of southern India: A comparative analysis. *The Indian Journal of Political Science*, 71.
- Thorat, S. and Fan, S. (2007). Public investment and poverty reduction: lessons from China and India. *Economic and Political Weekly*.
- Timmer, C. P. (2005). Agriculture and pro-poor growth: an Asian Perspective. *Centre for Global Development*.
- UN DESA. (2022). *SDG Good Practices: A compilation of success stories and lessons learned in SDG implementation*.
- UNICEF Data. (n.d.). *SDGs*. Retrieved from UNICEF Data: Monitoring the situation of children and women.
- UNICEF India. (2023). *Social Policy and Social Protection*. <https://www.unicef.org/india/what-we-do/social-policy-inclusion#:~:text=The%20solution,an%20inclusive%20and%20protective%20society.>

- World Bank. (2012). India: Issues and priorities for agriculture. <https://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities>
- World Bank. (2023). *Agriculture and Food*. <https://www.worldbank.org/en/topic/agriculture/overview>

SDG 2

- Alwang, J., Gotor, E., Thiele, G., Hareau, G., Jaleta, M., and Chamberlin, J. (2019). Pathways from research on improved staple crop germplasm to poverty reduction for smallholder farmers. *Elsevier*, 1-16.
- Gil, J. D., Reidsma, P., Giller, K., Todman, L., Whitmore, A., and van Ittersum, M. (2018). Sustainable Development Goal 2: Improved targets and indicators for agriculture and food security. <https://link.springer.com/article/10.1007/s13280-018-1101-4>
- Grovermann, C., Umesh, K. B., Quiédeville, S., Kumar, B., S., S., and Moakes, S. (2018). The economic reality of underutilised crops for climate resilience, food security and nutrition: assessing finger millet productivity in India. *Agriculture*, 8(9). doi: <https://doi.org/10.3390/agriculture8090131>
- Gulati, A., Roy, R., and Saini, S. (2021). *Revitalizing Indian Agriculture and Boosting Farmer Incomes*. Singapore: Springer. doi: <https://doi.org/10.1007/978-981-15-9335-2>
- Hinz, R., Sulser, T. B., Huefner, R., Mason-D'Croz, D., Dunston, S., Nautiyal, S., Ringler, C., Schuengel, J., Tikhile, P., Wimmer, F., and Schaldach, R. (2020). Agricultural development and land use change in India: A scenario analysis of trade-offs between UN Sustainable Development Goals (SDGs). *Earth's Future*, 8. doi: <https://doi.org/10.1029/2019EF001287>
- Hofstra, N., and Vermeulen, L. (2016). Impacts of population growth, urbanisation and sanitation changes on global human Cryptosporidium emissions to surface water. *International Journal of Hygiene and Environmental Health*, 219(7), 599-605.
- . Kumar, G. and Thangaraj, P. (2022). Green investment for sustainable agriculture: A missed opportunity? *Time of India*, April 12.
- Ministry of Agriculture and Farmers Welfare. (2023). Sustainable agricultural practices. <https://pib.gov.in/PressReleasePage.aspx?PRID=1911556>
- Ministry of Agriculture and Farmers Welfare. (2022). *Annual Report*. New Delhi: Government of India.
- Ministry of Agriculture and Farmers Welfare. (2022). *Rainfed Farming System*. New Delhi: Government of India. <https://agricoop.gov.in/en/RainfedDiv#:~:text=Rainfed%20agriculture%20occupies%20about%2051,highly%20diverse%20and%20risk%20prone.>
- Parichha, M. (2021). *Food Production in India Faces Twin Challenges of Pesticides and Monoculture*. <https://www.outlookindia.com/national/food-production-in-india-faces-twin-challenge-of-pesticide-and-waste-management-news-193733>
- Rai, R. (2019). Pradhan Mantri Fasal Bima Yojana: an assessment of India's crop insurance scheme. *ORF Issue Brief*, 4-7. https://orfonline.org/wp-content/uploads/2019/05/ORF_Issue_Brief_296_CropInsurance.pdf

- Ruel, M., Quisumbing, A., and Balagamwala, M. (2018). Nutrition-sensitive agriculture: what have we learned so far? *Global Food Security*, 128–153. doi:10.1016/j.gfs.2018.01.002
- Singh, A. (2022). Precision agriculture in India – opportunities and challenges. *Indian Journal of Fertilizers*, 18(4).
- University of Agricultural Science. (2016). Third Party Evaluation of Integrated Scheme on Oilseeds, Pulses, Oil palm and Maize. Tamil Nadu Agricultural University Agritech portal.
- UN DESA. (2016). *Goal 2: End Hunger, Achieve Food Security and Improved Nutrition and Promote Sustainable Agriculture*. New York: Department of Economic and Social Affairs, United Nations.

SDG 3

- Achterbosch, T.J., van Berkum, S. and Meijerink, G.W. (2014). Cash crops and food security; Contributions to income, livelihood risk and agricultural innovation. Wageningen, LEI Wageningen UR (University & Research centre), LEI Report 2014-015, 57 pp.; 20 fig.; 3 tab.; 60 ref.
- Aktar, M., Sengupta, D., and Chowdhury, A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. *National Library of Medicine*, 2(1), 1-12.
- CGIAR. (2016). Research program on agriculture for nutrition and health. <https://a4nh.cgiar.org/india/>
- Donham, K. J. and Thelin, A. (2016). Psychosocial conditions in agriculture. In A. Thelin and K. J. Donham, *Agricultural Medicine: Rural Occupational and Environmental Health, Safety, and Prevention* (Second Edition, pp. 351-370). New Jersey: John Wiley & Sons, Inc.
- Dhankar, N. and Kumar, J. (2023). Impact of increasing pesticides and fertilizers on human health: A review. *Materials Today: Proceedings*. Science Direct.
- Fan, S. (2015). How agriculture can improve health and nutrition. *World Economic Forum*. <https://www.weforum.org/agenda/2015/04/how-agriculture-can-improve-health-and-nutrition/>
- Fernandes, E. (2020). Farmer’s health: The conscience calls for action. *The Times of India*. <https://timesofindia.indiatimes.com/blogs/global-health-focus/farmers-health-the-conscience-call-for-action/>
- Gulati, A. and Roy, R. (2021). Linkage between agriculture, poverty and malnutrition in India. Revitalizing Indian agriculture and boosting farmer incomes. *India Studies in Business and Economics*. Singapore: Springer. https://doi.org/10.1007/978-981-15-9335-2_3
- Frimpong, S. O. and Vermund, S. H. (2022). The role of agriculture in achieving Universal Health Coverage in Africa. *Journal of Global Health*. doi:10.7189/jogh.12.03053
- Howden-Chapman, P., Siri, J., Chisholm, E., Chapman, R., Doll, C. N., and Capon, A. (2023). SDG 3 ensure healthy lives and promote well-being for all at all ages. International Science Council.

- IFPRI, CGIAR. (2006). *Understanding the Links Between Agriculture and Health*. (C. Hawkes, & M. Ruel, Eds.) 2020 Vision for Food, Agriculture and the Environment.
- IFPRI. (2018). 2018 Global Food Policy Report. <https://doi.org/10.2499/9780896292970>
- National Crime Records Bureau. (2021). *Accidental Deaths & Suicides in India 2021*. https://ncrb.gov.in/sites/default/files/ADSI-2021/ads2021_Chapter-2-Suicides.pdf
- NITI Aayog (2022). National Dialogue Indian Agriculture Towards 2030. https://www.fao.org/fileadmin/user_upload/FAO-countries/India/docs/Full_Paper-7.pdf
- Sarat, S. (2023). Farmers are seriously stressed out. *BusinessLine*. <https://www.thehindubusinessline.com/opinion/farmers-are-seriously-stressed-out/article67120559.ece>
- Stamati, P., Maipas, S., Kotampasi, C., Stamatis, P., and Hens, L. (2016). Chemical pesticides and human health: the urgent need for a new concept in agriculture. *Frontiers in Public Health*, 4. doi: <https://doi.org/10.3389/fpubh.2016.00148>
- The World Bank. (2008). *Agriculture for Development*. Washington: The World Bank. <https://openknowledge.worldbank.org/entities/publication/ba969388-b5eb-5155-b8f2-6d323a6e5a52>

SDG 4

- Aduroja, D. (2021). What is the Role of Youth in Agriculture? Heifer International. <https://www.heifer.org/blog/what-is-the-role-of-youth-in-agriculture.html>
- Agbaje, K. A., Martin, R. A., and Williams, D. L. (2001). Impact of sustainable agriculture on secondary school agricultural education teachers and programs in the north central region. *Journal of Agricultural Education*, 42(2), 38-45. <https://doi.org/10.5032/jae.2001.02038>
- Agriculture Skill Council of India. (n.d.). *Qualifications Handbook A Comprehensive Information Handbook to Foster Career in Agricultural Sector*. [https://facilities.aicte-india.org/KARMA/ssc-documents/Agriculture%20Skill%20Council%20Of%20India%20\(ASCI\).pdf](https://facilities.aicte-india.org/KARMA/ssc-documents/Agriculture%20Skill%20Council%20Of%20India%20(ASCI).pdf)
- Aliya. (2022). The role of youth in rural advisory services to support sustainable agriculture. RASSEA – Learning and networking towards sustainability. <https://rassea.org/2022/04/07/the-role-of-youth-in-rural-advisory-services-to-support-sustainable-agriculture/>
- Bisheko, M. J., and Rejikumar, G. (2023). Major barriers to adoption of improved postharvest technologies among smallholder farmers in sub-Saharan Africa and South Asia: A systematic literature review. *World Development Sustainability*, 2, 100070. <https://doi.org/10.1016/j.wds.2023.100070>
- Chandler, K. (2018). National framework for youth development (medium-term youth development plan). SILO.TIPS. <https://silo.tips/download/national-framework-for-youth-development-medium-term-youth-development-plan>
- Corona, G. L. (2023). The role of women in agriculture: challenges and opportunities. <https://www.linkedin.com/pulse/role-women-agriculture-challenges-opportunities-gabriela-lozano/>

- Devi, S. S., Aditya, K. S., Renjini, V., Gowda, C. S., Singh, D. R., and Kar, A. (2021). Agricultural education system in India: Present problems and strategies to meet the future challenges. *Indian Journal of Extension Education*, 57(3), 35-40. <https://doi.org/10.5958/2454-552x.2021.00098.0>
- FAO. (2014). *The State of Food and Agriculture: Innovation in Family Planning*. Rome: FAO. <https://www.fao.org/3/i4040e/i4040e.pdf>
- FAO. (2022). *This Rural Women's Day Let's Fight for Improved Education For Rural Women Globally*. Rome: FAO. <https://www.fao.org/dryland-forestry/news/newsdetail/fr/c/1608889/#:~:text=Through%20better%20education%2C%20women%20can,finance%20for%20climate%20smart%20agriculture>
- FAO. (2023). *Integrated Production and Pest Management Programme in Africa*. <https://www.fao.org/agriculture/ippm/programme/ffs-approach/en/>
- Gupta, V. (2016). *CMSA: A strategy of sustainable agriculture*. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 4. <https://www.ijraset.com/files/serve.php?FID=4935>
- Kates, T. M. (n.d.). Teaching sustainability: the role of education in the creation of sustainable agricultural systems, *Unpublished doctoral dissertation*, Michigan State University. https://www.nodai.ac.jp/cip/iss/english/past_iss/pdf/8th_abstract_e.pdf
- Kopf, B. (n.d.). Promoting sustainable agriculture to the youth, *Unpublished doctoral dissertation*, Michigan State University. https://www.nodai.ac.jp/cip/iss/english/past_iss/pdf/8th_abstract_e.pdf
- Lalitha, A., Purnima, K. S., Reddy, K. Gurava, Babu, Suresh Chandra, and Sambaiah, A. (2022). Strategic role of Indian State Agricultural Universities (SAUs) in rural development: A review. *Agricultural Reviews* 43(1): 84-90. <https://doi.org/10.18805/ag.R-2268>
- Ministry of Agriculture and Farmers welfare. (n.d.). *Agriclinics & Agribusiness Centres*. <https://www.agriclinics.net/AboutScheme.aspx>
- OECD. (2021). *Gender and the Environment Building Evidence and Policies to Achieve the SDGs: Building Evidence and Policies to achieve the SDGs*. OECD Publishing.
- Opulencia, R. L. (n.d.). Promoting sustainable agriculture to the Filipino youth, *Unpublished Doctoral Dissertation*, University of the Philippines Los Baños. https://www.nodai.ac.jp/cip/iss/english/past_iss/pdf/8th_abstract_e.pdf
- ReNature. (2021). *Empowering Women in Agriculture*. <https://www.renature.co/articles/empowering-women-in-agriculture/>
- Rural Advisory Services for Southeast Asia. (2021). Learning and networking towards sustainability. <https://rassea.org/2022/04/07/the-role-of-youth-in-rural-advisory-services-to-support-sustainable-agriculture/>
- Sameipour. (2017). Teachers' perceptions toward sustainable agriculture in an Ohio Science High School, *Unpublished Doctoral Dissertation*, The Ohio State University. https://etd.ohiolink.edu/apexprod/rws_etd/send_file/send?accession=osu149426481206391&disposition=inline
- Sayed, S. B. (2018). Transforming India through ICT enabled agriculture. *International Journal of Science and Research*. <https://www.ijsr.net/archive/v9i2/ART20204181.pdf>

- Singh, D. (2018). *Knowledge Management and Producer Organisations*. National Institute of Agricultural Extension Management (MANAGE).
<https://www.manage.gov.in/publications/discussion%20papers/MANAGE-Discussion%20Paper-3.pdf>
- Singh, V., Shukla, P., Sharma, L. K., Barnawal, V. K., Dave, A., Patel, C., Vaghamsi, M., and Singh, V. P. (2020). Role of innovative crop species diversification, mixed farming, polyculture, structural diversity and conservation agriculture in dry regions to end hunger and achieve sustainable development. *Journal of Pharmacognosy and Phytochemistry*, 9(5), 110-116. <https://doi.org/10.22271/phyto.2020.v9.i5b.12230>.
- Swanson, B. E., Bentz, R. P., and Sofranko, A. J. (1997). *Improving Agricultural Extension: A Reference Manual*. Rome: FAO.
- The World Bank. (2007). *Development and the Next Generation*.
<https://documents1.worldbank.org/curated/en/556251468128407787/pdf/359990WDR0complete.pdf>
- UN. (2015). How well are the links between education and other sustainable development goals covered in UN flagship reports?, *UN Department of Economic and Social Affairs (DESA) Working Papers*. <https://doi.org/10.18356/5e8a5518-en>
- United Nations Climate Change. (n.d.). *Sustainable Agriculture with Gender Inclusion and Participation*. Retrieved from: <https://unfccc.int/climate-action/momentum-for-change/women-for-results/sustainable-agriculture-with-gender-inclusion-and-participation-ecuador>

SDG 5

- ActionAid. (2017). *Policy Brief: Incorporation of Women's Economic Empowerment and Unpaid Care Work into Regional Policies: Africa..*
https://actionaid.org/sites/default/files/policy_brief_weeuw_africa_online_version.pdf
- Chitoor, J. S. and Mishra, S. K. (2012). Agricultural education for sustainable rural development in developing countries: challenges and policy options. *Journal of Education and Learning*, 6(2). doi 10.11591/edulearn.v6i2.154
- Corona, L. (2023). The role of women in agriculture: Challenges and opportunities. <https://www.linkedin.com/pulse/role-women-agriculture-challenges-opportunities-gabriela-lozano/>
- FAO. (2016). *Developing Gender-Sensitive Value Chains – A Guiding Framework*. Rome: FAO. <https://www.fao.org/3/i6462e/i6462e.pdf>
- FAO (2020). *The State of Food and Agriculture 2020*. Rome: FAO.
<http://dx.doi.org/10.4060/cb1447en>
- Ignaciuk, A. and Chit Tun, N.A. (2019). Achieving agricultural sustainability depends on gender equality. *International Food Policy Research Institute*.
<https://www.ifpri.org/blog/achieving-agricultural-sustainability-depends-gender-equality>
- Ministry of Labour and Employment. (2023.) Press Information Bureau. New Delhi.
<https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1911142>

- OECD. (2021). Gender and the environment building evidence and policies to achieve the SDGs: Building evidence and policies to achieve the SDGs. <https://www.oecd.org/env/gender-and-the-environment-3d32ca39-en.htm#:~:text=and%20the%20Environment,Building%20Evidence%20and%20Policies%20to%20Achieve%20the%20SDGs,requires%20targeted%20and%20coherent%20actions>.
- United Nations Climate Change. (2019). Sustainable agriculture with gender inclusion and participation. <https://unfccc.int/climate-action/momentum-for-change/women-for-results/sustainable-agriculture-with-gender-inclusion-and-participation-ecuador>
- Vasavada, S. (2022). *The link between women's land ownership and climate resilience*. India Development Review. <https://idronline.org/article/gender/women-farmers-land-ownership-and-climate-resilience/>

SDG 6

- Bose, P. (2023). An overview of sustainable fertilizer developments. AZoCleantech.com. <https://www.azocleantech.com/article.aspx?ArticleID=1678#:~:text=Reduced%20synthetic%20fertilizer%20use%20is,fertilizer%20sustainability%20and%20decreases%20pollution>.
- CBWG. (2021). *Annual Report 2020-21*. Faridabad: Central Ground Water Board. <http://cgwb.gov.in/cgwbpm/publication-detail/224>
- Devineni, N., Perveen, S., and Lall, U. (2022). Solving groundwater depletion in India while achieving food security. *Nature Communications*, 13. doi: <https://doi.org/10.1038/s41467-022-31122-9>
- FAO and Toilet Board Coalition. (2021). Future proofing agriculture systems - Circular sanitation economies for more resilient and sustainable food systems. *Land and Water Discussion Paper No. 18*, Rome, FAO. <https://doi.org/10.4060/cb2444en>
- FAO. (2017). *Water for Sustainable Food and Agriculture. A Report produced for the G20 Presidency of Germany*. Rome: Food and Agriculture Organization of the United Nations. <https://www.fao.org/3/i7959e/i7959e.pdf>
- Food and Agricultural Organisation of United Nations. (2017). *Water for Sustainable Food and Agriculture*. Rome, FAO. <https://www.fao.org/3/i7959e/i7959e.pdf>.
- Food and Agriculture Organization of the United Nations. (2017). Agriculture: cause and victim of water pollution, but change is possible. *Land and Water*. <https://www.fao.org/land-water/news-archive/news-detail/en/c/1032702/>
- Mateo-Sagasta, J., Zadeh, S., Turrall, H., and Burke, J. (2017). *Water Pollution from Agriculture: A global review. Executive summary*. Colombo: FAO. <https://www.fao.org/3/i7754e/i7754e.pdf>
- McGuinness, S. L., O'Toole, J., Ayton, D., Giriyan, A., Gaonkar, C. A., Vhaval, R., Cheng, A. C., and Leder, K. (2020). Barriers and enablers to intervention uptake and health reporting in a water intervention trial in rural India: A qualitative explanatory study. *The American Journal of Tropical Medicine and Hygiene*, 102(3), 507-517. <https://doi.org/10.4269/ajtmh.19-0486>
- Metcalfe, C., Guppy, L., and Qadir, M. (2017). *Global Barriers to Improving Water Quality: A Critical Review*. <https://doi.org/10.53328/srlt7852>

- Mishra, V., Asoka, A., Vatta, K., and Lall, U. (2018). Groundwater depletion and associated CO₂ emissions in India. *Advancing Earth and Space Sciences*, 6(12). doi: <https://doi.org/10.1029/2018EF000939>
- Niu, G., Zheng, Y., Han, F., and Qin, H. (2019). The nexus of water, ecosystems and agriculture in arid areas: A multiobjective optimization study on system efficiencies. *Agricultural Water Management*, 223, 105697. <https://doi.org/10.1016/j.agwat.2019.105697>
- Nkonya, E.M. Cenacchi, N., Ringler, C., and Lantier, D. (2023). *International Cooperation for Sustainable Land and Water Management*. Rome: FAO. https://www.fao.org/fileadmin/templates/solaw/files/thematic_reports/TR_16_web.pdf
- OECD. (2010). *OECD Studies on Water Sustainable Management of Water Resources in Agriculture*. OECD Publishing. <https://www.oecd.org/greengrowth/sustainable-agriculture/49040929.pdf>
- OECD. (n.d.). *Water and agriculture. Managing water sustainably is key to the future of food and agriculture*. <https://www.oecd.org/agriculture/topics/water-and-agriculture/>
- Ongley, E. D., and Food and Agriculture Organization of the United Nations. (1996). *Control of Water Pollution from Agriculture*. Rome: FAO.
- Pang, J., Liu, X., and Huang, Q. (2020). A new quality evaluation system of soil and water conservation for sustainable agricultural development. *Agricultural Water Management*, 240, 106235. <https://doi.org/10.1016/j.agwat.2020.106235>
- Parichha, M. J. (2022). Food production in India faces Twin Challenges of pesticide and monoculture. <https://www.outlookindia.com/national/food-production-in-india-faces-twin-challenge-of-pesticide-and-waste-management-news-193733>
- Sehgal Foundation. (2023). *Water Management for Sustainable Agriculture - Need of the Hour*. SM Sehgal Foundation. <https://www.smsfoundation.org/sustainable-agricultural-water-management-the-need-of-the-hour/>.
- UN Conference on Sustainable Development (Rio+20) (2011). Thematic session on water cooperation. UNESCO, UN Water, South-South News, UNDP, OSCE Offices in Dushanbe.
- Verma, S., and Shah, M. (2019). *Drought-Proofing through Groundwater Recharge Lessons from Chief Ministers' Initiatives in Four Indian States*. Rome: World Bank Group. <https://documents1.worldbank.org/curated/en/281991579881831723/pdf/Drought-Proofing-through-Groundwater-Recharge-Lessons-from-Chief-Ministers-Initiatives-in-Four-Indian-States.pdf>
- World Bank. (2012). *India Groundwater: a Valuable but Diminishing Resource*. Rome: World Bank. <https://www.worldbank.org/en/news/feature/2012/03/06/india-groundwater-critical-diminishing>

SDG 7

- Bhattacharya, S., and Cropper, M. L. (2003). *Options for Energy Efficiency in India and Barriers to Their Adoption a Scoping Study Options for Energy Efficiency in India and Barriers to Their Adoption: A Scoping Study*. <http://ssrn.com/abstract=1590510>Electroniccopyavailableat:<https://ssrn.com/abstract=1590510>Electroniccopyavailableat:<http://ssrn.com/abstract=1590510>

- FAO. (2011). *Energy Smart Food for People and Climate Change*. Rome: Food and Agriculture Organization of United States. <https://www.fao.org/3/i2454e/i2454e.pdf>
- FAO. (2018). *Emissions Due to Agriculture: Global, Regional and Country Trends 1990–2018*. New York: Food and Agriculture Organisation of United States. Retrieved 2023, from <https://www.fao.org/3/cb3808en/cb3808en.pdf>
- Garg, A., Dhar, S., Kankal, M. B., and Mohan, M. P. (2017). Good practice and success stories on energy efficiency in India: India energy efficiency series. www.energyefficiencycentre.org
- Garg, K. K., Bharati, L., George, B., and Acharya, S. (2017). Groundwater and solar energy: Synergies and trade-offs in groundwater-based irrigation expansion in India. *Environmental Research Letters*, 12(10), 104003.
- Gorjian, S., Fakhraei, O., Gorjian, A., Sharafkhani, A., and Aziznejad, A. (2022). Sustainable food and agriculture: employment of renewable energy technologies. *Current Robotics Reports*, 3(3), 153–163. <https://doi.org/10.1007/s43154-022-00080-x>
- Gorjian, S., Fakhraei, O., Gorjian, A., Sharafkhani, A., and Aziznejad, A. (2022). Sustainable food and agriculture: employment of renewable energy technologies. *Current Robotics Reports*, 3(3), 153–163. <https://doi.org/10.1007/s43154-022-00080-x>
- IRENA and FAO. (2021). Renewable energy and agri-food systems: advancing energy and food security towards Sustainable Development Goals. In *Renewable Energy and Agri-food Systems: Advancing Energy and Food Security towards Sustainable Development Goals*. Rome: IRENA and FAO. <https://doi.org/10.4060/cb7433en>
- Kawuma, B. (2022). Enhancing post-harvest operations with renewable energy to minimize food loss and wastage. Power For All. <https://www.powerforall.org/insights/impact/enhancing-post-harvest-operations-renewable-energy-minimize-food-loss-and-wastage#:~:text=Therefore%2C%20utilizing%20decentralized%20renewable%20energy,farmers%20and%20limit%20GHG%20emissions.>
- Khan, M. T. I., Ali, Q., and Ashfaq, M. (2018). The nexus between greenhouse gas emission, electricity production, renewable energy and agriculture in Pakistan. *Renewable Energy*, 118, 437–451. <https://doi.org/https://doi.org/10.1016/j.renene.2017.11.043>
- Kumari, P. (2022). Sustainable energy for cooling: A post-harvest management solution for India's smallholder farmers. Oorja Solutions. <https://www.oorjasolutions.org/blog/sustainable-cooling>
- Kumar, J., and Majid, M. A. (2020). Renewable energy for sustainable development in India: Current status, future prospects, challenges, employment, and investment opportunities. *Energy, Sustainability and Society* 10(1). <https://doi.org/10.1186/s13705-019-0232-1>
- Lecocq, F., Winkler, H. Daka, J.P. et al.(2022). *Mitigation and Development Pathways in the Near- to mid-term*. In *IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK and New York, NY: Cambridge University Press. doi: 10.1017/9781009157926.006
- Mainali, B., Luukkanen, J., Silveira, S., and Kaivo-Oja, J. (2018). Evaluating synergies and trade-offs among Sustainable Development Goals (SDGs): Explorative analyses of

- development paths in South Asia and Sub-Saharan Africa. *Sustainability (Switzerland)*, 10(3). <https://doi.org/10.3390/su10030815>
- Ministry of Jal Shakti. (2023). *Unified Registration Portal for GOBARDhan Plant*. New Delhi: Ministry of Jal Shakti, Government of India. <https://gobardhan.co.in/>
- Ministry of Power. (2023). *Distribution Schemes*. Ministry of Power, Government of India. <https://powermin.gov.in/en/content/national-electricity-fund>
- NAAS. (2018). *Renewable Energy: A New Paradigm for Growth in Agriculture*. <http://www.naasindia.org>
- Natarajan, Bhaskar, Kumar, Satish, Varun, Rajah, and Koshy, Cherail. (2021). *State of Energy Efficiency in India- A Compilation of Policies, Priorities and Potential*. <https://aeee.in/wp-content/uploads/2021/05/India's-Energy-Efficiency-Landscape-Report.pdf>
- Rodríguez-Díaz, J. A. (2012). More “crop per drop” - the energy trade-off in Spanish irrigated agriculture. *Outlook on Agriculture* 41(3): 149–151. <https://doi.org/10.5367/oa.2012.0099>
- Sacchelli, S., Garegnani, G., Geri, F., Grilli, G., Paletto, A., Zambelli, P., Ciolli, M., and Vettorato, D. (2016). Trade-off between photovoltaic systems installation and agricultural practices on arable lands: An environmental and socio-economic impact analysis for Italy. *Land Use Policy*, 56, 90–99. <https://doi.org/https://doi.org/10.1016/j.landusepol.2016.04.024>
- Smith, L. G., Williams, A. G., and Pearce, Bruce. D. (2015). The energy efficiency of organic agriculture: A review. *Renewable Agriculture and Food Systems*, 30(3), 280–301. <https://doi.org/DOI: 10.1017/S1742170513000471>
- Swanton, C. J., Murphy, S. D., Hume, D. J., and Clements, D. R. (1996). Recent improvements in the energy efficiency of agriculture: Case studies from Ontario, Canada. *Agricultural Systems*, 52(4), 399–418. [https://doi.org/https://doi.org/10.1016/S0308-521X\(96\)00012-1](https://doi.org/https://doi.org/10.1016/S0308-521X(96)00012-1)
- Wu, L., Elshorbagy, A., Pande, S., and Zhuo, L. (2021). Trade-offs and synergies in the water-energy-food nexus: The case of Saskatchewan, Canada. *Resources, Conservation and Recycling*, 164, 105192. <https://doi.org/https://doi.org/10.1016/j.resconrec.2020.105192>

SDG 8

- Bailey, S. (2020). Rural youth aspirations: Can Indian agriculture regain the interest of rural youth? TIGR2ESS. <https://tigr2ess.globalfood.cam.ac.uk/news/rural-youth-aspirations-can-indian-agriculture-regain-interest-rural-youth>
- Bera, A. (2021). Resource use efficiency and optimization techniques in Indian agriculture. https://www.researchgate.net/publication/351248075_Resource_Use_Efficiency_and_Optimization_Techniques_in_Indian_Agriculture
- Boettiger, S. and Sanghvi, S. (2019). *How digital innovation is transforming agriculture: Lessons from India*. McKinsey & Company. Retrieved at <https://www.mckinsey.com/industries/agriculture/our-insights/how-digital-innovation-is-transforming-agriculture-lessons-from-india#/>

- Chand, K. K. (n.d.). View of agripreneurship: A tool for economic development of India in the New Millennium. *International Journal on Recent Trends in Business and Tourism*.
<https://ejournal.lucp.net/index.php/ijrtbt/article/view/871/787#:~:text=Barriers%20of%20Entrepreneurship%20Development,their%20farming%20into%20an%20enterprise>
- Duckett, M. K. (n.d.). *Empowering Female Farmers to Feed the World*. National Geographic.
<https://www.nationalgeographic.com/culture/article/partner-content-empowering-female-farmers>
- FAO. (2011). *The State of Food and Agriculture*. Rome: Food And Agriculture Organization of The United Nations. <https://www.fao.org/3/i2050e/i2050e.pdf>
- FSII. (n.d.). Encouraging youth in agriculture opportunities, challenges, and strategies for the future. Federation of Seed Industry of India. <https://fsii.in/encouraging-youth-in-agriculture/>
- Gołaś, M., Sulewski, P., Waś, A., Kłoczko-Gajewska, A., and Pogodzińska, K. (2020). On the way to sustainable agriculture—eco-efficiency of Polish commercial farms. *Agriculture*, 10(10). <https://doi.org/10.3390/agriculture10100438>
- Gothoskar, S. (2021). To fully understand the migrant worker crisis, we need a larger perspective. *The Wire*. <https://thewire.in/rights/migrant-worker-crisis-larger-perspective-farm-land-industry>
- Gulati, A., Terway, P., and Hussain, S. (2018). Crop Insurance in India: Key issues and way forward. ICRIER. <https://icrier.org/publications/crop-insurance-in-india-key-issues-and-way-forward/>
- Gussoni, D. (2021). *India's Overpopulation: Human Trafficking and Child Labour*. SHEQUALITY. <https://shequalityblog.org/2021/06/23/indias-overpopulation-human-trafficking-and-child-labour/>
- Hans, V. B. and Colaco, V. M. (2019). Sustainable agriculture and economic growth. *Journal of Emerging Technologies and Innovative Research*, 6(1).
<https://doi.org/https://www.jetir.org/papers/JETIR1901566.pdf>
- Holling, C. S. (1973). Resilience and stability of Ecological Systems. *Annual Review of Ecology and Systematics*, 4(1), 1–23.
<https://doi.org/10.1146/annurev.es.04.110173.000245>
- ICAR. (2019). Arya attracting and retaining youth in agriculture - ICAR. Division of Agricultural Extension. <https://ataribengaluru.icar.gov.in/docs/pub/2.pdf>
- Ignaciuk, A., and Tun, N. A. C. (2019). Achieving agricultural sustainability depends on gender equality. International Food Policy Research Institute.
<https://www.ifpri.org/blog/achieving-agricultural-sustainability-depends-gender-equality>
- Joshi, P. K. (2005). Crop diversification in India: nature, pattern and drivers. *National Centre for Agricultural Economics and Policy Research (NCAP) Policy Retreat and Seminar on Agriculture, Food Security and Rural Development*, 3, 1–33.
- Kaur, N., and Gulati, S. (2022). Trafficking of children for child labour in India. *International Journal of Education, Modern Management, Applied Science & Social Science*, 6(4), 24–28.

https://doi.org/https://www.researchgate.net/publication/361657489_TRAFFICKING_OF_CHILDREN_FOR_CHILD_LABOUR_IN_INDIA

- Kumar, V. (2021). Trends and performance of India's agricultural trade in the midst of COVID-19 pandemic. *Indian Journal of Agricultural Economics*, 76(3).
<https://doi.org/https://www.nabard.org/auth/writereaddata/tender/2709224946trends-and-performance-of-indias-agricultural-trade-in-the-midst-of-covid-19-pandemic.pdf>
- Kundu, A. and Das, S. (2018). Gender wage gap in the agricultural labor market of India: An empirical. Munich Personal RePEc Archive. https://mpra.ub.uni-muenchen.de/95487/1/MPRA_paper_95487.pdf
- Ministry of Agriculture and Farmers Welfare. (2023). *Post Harvest Loss of Fruits and Vegetables*. Press Information Bureau. New Delhi. Retrieved from <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1910360>
- Ministry of Agriculture and Farmers Welfare Government of India. (2019). Agriculture Census 2015-16. https://agcensus.nic.in/document/agcen1516/T1_ac_2015_16.pdf
- Mittal, S. (2023). The key role of sustainable agriculture in improving livelihoods and enhancing food security. *Times of India Blog*.
<https://timesofindia.indiatimes.com/blogs/voices/the-key-role-of-sustainable-agriculture-in-improving-livelihoods-and-enhancing-food-security/>
- Pachauri, S. (2019). The invisibility of gender in Indian agriculture. *Down To Earth*.
<https://www.downtoearth.org.in/blog/agriculture/the-invisibility-of-gender-in-indian-agriculture-63290>
- Paroda, R. (2022). Crop diversification for sustainable agriculture. *Ecology, Economy and Society—the INSEE Journal*, 5(1). <https://doi.org/10.37773/ees.v5i1.611>
- Potent, J. (2016). Sustainable Agriculture through innovation and collaboration. Earth Institute. <https://news.climate.columbia.edu/2016/11/16/%EF%BB%BFsustainable-agriculture-through-innovation-and-collaboration/>
- RBI. (2020). *Master Directions – Priority Sector Lending (PSL) – Targets and Classification*. Reserve Bank of India.
https://www.rbi.org.in/Scripts/BS_ViewMasDirections.aspx?id=11959
- Sehgal Foundation. (2023). Role of modern technology in agriculture. SM Sehgal Foundation. <https://www.smsfoundation.org/role-of-modern-technology-in-agriculture/>
- Sheniga, M. (2022). Rural agriculture and the new wave of migrant workers to rural space. The Peninsula Foundation. <https://www.thepeninsula.org.in/2022/08/18/rural-agriculture-and-the-new-wave-of-migrant-workers-to-rural-space/>
- Singh, N. (2011). Indian agriculture: before and after economic reforms. *European Journal of Business and Management*, 3(4), 292–298.
<https://doi.org/https://core.ac.uk/download/pdf/234624069.pdf>

SDG 9

- Achterbosch, T., van Berkum, S., and Meijerink, G. (2014). Cash crops and food security: contributions to income, livelihood risk and agricultural innovation. LEI Wageningen UR.

- Ayhan, S., Gözükar, F., and Koruk, I. (2017). Does working in the agricultural sector affect the selection of a family planning method? *Health Care for Women International*, 38(3). doi:10.1080/07399332.2017.1278603
- Balamurugan, S., Divyabharathi, N., Bowiya, M., Shermey, R., and Shanker, D. K. (2016). Internet of agriculture: applying IoT to improve food and farming technology. *International Research Journal of Engineering and Technology*, 3(10).
- Brown, E., Natoli, N., McLaughlin, R., and Mehta, K. (2015). Pathways and barriers to diabetes screening: observations from rural Kenya. *Procedia Engineering*. doi: <http://dx.doi.org/10.1016/j.proeng.2015.06.096>
- Chhachhar, A. R., Qureshi, B., Khushk, G. M., and Maher, Z. A. (2014). Use of mobile phone among farmers for agriculture information. *European Journal of Scientific Research*, 119(2): 265-271.
- Donham, K. J., and Thelin, A. (2016). Psychosocial conditions in agriculture. In *Agricultural Medicine: Rural Occupational and Environmental Health, Safety, and Prevention* (Second Edition ed., pp. 351-370). New Jersey: John Wiley & Sons, Inc.
- Frontiers in Nutrition. (n.d.). *Nutrition and Sustainable Development Goal 9: Industry, Innovation, and Infrastructure*. Retrieved from Frontiers in Nutrition: <https://www.frontiersin.org/research-topics/40804/nutrition-and-sustainable-development-goal-9-industry-innovation-and-infrastructure#overview>
- GCCA. (2021). *Sustainability Innovation*. Retrieved from GCCA Association: <https://gccassociation.org/sustainability-innovation/the-un-sustainable-development-goals/sdg-9-industry-innovation-and-infrastructure/>
- Golait, R. (2007). Current issues in agriculture credit in India: An assessment. *Reserve Bank of India Occasional Papers*, 28.
- Gupta, N., Pradhan, S., Jain, A., and Patel, N. (2021). *Sustainable Agriculture in India 2021: What We Know and How to Scale up*. New Delhi: Council on Energy, Environment and Water.
- Holcomb, A. (2018). Foreign Direct Investment and Regulatory Uncertainty: Failures of the "Make in India" Campaign. University of Texas, College of Business Administration. El Paso: Americans for Limited Government Foundation.
- Howden-Chapman, P., Siri, J., Chisholm, E., Chapman, R., Doll, C. N., and Capon, A. (2023). SDG 3 Ensure Healthy Lives and Promote Well-Being for All at All Ages. *International Science Council*. <https://council.science/wp-content/uploads/2017/03/SDGs-interactions-3-healthy-lives.pdf>
- Liu, J., Chai, Y., Xiang, Y., Zhang, X., Gou, S., and Liu, Y. (2018). Clean energy consumption of power systems towards smart agriculture: roadmap, bottlenecks and technologies. *CSEE Journal of Power and Energy Systems*, 4(3).
- Llanto, Gilberto M. (2012). The impact of infrastructure on agricultural productivity, *PIDS Discussion Paper Series, No. 2012-12*, Philippine Institute for Development Studies (PIDS), Makati City
- MOFPI. (2022). *To Determine Post-harvest Losses in Agri produce in India*. New Delhi: Ministry of Food Processing Industries. https://www.mofpi.gov.in/sites/default/files/study_report_of_post_harvest_losses.pdf

- NABARD. (2021). Market vulnerabilities and potential of horticulture crops in india: with special reference to top crops. Indian society of agricultural marketing. Telangana. <https://www.nabard.org/auth/writereaddata/tender/2709225958market-vulnerabilities-and-potential.pdf>
- OECD. (2001). Adoption of Technologies for Sustainable Farming Systems. <https://www.oecd.org/greengrowth/sustainable-agriculture/2739771.pdf>
- OECD. (n.d.). Agricultural productivity and innovation. Retrieved from OECD: <https://www.oecd.org/agriculture/topics/agricultural-productivity-and-innovation/>
- Pati, M. K., Swaroop, N., Kar, A., Aggarwal, P., Jayanna, K., and Damme, W. V. (2020). A narrative review of gaps in the provision of integrated care for noncommunicable diseases in India. *Public Health Review*. doi: <https://doi.org/10.1186/s40985-020-00128-3>
- Pradhan, P., Costa, L., Rybski, D., Lucht, W., and Kropp, J. P. (2017). A systematic study of Sustainable Development Goal (SDG) Interactions. *Earth's Future*, 5(11).
- Rahman, H. Z., and Hossain, M. (1995). *Rethinking Rural Poverty: Bangladesh as a Case Study*. The University Press Limited (UPL).
- Rao, P., Birthal, P., and Joshi, P. (2006). Diversification towards high value agriculture: role of urbanisation and infrastructure. *Economic and Political Weekly*, 41(26).
- Rodrigues, M. and Rodriguez, A. (2013). *Information and Communication Technologies for Agricultural Development in Latin America: Trends, Barriers and Policies*. pp. 205-258. <https://repositorio.cepal.org/items/d59d0523-12c4-416e-b45a-93629b2a6199>
- Sattler, B. and Davis, A. D. (2008). Nurses' role in children's environmental health protection. *Pediatric Nursing*, 34(4).
- Shamdasani (2021). *Rural road infrastructure & agricultural production: Evidence from India*. Journal of Development Economics. Vol 152. <https://doi.org/10.1016/j.jdevco.2021.102686>
- Singh, P. (2004). Indian agricultural development in changing scenario - past, present and future. *Journal of the Indian Society of Agricultural Statistics*, 58(1), 37-49.
- Tenaw, S. and Islam, K. (2009). Rural financial services and effects of microfinance on agricultural productivity and on poverty. University of Helsinki, Department of Economics and Management.
- UN Water. (2021). Water, Food and Energy. <https://www.unwater.org/water-facts/water-food-and-energy>
- World Bank. (2003). *Rural Financial Services: Implementing the Bank's Strategy to Reach the Rural Poor*. Washington: World Bank, Agriculture and Rural Development Department. World Bank Publications.
- World Bank. (2008). *Agriculture for Development*. Washington: The World Bank.

SDG 10

- Abraham, M. and Pingali, P. (2020). *Transforming smallholder agriculture to achieve the SDGs. The Role of Smallholder Farms in Food and Nutrition Security*, 173-209. https://doi.org/10.1007/978-3-030-42148-9_9

- Adenle, A. A., Manning, L., and Azadi, H. (2017). Agribusiness innovation: A pathway to sustainable economic growth in Africa. *Trends in Food Science and Technology*, 59, 88–104. <https://doi.org/10.1016/j.tifs.2016.11.008>
- Adhana, D. (2017). *Foreign Direct Investment in Indian agricultural Sector: Opportunities and Challenges*. Social Science Research Network.
- Balasubramanian, R. (2010). Urbanization, population pressure and agricultural intensification: Evidence from Tamil Nadu in India. *AgEcon Search*. <https://doi.org/10.22004/ag.econ.174480>
- Benjamin, E. O. (2015). Financial institutions and trends in sustainable agriculture: Synergy in rural sub-Saharan Africa. *Doctoral Dissertation*, Universitätsbibliothek Wuppertal.
- Branca, G., McCarthy, N., Lipper, L., and Jolejole, M. C. (2011). *Climate Smart Agriculture: A Synthesis of Empirical Evidence of Food Security and Mitigation Benefits from Improved Cropland Management*. CGIAR.
- Budiasa, I. W. (2020). Green financing for supporting sustainable agriculture in Indonesia. *IOP Conference Series*. <https://doi.org/10.1088/1755-1315/518/1/012042>
- Falco, C., Donzelli, F., and Olper, A. (2018). Climate change, agriculture and migration: a survey. *Sustainability*, 10(5), 1405. <https://doi.org/10.3390/su10051405>
- FAO, IFAD, UNICEF, WFP, and WHO. (2022). The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable. <https://doi.org/10.4060/cc0639en>
- FAO. (2014). *Building a Common Vision for Sustainable Food and Agriculture: Principles and Approaches*. Rome: FAO
- FAO. (2023). *The Status of Women in Agrifood Systems*. Rome: FAO <https://www.fao.org/3/cc5343en/cc5343en.pdf>
- Fisher, E. (2022). *Social Equity in Climate-Resilient Agriculture*. <https://www.diva-portal.org/smash/get/diva2:1729398/FULLTEXT01.pdf>
- Government of Chhattisgarh. (2022). *Chhattisgarh Inclusive Rural and Accelerated Agriculture Growth Project (CHIRAAAG)*. Department of Agriculture Development and Farmer Welfare and Biotechnology.
- Grabowski, P., Djenontin, I. N. S., Zulu, L. C., et al. (2020). Gender- and youth-sensitive data collection tools to support decision making for inclusive sustainable agricultural intensification. *International Journal of Agricultural Sustainability*, 19(5–6), 359–375. <https://doi.org/10.1080/14735903.2020.1817656>
- Grau, H. R. and Aide, T. M. (2007). Are rural–urban migration and sustainable development compatible in mountain systems? *Mountain Research and Development*, 27(2), 119–123.
- Hariharan, V. K., Mittal, S., Rai, M., Agarwal, T., Kalvaniya, K., Stirling, C. M., and Jat, M. (2018). Does climate-smart village approach influence gender equality in farming households? A case of two contrasting ecologies in India. *Climatic Change*, 158(1), 77–90. <https://doi.org/10.1007/s10584-018-2321-0>
- Havemann, T., Negra, C., and Werneck, F. (2022). Blended finance for agriculture: exploring the constraints and possibilities of combining financial instruments for sustainable transitions. In *Social Innovation and Sustainability Transition* (pp. 347–358). https://doi.org/10.1007/978-3-031-18560-1_23

- IPCC. (2023). *Climate Change 2023 Synthesis Report*.
https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf
- Karlsson, J., (2014). *Challenges and opportunities of foreign investment in developing Country agriCulture for sustainable development*. FAO Commodity and Trade Policy Research Working Paper.
- Kusnandar, K., Brazier, F. M. T., and Van Kooten, O. (2019). Empowering change for sustainable agriculture: the need for participation. *International Journal of Agricultural Sustainability*, 17(4), 271–286.
<https://doi.org/10.1080/14735903.2019.1633899>
- Muhie, S. H. (2022). Novel approaches and practices to sustainable agriculture. *Journal of Agriculture and Food Research*, 10, 100446.
<https://doi.org/10.1016/j.jafr.2022.100446>
- Reddy, Ratna V. (1995). Environment and sustainable agricultural development: conflicts and contradictions. *Economic and Political Weekly*. <http://www.jstor.org/stable/4402531>
- Setsoafia, E. D., Ma, W. and Renwick, A. (2022). *Effects of sustainable agricultural practices on farm income and food security in northern Ghana*. *Agriculture and Food Economics*. <https://link.springer.com/article/10.1186/s40100-022-00216-9>
- Squire, P. J. (2003). Strategies for enhancing women’s full participation in sustainable agricultural development and environmental conservation in sub-Saharan Africa. *Journal of International Agricultural and Extension Education*, 10(1), 4-10
- Tayleur, C., Balmford, A., Buchanan, G. M., Butchart, S. H. M., Ducharme, H., Green, R. E., Milder, J. C., Sanderson, F. J., Thomas, D., Vickery, J. A., and Phalan, B. (2016b). Global coverage of agricultural sustainability standards, and their role in conserving biodiversity. *Conservation Letters*, 10(5), 610–618. Retrieved from
<https://doi.org/10.1111/conl.12314>
- UN. (2023). *The Sustainable Development Goals Report 2023: Special edition*.
<https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf>
- Zulu, L. C., Djenontin, I. N., and Grabowski, P. (2021). From diagnosis to action: Understanding youth strengths and hurdles and using decision-making tools to foster youth-inclusive sustainable agriculture intensification. *Journal of Rural Studies*, 82, 196-209. <https://doi.org/10.1016/j.jrurstud.2021.01.023>

SDG 11

- Chen, S., Chen, H., Yang, R., and Ye, Y. (2023). Linking social-ecological management and ecosystem service bundles: Lessons from a peri-urban agriculture landscape. *Land Use Policy*, 131, 106697. <https://doi.org/10.1016/j.landusepol.2023.106697>
- Contesse, M. E., Van Vliet, B., and Lenhart, J. (2018). Is urban agriculture urban green space? A comparison of policy arrangements for urban green space and urban agriculture in Santiago de Chile. *Land Use Policy*, 71, 566–577.
<https://doi.org/10.1016/j.landusepol.2017.11.006>
- Daugstad, K., Rønningen, K., and Skar, B. (2006). Agriculture as an upholder of cultural heritage? Conceptualizations and value judgements—A Norwegian perspective in

- international context. *Journal of Rural Studies*, 22(1), 67–81.
<https://doi.org/10.1016/j.jrurstud.2005.06.002>
- FAO. (2019). *FAO Framework for the Urban Food Agenda. Leveraging SubNational and Local Government Action to Ensure Sustainable Food Systems and Improved Nutrition*. Rome: Food and Agriculture Organization of the United Nations
- Ghazy, F. S. (2022). Sustainable urban design for slums. *International Journal of Advances Engineering and Civil Research*. 2(2), 19–63.
<https://doi.org/10.21608/ijaecr.2023.216221.1017>
- Gray, R. (2020). Agriculture, transportation, and the COVID-19 crisis. *Canadian Journal of Agricultural Economics-revue Canadienne D Agroeconomie*, 68(2), 239–243.
<https://doi.org/10.1111/cjag.12235>
- Hinz, R., Sulser, T. B., Huefner, R. et al. (2020). Agricultural development and land use change in India: A scenario analysis of trade-offs between UN Sustainable Development Goals (SDGs). *Earth's Future*, 8(2).
<https://doi.org/10.1029/2019ef001287>
- IPCC. (2019). *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.
- Min, Q. and Zhang, B. (2019). Research progress in the conservation and development of China-Nationally Important Agricultural Heritage Systems (China-NIAHS). *Sustainability*, 12(1), 126. <https://doi.org/10.3390/su12010126>
- Mishra, A. K., Bruno, E., and Zilberman, D. (2021). Compound natural and human disasters: Managing drought and COVID-19 to sustain global agriculture and food sectors. *Science of the Total Environment*, 754, 142210.
<https://doi.org/10.1016/j.scitotenv.2020.142210>
- Mitchell, N. and Barrett, B. (2015). Heritage values and agricultural landscapes: towards a new synthesis. *Landscape Research*, 40(6), 701–716.
<https://doi.org/10.1080/01426397.2015.1058346>
- Sarker, A. H., Bornman, J. F., and Marinova, D. (2019). A framework for integrating agriculture in urban sustainability in Australia. *Urban Science*, 3(2), 50.
<https://doi.org/10.3390/urbansci3020050>
- Surya, B., Syafri, S., Hadijah, H., Baharuddin, B., Fitriyah, A. T., and Sakti, H. H. (2020). Management of Slum-Based Urban Farming and economic empowerment of the community of Makassar City, South Sulawesi, Indonesia. *Sustainability*, 12(18), 7324. <https://doi.org/10.3390/su12187324>
- Tsuchiya, K., Hara, Y., and Thaitakoo, D. (2015). Linking food and land systems for sustainable peri-urban agriculture in Bangkok Metropolitan Region. *Landscape and Urban Planning*, 143, 192–204. <https://doi.org/10.1016/j.landurbplan.2015.07.008>
- United Nations. (2019). Department of Economic and Social Welfare.
<https://www.un.org/development/desa/en/news/population/world-population-prospects->

2019.html#:~:text=The%20world's%20population%20is%20expected,United%20Nations%20report%20launched%20today

Wall, E. and Smit, B. (2005). Climate change adaptation in light of sustainable agriculture. *Journal of Sustainable Agriculture*, 27(1), 113–123.
<https://doi.org/10.1300/j064v27n01>

World Bank. (2023). *Urban Development*.
<https://www.worldbank.org/en/topic/urbandevelopment/overview>

SDG 12

Adenle, A. A., Azadi, H., and Manning, L. (2017c). The era of sustainable agricultural development in Africa: Understanding the benefits and constraints. *Food Reviews International*, 34(5), 411–433. <https://doi.org/10.1080/87559129.2017.1300913>

Babla, M., Katwal, U., and Yong, M. (2022). Value-added products as soil conditioners for sustainable agriculture. *Resources, Conservation and Recycling*, 178, 106079.
<https://doi.org/10.1016/j.resconrec.2021.106079>

BIRAC. (2022). *India Bioeconomy Report 2022*.
https://birac.nic.in/webcontent/1658318307_India_Bioeconomy_Report_2022.pdf.

Bucci, G., Bentivoglio, D., and Finco, A. (2018). Precision agriculture as a driver for sustainable farming systems: state of art in literature and research. *Calitatea*, 19(S1), 114-121

Da Silveira, F., Lermen, F. H., and Amaral, F. G. (2021). An overview of agriculture 4.0 development: Systematic review of descriptions, technologies, barriers, advantages, and disadvantages. *Computers and Electronics in Agriculture*, 189, 106405.
<https://doi.org/10.1016/j.compag.2021.106405>

Devi, A. Therese, M. Julie. Dharanyadevi, P. and Pravinkumar, K. (2021). *IoT Based Food Grain Wastage Monitoring and Controlling System for Warehouse*. International Conference on System, Computation, Automation and Networking (ICSCAN). Puducherry, pp. 1-5, doi: 10.1109/ICSCAN53069.2021.9526400. FAO, IFAD, UNICEF, WFP, and WHO. (2022). The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable. <https://doi.org/10.4060/cc0639en>

FAO. (2014). *Building a Common Vision for Sustainable Food and Agriculture: Principles and Approaches*. Rome: FAO

FAO. (2021). *Public Food Procurement for Sustainable Food Systems and Healthy Diets - Volume I*. Rome: FAO <https://doi.org/10.4060/cb7960en>

Fiksel, J. and Lal, R. (2018). Transforming waste into resources for the Indian economy. *Environmental Development*, 26, 123–128.
<https://doi.org/10.1016/j.envdev.2018.02.002>

Food and Fertilizer Technology Center for Asian and Pacific Region. (2023). *India: Punjab becomes First State in India to start a bio-fertilizer*. Retrieved from lab. <https://apbb.fftc.org.tw/news/353>

Garcia-Herrero, I., Hoehn, D., Margallo, M. et al. (2018). On the estimation of potential food waste reduction to support sustainable production and consumption policies. *Food Policy*, 80, 24–38. <https://doi.org/10.1016/j.foodpol.2018.08.007>

- GoI. (2022). Bio-decomposer technology for stubble burning. <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1814544>
- GoI. (2023). Cabinet approves constitution and empowerment of an inter-ministerial committee (IMC) for facilitation of “World’s largest grain storage plan in cooperative sector”. <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1928599>
- Grover, S. and Gruver, J. (2017). ‘Slow to change’: Farmers’ perceptions of place-based barriers to sustainable agriculture. *Renewable Agriculture and Food Systems*, 32(6), 511–523. <https://doi.org/10.1017/s1742170516000442>
- Heyl, K., Ekaradt, F., Sund, L., and Roos, P. (2022). Potentials and limitations of subsidies in sustainability governance: the example of agriculture. *Sustainability*, 14(23), 15859. <https://doi.org/10.3390/su1423158>.
<https://ieeexplore.ieee.org/abstract/document/9526400>
- Illukpitiya, P. and Yanagida, J. F. (2010). Farming vs forests: Trade-off between agriculture and the extraction of non-timber forest products. *Ecological Economics*, 69(10), 1952–1963. <https://doi.org/10.1016/j.ecolecon.2010.05.007>
- IPCC. (2019). *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.
- IPCC AR6 WG II. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability*. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_TechnicalSummary.pdf
- Jacquet, F., Jeuffroy, M., Jouan, J. et al. (2022). Pesticide-free agriculture as a new paradigm for research. *Agronomy for Sustainable Development*, 42(1). <https://doi.org/10.1007/s13593-021-00742-8>
- Khan, N. M., Ray, R. L., Sargani, G. R. et al. (2021). Current progress and future prospects of agriculture technology: gateway to sustainable agriculture. *Sustainability*, 13(9), 4883. <https://doi.org/10.3390/su13094883>
- Kitinoja, L., Saran, S., Roy, S., and Kader, A. A. (2011). Postharvest technology for developing countries: challenges and opportunities in research, outreach and advocacy. *Journal of the Science of Food and Agriculture*, 91(4), 597–603. <https://doi.org/10.1002/jsfa.4295>
- Klerkx, L. and Jansen, J. (2010). Building knowledge systems for sustainable agriculture: supporting private advisors to adequately address sustainable farm management in regular service contacts. *International Journal of Agricultural Sustainability*, 8(3), 148-163.
- Kumar, N., Chaudhary, A., et al. (2023). Crop residue management challenges, opportunities and way forward for sustainable food-energy security in India: A review. *Soil and Tillage Research*, 228. https://www.researchgate.net/publication/367126211_Crop_residue_management_challenges_opportunities_and_way_forward_for_sustainable_food-energy_security_in_India_A_review

- Reddy, H.K (2019). *Social Entrepreneurship and Ecotourism: The Role of Social Entrepreneurs in Ecotourism Development*. PhD thesis, Kaposvári Egyetem.
- Mangla, S. K., Govindan, K., and Luthra, S. (2017). Prioritizing the barriers to achieve sustainable consumption and production trends in supply chains using fuzzy Analytical Hierarchy Process. *Journal of Cleaner Production*, 151, 509–525. <https://doi.org/10.1016/j.jclepro.2017.02.099>
- Ministry of Agriculture and Farmers Welfare. (2022). *Crop Residue: Waste or Wealth?* <https://krishi.icar.gov.in/jspui/handle/123456789/71699#:~:text=The%20CR%20const%20of%20plant,rather%20an%20essential%20natural%20resource>
- MOFPI. (2022). *To Determine Post-harvest losses in agri produce in India*. New Delhi: Ministry of Food Processing Industries. https://www.mofpi.gov.in/sites/default/files/study_report_of_post_harvest_losses.pdf
- Pan, S., Gao, M., Kim, H., Shah, K. J., Pei, S., and Chiang, P. (2018). Advances and challenges in sustainable tourism toward a green economy. *Science of The Total Environment*, 635, 452-469. <https://doi.org/10.1016/j.scitotenv.2018.04.134>
- Panpatte, D. G., Jhala, Y. K., Shelat, H. N., and Vyas, R. V. (2016). *Nanoparticles: The Next Generation Technology for Sustainable Agriculture*. In Springer eBooks (pp. 289–300). https://doi.org/10.1007/978-81-322-2644-4_18
- Panwar, N. L., Kaushik, S., and Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. *Renewable & Sustainable Energy Reviews*, 15(3), 1513–1524. <https://doi.org/10.1016/j.rser.2010.11.037>
- Parsons, K. and Barling, D. (2022). Identifying the policy instrument interactions to enable the public procurement of sustainable food. *Agriculture*, 12(4), 506. <https://doi.org/10.3390/agriculture12040506>
- Pearce, D., Hamilton, K., and Atkinson, G. (1996). Measuring sustainable development: progress on indicators. *Environment and Development Economics*, 1(1), 85–101. <https://doi.org/10.1017/s1355770x00000395>
- Pennsylvania Envirothon. (2019). *Agriculture and the Environment: Knowledge and Technology to Feed the World*. <https://charlesscd.com/wp-content/uploads/2019/03/agriculture-and-the-environment-2019-Pennsylvania-Envirothon.pdf>
- Piñeiro, V., Arias, J., Dürr, J., et al. (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nature Sustainability*, 3(10), 809–820. <https://doi.org/10.1038/s41893-020-00617-y>
- Priyadarshini, P. and Abhilash, P. (2020). Policy recommendations for enabling transition towards sustainable agriculture in India. *Land Use Policy*, 96, 104718. <https://doi.org/10.1016/j.landusepol.2020.104718>
- Reganold, J. P., Papendick, R. I., and Parr, J. F. (1990). Sustainable agriculture. *Scientific American*, 262(6), 112–121. <http://www.jstor.org/stable/24996835>
- Santeramo, F. G., and Lamonaca, E. (2021). Food loss–food waste–food security: a new research agenda. *Sustainability*, 13(9), 4642. <https://doi.org/10.3390/su13094642>
- Santhoshkumar, M., Reddy, G. C., and Sangwan, P. S. (2017). A review on organic farming-sustainable agriculture development. *International Journal of Pure & Applied Bioscience*, 5(4), 1277-1282.

- Shankar, Priyamvada, Selinger, Sandra, and Janssen, Ole. (2020). Artificial intelligence driven crop protection optimization for sustainable agriculture. <https://ieeexplore.ieee.org/abstract/document/9311082>
- Shrivastava, P. (1995). The role of corporations in achieving ecological sustainability. *Academy of Management Review*, 20(4), 936-960.
- Singh, J. S., Pandey, V. C., and Singh, D. P. (2011). Efficient soil microorganisms: A new dimension for sustainable agriculture and environmental development. *ScienceDirect*, 140(3–4), 339–353. <https://doi.org/10.1016/j.agee.2011.01.017>
- Smith, B. G. (2007). Developing sustainable food supply chains. *Philosophical Transactions of the Royal Society B*, 363(1492), 849–861. <https://doi.org/10.1098/rstb.2007.2187>
- Somlai, R. (2022). Insights into business strategies for reducing food waste in the Australian food industry. *Business Strategy and the Environment*. <https://doi.org/10.1002/bse.3292>
- Swensson, L. F. and Tartanac, F. (2020). Public food procurement for sustainable diets and food systems: The role of the regulatory framework. *Global Food Security*, 25, 100366. <https://doi.org/10.1016/j.gfs.2020.100366>
- UN. (2021). UN calls for urgent action to feed the world’s growing population healthily, equitably and sustainably. United Nations. <https://www.un.org/sustainabledevelopment/blog/2021/04/un-calls-for-urgent-action-to-feed-the-worlds-growing-population-healthily-equitably-and-sustainably/>
- UN. (2022). Sustainable consumption and production. <https://www.un.org/sustainabledevelopment/sustainable-consumption-production/>
- Venkatramanan, V. Shah, S. Rai, A.K. and Prasad, R. (2020). *Nexus Between Crop Residue Burning, Bioeconomy and Sustainable Development Goals Over North-Western India*. Vol 8. <https://www.frontiersin.org/articles/10.3389/fenrg.2020.614212/full>
- Wang, M., Janssen, A. B., Bazin, J., Strokal, M., Ma, L., and Kroeze, C. (2022). Accounting for interactions between Sustainable Development Goals is essential for water pollution control in China. *Nature Communications*, 13(1). <https://doi.org/10.1038/s41467-022-28351-3>
- World Economic Forum. (2023). AI for agriculture: How Indian farmers are harnessing emerging technologies to sustainably increase productivity. https://www.weforum.org/impact/ai-for-agriculture-in-india/?gclid=CjwKCAjww7KmBhAyEiwA5-PUSi15H5xYPgeVIQDnRLcbk55_tjkOuTITRGplmYfREbNdKnbwzWkZsxoCQzAQAvD_BwE
- Zheng, W. (2010). *Using Biochar as a Soil Amendment for Sustainable Agriculture*. <https://www.ideals.illinois.edu/items/25668>

SDG 13

- Agrawal, A. (2008). *The Role of Local Institutions in Adaptation to Climate*. <https://doi.org/10.1596/28274>

- Bahinipati, C. S., and Gupta, A. K. (2022). Methodological challenges in assessing loss and damage from climate-related extreme events and slow onset disasters: Evidence from India. *International Journal of Disaster Risk Reduction*, 83. <https://doi.org/10.1016/j.ijdr.2022.103418>
- Bruce M, C., James, H., Janie, R., et al. (2018). Urgent action to combat climate change and its impacts (SDG 13): transforming agriculture and food systems. *Current Opinion in Environmental Sustainability*, 34 (SDG 13), 13–20. <https://doi.org/10.1016/j.cosust.2018.06.005>
- de Jong, W., Galloway, G., Colfer, C. J. P., Katila, P., Winkel, G., and Pacheco, P. (2019). Synergies, trade-offs and contextual conditions shaping impacts of the sustainable development goals on forests and people. *Sustainable Development Goals: Their Impacts on Forests and People*, 577–600. <https://doi.org/10.1017/9781108765015.020>
- Gupta, D. and Prakash, A. (2023). Barriers and opportunities in achieving climate and sustainable development goals in India: a multilevel analysis. *Journal of Integrative Environmental Sciences*, 20 (1), 1–16. <https://doi.org/10.1080/1943815X.2022.2163665>
- IPCC. (2019). Climate Change and Land: *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.
- IPCC. (2022) Climate Change 2022: Impacts, Adaptation, and Vulnerability. *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegria, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.
- Louman, B., Keenan, R. J., Kleinschmit, D., et al. (2019). *Chapter 13 SDG 13: Climate Action – Impacts on Forests and People*. 419–444.
- Mahapatra, R. (2021). Climate crisis has cost India 5 million hectares of crop in 2021. *Down to Earth*. <https://www.downtoearth.org.in/news/climate-change/climate-crisis-has-cost-india-5-million-hectares-of-crop-in-2021-80809#:~:text=In%202016%2C%20damage%20to%20crops,crore%20loss%20for%20the%20farmers>
- Orchard, S., Glover, D., Thapa Karki, S., Ayele, S., Sen, D., Rathod, R., and Rowhani, P. (2020). Exploring synergies and trade-offs among the sustainable development goals: collective action and adaptive capacity in marginal mountainous areas of India. *Sustainability Science*, 15(6), 1665–1681. <https://doi.org/10.1007/s11625-019-00768-8>
- Schneider, L., Rebetez, M., and Rasmann, S. (2022). The effect of climate change on invasive crop pests across biomes. *Current Opinion in Insect Science*, 50, 1–5. <https://doi.org/10.1016/j.cois.2022.100895>
- World Bank. (2021). *Climate Smart Agriculture*. <https://www.worldbank.org/en/topic/climate-smart-agriculture>

SDG 14

- Acharya, S., and Adak, T. (2009). Wetland management for sustainable development. *Journal of Soil and Water Conservation*, 25-30.
- Blanc, D. L., Freire, C., and Vierros, M. (2017). *Mapping the Linkages Between Oceans and other Sustainable Development Goals: A preliminary exploration*. Department of Economic & Social Affairs
- Chakraborty, N., Mitra, R., Pal, S., Ganguly, R., Acharya, K., Minkina, T., Sarkar, A., et al. (2023). Biopesticide consumption in india: insights into the current trends. *Agriculture*, 13(3), 557
- De, A, Bose, R, Kumar, A, and Mozumdar, S (eds) (2014). Worldwide pesticide use. In *Targeted Delivery of Pesticides Using Biodegradable Polymeric Nanoparticles*. Berlin: Springer, pp 5–6
- GOI. (2014). *Integrated Pest Management Plan*. Ministry of Agriculture and Farmers Welfare (MoAFW). New Delhi: Government of India (GOI).
- GOI. (2022). *Swachh Sagar, Surakshit Sagar/Clean Coast Safe Sea Campaign*. Ministry of Earth Science (MoS). New Delhi: Government of India (GOI).
- Govan, H. et al. 2009. *Status and potential of locally-managed marine areas in the South Pacific: Meeting nature conservation and sustainable livelihood targets through wide-spread implementation of LMMAs*. SPREP/WWF/ WorldFish-Reefbase/CRISP. 95pp
- Hilmi N., Allemand D., Kavanagh C., Laffoley D., Metian M., Osborn D., and Reynaud S. (eds.) (2015). *Bridging the Gap Between Ocean Acidification Impacts and Economic Valuation: Regional Impacts of Ocean Acidification on Fisheries and Aquaculture*. Gland, Switzerland: IUCN. 136 pages.
- ICSU ISSC(2015). *Review of the Sustainable Development Goals: The Science Perspective*. Paris: International Council for Science (ICSU).
<http://www.icsu.org/publications/reports-andreviews/review-of-targets-for-the-sustainable-development-goals-thescience-perspective-2015/SDG-Report.pdf>
- Fernandes, Ines, Schwartz, Melanie, and Hummer, Lucy. (2021). *Bringing a Sea of Change: Ocean Ecosystem Services' Contribution to Sustainable Food Systems*. International Institute of Sustainable Development.
- Khan, M.J., Zia, M.S., and Qasim, M. (2010). *Use of pesticides and their role in environmental pollution*. *World Acad Sci Eng Technol* 72:122–128
- Ministry of Agriculture and Farmers Welfare. *Statistical Database: Directorate of Plant Protection, Quarantine & Storage*. Government of India. Retrieved at <https://ppqs.gov.in/statistical-database>
- National Academy of Agricultural Sciences, NASC. (2022). *Precision Agriculture in India: A Perspective*, 6(5), 3. <https://doi.org/10.1002/j.2048-7940.1981.tb00682.x>
- Paul, D. (2021). *Protecting the Marine Environment from Land-based Activities*. International Institute of Sustainable Development
- Preethan, Parvathi and Gupta, Shubham. (2020). *Nature-based Solutions for reimagining the pathway to a sustainable future*. WRI India. <https://wri-india.org/blog/nature-based-solutions-reimagining-pathway-sustainable-future>

- Subramanian, A., Nagarajan, A., Vinod, S., et al. (2023). Long-term impacts of climate change on coastal and transitional eco-systems in India: an overview of its current status, future projections, solutions, and policies. *Royal Society of Chemistry*, 13, 12204-12228.
- UNEP. (2018). *Enhancing livelihoods in rural communities of Armenia through mainstreaming and strengthening agricultural biodiversity conservation and utilization*.
- UNESCO. (2022). United Nations Educational, Scientific and Cultural Organization. Retrieved at <https://www.unesco.org/en/un-ocean-conference-2022>
- United Nations Environment Programme. (2022). *Synthesis Report on the Environmental and Health Impacts of Pesticides and Fertilizers and Ways to Minimize Them*. Geneva: UNEP
<https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/38409/pesticides.pdf>
- United Nations. (2022). *Report of the 2022 United Nations Conference to Support the Implementation of Sustainable Development Goal 14: Conserve and Sustainably Use the Oceans, Seas and Marine Resources for Sustainable Development*. Conference 230, New York: UN
- Visbeck, M. (2018). Ocean science research is key for a sustainable future. *Nat Commun* 9, 690 <https://doi.org/10.1038/s41467-018-03158-3>

SDG 15

- Arunachalam, A., Sundaram, S., and Handa, A. (2021). Administring Agroforesrty at district level. *Current Science*, 121(4).
- Bansard, J. and Schröder, M. (2021). *The Sustainable Use of Natural Resources: The Governance Challenge*. International Institute for Sustainable Development. <https://www.iisd.org/articles/deep-dive/sustainable-use-natural-resources-governance-challenge>
- Biodiversity International, CGIAR, Clarmondial. (2017). Reducing risks and seizing opportunities: integrating biodiversity into food and agriculture investments. https://www.clarmondial.com/wp-content/uploads/2017/07/ABD_Index_Investor_summary.pdf
- C40 Knowledge Community. (2021). A snapshot of urban green finance in two Indian cities: Case studies of Hyderabad and Kolkata. *Cities Climate Finance Leadership Alliance, Climate Policy Initiative*. https://www.c40knowledgehub.org/s/article/A-snapshot-of-urban-green-finance-in-two-Indian-cities-Case-studies-of-Hyderabad-and-Kolkata?language=en_US
- Campbell, B., Hansen, J., Rioux, J., Stirling, C., Twomlow, S., and Wollenburg, E. (2018). Urgent action to combat climate change and its impacts (SDG 13): transforming agriculture and food systems. *Current Opinion in Environmental Sustainability*. Vol 34. pp 13-20. doi: <https://doi.org/10.1016/j.cosust.2018.06.005>
- CGIAR. (2014). Increasing homogeneity of world food supplies warns of serious implications for farming and nutrition. *Science Daily*. www.sciencedaily.com/releases/2014/03/140303154102.htm.

- Cotula, L. (2015). Land rights and investment treaties. IIED. <https://pubs.iied.org/sites/default/files/pdfs/migrate/12578IIED.pdf>
- Cotula, L. (2016). Rethinking investment treaties to advance human rights. *IIED Briefing*. <https://pubs.iied.org/sites/default/files/pdfs/migrate/17376IIED.pdf>
- Food and Agriculture Organization of the United Nations. (2002). *Land Tenure and Rural Development*. Rome: FAO
- GOI. (2022). *Sahi Fasal' Campaign*. New Delhi: Ministry of Jal Shakti.
- International Science Council. (2019). *A Guide to SDG Interactions: from Science to Implementation*. <https://council.science/publications/a-guide-to-sdg-interactions-from-science-to-implementation/>
- IPCC. (2019). *Special Report on Climate Change and Land*. <https://www.ipcc.ch/srccl/>
- Kang, S.-M., Waqas, M., Khan, A. L., and Lee, I.-J. (2014). Plant-growth-promoting rhizobacteria: potential candidates for gibberellins production and crop growth promotion. In *Use of Microbes for the Alleviation of Soil Stresses*, Vol. 1 ed. Miransari M. New York, NY: Springer New York, 1–19. 10.1007/978-1-4614-9466-9_1
- Kasim, W. A., Osman, M. E., Omar, M. N., Abd El-Daim, I. A., Bejai, S., and Meijer, J. (2013). Control of drought stress in wheat using plant-growth-promoting bacteria. *J. Plant Growth Regul.* 32 122–130. 10.1007/s00344-012-9283-7
- Khandker, S.R. and Koolwal, G.B. (2016). How has microcredit supported agriculture? Evidence using panel data from Bangladesh. *Agricultural Economics*, 47: 157-168. <https://doi.org/10.1111/agec.12185>
- Kumar R., Patra, M.K., Thiruganavel, A., Chatterjee, D., and Deka B.C. (2016). Towards the natural resource management for resilient shifting cultivation system in eastern Himalayas. In *Conservation Agriculture*. Singapore: Springer, p 409–436
- Metzger J.P. (2003). Effects of slash-and-burn fallow periods on landscape structure. *Environ Conserv* 30(4):325–333. <https://doi.org/10.1017/S0376892903000341>
- NITI Aayog. (2018). *Report of Working Group III; Shifting Cultivation: Towards a Transformational Approach*. http://niti.gov.in/writereaddata/files/document_publication/doc3.pdf
- Ramamurthy, V., Singh, S., and Chattara, S. (2016). *Land Resource Inventory Towards Village Level Agricultural LUP*. Indian Council of Agriculture Resource, 644-667.
- Ritse, V., Basumatary, H., Kulnu, A.S., Dutta, G., Phukan, M.M., and Hazarika N. (2020). Monitoring land use land cover changes in the Eastern Himalayan landscape of Nagaland, Northeast India. *Environ Monit Assess*, 192(11). <https://doi.org/10.1007/s10661-020-08674-8>
- SDG Indicators. (2023). Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. <https://unstats.un.org/sdgs/report/2016/goal-15/#:~:text=Goal%2015%20focuses%20specifically%20on>
- Subedi, R., Karki, M., and Panday, D. (2020). *Food System and Water–Energy–Biodiversity Nexus in Nepal: A Review*. Agronomy.

- UN Women (2020). *Realizing Women's Rights to Land and Other Productive Resources*. 2nd ed. <https://www.unwomen.org/en/digital-library/publications/2020/10/realizing-womens-rights-to-land-and-other-productive-resources-2nd-edition>
- United Nations Environment Programme. (2017). *Goal 15: Life on land*. UNEP - UN Environment Programme. <https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-15>
- United Nations. (n.d.). Department of Economic and Social Affairs: Statistical Division. Retrieved at [https://unstats.un.org/sdgs/report/2016/goal-15/Zhao, C., B. Liu, S. Piao, X. et al. \(2017\). Temperature increase reduces global yields of major crops in four independent estimates. *Proceedings of the National Academy of Sciences of the United States of America \(PNAS\)* 114 \(35\): 9326–9331. <https://www.pnas.org/content/114/35/9326>. Accessed 26 May 2020.](https://unstats.un.org/sdgs/report/2016/goal-15/Zhao, C., B. Liu, S. Piao, X. et al. (2017). Temperature increase reduces global yields of major crops in four independent estimates. Proceedings of the National Academy of Sciences of the United States of America (PNAS) 114 (35): 9326–9331. https://www.pnas.org/content/114/35/9326)

SDG 16

- Agarwal, B. (2010). *Gender and Green Governance: The political economy of women's presence within and Beyond Community Forestry*. Oxford: Oxford University Press.
- Agarwal, B. (2014). Food sovereignty, food security and democratic choice: critical contradictions, difficult conciliations. *The Journal of Peasant Studies*, 41(6), 1247–1268. <https://doi.org/10.1080/03066150.2013.876996>
- Boyd, D. (n.d.). Human rights depend on healthy and sustainable food systems. https://www.ohchr.org/sites/default/files/2022-05/Food-Summary-Final.pdf?trk=public_post_comment-text
- Dixon, D. (2018). *India's Stance on SDG 16: Peace, Justice and Strong Institutions*. UNADAP. <https://www.unadap.org/post/india-s-stance-on-sdg-16-peace-justice-and-strong-institutions>
- Dyer, J. (2020). Farmers and the fear of crime: Improving agricultural productivity through farm protection in Kenya: The Abdul Latif Jameel poverty action lab. The Abdul Latif Jameel Poverty Action Lab (J-PAL). <https://www.povertyactionlab.org/evaluation/farmers-and-fear-crime-improving-agricultural-productivity-through-farm-protection-kenya>
- Economic Times. (2015). Kerala's Kudumbashree to expand organic farming; to woo more women. *The Economic Times*. <https://economictimes.indiatimes.com/news/economy/agriculture/keralas-kudumbashree-to-expand-organic-farming-to-woo-more-women/articleshow/48786155.cms>
- FAO. (2011). *The state of Food and Agriculture 2010-2011*. Rome: Food and Agriculture Organization of the United Nations (FAO). <https://www.fao.org/3/i2050e/i2050e.pdf>
- FAO. (2018). The 10 Elements of Agroecology Guiding the Transition to Sustainable Food and Agricultural Systems. <https://www.fao.org/3/i9037en/i9037en.pdf>
- Fink, R. (2002). *Corruption and the Agricultural Sector*. United States Agency for International Development . https://pdf.usaid.gov/pdf_docs/Pnact873.pdf
- GIIN. (n.d.). *Improving Social Equity and Justice Through Agriculture*. The GIIN. <https://navigatingimpact.thegiin.org/strategy/sa/improving-social-equity-and-justice-through-agriculture/#footnote-2>

- Ignaciuk, A., and Tun, N. A. C. (2019). Achieving agricultural sustainability depends on gender equality. IFPRI. <https://www.ifpri.org/blog/achieving-agricultural-sustainability-depends-gender-equality>
- ILO. (2000). *Safety and Health in Agriculture*. International Labour Office. https://www.ilo.org/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/publication/wcms_110193.pdf
- Meshram, V. (n.d.). Save Indian Farmers. <https://www.saveindianfarmers.org/the-plight-of-women-farmers-in-india/>
- Ministry of Agriculture and Farmers Welfare Government of India. (2019). Agriculture Census 2015-16. https://agcensus.nic.in/document/agcen1516/T1_ac_2015_16.pdf
- Mohan, V. (2021). Suicides of agricultural labourers rise by 18%: NCRB Report: India News - Times of India. *The Times of India*. <https://timesofindia.indiatimes.com/india/suicides-of-agricultural-labourers-rise-by-18-ncrb-report/articleshow/87344897.cms>
- NIRDPR, and CORD. (n.d.). A case study on women leadership in Panchayati Raj Institutions. http://nirdpr.org.in/nird_docs/casestudies/cord/cord1.pdf
- NITI Aayog. (2016). *Report of the Expert Committee and Model Law on Agricultural Land Leasing*. New Delhi: Niti Aayog. <https://www.niti.gov.in/sites/default/files/2020-05/Report-of-the-Expert-Committee-and-Model-Law-on-Agricultural-Land-Leasing.pdf>
- Nkombo, N. (2018). Three ways the African Union can fight corruption in agriculture, and win. *Farming First*. <https://farmingfirst.org/2018/01/three-ways-the-african-union-can-fight-corruption-in-agriculture-and-win/>
- Rahman, K., Williams, A., and Vidalic, H. (2021). Anti-corruption measures for reducing corruption in agriculture. U4 anti-corruption helpdesk. https://knowledgehub.transparency.org/assets/uploads/kproducts/Anti-corruption-measures-for-reducing-corruption-in-agriculture_09.03.2022_U4-reviewed_PR.pdf
- Sugden, F., Agarwal, B., Leder, S., Saikia, P., Raut, M., Kumar, A., and Ray, D. (2020). Experiments in farmers' collectives in eastern India and Nepal: Process, benefits, and challenges. *Journal of Agrarian Change*, 21(1), 90–121. <https://doi.org/10.1111/joac.12369>
- Suhag, R. (2016). *Report summary - PRS legislative research*. PRS Legislative. https://prsindia.org/files/policy/policy_committee_reports/1462167280_Report%20Summary%20land%20leasing%20act,%202016.pdf
- Tacconi, L., and Williams, D. A. (2020). *Corruption and anti-corruption in environmental and resource management*. *Annual Review of Environment and Resources*. <https://www.annualreviews.org/doi/10.1146/annurev-enviro-012320-083949>
- UNOOSA. (n.d.). *United Nations Office for Outer Space Affairs*. Sustainable Development Goal 16: Peace, Justice and Strong Institutions. <https://www.unoosa.org/oosa/en/ourwork/space4sdgs/sdg16.html>
- Varela, D. T. (n.d.). *Freedom of Opinion and Expression and Sustainable Development - Why Voice Matters*. OHCHR. <https://www.ohchr.org/sites/default/files/documents/issues/expression/cfis/sustainable>

-development/subm-sustainable-development-freedom-of-expression-others-damian-varela-11.pdf

Vijayan, D. (2018). Effects of Kudumbasree JLG Farming on Women Empowerment: A Study in Ernakulam District. *International Journal of Creative Research Thoughts*, 6(2), 1517–1527. <https://doi.org/https://ijcrt.org/papers/IJCRT1812626.pdf>

SDG 17

Adedoyin, F. F., Osundina, O. A., Bekun, F. V., and Asongu, S. A. (2015). Toward achieving sustainable development agenda. *Open Agriculture*. <https://doi.org/10.1515/opag-2022-0111>

Anderson, M. (1989). *International Technology Transfer in Agriculture*. USDA. <https://naldc.nal.usda.gov/download/CAT89930580/PDF>

Barwale, B. R. (2007). Partnership for prosperity. *Agricultural Transformation through Public-Private Partnership: An Interface*. <https://icar.org.in/files/Public-Private-Partnership.pdf>

Bellmann, C. (2023). *Fostering Cooperation on Sustainable Agriculture and Trade at the WTO*. International Institute for Sustainable Development. <https://www.iisd.org/articles/policy-analysis/fostering-cooperation-sustainable-agriculture-trade-wto>

Deloitte. (2020). *Building Partnerships for Sustainable Agriculture and Food Security*. Deloitte Switzerland. <https://www2.deloitte.com/ch/en/pages/about-deloitte/articles/nva-country-partnership-guide.html>

Díaz-Cassou, J., Erce, A., and Vázquez-Zamora, J. J. (2008). Recent episodes of sovereign debt restructurings: A case-study approach. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.1210382>

Enweze, C. (n.d.). *Role Of International Financial Institutions in Capacity Building in Africa*. IMF. <https://www.elibrary.imf.org/downloadpdf/book/9781589060722/ch006.xml>

European Commission. (n.d.). *Global partnerships*. Research and innovation. https://research-and-innovation.ec.europa.eu/research-area/agriculture-forestry-and-rural-areas/global-partnerships_en

FAO. (2023). Global frameworks shaping national climate policies. *Enabling policy Environment for Climate-Smart Agriculture*. <https://www.fao.org/climate-smart-agriculture-sourcebook/enabling-frameworks/module-c3-policy/chapter-c3-3/en/>

FAO. (2023). *Sustainable Food and Agriculture*. Rome: Food and Agriculture Organization of the United Nations. <https://www.fao.org/sustainability/international-partnerships/en/>

Food And Agriculture Organization. (2004). Capacity building for biotechnology in food and agriculture. *The State of Food And Agriculture*. <https://www.fao.org/3/Y5160E/y5160e00.htm#TopOfPage>

Government of India and Government of USA. (2000). *The Indo-U.S. Science and Technology Forum*. <https://iusstf.org/>

Government of India and Government of UK. (2006). *UK-India Education and Research Initiative (UKIERI)*. <http://www.ukieri.org/>

- Government of UK. (2022). *Increasing UK–Kenya Trade and Investment in the Horticulture Sector*. <https://www.gov.uk/government/case-studies/increasing-uk-kenya-trade-and-investment-in-the-horticulture-sector>
- Ibrahim, R. L., Yu, Z., Hassan, S., Ajide, K. B., Tanveer, M., and Khan, A. R. (2022). Trade facilitation and agriculture sector performance in Sub-Saharan Africa. *Technology-Enabled Circular Economy Practices in Energy Production and Consumption Patterns*, 102022. <https://doi.org/10.3389/fenvs.2022.962838>
- Jena, L. P. (2023). *Debt Restructuring of Vulnerable Countries*. New Delhi: Observer Research Foundation. <https://www.orfonline.org/expert-speak/debt-restructuring-of-vulnerable-countries/>
- Katyal, J. C. (2007). Public-private partnership — context HRD. *Agricultural Transformation through Public-Private Partnership: An Interface*. <https://icar.org.in/files/Public-Private-Partnership.pdf>
- Konde, V., Senior, G., and Groenbech, M. (2004). Facilitating transfer of technology to developing countries: A survey of home-country measures. UNCTAD. https://unctad.org/es/system/files/official-document/iteipc20045_en.pdf
- Kumar, N. (2009). South-South and triangular cooperation in Asia-Pacific: towards a new paradigm in development cooperation. *UNESCAP working paper*.
- Maiti, S. and Geetha, S. K. (2007). India’s herbal heritage. *Agricultural Transformation through Public-Private Partnership: An Interface*. <https://icar.org.in/files/Public-Private-Partnership.pdf>
- Metz, B., Davidson, O., Martens, J. W., Rooijen, S. V., and Macgrory, L. V. (2000). *Methodological and Technological Issues in Technology Transfer*. IPCC. <https://archive.ipcc.ch/ipccreports/sres/tectran/index.php?idp=0>
- Moussa, S. Z. (2002). Technology transfer for agricultural growth in Africa. African Development Bank. <https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/00157678-EN-ERP-72.PDF>
- OECD. (2011). *Towards Green Growth A Summary for Policy Makers May 2011*. <https://www.oecd.org/greengrowth/48012345.pdf>
- OECD. (2013). *Policy Framework for Investment in Agriculture*. https://www.oecd.org/daf/inv/investment-policy/PFIA_April2013.pdf
- OECD. (2015). *Policy Coherence for Inclusive and Sustainable Development*. <https://www.oecd.org/dac/POST-2015%20PCD.pdf>
- OECD. (2019). Policy coherence in food and agriculture. In *Innovation, productivity and sustainability in food and agriculture: Main findings from country reviews and policy lessons*.
- OECD. (2021). Principles for policy coherence. *Making Better Policies for Food Systems*. <https://doi.org/10.1787/ddfba4de-en>
- Perch, L. (2012). *The Role of South-South Cooperation in Inclusive and Sustainable Agricultural Development*. International Policy Centre for Inclusive Growth (IPC-IG). <https://www.fao.org/family-farming/detail/en/c/1032354/>
- https://www.researchgate.net/publication/290059190_Impact_of_public_private_partnership_in_agriculture_A_review

- Rai, C. K., Arti, Kumar, S., Acad, A. K., and Kumar, M. (2017). Economic empowerment. *Public Private Partnership in Agriculture: A Stern Review*, 6. <https://doi.org/10.20546/ijemas.2017.609.431>
- Schneider, A., and Kernohan, D. (2006). *The Effects of Trade Liberalisation on Agriculture in Smaller Developing Countries: Implications for the Doha round*. CEPS. https://www.files.ethz.ch/isn/25338/244_Effects%20of%20Trade%20Liberalization.pdf
- Shepherd, M., Turner, J., Small, B., and Wheeler, D. (2018). *Priorities for science to overcome hurdles thwarting the full promise of the 'digital agriculture' revolution*. *Journal of the Science of Food and Agriculture*. doi: <https://doi.org/10.1002/jsfa.9346>
- Smaller, C. (2014). *The Global Response to Foreign Investment in Agriculture*. International Institute for Sustainable Development. https://www.iisd.org/system/files/publications/global_response_foreign_investment_ag_en.pdf
- Srinivasan, N. (2007). Technology commercialization and financing. *Agricultural Transformation through Public-Private Partnership: An Interface*. <https://icar.org.in/files/Public-Private-Partnership.pdf>
- Strode, M., Auslan, J. M., Spanneut, C., Wiiloughby, C., Powell, M., Gafishi, P. N., and Thomsen, T. (2009). *Evaluation of the Implementation of the Paris Declaration: Thematic Study of Support to Statistical Capacity Building: Synthesis report*. <https://www.oecd.org/dac/evaluation/dcdndep/43189996.pdf>
- Sun, Z., and Zhang, D. (2021). Impact of trade openness on food security: evidence from panel data for central asian countries. *Foods*. <https://doi.org/10.3390/foods10123012>
- Tang, L., and Sun, S. (2022). Fiscal incentives, financial support for agriculture, and urban-rural inequality. *International Review of Financial Analysis*, 80, 102057. <https://doi.org/10.1016/j.irfa.2022.102057>
- Thomson, A., and Metz, M. (1998). Impact of policy on food security. *Implications of Economic Policy for Food Security: A Training Manual*. <https://www.fao.org/3/X3936E/X3936E00.htm>
- Tinbergen, J. (1952), *On the Theory of Economic Policy*. Amsterdam: North-Holland Publishing Company. <http://www.garfield.library.upenn.edu/classics1986/A1986C401200001.pdf>
- UN. (n.d.). *Promoting Sustainable Agriculture & Rural Development*. https://www.un.org/esa/dsd/agenda21/res_agenda21_14.shtml
- UNCTAD. (2023). *Technology and Innovation Report 2020*. United Nations Conference on Trade and Development. Retrieved at <https://unctad.org/tir2023>.
- UNDP. (2011). Official Development Assistance. *Towards Human Resilience: Sustaining MDG Progress in an Age of Economic Uncertainty*. https://www.undp.org/sites/g/files/zskgke326/files/publications/Towards_SustainingMDG_Web1005.pdf
- UNEP/SFSP (2019). *Collaborative Framework for Food Systems Transformation A multi-stakeholder Pathway for Sustainable Food Systems*. United Nations Environment Programme and One Planet Network Sustainable Food Systems Programme,

<http://www.oneplanetnetwork.org/initiative/setting-table-our-children-improving-governance-food-systems>

- United Nations. (2009). The role of South–South and triangular cooperation for sustainable agriculture development and food security in developing countries. UNCTAD. https://unctad.org/system/files/official-document/ciimem2d5_en.pdf
- United Nations. (2009). *2009 World Survey on the Role of Women in Development: Women’s Control over Economic Resources and Access to Financial Resources, including Microfinance*. Department of Economic and Social Affairs. Retrieved at <https://www.un.org/womenwatch/daw/public/WorldSurvey2009.pdf>
- United Nations. (2023). Global finance officials discuss strategies to help debt-burdened developing countries overcome poverty, climate risk, as financing for development forum continues. <https://press.un.org/en/2023/ecosoc7119.doc.htm>
- United Nations. (n.d.). FAO AgrInvest: Enabling sustainable private investment in agri-food systems and specific value chains. <https://sdgs.un.org/partnerships/fao-agrinvest-enabling-sustainable-private-investment-agri-food-systems-and-specific>
- USAID. (n.d.). *Policy Brief Increasing CSA Investment Through Fiscal Incentives U.S. Government*. https://climatefocus.com/wp-content/uploads/2022/06/brief_2_-_increasing_csa_investment_through_fiscal_incentives.pdf
- Velten, S., Jager, N.W. & Newig, J. (2021). *Success of Collaboration for Sustainable Agriculture: A case study meta-analysis*. *Environ Dev Sustain* 23, 14619–14641. Retrieved at <https://doi.org/10.1007/s10668-021-01261-y>
- Virginia Tech College of Agriculture and Life Sciences and Virginia Tech Foundation. (2023). *Private Sector Invests in the Success of Agriculture*. GAP Report. <https://globalagriculturalproductivity.org/policy-goals-for-a-productive-sustainable-healthy-world/private-sector-engagement/>
- Wang, W., Wang, J., Liu, K., and Wu, Y. J. (2020). Overcoming barriers to agriculture green technology diffusion through stakeholders in China: A social network analysis. *International Journal of Environmental Research and Public Health*, 17(19), 6976. <https://doi.org/10.3390/ijerph17196976>
- World Bank. (2022). *Agriculture Finance & Agriculture Insurance*. Retrieved at <https://www.worldbank.org/en/topic/financialsector/brief/agriculture-finance>
- World Economic Forum. (2016). *Building Partnerships for Sustainable Agriculture and Food Security A Guide to Country-Led Action*. <https://www3.weforum.org/docs/IP/2016/NVA/NVAGuidetoCountryLevelAction.pdf>
- Zimmermann, A. and Rapsomanikis, G. (2023). Trade and sustainable food systems. *Science and Innovations for Food Systems Transformation*, 685-709. https://doi.org/10.1007/978-3-031-15703-5_36

ANNEXURES

Annexure 1: English Translations of Key Measures

Name of policies/schemes	English Translation
<i>Atal Bhujal Yojana (ABY)</i>	Atal Ground Water Scheme
<i>Mahila Kisan Sashaktikaran Pariyojaan (MKSP)</i>	Women Farmers Empowerment Project
<i>Paramparagat Krishi Vikas Yojana (PKVY)</i>	Traditional Agriculture Development Scheme
<i>Pradhan Mantri Fasal Bima Yojana (PMFBY)</i>	Prime Minister's Crop Insurance Scheme
<i>Pradhan Mantri Janjatiya Vikas Mission (PMJVM)</i>	Prime Minister's Tribal Development Mission
<i>Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyaan (PM KUSUM)</i>	Prime Minister's Farmer Energy Security and Development Program
<i>Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)</i>	Prime Minister's Agriculture Irrigation Scheme
<i>Pradhan Mantri Kisan Sampada Yojana (PMKSY)</i>	Prime Minister's Farmer Food Processing Scheme
<i>Rashtriya Krishi Vikas Yojana (RKVY)</i>	National Agricultural Development Scheme

Annexure 2: Semi-structured Questionnaire Used in the Study

The semi-structured questionnaire is designed to capture relevant data points, opinions, and perspectives from you. Your expertise and insights are highly valuable to us as we proceed to understand the policy interface between SDGs and sustainable agriculture.

Key points included:

- Role of the ministry in promoting sustainable and climate-sensitive agriculture
- Strengthening the national policy interface between the ministry's mandate and sustainable agriculture
- Promotion of synergies between various schemes for promoting ecosystem-based approaches in agriculture and natural resources management
- Mitigation of any trade-offs
- Cross-cutting issues: institutions, credit support, access to market, data, systemic approaches

Annexure 3: List of Experts Engaged in the Consultations

Name of Experts	Designation	Organization
Aakriti Uttam	Programme Officer	Development Alternatives Group
Abhishek Sinha	Director	Central Water Commission, RK Puram
Aditya Petwal	Associate Director	Centre for Responsible Business (CRB)
Akhilesh Sharma	Assistant Program Lead	S M Sehgal Foundation
Alka Bhargava	Sr. Policy Advisor	United Nations Environment Programme (UNEP): The Economics of Ecosystems and Biodiversity (TEEB)
Amlan Mishra	Research Associate	The Energy and Resources Institute (TERI)
Anagha Krishnan	Research Associate	Mu Gamma Consultants Pvt. Ltd
Anandajit Goswami	Research Fellow	Ashoka University
Arkajyoti Patra	Programme Policy Officer	World Food Programme (WFP)
Arpit Goel	Consultant	GURUJAL
Ashutosh Senger	Policy Researcher	Advocate
Bansari Nag	National Project Coordinator	International Labour Organization
Bhavya Batra	PhD Scholar	TERI-School of Advanced Studies
Bhawna Mangla	Research Manager	Abdul Latif Jameel Poverty Action Lab
Biplove Singh	Manager - Strategy	End Poverty
Chetana Chaudhuri	Fellow	National Council of Applied Economic Research
Chime Youdon	Research Fellow	National Maritime Foundation
Chris Garroway	Resident Coordinator	United Nations Resident Coordinator's Office (UNRCO)
D R Sena	Researcher - Hydrology and Water Resources Management	International Water Management Institute (IWMI)
Debadityo Sinha	Lead in Climate and Ecosystem	Vidhi Legal Policy
Debesh Roy	Chairman	Inspire, New Delhi
Deepak Chamola	Adviser	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Name of Experts	Designation	Organization
Dennis Baby	Junior Associate	World Resources Institute (WRI) India
Dev Nathan	Visiting Professor	Institute for Human Development, Delhi; Research Director, Gen Dev Centre, Delhi
Dhriti Pathak	Climate Change Analyst	World Bank
Drishya Pathak	Research Associate	Centre for Human Progress
Gargi Upadhyay	Lead-Research and Analytics Sustainable Agriculture	World Wildlife Fund (WWF) India
Girija Bharat	Managing Director	Mu Gamma Consultants Pvt. Ltd.
Guru Koppa	Director	The Nature Conservancy (TNC) India
Gyan Prakash Rai	Policy Manager	The Nature Conservancy (TNC) India
Jai Kumar Gaurav	Senior Advisor (Climate Change and Circular Economy)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
Jayahari K M	Country Coordinator	Food and Land Use Coalition (FOLU) - India
John Vachaparambil	Associate Fellow	National Maritime Foundation (NMF)
K P Tripathi	Principal Scientist	Indian Council of Agricultural Research (ICAR)
K.J.S Satyasai	CGM, Retd.	Economic Analysis and Research, (National Bank for Agriculture and Rural Development)
K.K Chaturvedi	Principal Scientist, IT Unit	Indian Council of Agricultural Research (ICAR)- Indian Agricultural Statistics Research Institute (IARI)
Kangkanika Neog	Programme Associate	Council on Energy, Environment and Water
Kanwal Nayan Singh	Manager	World Resources Institute (WRI) India
Karan Shinghal	Research Analyst	Council on Energy, Environment and Water
Karnika Palwa	Researcher	Urban Agriculture Expert
Komal Mittal	Research Associate	Centre for Human Progress
Krishan Rautela	Natural Resources and Agriculture Specialist	Asian Development Bank

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Name of Experts	Designation	Organization
Kriti Bhagat	Research Associate	Giri National Labour Institute
Kritika Gadpayle	Senior Consultant	Ernst & Young
Livleen Kahlon	Associate Director	The Energy and Resources Institute (TERI)
Madhav Gholkar	Climate Resilient Agriculture (Lead)	Watershed Organization Trust (WOTR)
Malancha Chakrabarty	Senior Fellow	Observer Research Foundation (ORF)
Mandira Kochar	Fellow	The Energy and Resources Institute (TERI)
Mansi Chopra	Deputy Director	Hriday
Marcella Souza	Director	Watershed Organization Trust (WOTR)
Mayank Agarwal	Lead, Just Transition	Climate Trends
Mini Govindan	Senior Fellow	The Energy and Resources Institute (TERI)
Monisha Chaudhary	Partner	Hindrise Social Welfare Foundation
Monisha Mukherjee	Team Coordinator	PRADAN - Professional Assistance for Development Action
Murli Dhar	Director	World Wildlife Fund (WWF) India
N Sai Balaji	Senior Research Fellow	Jawaharlal Nehru University (JNU)
Narender Kumar	Founder	Hindrise Social Welfare Foundation
Neetika W Chhabra	Fellow	The Energy and Resources Institute (TERI)
Neha Khanna	Senior Manager	Climate Policy Initiative
Neha Lakhwan	Research Associate	Mu Gamma Consultants Pvt. Ltd
Nirmal Sunkari	Founder	Agri Maps
Nitya Nanda	Director	Council for Social Development
Nityananda Dhal	Integrator	PRADAN - Professional Assistance for Development Action
Nivedita Choleyil	Program Associate	World Resources Institute (WRI) India
Niyati Seth	Associate Fellow - Water Resources	The Energy and Resources Institute (TERI)
Pallas Chandel	Junior Climate Change Advisor	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
Pradeep Dubey	Program Manager	World Resources Institute (WRI) India

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Name of Experts	Designation	Organization
Pradeep Kumar	Post-Doctoral Fellow	Jawaharlal Nehru University (JNU)
Pradya Paithankar	Head-Climate Change, Resilient Food Systems, DRR	World Food Programme (WFP)
Prajakta Sawant	PhD Candidate	Jawaharlal Nehru University (JNU)
Pranay Sinha	Program Officer	Bill & Melinda Gates Foundation (BMGF)
Priyanka Anand	Project Associate - Crop Residue Management	The Nature Conservancy India (TNC India)
Puja Singh	Project Manager	Indian Institute of Technology (IIT), Delhi
Purabi Chatterjee	Policy Associate	Agriculture and Environment, Energy, and Climate Change sector, Abdul Latif Jameel Poverty Action Lab
Pushp Bajaj	National Consultant on Blue Economy	United Nations Development Programme (UNDP)
R K Sony	Senior Manager	Food and Land Use Coalition (FOLU) - India
R S Yadav	Principal Scientist	Indian Council of Agricultural Research (ICAR)
Raghavan Sampathkumar	ED, FSII	Alliance for Agri Innovation
Rakhi Kashyap	Associate Lead - Climate Change and DRR	Data Civic Lab
Ramya Kapoor	Founder	Indickshana Initiative
Ranjeet Singh	Deputy Director (Project Development Facility)	Small Farmers Agri-Business Consortium (SFAC)
Reuben Gergan	Consultant	United Nations Environment Programme (UNEP)
Rhea Malhotra	Consultant-TEEB	TEEBAgriFood-India, UNEP
Richa Sharma	Fellow	The Energy and Resources Institute (TERI)
Ripu Bhanjan	Advisor	Swaniti Initiative
Rohit Saini	Fellow	Research and Information System for Developing Countries (RIS)
Rupa Upadhyay	Professor	Lady Irvin College

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Name of Experts	Designation	Organization
Sachin Kumar Ved	Junior Scientific Officer	National centre for organic and Natural Farming
Sai Krishna	CEO	National Skills Foundation of India
Samriddhi	Associate Lead - Public Finance	CivicDataLab
Sanchit Saran Agarwal	Associate Fellow	The Energy and Resources Institute (TERI)
Sarat Kannepalli	Advisor, Climate Change	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
Saswata Chaudhury	Senior Fellow	The Energy and Resources Institute (TERI)
Saurabh Thakur	International Consultant	Global Maritime Crime Programme, United Nations
Seema Yadav	Senior Programme Associate	World Resources Institute (WRI) India
Shaguna Gahilote	Education and Livelihood Specialist	United Nations Women
Shalander Kumar	Deputy Global Research Program Director	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Shashi Bhushan Tripathi	Professor	TERI School of Advanced Studies (TSAS)
Shoba Suri	Senior Fellow	Observer Research Foundation (ORF)
Shraddha Srikant	National Project Coordinator	United Nations Industrial Development Organization (UNIDO)
Shreya Chakroborty	Researcher	Consultative Group on International Agricultural Research (CGIAR)
Shyam Sundar Sridhar	Policy Manager- Agriculture and Finance	Abdul Latif Jameel Poverty Action Lab
Siddhant Malhotra	Technical Advisor	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
Subrata Singh	Acting Executive Director	Foundation for Ecological Security
Sukrit Joshi	Research Assistant	Research and Information System for Developing Countries (RIS)
Sumit Roy	Head Agriculture Production Initiative	World Wildlife Fund (WWF) India
Sunil Kumar Gupta	Research Lead	Asian Development Research Institute
Susanta Mahato	Post Doctoral Fellow	Jawaharlal Nehru University (JNU)

SDG BLUEPRINT FOR SUSTAINABLE AGRICULTURE

Name of Experts	Designation	Organization
Swati Nayak	Scientist & S.A Lead Seed Systems	International Rice Research Institute (IRRI)
Syed Ali	Research Associate	Research and Information System for Developing Countries (RIS)
Tapan Chakraborty	Scientist	Central Ground Water Board, Government of India
Trinayana Kaushik	Research Associate	The Energy and Resources Institute (TERI)
Upasana Singh	President	All India Women Conference
V Sampath	Manager Monitoring and Evaluation	End Poverty
Vachspati Pandey	Assistant Director	National centre for organic and Natural Farming
Vaishali Chopra	Project Officer	Hriday
Vaishali Kanojia	Deputy Director (Project Development Facility)	Development Alternatives
Vani Rijhwani	Climate Change Analyst	World Bank
Vartika Singh	Sr Research Analyst	Consultative Group on International Agricultural Research (CGIAR)- (IFPRI) Food and Nutrition Policy
Vidvatta Sharma	Program Manager	Shakti Sustainable Energy Foundation
Vineet Kumar	Programme Manager	Centre for Science and Environment (CSE)
Vivek Mishra	Director DY LLP	Ernst & Young
Yogesh Kapoor	Senior Advisor	Development Alternatives Group



SDG Blueprint for Sustainable Agriculture

The sustainable development goals (SDGs) contain seventeen goals which have a bearing on multiple issue areas including agriculture. This study sought to develop an SDG Blueprint to inform integrated approaches to sustainable agriculture at the national level in India. It is crucial that the lenses of sustainable development, climate action, value chains, and multi-stakeholder approaches be considered for sustainable agriculture to contribute towards food security, livelihoods, and ecosystem integrity. The scope of the study was to examine the national policy interface of sustainable agriculture with SDGs. Through tools such as stakeholder mapping, systematic literature review, sustainable agriculture metrics, nominal group techniques, key informant interviews, and stakeholder validation, an SDG Blueprint is developed to inform policy and praxis on the issue of sustainable agriculture.

