FOOD FORWARD NDCs

Reducing emissions from rice cultivation

Overview

Rice is the third-most cultivated cereal crop globally, after maize and wheat, and it accounts for about one-fifth of global calorie consumption. It is a vital staple food for much of the world's population and has critical economic and cultural significance in many developing countries, particularly in Asia. However, rice cultivation faces challenges including declining or stagnant yields, and is associated with an array of negative environmental impacts, including the contamination of natural resources due to excessive use of agrochemicals, biodiversity loss and methane (CH_4) emissions. Rice is responsible for about 1.5% of global greenhouse gas (GHG) emissions and 48% of total GHG emissions from croplands. Rice cultivation also consumes approximately 40% of global freshwater resources and has low water use efficiency (i.e. the ratio of the produced economic yield to the amount of water used).

Concrete measures to implement

Improved irrigation and drainage systems that avoid continuous flooding throughout the growing season can reduce methane emissions and other negative environment impacts generated through rice cultivation. Practices include:

- Alternate wetting and drying (AWD), can also be called "controlled irrigation" or "multiple irrigation" around key rice-crop growth periods such as flowering. This helps to control weeds and ensure rice crops have sufficient water while reducing methane emissions from paddy rice systems, as well as the uptake of arsenic by rice plants, which is highly unhealthy for human consumption.

- Mid-season drainage, also called a single drawdown of water during the mid-season, involves drainage for 5–10 days during the crop growing season, which generates GHG reduction benefits.
- Direct seeding: seeding rice into dry soil rather than already flooded fields, which reduces methane emissions by reducing the flooding season by approximately one month.
- Aerobic Rice system: growing rice in well-drained, non-saturated soils. This may yield lower crop production than other rice cultivation methods but can be suitable for drier or water-scarce climates.
- The System of Rice Intensification (SRI) approach combines AWD irrigation measures with improved soil, nutrient and plant management practices to reduce emissions and increase yields. SRI practices should be tailored to local conditions and be combined with a range of agroecological approaches, such as Conservation Agriculture (CA), but should always follow these key principles:
    - Early establishment of young plants
    - Low plant density
    - Enhanced soil fertility: Add organic matter to the soil and practice mechanical weeding (manual or motorized), instead of chemical weeding.
    - Apply the minimum amount of water needed: Apply AWD irrigation techniques.
- Alternative practices to rice-straw burning that reduce GHG emissions include:
    - Using rice straws and residues: Rice straw and residue that are usually removed from rice fields by burning can instead be harvested and used to make paper, replace wood products (e.g. medium-density fiberboard, MDF) or as biochar.
    - Mulch rice straw residues and retain them in field: After harvest rice crop residues can be mulched and left on the field or incorporated in the soil, before seeding the next crop (see the example of Happy Seeder, a no-tillage and direct-seeding system developed in India).

    - Use diverse, older, local rice genotypes that produce more biomass, which can be used as a soil amendment.
- Research options for climate-resilient adapted rice varieties.

Enabling governance measures

- Promotion of inclusive farmer organisations/cooperatives for local development, community- driven approaches and support for capacity building.
- Promotion of rental services for agricultural machinery for smallholders to access services of agricultural machinery (e.g. tractors, harvesters and threshers).
- Policies to promote the adoption of input-saving technologies.
- Improving equitable access to institutional credit and finance to farmers for income stabilisation.
- Piloting and refining financing mechanisms (e.g. Payment for Environmental Services).
- Investment in R&D for developing and supporting technological innovations in all stages of the rice value chain.
- Targetted training programmes to build the capacity of young people to access and effectively use new technology and information for rice production.
- Capacity-building, education, and training with farmers on the harmful impacts of burning rice straw.
- Support the production of locally adapted rice varieties and design systems to make quality seeds available and affordable to smallholders.
- The redirection of subsidies to avoid the excessive use of environmentally harmful inputs and support the use of quality organic inputs.
- Update government training programmes to incorporate innovative cultivation practices that produce lower emissions rice.

Tools and MRV systems to monitor progress

Calculators and Trackers

FAO EX-Ante Carbon-balance Tool (EX-ACT)

FAO EX-Ante Carbon-balance Tool provides users with a consistent way of estimating and tracking the outcomes of agricultural interventions on GHG emissions

Link: https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act/en/

IRRI Greenhouse Gas Calculator

IRRI's SECTOR Greenhouse Gas Calculator for cropland uses the IPCC Tier 2 approach and requires inputs from the user on cropping area, yield, and management practices.

Link: https://ghgmitigation.irri.org/knowledge-products/mrv-toolbox/sector

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Guides and handbooks

IRRI GHG Mitigation in Rice Information Kiosk

International Rice Research Institute's (IRRI) GHG Mitigation in Rice Information Kiosk serves as an information hub for greenhouse gas emissions and mitigation options in rice production systems.

Link: https://ghgmitigation.irri.org/#h.p_KzsN-LYMInrb

SRI-2030

Through the Sustainable Rice NDC Alliance, SRI-2023 assists governments with implementing measures to reduce emissions and increase yields from rice cultivation.

Link: https://www.sri-2030.org/

Climate change mitigation benefits

- AWD and SRI systems can reduce methane emissions by 35-48% compared to conventional cultivation systems.
- Aerobic rice system can reduce methane emissions by up to 70%.
- Combined systems, such as dry seeding with AWD, have been found to reduce emissions by up to 90% compared to rice flooding methods.
- SRI can double carbon sequestration rates.

Other environmental benefits

- Air pollution reduction and public health benefits from avoided post-harvest residue burning.
- Reduced energy consumption and associated emissions from reduced water pumping for irrigation.
- Reduced land-use change and associated emissions from sustainable intensification practices (e.g. SRI) that maintain or increase rice yields prevent further conversion of natural areas into agricultural land.

Adaptation benefits

- Livelihood benefits and poverty alleviation for farmers through reduced farming input costs (e.g. less fertiliser use through residue mulching and water reduction) and increased productivity.
- Increased crop yields: Practices such as AWD can maintain crop yields if done correctly, and SRI can significantly increase yields. A recent meta-analysis found that SRI increased yields by an average of 56% when compared to conventional cultivation practices.
- Water saving: Reduced water use enables freshwater supply for other uses and/or downstream ecosystem services.
- Potential for increased gender equality: Women provide much of the labor input in rice-producing areas and as such, may yield more benefits from improved rice cultivation techniques that reduce the labor intensity. This may in turn provide time- and energy savings for women with other household or childcare responsibilities.

Other sustainable development benefits

- Improved irrigation and drainage systems in rice cultivation can contribute to nine different SDGs, according to **RICE**, a collaboration between the International Rice Research Institute, Africa Rice Center (AfricaRice), and International Center for Tropical Agriculture (CIAT):
  - SDG 1 (No poverty)
  - SDG 2 (Zero hunger)
  - SDG 5 (Gender equality)
  - SDG 6 (Clean water and sanitation)
  - SDG 8 (Decent work and economic growth)
  - SDG 12 (Responsible consumption and production)
  - SDG 13 (Climate action): GHG emissions reduction through rice cultivation.
  - SDG 15 (Life on land)

Assamese farmers irrigating rice fields, Assam, India.

Implementation challenges and potential externalities and trade-offs

- Although AWD and aerobic rice cultivation methods have **shown to have higher yields**, in some parts of the world these have not been widely adopted due to the **risk of yield reductions** – compared to conventional methods – if practices are not optimally implemented.
- SRI requires farmers to have higher levels of knowledge and skills, particularly relating to transplanting, water management and nutrient management. This can be a barrier to adoption for some farmers.
- Water-saving practices such as AWD and direct seeding may increase the risk of weed infestations, since rice plants are initially smaller, and weeds can more easily compete for resources. This can necessitate higher additional farm-level investment needs for chemical, mechanical or biological weed control.
- Poor seed germination and sub-optimal plant population can cause low yields in direct seeding.
- Drainage has the unintended effect of increasing nitrous oxide (N_2O) emissions, but this is always offset by the reduction in methane emissions.

Measures to address potential externalities and trade-offs

- To prevent yield reductions in AWD it is important to continuously irrigate crops during and after the start of the reproductive phase of the crop (i.e. flowering to grain filling), when it is most sensitive to water shortage.
- Farmers may need to increase weed control measures for aerobic rice cultivation, such as herbicides or manual weeding, to maintain yields. However, with correct implementation of AWD techniques, increases in such methods should still remain minimal.
- Targeted training and extension services should be implemented or strengthened to support farmers.
- **Integrated pest management practices**, together with pest-resistant varieties and judicious use of pesticides, can reduce pesticide use and the overall loss due to pests.
- Excessive use of chemical fertilizers can be avoided by applying integrated nutrient management.
    - The integration of legume cover crops between main crops can help improve soil health.
    - Composting crop residues instead of burning them can help to reduce external input costs and improve soil health.
- Nutrient loss and nitrous oxide emissions and be reduced by applying site- and season-specific nutrient management (SSNM).

Implementation costs

These practices can reduce the cost of rice cultivation and increase farmers' incomes. However, cost of implementation varies by country, local context, and may depend on the existence of irrigation or other agricultural technology.

- In a 2019 analysis of SRI implementation in Malaysia, researchers found SRI techniques had significant financial and food security benefits from increased profit and rice yield for farmers. SRI reduces cost by optimizing the use of inputs like seeds, synthetic fertilizers, and water, ultimately resulting in increased farmers' profits.

- In one analysis, AWD, modified SRI and direct-seeded rice increased yield by 960kg/ha, 930 kg/ha and 770 kg/kg, respectively, which increased farmers' income and decreased the cost of cultivation by up to USD 169/ha.
- The International Rice Research Institute advises that if the goal is to calculate the highest mitigation impact-to-cost ratio to reach an NDC goal, it is necessary to include a project investment analyses that includes implementation costs for infrastructure development, capacity building (i.e. training of farmers), and expenses related to taking baseline measurements, monitoring, reporting and verifying farmer practices as well as the **resulting emission reductions**.

Intervention in practice

- In **Bohol, the Philippines**, the National Irrigation Administration (NIA), supported by the Japanese government, took a proactive approach to address a declining and unreliable water supply. Their solution involved the construction of a new dam. To optimize the use of irrigation water from this dam, the NIA implemented an AWD irrigation schedule for rice cultivation in 2006. The reliable flow of water, even in a surface-water system, has allowed the AWD intervention to be successful. Farmers have been able to cultivate a larger area with a 16% increase in irrigated land and, in some parts of the island, they have been able to plant two rice crops each year instead of one.
- In **Vietnam**, with support from FAO, the Plant Protection Department (PPD) began conducting SRI training in three provinces in 2003. Results showed that, on average, farmers who implemented SRI methods increased their income by USD 200 per hectare compared to conventional rice production methods. The increase in income is a result of both higher yields – 500 kilos or more per hectare – and savings on input purchases. By 2011, 1 million farmers had adopted SRI. The PPD reported that SRI adoption covered 16% of the rice land in the north, and 6% of the rice cropland in the country overall.
- The FCDO-funded, LINKS project in Northern Nigeria trained over 45,000 farmers on SRI practices. As a result, yields doubled, the cost of

production fell by 26%, farmer profits increased by over six times, and GHG emissions decreased by 40%.

- The SRI-WAAPP project implemented between 2014 and 2016 in 13 ECOWAS trained 50,048 farmers (33% women) on SRI practices on both irrigated (40%) and rainfed lowland systems (60%). Average SRI yield for irrigated rice increased by 56% while, in rainfed lowland systems, SRI yields averaged +86% increase. Today, a follow up initiative is being implemented in the same area under the name of RICOWAS project.

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