# Greenhouse gas emissions from rice, peanut and millet farms in peninsular India: Effects of water and nitrogen management

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Fair Climate Network

## Background

At Environmental Defense Fund, low-carbon farming (LCF) is an integral component of our international climate work and we recognize that any intervention to mitigate agricultural greenhouse gas emissions should meet farmers' interest and food security needs.

Climate change is already imperiling the livelihoods of small-scale farmers around the globe by exacerbating droughts, heat waves, floods and other extreme-weather events, as well as creating an influx of new pests and diseases. Worldwide, 500 million smallholder farms produce about 80% of the food consumed in Asia and sub-Saharan Africa, and provide livelihoods for more than 2 billion people.[1] In arid and semi-arid regions – home to more than 40% percent of the world's population, including 650 million of the poorest, most food-insecure people – dryland agriculture is particularly vulnerable to drought.[2] Densely populated low-lying coastal areas, where significant agricultural production also takes place, are already experiencing rising sea levels that worsen floods and saline intrusion (i.e., seawater contamination of soils and ground water supplies). Unless business-as-usual GHG emission intensity trends are altered, additional warming will devastate these vulnerable agricultural communities, further exacerbating the immense challenges of poverty alleviation, food and water security, and energy access already being faced by developing countries.

## Objectives

### Broader context

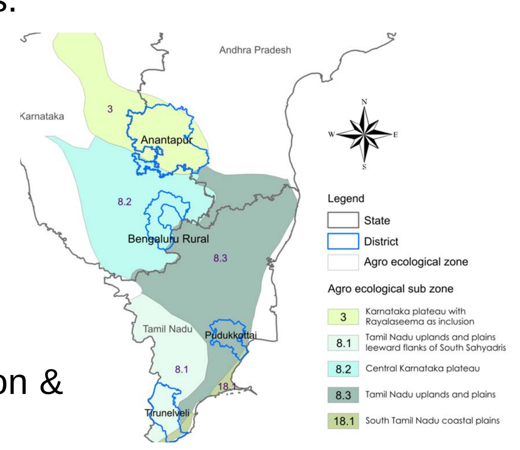
**GHG emissions reduction measurement for methodology development**

As a part of our Low carbon farming project, five GHG measurement laboratories have been set up across three states in peninsular (south) India. These laboratories and associated representative farms represent different agro-ecological sub-zones (AEZ) within the dry-land agriculture belt for which no reliable datasets on GHG emission have been available. The low carbon farming project activities also include collection of extensive surveys for determining baseline economic, demographic and farming practices; research on determining alternative "sustainable" package of farming practices which increase/maintain yield and economic benefit while decreasing GHG emissions; and monitoring, self-reporting and third party verifications. In the near future, we will use the GHG data to calibrate a biogeochemical model to extrapolate emission reductions over large jurisdictions and develop carbon offset methodologies.

### This study

Analysis of nitrous oxide ($N_2O$) and methane ($CH_4$) emission reduction, yield and farm economics at farms representing 2 AEZ and 3 crops:

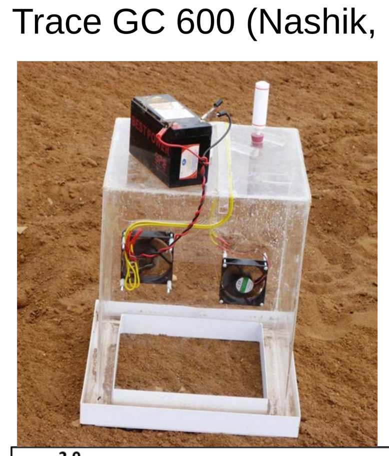
- Groundnut (Peanut) & Rice crop at Accion Fraterna (AF), Anantapur, Andhra Pradesh
- Millet crop at Social Animation Centre for Rural Education & Development (SACRED), rural Bangalore, Karnataka

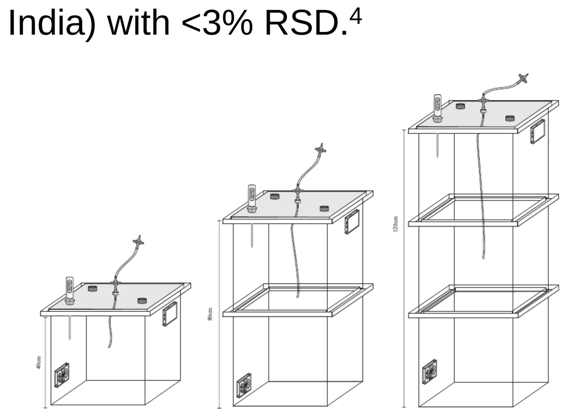


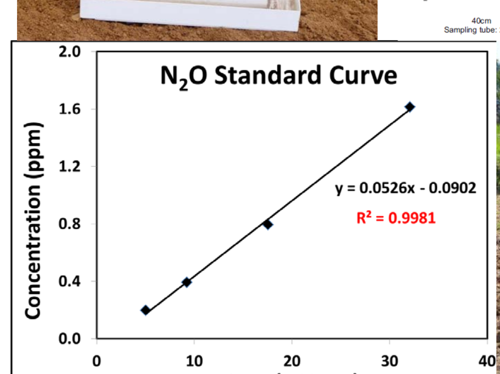

## Methodology

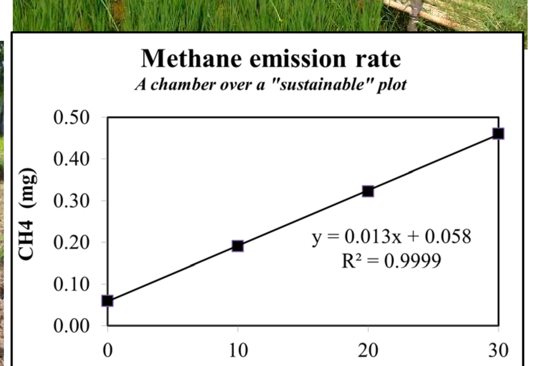
### Nitrous oxide and methane concentration measurement

Field sampling at 3 replicate plots for both baseline (BP) and alternative practices (AP) for growing rice, millet and groundnut using customized GRACEnet protocol.[3] The GHG emission rates quantified less than 12 hours after sample collection using ThermoFisher Trace GC 600 (Nashik, India) with <3% RSD.[4]



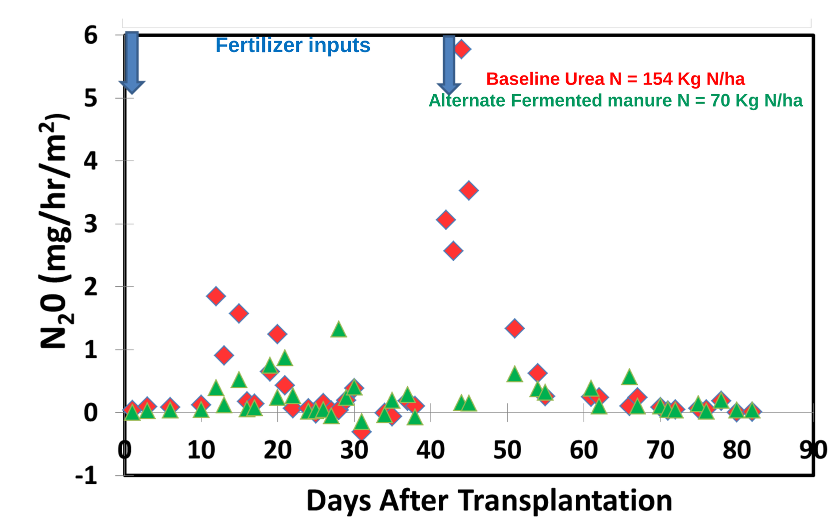





## Results

**Fig. 1 Seasonal $N_2O$ emissions: Rice**
(Anantapur, Andhra Pradesh, AEZ 3.0)




◆ **Baseline practices (BP)** (Average of 3 replicates): 154 Kg N/ ha as 2 Urea or DAP applications, chemical pesticides, irrigation every 2nd day (not permanently flooded)

▲ **Alternate practices (AP)** (Average of 3 replicates): 70 Kg N/Ha as manure (FYM & fermented liquids); Neem cake as pesticide; Irrigation every 3-5th day (AWD)

**Fig. 2 Seasonal $N_2O$ emissions: Millet**
(Bangalore, Karnataka, AEZ 8.2)[5]

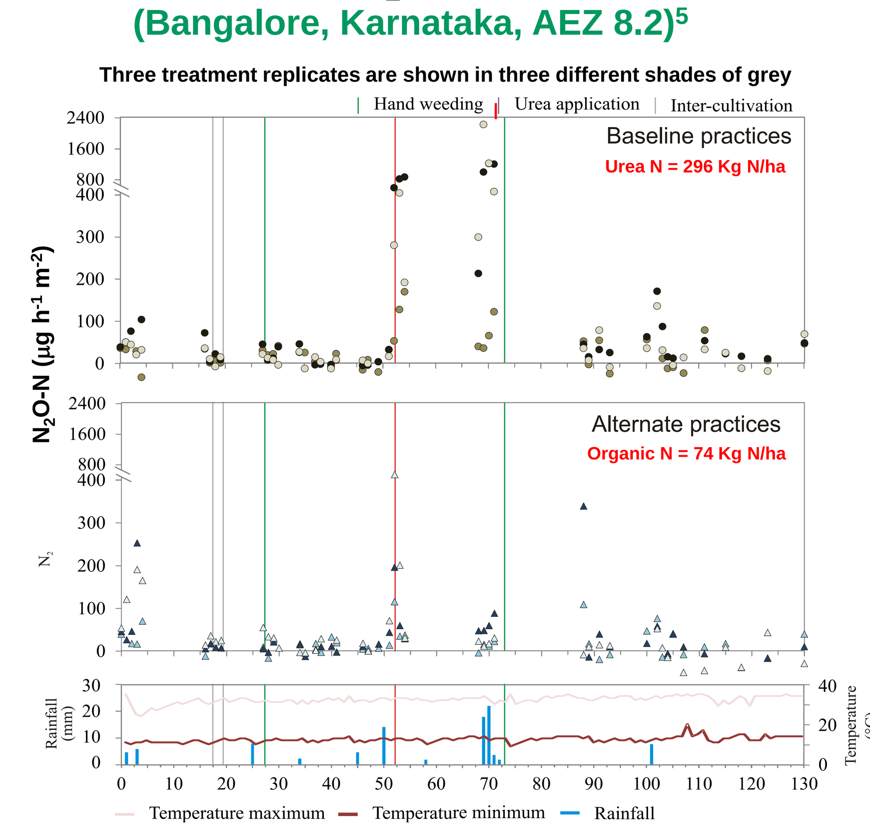
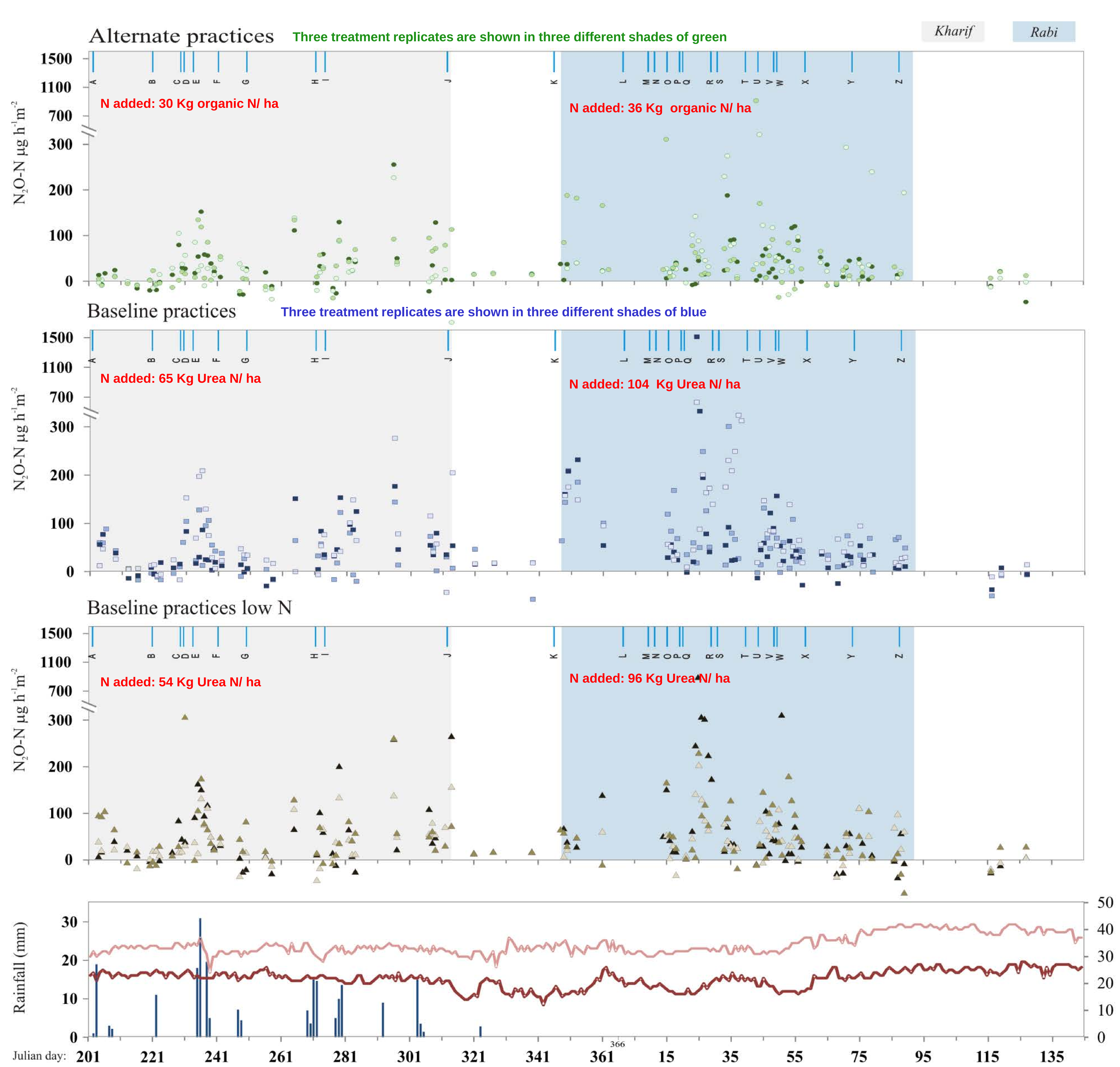



**Fig. 3 Annual $N_2O$ emissions 2012-2013: Groundnut**
*Kharif* (rainfed) & *Rabi* (irrigated) seasons with two fallow periods, Anantapur, AEZ 3.0)[6]




**Julian Day 201 is July 19, 2012 (the day *Kharif* crop was sown). Julian Day 366 is Dec 31, 2012. Events: A - Sowing, B – Weeding, C - AP and BP low N plots irrigated, D - BP plots irrigated, E -Weeding, F - Gypsum, G - Ghanajeewamrutha (AP plots), H - Muriate of potash (BP plots), I - Weeding, J - Harvest, Between J & K: Fallow, K - Sowing, L - Irrigation, M - Jeewamrutha (AP plots), N - Irrigation, O – Gypsum (all plots), P - Urea (BP plots), Q & R - Irrigation, S - Jeewamrutha (AP plots), T, U and V- Irrigation, W - Jeewamrutha (AP plots), X & Y- Irrigation, Z – Harvest, After Z – Fallow**

## Conclusions

- Dryland $N_2O$ emission is triggered by rain (upland crops) & N input and draining (rice). Significant $N_2O$ consumption during dry periods (both upland and rice crop).
- For peninsular India, low-carbon rice cultivation practices (which combine water and N management) offer very large emission reduction potential (2-5 metric tons $CO_2$e per hectare per season) with most of the reduction due to $N_2O$ emission reduction.
- Smaller reductions (0.15-0.5 metric tons $CO_2$e per hectare per season) from peanut & millet cultivation. Table 1 shows the GHG mitigation potential from peanut cultivation in the district where the study was conducted (& country assuming similar reduction) .

**Table 1. Groundnut (AEZ 3.0, South India)**

| | Nitrous oxide emissions (Kg $N_2O$ N/ha) | | Nitrous oxide emissions (ton $CO_2$e/ha) | | GHG mitigation potential (million ton $CO_2$e/ha) | |
|---|---|---|---|---|---|---|
| | Baseline | Sustainable | Baseline | Sustainable | Anantapur | India |
| **Rainfed (*Kharif*) season** | | | | | | |
| This study | 1.431 | 1.095 | 0.67 | 0.513 | 0.110 | 0.600 |
| IPCC EF (1%) | 0.658 | 0.341 | 0.308 | 0.16 | 0.104 | 0.566 |
| Indian EF (0.58%)[7] | 0.381 | 0.193 | 0.179 | 0.091 | 0.062 | 0.336 |
| **Irrigated (Rabi) season** | | | | | | |
| This study | 1.975 | 1.187 | 0.925 | 0.556 | 0.00050 | 0.385 |
| IPCC EF (1%) | 1.043 | 0.297 | 0.489 | 0.139 | 0.00048 | 0.365 |
| Indian EF (0.58%)[7] | 0.605 | 0.173 | 0.283 | 0.081 | 0.00028 | 0.211 |

**For South India, Tier 1 IPCC & Indian regional emissions factors need revision. They**

- grossly under-estimate both the amount of $N_2O$ emissions from baseline rice cultivation practices, and the extent to which these emissions can be reduced through better fertilizer/water management
- Under-estimate the amount of $N_2O$ emissions from groundnut and millet.
- Over-estimate the $CH_4$ emission reduction due to water management for rice.

## Policy implications

Climate mitigation will need to meet the development and food security needs of developing nations and there is an urgent need for strategies that provide a "triple win" 1) enhance farmers' economic development; 2) make agriculture resilient to the impacts of climate change and increase yield thereby increasing food security; 3) mitigate agriculture's GHG emissions to avoid dangerous climate change.

**Our results demonstrate that "Agricultural triple win" is possible.** Our alternate packages maintain/increase yields (seed, above & belowground data gathered but not shown), reduce GHG emissions (Fig 1-3) and increase farmer's profit (Table 2).

**Table 2. Groundnut: Input farming cost**

| Season/Treatment | Seed (Rs*/ha) | Fertilizer (Rs*/ha) | Labor (Rs*/ha) | Total farming cost (Rs*/ha) | Benefit to farmer (Rs*/ha) |
|---|---|---|---|---|---|
| Kharif Baseline | 15561 | 7237 | 22346 | 45023 | |
| Kharif Alternate | 15561 | 1976 | 22346 | 40130 | 5014 |
| Rabi Baseline | 20007 | 6471 | 21170 | 47649 | |
| Rabi Alternate | 20007 | 1976 | 21170 | 43400 | 4248 |

* Rs. 6000 = US $100

In addition, these practices reduce GHG intensive external inputs (synthetic fertilizer and pesticides) and reduce nitrogen loading in the environment by 20-40% thereby increasing water quality. Alternate rice farming also reduces water use by 25-30% and improve long-term soil health by optimizing organic matter and increasing water holding capacity.

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