POLICY BRIEF

T20 SOUTH AFRICA 2025

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Harvesting Sustainability: How Crop Diversification Fuels Climate and Biodiversity Goals

2025

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Accelerating Climate Action and the Just Energy Transition

Abstract

The cultivation of rice, though a staple food source, is water-intensive and a major contributor to methane and nitrous oxide emissions, potent greenhouse gases, exacerbating climate change.[1] For example, rice cultivation alone contributes to 16.68% of the Indian agricultural sector's global greenhouse gas (GHG) emissions.[2] With depleting water resources and mounting climate challenges, there is a need for sustainable agricultural practices.

Crop diversification offers a promising solution by introducing alternative crops like millets, pulses, and oilseeds into rice-growing regions, reducing methane emissions while enhancing biodiversity and soil health.[3] Crop diversification is a vital strategy to address both ecological and economic goals. Therefore, shifting from rice monocultures can help reduce GHG emissions, promoting the biodiversity–climate–development nexus and long-term sustainability.

The G20 is uniquely positioned to drive this transformation by championing policies and programmes that encourage sustainable agricultural practices. As a global forum, the G20 can leverage its influence to align efforts under the UNFCCC, CBD, and UNCCD, ensuring synergistic outcomes across climate, biodiversity, and land-use goals. Subsidy reforms incentivising farmers to adopt diverse cropping systems – like rice-pulse rotations – reduce monoculture farming's environmental burden and enhance soil health. The G20 could leverage the fund to support investments in climate-smart technologies and solutions, such as developing methane-reducing rice varieties or drought-resistant crops. Financing innovations through private-sector and development bank partnerships can be instrumental, as demonstrated by the African Development Bank's climate-resilient agriculture programme,[4] to support investments in climate-smart technologies and solutions, such as developing methane-reducing rice varieties or drought-resistant crops.

Keywords: Crop Diversification, Short-lived Climate Pollutants, Methane Mitigation, Carbon Finance, Subsidy Reforms, Agri-market Linkages

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[1] Pathak, H., et al. "Greenhouse Gas Emission from Indian Agriculture: Trends, Mitigation and Policy Needs." *Indian Council of Agricultural Research*. Accessed January 28, 2025. https://krishi.icar.gov.in/jspui/bitstream/123456789/32431/1/GreenhouseGasEmissionfromIndianAgricultureHPathaketal%20%281%29.pdf

[2] Government of India. *India: Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change (BUR-4)*. New Delhi: Ministry of Environment, Forest and Climate Change, 2021, 42. Accessed January 28, 2025. https://unfccc.int/sites/default/files/resource/India%20BUR-4.pdf

[3] Kumar, Rakesh, J.S. Mishra, Surajit Mondal, Ram Swaroop Meena, P.K. Sundaram, B.P. Bhatt, R.S. Pan, et al. "Designing an Ecofriendly and Carbon-Cum-Energy Efficient Production System for the Diverse Agroecosystem of South Asia." *Energy* 214 (January 2021): 118860. https://doi.org/10.1016/j.energy.2020.118860.

[4] African Development Bank Group. "Africa Adaptation Acceleration Program." AFDB Initiatives and Partnerships, n.d https://www.afdb.org/en/aaap

Diagnosis

The Challenge

Agriculture and Climate Change: Critical Feedback Loop

Climate change heightens agrarian vulnerability, reduces crop yields, biodiversity, nutritional quality, and farmer incomes,[5,6] particularly for smallholder farmers who produce 70–80% of global food.[7,8] In major rice-producing countries – China, India, and Indonesia – the impact of climate change on rice is well-documented. In India, cereal yields are expected to decline by 3–20% by 2050, with rainfed rice most affected;[9] and a 1°C rise may reduce agricultural revenues by 17–21%.[10]

The agricultural sector also accounts for 11.7% of global greenhouse gas (GHG) (2021)[11] and is a major source of short-lived climate pollutants (SLCPs).[12]

[5] Gulati, Ashok, Shyama Jose, Sanchit Gupta, eds. *Climate-Proofing Agriculture*. Agri-Food Trends and Analytics Bulletin, 2023. https://icrier.org/pdf/bulletins/AFTAB_Vol-3_Issue-1.pdf.

[6]Touch, Van, Daniel K Y Tan, Brian R Cook, et al. "Smallholder Farmers' Challenges and Opportunities: Implications for Agricultural Production, Environment and Food Security." *Journal of Environmental Management* 370 (2024): 122536. https://doi.org/10.1016/j.jenvman.2024.122536.

[7] Morton, John F. "The Impact of Climate Change on Smallholder and Subsistence Agriculture." *Proceedings of the National Academy of Sciences* 104, no. 50 (2007): 19680–85. https://doi.org/10.1073/pnas.0701855104.

[8]Touch et al., "Smallholder Farmers' Challenges and Opportunities: Implications for Agricultural Production, Environment and Food Security."

[9] "Impact of Climate Change on Agriculture" PIB, March 23, 2023. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1909206.

[10] Mohapatra, Souryabrata, Le Wen, Basil Sharp, and Dukhabandhu Sahoo. "Unveiling the Spatial Dynamics of Climate Impact on Rice Yield in India." *Economic Analysis and Policy* 83 (July 30, 2024): 922–45. https://doi.org/10.1016/j.eap.2024.07.021.

[11] Ge, Mengpin "Where Do Emissions Come From? 4 Charts Explain Greenhouse Gas Emissions by Sector." World Resources Institute, n.d. https://www.wri.org/insights/4-charts-explain-greenhouse-gas-emissions-countries-and-sectors.

[12] The agricultural sector — including rice cultivation, manure management, livestock, and residue burning — contributes to 40% of methane (CH_4) emissions, which is 81 times more potent than CO_2 over a 20-year timescale; 84% of nitrous oxide (N_2O) emissions, which is 273 times more potent over a 100-year timescale; and significant amounts of tropospheric ozone (O_3) and black carbon (BC), which is 1500 times more potent; GHG Protocol. "IPCC Global Warming Potential Values," August 7, 2024. https://ghgprotocol.org/sites/default/files/2024- 08/Global-Warming-Potential-Values%20%28August%202024%29.pdf;

Compared to carbon dioxide (CO_2), SLCPs have a higher warming potential, cause ecosystem damage, and 93% of the global yield loss.[13] Rice, grown on 12% of global cropland, accounts for 10.1% of agricultural emissions.[14] It contributes 6–22% of methane (CH_4) and 11% of N_2O emissions, driven by methanogenic bacteria in waterlogged fields and the use of nitrogen fertilizers, respectively.[15] CH_4 is a precursor to tropospheric ozone (O_3), which leads to 3–4% of yield loss for rice.[16] Stubble burning contributes about 5% of black carbon (BC) emissions, which reduces the light available to plants and raises surface temperature.[17]

Global food demand is projected to rise by 70% by 2050,[18] including an 11% for rice.[19] The associated increase in SLCPs, which drives 40–45% of warming, risks intensifying regional heat and water stress, undermining yield stability and accelerating a negative climate–agriculture feedback loop.[20]

Loaiza, Sandra, Louis Verchot, Drochss Valencia, et al. "Identifying Rice Varieties for Mitigating Methane and Nitrous Oxide Emissions Under Intermittent Irrigation." *Journal of Environmental Management* 372 2024): 123376. https://doi.org/10.1016/j.jenvman.2024.123376.

13 Shindell, Drew T. "Crop Yield Changes Induced by Emissions of Individual Climate-altering Pollutants." *Earth S Future* 4, no. 8 (July 12, 2016): 373–80. https://doi.org/10.1002/2016ef000377.

14 Wang, Xiang, Xiaoyan Chang, Libang Ma, Jing Bai, Man Liang, and Simin Yan. "Global and Regional Trends in Greenhouse Gas Emissions From Rice Production, Trade, and Consumption." *Environmental Impact Assessment Review* 101 (May 10, 2023): 107141. https://doi.org/10.1016/j.eiar.2023.107141.

15 Loaiza et al., "Identifying Rice Varieties for Mitigating Methane and Nitrous Oxide Emissions Under Intermittent Irrigation."

16 The Climate and Clean Air Coalition. *Time to Act to Reduce Short-lived Climate Pollutants*, 2014. https://www.ccacoalition.org/sites/default/files/resources/Time%20To%20Act%20to%20reduce%20Short-Lived%20Climate%20Pollutants.pdf.

17 "Black Carbon", The Climate and Clean Air Coalition, accessed April 5, 2025 https://www.ccacoalition.org/short-lived-climate-pollutants/black-carbon.

18 Food and Agriculture Organization of The United Nations. *"Expert Report on How to Feed the World in 2050." (June 2009). https://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf.*

19 Pede, Valerien O., Harold Glenn Valera, Ashok K. Mishra, and Jean Balié. "Future of Rice in Asia: Perspectives and Opportunities, 2050." In *WORLD SCIENTIFIC eBooks*, 108–38, 2024. https://doi.org/10.1142/9789811278297_0005.

20 Institute for Governance & Sustainable Development. *Primer on Short-Lived Climate Pollutants*, 2013. https://igsd.org/documents/PrimeronShort-LivedClimatePollutantsFeb192013.pdf.

Crop Diversification for SLCP Mitigation and Biodiversity Goals

Across the world, the Green Revolution tripled agricultural output since the 1960s; but it also drove emissions, ecological stress, pest vulnerability, and nutritional decline.[21] For example, China's 74% rise in crop production (1986–2016) came with approximately 300% more fertilizer use. In India, high-yielding varieties with 20% more grain[22] and fossil subsidies, increased cropping intensity to 2–3 cycles a year but resulted in the depletion of groundwater by 10–12m below ground-level (2000–2022),[23] and loss of indigenous cultivars resistant to drought, salinity and floods.

Bearing in mind the socio-economic security provided by cereal crops, diversification[24] to climate-smart, high-value crops like legumes, fruits, vegetables, millets, oilseeds offer a pathway to manage associated CH_4,[25] BC and N_2O emissions (through reduced residue and synthetic nitrogen use and biological nitrogen-fixation[26]). This shift brings individual to large-scale co-benefits including

[21] Pingali, "Green Revolution: Impacts, Limits, and the Path Ahead."

[22] Nelson, Ann Raeboline Lincy Eliazer, Kavitha Ravichandran, and Usha Antony. "The Impact of the Green Revolution on Indigenous Crops of India." *Journal of Ethnic Foods* 6, no. 1 (October 1, 2019). https://doi.org/10.1186/s42779-019-0011-9.

[23] Singh, Reena. Purvi Thangaraj, Ritika Juneja, Ashok Gulati. "Saving Punjab and Haryana From Ecological Disaster: Re-aligning Agri-Food Policies." Policy brief. Indian Council for Research on International Economic Relations (ICRIER), 2024. https://icrier.org/pdf/PB-21.pdf.

[24] Crop diversification refers to growing multiple crops within a farm holding or across different regions . This includes spatial diversification (i.e. intercropping or growing multiple crops together in the same field), temporal diversification (i.e. seasonal or annual crop rotations), genetic diversification (using various crop varieties).

Vernooy, Ronnie. "Does Crop Diversification Lead to Climate-related Resilience? Improving the Theory Through Insights on Practice." *Agroecology and Sustainable Food Systems* 46, no. 6 (May 12, 2022): 877–901. https://doi.org/10.1080/21683565.2022.2076184.

[25] Tata-Cornell Institute for Agriculture and Nutrition (TCI) and Professional Assistance for Development Action (PRADAN). "Moving From Rice to More Sustainable Crops Can Significantly Lower Chhattisgarh's Greenhouse Gas Emissions." Report. *TCI SPECIAL POLICY BRIEF*, n.d. https://tci.cornell.edu/wp-content/uploads/2025/01/Policy_Brief_Promoting_Agricultural_Diversification_Climate_Resiliency_Chhattisgarh_India.pdf.

[26] Yang et al., "Diversifying Crop Rotation Increases Food Production, Reduces Net Greenhouse Gas Emissions and Improves Soil Health."

improved health, dietary diversity, food and income security, ecological resilience, and soil health.[27]

Challenges to Crop Diversification: Insights from India

Given the advantages of diversifying from paddy, national and sub-national policies – including climate action plans – are promoting this shift.[28] Financial incentives like assured procurement[29] and deficiency payments for alternative crops[30] (India)[31] and behavioural nudges (Indonesia)[32] have been introduced. Yet the traditionally developed specialised agro-food chains present some systemic barriers.

1. *Trade-off with assured profitability:* With limited allocated funding for R&D and training,[33] farmers associate high risk with diverting scarce land to alternative crops.[34]
2. *Entrenched cropping systems and market networks:* The dominance of paddy–wheat rotations in India is underpinned by robust post-harvest marketing, and credit infrastructure.[35] The absence of similar support and

[27] Vernooy, "Does Crop Diversification Lead to Climate-Related Resilience? Improving the Theory Through Insights on Practice."

[28] The State Action Plan on Climate Change of Uttar Pradesh and, Odisha recognize crop diversification as a climate mitigation strategy

[29] Called Minimum Support Price (MSP)in India

[30] Damodaran, Harish. "Why Haryana's Agriculture Is Different From Punjab's." *The Indian Express*, October 1, 2024. https://indianexpress.com/article/explained/explained-economics/haryana-agriculture-different-punjab-9551911/.

[31] Punjab and Haryana offering incentives of 7000/acres and 8000/ha for shifting to crops like maize funded 60:40 ration centre and state.

[32]Ludher, Elyssa. "Diversifying From Rice to Alternative Crops in Southeast Asia,"*Fulcrum* January 12, 2024. https://fulcrum.sg/diversifying-from-rice-to-alternative-crops-in-southeast-asia/.

[33] Keller, Chigusa, Smita Joshi, Tanay Joshi, Eva Goldmann, and Amritbir Riar. "Challenges for Crop Diversification in Cotton-based Farming Systems in India: A Comprehensive Gap Analysis Between Practices and Policies." *Frontiers in Agronomy* 6 (2024). https://doi.org/10.3389/fagro.2024.1370878.

[34] Basu, Ranjini. "Fraught With Contestations: Crop-Diversification Under Agrarian Distress in Indian Punjab," Post-doc diss., *n.d.* University of Pennsylvania Institute for Advanced Study of India.

[35] Basu. "Fraught With Contestations: Crop-Diversification Under Agrarian Distress in Indian Punjab"

access to responsive markets for alternative crops force farmers into distressed sales and to absorb the price volatility making their scaled adoption difficult.

3. *Skewed incentives:* In India, despite extension of assured procurement prices for alternate crops, rotations replacing paddy would still lead to revenue loss for farmers.[36] Higher wholesale prices[37] and Green Revolution-era incentives – fertilizer and power subsidies[38] – make paddy an economic choice even in water-scarce regions.[39]
4. *Irrigation infrastructure:* Existing infrastructure continues to support water-intensive crops even in dry regions and the absence of a groundwater management and pricing mechanism discourages water–efficient alternatives.[40]
5. *Higher labour and input demand:* Absence of ready resource pools for crops like cotton, groundnut, and chilli make the crops unaffordable without credit or mechanisation.[41]

[36] Saini, Shweta, and T Nanda Kumar. "Why Punjab's Farmers Are Unlikely to Diversify Their Produce Despite MSP Guarantee." *The Indian Express*, March 21, 2024. https://indianexpress.com/article/opinion/columns/why-punjabs-farmers-are-unlikely-to-diversify-their-produce-despite-msp-guarantee-9225435/ .

[37] Express News Service. "Farmers in Odisha Return to Paddy Cultivation for Lure of Minimum Support Price." The New Indian Express, August 25, 2024. https://www.newindianexpress.com/states/odisha/2024/Aug/25/farmers-in-odisha-return-to-paddy-cultivation-for-lure-of-minimum-support-price.

[38] Singh. "Saving Punjab and Haryana From Ecological Disaster: Re-Aligning Agri-Food Policies."

[39] Gulati, Ashok, Ritika Juneja, Purvi Thangaraj, eds. *Re-aligning Agri-Food Policies for Protecting Soil, Water, Air, and Biodiversity (SWAB)*, Agri-Food Trends and Analytics Bulletin, 2024. https://icrier.org/pdf/bulletins/AFTAB_Vol-3_Issue-1.pdf.

[40] Kumar, Pradeep. "Crop Diversification in Punjab: Challenges and Opportunities," *Borlaug Institute for South Asia.* accessed on April 5, 2025. https://bisa.org/crop-diversification-in-punjab-challenges-and-opportunities/.

[41] Varsha, Navitha, Syamkrishnan P. Aryan, Divyata Joshi, Shreenivas Dharmaraja, "Addressing the Labour Barrier in the Transition to Crop Diversification." Water, Environment, Land and Livelihoods (WELL) Labs, Institute for Financial Management and Research (IFMR) Society. 2025. and Research (IFMR) Society. https://welllabs.org/labour-barrier-transition-crop-diversification/

6. *Market instability:* Remunerative alternatives like soybeans[42] and vegetables[43] are risky ventures for diversification, without price assurance.
7. *Socio-political barriers:* Concerns over the complexity of diversified systems,[44] potential food shortages and inflationary pressures generate political hesitation.

Relevance to the G20

The G20 represents 85% of global GDP[45] and includes countries with high emissions[46] and persistent undernutrition.[47] Moreover, one Mt of CH_4 is estimated to cause a loss of 145 Kt of staple crops – disproportionately affecting Brazil, China, India, and the US Paddy fields in China and South Asia emit about 8Mt of CH_4 annually each, while Southeast Asia (including Korea and Japan) emits about 10Mt.[48] In the Global South, where food security remains a pressing concern, CH_4 is a survival emission. Thus, strategies must ensure livelihood security with the co-benefit of reducing these potent pollutants.[49]

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42 Chawla, Akshi, and Akshi Chawla. "A Summer of Discontent for India's Soybean Farmers » CEDA." *CEDA »* (blog), November 7, 2024. https://ceda.ashoka.edu.in/a-summer-of-discontent-for-indias-soybean-farmers/.

43 "Cobweb Phenomenon: How an Abundant Crop Ruins Farmers." The Hindu, May 8, 2017. https://www.thehindu.com/news/national/karnataka/glut-ruins-farmers-trapped-in-cobweb-phenomenon/article18404845.ece.

44 Mihrete, Tesfahun Belay, and Fasikaw Belay Mihretu. "Crop Diversification for Ensuring Sustainable Agriculture, Risk Management and Food Security." *Global Challenges* 9, no. 2 (January 12, 2025). https://doi.org/10.1002/gch2.202400267.

45 "About G20," n.d., Accessed on May 12, 2025, https://g20.org/about-g20/.

46 Friedrich, Johannes. "This Interactive Chart Shows Changes in the World's Top 10 Emitters." World Resources Institute, March 2,2023 https://www.wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters.

47 United Nations Children's Fund (UNICEF), *Undernourished and Overlooked: A Global Nutrition Crisis in Adolescent Girls and Women*, UNICEF Child Nutrition Report Series, 2022 (New York: UNICEF, 2023).

48 United Nations Environment Programme and Climate and Clean Air Coalition. *Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions*. Nairobi: United Nations Environment Programme, 2021.

49 Government of India, Ministry of Environment and, Forest and Climate Change, "Lok Sabha Unstarred Question No. 2970, Global Methane Pledge", August 7, 2023. https://sansad.in/getFile/loksabhaquestions/annex/1712/AU2970.pdf?source=pqals

With only 12% of the 2030 SDG agenda on track,[50] recent Global South G20 presidencies have underscored agri-food systems reforms as pathways to poverty reduction, nutrition, biodiversity, and emission goals,[51] which are particularly significant for Africa.

India's presidency reaffirmed the right to adequate food through the Deccan High–Level Principles and launched the MAHARISHI Initiative,[52] encouraging cereal-dominant economies to adopt traditional, climate-resilient crops requiring minimal synthetics.[53] Brazil advanced the agenda with the Global Alliance against Hunger and Poverty (GAHP) and TF–CLIMA[54] aiming to mobilise finance for evidence-based, cross-sectoral food policies. Africa's presidency furthers this with a dedicated Task Force on Food Security that prioritises strategic investment, price stabilisation and climate resilience which can encourage and be addressed by strategies like crop diversification. Aligned with South Africa's leadership at the Committee on World Food Security, this opens a window for policy and technology exchange, and devolved climate and biodiversity finance, enabling rapid SLCP mitigation through food systems.[55]

Recommendations

Crop diversification can improve dietary diversity by 15–20%, result in 30% reduction in pest–related yield loss, and a 15% yield increase under climate stress,

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[50] Brazil G20, "G20 Rio De Janeiro Leaders' Declaration," 2024, https://g20.org/wp-content/uploads/2024/11/G20-Rio-de-Janeiro-Leaders-Declaration-EN.pdf.

[51] JUST RURAL TRANSITION, "The Case for Repurposing Public Support to Agriculture," 2021, https://justruraltransition.org/wp-content/uploads/sites/12/2021/05/JRT-Repurposing_Policy_Brief.pdf.

[52] Millets and other Ancient Grains International Research Initiative.

"General (Dr.) V K Singh (Retd.) Inaugurates the G20 Meeting of Agricultural Chief Scientists (MACS),"PIB, April 14, 2023. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1917391.

[53] Ludher."Diversifying From Rice to Alternative Crops in Southeast Asia"

[54] Task Force on a Global Mobilisation against Climate Change

[55] G20 South Africa Agriculture Working Group, Sherpa Track, " Concept Note Task Force 2 Food Secuirty", 2025, https://g20.org/wp-content/uploads/2025/04/TASK-FORCE-2-CONCEPT-NOTE.pdf.

enhancing farmer income. Additionally, it can lead to 30–40% increase in agricultural biodiversity.[56]

However, crop diversification also requires policy shifts, investments, and international cooperation. To ensure sustained momentum, some recommendations to the G20 include:

1. Repurposing Agricultural Support from Paddy Dominance for Climate Adaptation

- **Market linkages for alternate crops**: Globally, agriculture receives over $700 billion annually – mostly supporting cereal grains and direct income aid.[57] Crop diversification enables repurposing part of this support toward infrastructure and R&D for nutrient–dense crops. Agro-ecological production clusters and digital integration can strengthen market linkages.[58]
- **Reorienting subsidies**: Input subsidies for urea and power drive emissions and lock–in paddy. Shifting to 'area-diversified' incentives – agnostic to input or crop type – can serve as behavioural nudges.[59]
- **R&D for methane mitigation in agriculture**: Improving productivity of paddy and alternative crops addresses concerns of food security and profitability-trade-off[60] while also achieving climate goals. Techniques such as System of Rice Intensification, Alternate Wetting and Drying, and Direct Seeded

[56] Mihrete and Mihretu, "Crop Diversification for Ensuring Sustainable Agriculture, Risk Management and Food Security."

[57] JUST RURAL TRANSITION, "The Case for Repurposing Public Support to Agriculture," 2021, https://justruraltransition.org/wp-content/uploads/sites/12/2021/05/JRT-Repurposing_Policy_Brief.pdf.

[58] "Achieving Samrudhi: Odisha's New Agriculture Policy Focuses on Crop Diversification, Market Linkages & Use of Technology." *Financial Express*, March 16, 2020. https://www.financialexpress.com/opinion/achieving-samrudhi-odishas-new-agriculture-policy-focuses-on-crop-diversification-market-linkages-use-of-technology/1900067/.

[59] Gulati. *Re-aligning Agri-Food Policies for Protecting Soil, Water, Air, and Biodiversity (SWAB)*.

[60] Saini and Kumar, "Why Punjab's Farmers Are Unlikely to Diversify Their Produce Despite MSP Guarantee."

Rice contribute to methane reductions of 10–50%[61] [62] [63] without adversely affecting yield. However, collaborative cross–sectional and longitudinal research on these and emerging techniques – varietal improvement, Azolla algae, methanotrophs and rice–straw biochar – is required.

2. Innovation and collaboration for building farmer resilience

- **Enhancing rural infrastructure**: Investment in electrification, transportation and infrastructure can unlock private investment for rural areas. Contract farming, agri-tech and climate start-ups can facilitate better price realisation, enhance risk appetite, bridge market and capital gaps for low-methane crops.
- **Public-Private engagements**: India's dairy sector demonstrates the potential of cooperatives for improving logistics and market linkages.[64] Similarly, the African Development Bank's Adaptation Acceleration Programme exemplifies the importance of private and developmental bank collaboration for financing agri-climate innovations.[65]
- **Carbon Financing**: Since rice cultivation primarily emits CH_4 and N_2O, the GWP100 and GWP20 metric proves to be inadequate to measure the abatement interventions in paddy fields. Instead, the RfP (Radiative Forcing Protocol) can account for varying time–horizons of non-CO_2 gases and the diversification co–benefits, thus enhancing credit quality and quantity.

[61] NDCs, Food Forward. "Reducing Emissions From Rice Cultivation - Food Forward NDCs." Food Forward NDCs, August 7, 2024. https://foodforwardndcs.panda.org/food-production/reducing-emissions-from-rice-cultivation/.

[62] Asian Development Bank. "How Can We Incentivize Reducing Methane Emission in Rice Farming in Asia?"ADB, January 12, 2024. https://www.adb.org/news/events/how-can-we-incentivize-reducing-methane-emission-rice-farming-asia.

[63] Wipogreen."Direct-seeding of rice (DSR)," accessed on April 5, 2025. https://wipogreen.wipo.int/wipogreen-database/articles/146703.

[64] Das, Raya, and Ashok Gulati. "Crop Diversification for Farmers and Agricultural Labourers." *ICRIER Policy Brief*, 2025, 1. https://icrier.org/pdf/pb34_Crop-Diversification-for-Farmers.pdf.

[65]African Development Bank Group. "Africa Adaptation Acceleration Program." AFDB Initiatives and Partnerships, n.d.https://www.afdb.org/en/aaap

- **Strengthen Agri-Climate Information Systems***:* Investment in early warning systems, GHG monitoring, and farmer demonstrations helps smallholders plan cropping cycles, access schemes, optimise inputs, and claim climate finance.[66]The Agricultural Market Information System (AMIS), GEOGLAM[67] has proven effective in responding to price and climate volatility[68] and can be expanded to include alternate crops and fertilizers, complementing the GAHP on monitoring region-specific crop diversification.
- **Leveraging Global Initiatives***:* MAHRISHI and GAHP offer a model for consolidating and communicating best practices. The G20 should integrate evidence of successful diversification and develop MRV-MEL[69] frameworks accounting for all GHGs and maximising payouts to beneficiaries (using RfP for carbon-credit generation). Coordinated devolution of financing – such as ESG-linked funds and Global Agriculture and Food Security Program (GAFSP)[70] to smallholders and the last administrative mile can strengthen infrastructure and leverage people's science to de-risk diversification.

A central policy question remains – how much land can be diversified without endangering food security? Evidence suggests reducing one Mt of CH_4 can boost rice yields by 31Kt.[71] The G20 must address critical knowledge, policy, and technology gaps to enable sustainable crop diversification and intensification. For instance enhancing the coverage (and granularity) of the International Methane Emissions Observatory to the agricultural sector; leading a common

[66] Touch et al., "Smallholder Farmers' Challenges and Opportunities: Implications for Agricultural Production, Environment and Food Security."

[67] Group on Earth Observations Global Agricultural Monitoring Initiative

[68] Drechsler, Denis. "AMIS – Enhancing Food Market Transparency and Policy Coordination." International Journal for Rural Development, 2023. https://www.rural21.com/fileadmin/downloads/2023/en-02/rural2023_02_S13-13.pdf.

[69] MRV (Measurement, Reporting, and Verification)- MEL (Monitoring, Evaluation, and Learning)

[70] "Global Agriculture and Food Security Program," March 14, 2025. https://www.gafspfund.org/

[71] UNEP and CCAC. *Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions*.

framework for monitoring adaptation and mitigation in agriculture; and mobilising cross-border, multilateral and blended finance for scaling solutions.

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