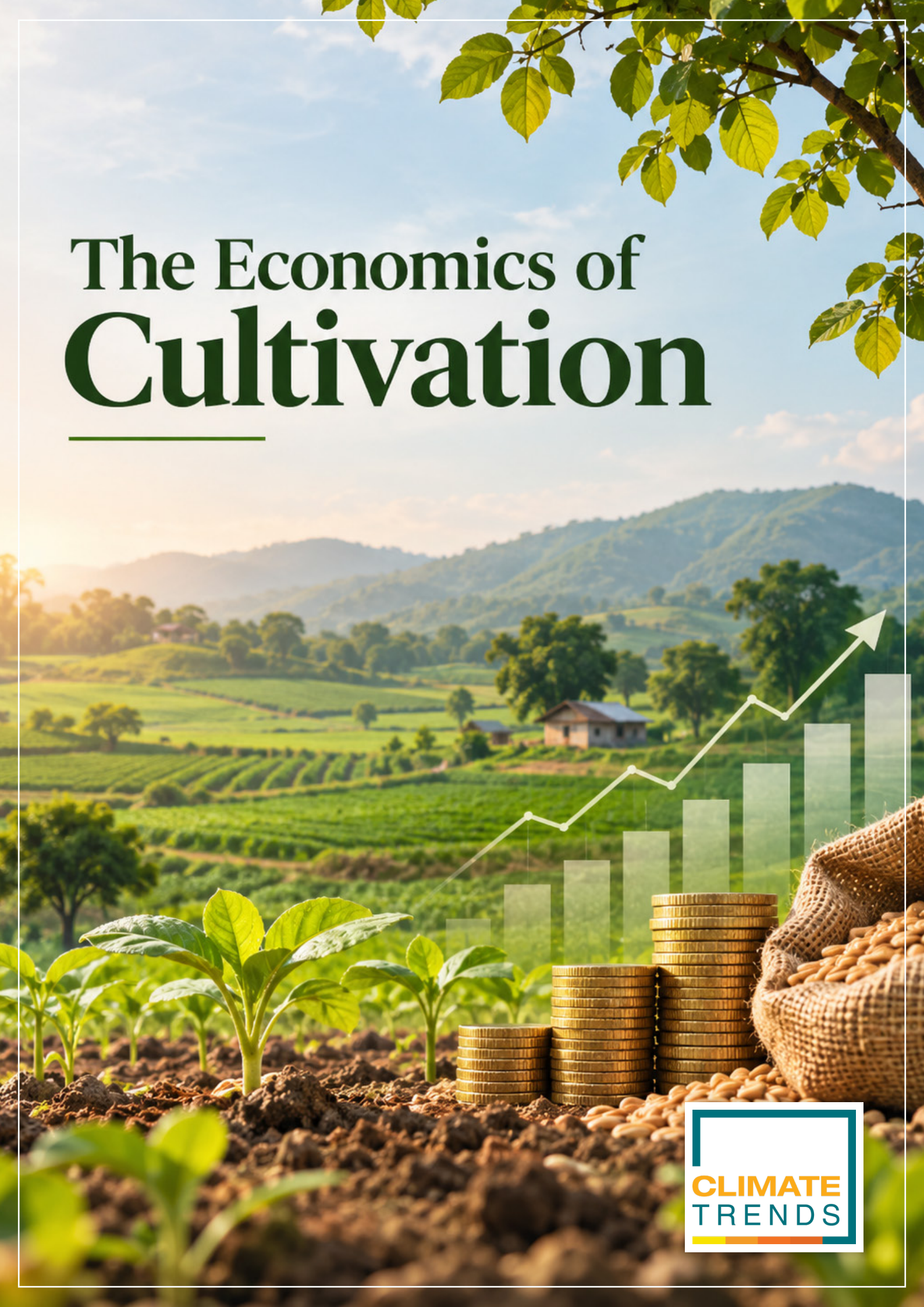
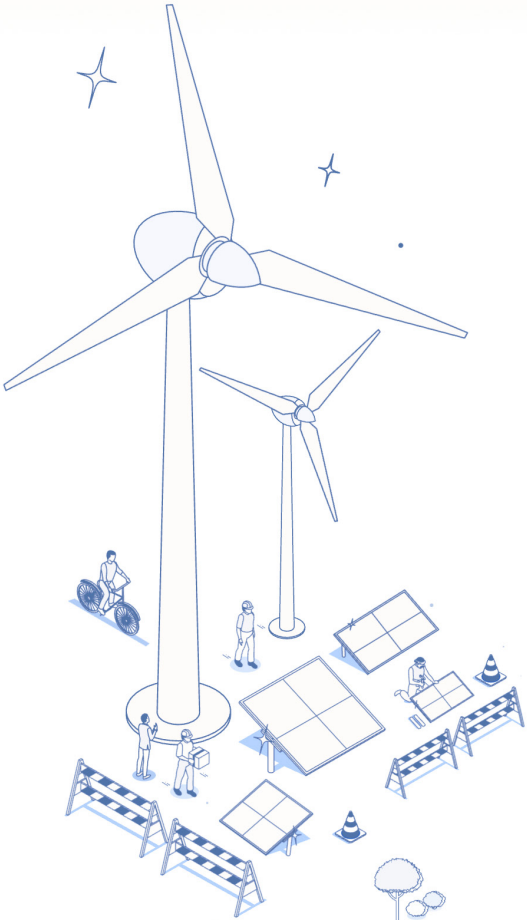
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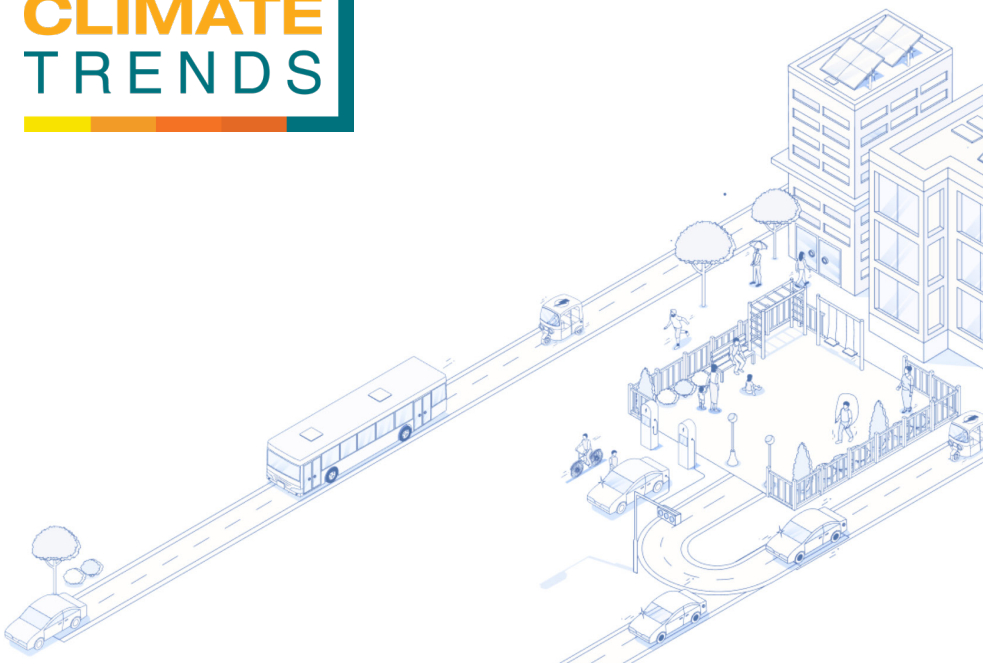
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Abstract

A farmer who uses subsidised urea gets a profitable crop. The country receives something else: a subsidy expenditure that fluctuates with world gas prices, imported feedstock that Hormuz can block, greenhouse gases from factories and fields, and soils and aquifers that absorb the excess. This paper starts from the global fertiliser industry and works down to the Indian farm. It then compares private and social returns for fertiliser-intensive wheat and paddy in eight states. In every wheat case tested, the social return was below the private return (by 36 to 182 per cent), and in two of five it turned negative. The 2010 subsidy reform, which left urea's price fixed, was followed by a statistically significant rise in the nitrogen share of fertiliser use. Organic and natural farming are not a free fix, but with extension support they have raised farmer profits without cutting yields.

01: Background

1.1 The global picture: fertiliser, fossil fuel and climate

Synthetic nitrogen, made when you combine hydrogen, derived from natural gas or coal, with air at high temperature and pressure (the Haber-Bosch process), is, in other words, processed fossil fuel. The broader carbon footprint of the full synthetic nitrogen supply chain (2018 data) is about 1.13 gigatonnes of carbon dioxide equivalent, which is 2.1 per cent of total greenhouse-gas emissions and 10.6 per cent of those from agriculture, with 38.8 per cent from manufacture, 58.6 per cent from nitrous oxide releases in fields and 2.6 per cent from transporting it around the world.[1] The four biggest players combined- China, India, the United States and the EU-28 make up 62 per cent.[1] Nitrous oxide warms roughly 300 times more than CO per tonne, and crops take up roughly half of the applied nitrogen.[2]

What organic farming could save. Because organic systems do not use synthetic nitrogen, the 1.13 Gt supply chain is the theoretical ceiling, and the manufacturing slice (about 0.44 Gt) is saved only if nitrogen is replaced by legumes, manures and biofertilisers. Measured savings are smaller but real. A global meta-analysis found that organic soils emit 492 ± 160 kg CO_2e per hectare per year less nitrous oxide than non-organic soils, although per tonne of crop the advantage disappears if the yield gap exceeds about 17 per cent.[3] A European review found median energy use per unit of product was 21 per cent lower under organic management, mainly because synthetic nitrogen is so energy-intensive to make.[4]

1.2 Who makes it, who buys it

For fertiliser nutrient production, China, Russia, the US, India and Canada account for the majority (over 60%). China itself produces about a quarter of world fertiliser and more than a third of phosphate. Potash is the most concentrated, with around 2/3 of production and reserves concentrated in Canada, Russia and Belarus. Only between 10 and 15% of nitrogen and phosphate fertiliser is traded internationally, compared to 75% of potash.[5,6] Russia alone accounts for one fifth of global fertiliser trade.[7] Major importers include: Brazil, India and the US; Brazil imports nearly all its fertiliser, and India is the second largest urea importer after Brazil.[8] Sub-Saharan Africa is the region most exposed to price spikes, given that this is a region in which fertiliser use is relatively low and fiscal space is thin.[9] Appendix Table A1 summarises this compositional structure.

1.3 When geopolitics hits the fertiliser bag

Hormuz, 2026. After the effective closure of the Strait of Hormuz in late February 2026, all outbound fertiliser cargoes stopped. This strait normally accounts for about one third of seaborne fertiliser trade[10], with 34 per cent of urea, 23 per cent of ammonia, 20 per cent of phosphates and 44 per cent of sulphur.[10] Meanwhile, the World Bank's fertiliser price index increased by more than 12 per cent during the first quarter of 2026, and urea spiked 53. 7 per cent in March to around US$726 a tonne, its highest level in four years.[9] By July, prices had fallen as China resumed urea exports, but sulphur and phosphate remained tight.

Ukraine. The 2022 invasion first pushed gas, potash and nitrogen prices up and disrupted Russian and Belarusian supply, which India then tried to replace from Israel, Oman, Canada and Saudi Arabia.[11] In 2026, the problem has returned in a new form: Ukrainian drone strikes on Russian plants such as Dorogobuzh and Apatit, plus Russian export caps, have limited Russia's ability to fill the gap left by the Gulf; Russian output in April 2026 was 2.5 Mt, down 2.1 per cent year on year.[12]

What it did to India. Approximately 41 per cent of India's crude, 55 per cent of its LNG and around 88 to 90 per cent of its LPG normally transit Hormuz.[13] S&P Global reports a loss for India in crude of around 20 per cent, for LPG of around 12 per cent and for LNG of around 16 per cent.[14] Households experienced the shock first through the LPG shortfall, and the government responded by promoting piped gas (an additional 580,000 new connections in March alone). The same shock was felt by producers of fertiliser: Petronet LNG announced force majeure on 3 March, plants were capped at 60-70 per cent of gas as a result, and urea production shrank by 0.8 Mt in March.[15] There was no national shortage after this, but this was because India had stockpiled reserves and diversified its sourcing strategy; from the beginning of the crisis through to early June it added 6.9 Mt of domestic urea and 1.8 million tonnes of imported urea.[16] There was no reduction in dependence. The costs of that were transferred onto the shoulders of the exchequer.

1.4 India: production, consumption and emissions

India is the second-largest fertiliser producer in the world, accounting for around 20 per cent of global fertiliser production.[8] Fertiliser production of urea increased from 22.7 Mt in 2013-14 to 30.7 Mt in 2024-25 (+35 per cent), and DAP plus NPK from 11.0 to 15.9 Mt (+44 per cent).[17] Nutrients (N+P+K) consumption increased from 0.2 Mt in 1960-61 to 12.5 Mt in 1990-91 and 30.6 Mt in 2023-24 (Appendix Fig. A1b).[18,19,20] Per hectare, nutrient consumption increased from around 2 kg in the 1960s to around 150 kg in 2021-22.[8] Consumption of products was 67.6 Mt in 2022-23 and 65.3 Mt in 2024-25.

In India, manufacturing caused around 25 Mt CO_2e in 2022-23 (0.58 t CO_2 per tonne of fertiliser: urea 16.2 Mt; DAP 2.5 Mt; complex fertilisers 6.1 Mt). 85 per cent arises from natural gas, and around 60 per cent of the gas used is imported.[8] The dependence is profound. India imported about 10.2 Mt of urea and 6.7 Mt of DAP in 2022-23; India's proportion of phosphate rock import is 90 per cent, 80 to 90 per cent of ammonia used in non-urea plants is imported, and the country's potash is entirely imported, as the country has no reserves.[8,17] India's domestically available 'self-sufficiency' (about 87 per cent of urea use) so rests on the gas being imported.

1.5 Chemical farming in India: a short history & its effects

The Green Revolution (high-yielding seeds, irrigation, and fertiliser) turned a PL-480 food aid-dependent country into a nearly self-sufficient grain-producing country, and that achievement is real. But the returns are now declining in many places. ICAR data shows the grain-per-kg fertiliser ratio fallen from 13.4 kgs in 1970 to 2.7 kgs in 2015,[21] & nationwide soil-testing found 97 per cent of samples low in nitrogen, 85 per cent low in organic carbon, 83 per cent low in phosphorus and 71 per cent low in potassium (Centre for Science and Environment analysis of soil-test data).[21] Nitrogen dominates: its share of NPK consumption was 69.9 per cent in 2012-13 against a norm of nearly 57 per cent.[22] Long-term ICAR experiments indicate balanced fertiliser alone does not harm soil; what does is N-only fertiliser use without organic addition.[23] Nitrate above the BIS drinking-water limit has been recorded from Punjab, Haryana, Rajasthan, Uttar Pradesh and Tamil Nadu in groundwater.[25] The often-made 'pesticide-cancer link' for Punjab remains scientifically challenged, and this paper does not estimate it.

1.6 Policy landscape: what makes chemicals look cheap

The price of urea is administratively fixed at ₹242 for a 45 kg bag, and the government bears the price difference with the delivered cost. Phosphorus and potash have been under the Nutrient Based Subsidy (NBS) since April 2010, but urea was not included, so nitrogen remains far cheaper than the other nutrients. For kharif 2026, the NBS rates are 47.32 per kg. For nitrogen, 52.76 per kg. For phosphate & 2.38 for potash.[25] A parliamentary committee has characterised the exclusion of urea in the NBS as one of the main defects in the design of the new scheme.[26] The total fertiliser subsidy was highest (~Rs. 2.25 lakh crore) in 2022-23, was Rs. 1.86 lakh crore in 2025-26 (revised), and is Rs. 1.71 lakh crore in 2026-27.[27]

To put this in perspective, the countervailing institutional effort is modest. The approved outlay of the National Mission on Natural Farming is only ₹24,81 crore to achieve results on one crore farmers and 7.5 lakh hectares,[28] which is about 1.5% of one year fertiliser subsidy. PM-PRANAM offers incentives to the states for reduction in fertiliser use, but against a moving baseline.

1.7 How much of India is organic?

In 2024-25, farm area under NPOP certification was 3.96 Mha: 2.25 Mha organic and 1.71 Mha in conversion.[29] Against the net sown area of 139.0 Mha,[18] that is about 2.8 per cent, with just 1.6 per cent being fully certified and over 97 per cent chemical-based/or uncertified (Appendix Fig. A1a). Madhya Pradesh has the maximum certified area. With the most organic producers, India has the thinnest of slices of land, and this certified figure does not count participatory-guarantee and natural-farming plots in the total, and so it underestimates the minimal-input farmland.

1.8 Rationale and Research Questions

The farmer's ledger tells you how much fertiliser is bought and how much crop is sold. It ignores the subsidy paid by taxpayers, the carbon emitted during production, manufacture and application, and the foreign currency and supply risk faced by India. This study considers:

- **RQ1.** How much lower is the social rate of return to fertiliser-intensive wheat and paddy relative to the private rate of return, once fiscal and climate costs are included, and is this difference greater in cases of heavier fertiliser use?
- **RQ2.** Did India's price policy (i.e. the 2010 policy change, which decontrolled phosphate and potash but left urea's price fixed) push farmers out of the other fertilisers and toward nitrogen?

Table 1: Key Numbers at a Glance

Indicator	Figure	Source
Global synthetic-N supply-chain emissions	1.13 Gt CO_2e (2.1% of global GHG), 2018	Menegat et al.[1]
Share of seaborne urea passing Hormuz	About 34%	WTO analysis[10]
Urea price jump, March 2026	+53.7% to about US$726/t	World Bank[9]
India fertiliser manufacturing emissions	About 25 Mt CO_2 (2022-23)	CEEW[8]
India urea output, 2024-25	30.7 Mt (+35% since 2013-14)	DoF/PIB[17]
Fertiliser subsidy, 2025-26 RE / 2026-27 BE	₹1.86 / ₹1.71 lakh crore	Argus Media[27]
Certified organic share of net sown area	1.6% (2.8% with conversion)	APEDA;[29] RBI[18]

02: Methodology

States and crops. Eight states have been selected to span a range of chemical intensity and of organic production. Punjab and Haryana represent the Green Revolution 'core' with the most extreme N: K ratios, while Uttar Pradesh juxtaposes high-input and low-input wealth and Bihar low-phosphorus and potash reliance as a control. Madhya Pradesh has the largest certified organic area, and Chhattisgarh is a high-value organic rice pioneer. Andhra Pradesh coordinates the world's largest natural-farming programme (ZBNF/APCNF), and Karnataka is a second natural-farming case. The staples of wheat, paddy, and maize dominate fertiliser consumption, while cotton and groundnut are cash crops with natural-farming evidence from Andhra Pradesh. Quantitative testing is undertaken for state-crop-year cells with complete official data on cost, price, and yield; Sikkim, relying solely on organic regulation, is treated qualitatively.

Methods:
(i) Private net return = revenue - C2 cost (the comprehensive cost, including family labour and land rent); social net return = private return - fiscal subsidy pass-through (NBS rate × recommended dose) - greenhouse-gas cost (field N_2O based on IPCC Tier 1 factors; upstream emissions based on shares from Menegat et al. (US$51/t$CO_2$e, the US EPA central estimate);[30,1]

(ii) Fertiliser intensity: state N+P+K kg/ha multiplied by the average NBS rate of that year yields gives an implied fiscal liability per hectare, from an agricultural input and because of this exogenous to yield differences.

(iii) Policy test: index of nitrogen vs phosphate NBS rates, a state snapshot of N:P:K and N:K:P ratios around 2010, and a segmented (interrupted time-series) regression of the national nitrogen-to-total-agricultural-share, 1971-72 to 2013-14, with break-points at the 1992 decontrol and the 2010 reform, with Newey-West standard errors (two lags; Durbin-Watson 1.37), following the standard segmented-regression setup.[31, 32]

Table 2: Data Sources

Data	Source	Used for
Cost of cultivation (C2)	CACP and Directorate of Economics and Statistics, cost-of-cultivation series (official)	Private return
Prices, yields	CACP/AGMARKNET farm-gate prices; MSP notifications; DES yields	Private return
Subsidy rates	Department of Fertilisers NBS per-kg notifications, 2010-11 to 2022-23; Cabinet decisions	Social cost; H3 price index

Fertiliser use	State N+P+K per hectare from Rajya Sabha/Lok Sabha replies; Chand and Pavithra series, 1971-72 to 2013-14;[22] RBI Handbook[18]	Intensity; H3 tests
Production, trade, emissions	DoF Annual Report and PIB;17 FAI Fertiliser Statistics; CEEW;[8] IFA;[33] USDA FAS;[6] farmdoc daily;[5] Menegat et al.[1]	Background; emission factors
Shocks 2022-26	World Bank Commodity Markets Outlook (April 2026);[9] WTO;[10] S&P Global;[14] Bloomberg;[12] Reuters[7]	Trade and geopolitics
Organic area, policy	APEDA NPOP statistics;[29] RBI land-use tables;[18] PIB/Rajya Sabha (NMNF);[28] Argus (budget)[27]	Pie chart; policy
Evidence on organic	Berger et al.;[34] Skinner et al.;[3] European Commission;[4] ICAR long-term experiments;[23] Drechsel et al.[35]	Comparison; inferences

Limits. State averages hide within-state differences. A fixed recommended dose is applied to every cell, and the two paddy cells reuse the wheat dose and omit methane. These choices are flagged where used.

03: Inferences

3.1 The farmer's profit is bigger than the nation's profit

Suppose we took a hectare of wheat in Punjab in 2019-20. The farmer has received a profit of about Rs. 31,900. But the government has paid out a subsidy on the fertiliser, and manufacture and application of this fertiliser resulted in the release of greenhouse gases. Under the assumptions of this report, these costs amount to about Rs. 11,550 per hectare. After deducting the subtended costs, the nation's profit is Rs. 20,350, which is 36 per cent lower. The nation's profit was lower than the farmer's in all five cases by 36 to 182 per cent (about 90 per cent on average). The farmer was profitable in two cases (Punjab 2010-11 and Bihar 2019-20), but the nation made a net loss. The paddy farmer in Andhra Pradesh was unprofitable even before the subtended costs were included. (See Table A3 in the Appendix and Fig. A2c.)

3.2 The more fertiliser used, the bigger the hidden bill

Punjab and Haryana use a far higher amount of fertilisers per hectare of sown area than the Indian average, and the denominator effect alone means that the hidden subsidy behind each hectare is much higher. During 2021-22, for example, Punjab's implied exposure was at Rs. 6,283/hectare and Haryana's at Rs. 5,198/hectare compared to the Rs. 3,630/hectare in India. During 2022-23 (the year when global prices hit the ceiling), Punjab's implied exposure peaked at Rs.14072/hectare - nearly four times the all-India rate. Simply put, intensive farming in a state inherently commits itself to a bill that rises and falls with the world market. (Table A4.)

3.3 A policy choice tilted farmers towards nitrogen

The slow progress towards a more balanced fertiliser mix predates 2010 reforms, with nitrogen share falling from 63.9 per cent (2007-08) to 58.8 per cent (2009-10). The 2010 reform then opened up phosphate and potash prices, but froze urea prices. In the next three years, the nitrogen share increased sharply, reaching 69.9 per cent in 2012-13. The hypothesis test indicates that nitrogen share increased at a rate 4.4 percentage points per year faster post-2010 than before ($p < 0.001$). If the old pre-reform trend had persisted, the 2013-14 share would have been around 58 per cent, not 71 per cent. The two most nitrogen-dependent States, Punjab and Haryana, have N: K ratios of 21 and 20, respectively, against an all-India average of 5. One caveat: only four years of post-reform data are available, and data since 2014 are desirable. (Table A5, Fig. A2d.)

3.4 Going organic can pay, but only with support.

Andhra Pradesh has farms in the natural-farming programme earning more than twice as much profit, at similar yields, as chemical farms because of lower inputs and also higher bird numbers.[34] Sikkim presents the opposite: certification preceded training and credit, and yields fell for most farmers. The 2021 sudden ban on fertiliser in Sri Lanka demonstrates the financial pain of abrupt policy change.[35] The key is that transition support is more important than its nomenclature.

So: (1) chemical agriculture is more financially beneficial to the farmer than to society; (2) this benefit increases with fertiliser use; (3) but half of this benefit was instigated through policy; and (4) organic conversions are feasible if farmer training and inputs are provided first.

04: Conclusion

The research extends the typical farm-gate comparison to what the exchequer, the climate and the supply chain pay. It finds the expense of such fertiliser is limited only at the cash register: nitrogen costs are artificially suppressed by a subsidy, which is influenced by global gas prices as the examples in 2022 and 2026 demonstrated, and a rule for setting prices that itself distorts nutrient use.

How the government can use it is a way to quantify a budget line: where every rupee of subsidy flows, which states are most at risk, and what the 2010 mistake was worth. A few practical fixes. Subsidise urea per nutrient so that nitrogen won't be artificially cheapest; link Soil Health Card advice to some portion of the subsidy; tie the PM-PRANAM baseline to a fixed year, not last year's subsidy; and have a single agency responsible for both fertiliser prices and soil health now spread over different ministries.

What do farmers need to do with it? A farmer can replicate a plot's test: add up the subsidy-equivalent and the soil-nutrients drawdown in the fertiliser bill, and check if the profit holds up. The key proven interventions are taking a soil test before every season, substituting nitrogen with compost, legumes, and biofertiliser, and aggregating together with others to purchase bio-inputs and expertise.

Sustainable ways to transition to organic

Carbon and ecosystem payments. Eliminating synthetic nitrogen reduces roughly 0.49 t CO_2e per hectare per year of field N_2O.[3] At the US$51 social cost of carbon, this is worth about ₹2,300 per hectare (at ₹90 per dollar). Market credit prices tend to be below the social cost; the market credits augment a transition, rather than being the primary driver. The natural step is a domestic carbon-market or ecosystem-payer channel, paid for observed soil-carbon and nitrate response.

Process part of the subsidy. Banning fertiliser subsidy to turn it into low-input transition payments per hectare (as is proposed in NMNF, on a huge scale) costs less than the non-budgeted cost of continuing it. At the report's cost of Rs. 11,554 per hectare in transplanted rice, every million hectares that are transitioned to low-input rice would save Rs. 1,155 crore annually, of which only the fiscal segment is a direct budget advantage.

Back biofertilisers and local inputs. Quality standards, testing centres and commitment to water bodies, plants, and ground for bio-input resource centres (10,000 targeted under NMNF) are about as critical as demand, as farmers will not convert without quality inputs. Biofertilisers rely on biologically fixed nitrogen instead of industrially manufactured nitrogen and so reduce marginal import exposure.

Extensions first, certification second. Charge for training and handholding before withdrawal of subsidy, and expand it state-wise per certified results, e.g., Andhra Pradesh but not Sikkim.

Insurance link. Provide a premium discount for validated low-input farms when findings provide a proven evidence base.

Table 3: Incentive options compared.

Instrument	How it works	Who pays	Main risk
Carbon/ecosystem credits	Pay per tonne CO_2e or nitrate load avoided, measured	Buyers, carbon market, or state	Measurement cost; low market prices
Transition payment per hectare	Direct transfer for 2-3 years while yields adjust	Subsidy savings	Needs extension support
Biofertiliser and bio-input support	Quality testing, local production centres, price parity	Government, industry	Poor-quality products erode trust
Urea into NBS / fixed baseline	Removes the price tilt towards nitrogen	Politically costly	Farmer backlash if abrupt
Insurance premium discount	Lower premium for verified low-input plots	Insurers, government	Needs yield-stability evidence

Next steps. The social-return result rests on seven cells; extending it to maize, cotton and groundnut, adding methane for paddy, and publishing a standing state-year panel of fertiliser use would make the conclusions firmer.

05: A Practical Pathway to Transition to Organic Farming

This is a matter of sequencing: How do farmers abandon a chemically-based approach to farming without converting the economic cost to a loss of income? Why it takes time. Across the world, organic production was between 22 and 35 per cent more profitable after taking into account real price premiums, even at a yield loss of between 10 and 18 per cent; the price premium required to break even was in the range of 5 and 7 per cent, but labour costs were 7 to 13 per cent higher.[36] The snag is in the timing: the costs are present from day one while the price premium does not manifest until certification, which entails a conversion period of two to three years.[38]

Step 1: Soil and some substitution. Apply the recommended dosage of soil test-based fertiliser and then substitute organic manure, green manure, bio-fertilisers, and organic inputs for a part of the chemical fertiliser dose. In a two-year basmati rice-wheat experiment at ICAR-IIFSR Modipuram, the plots, which received 50 to 75 per cent of the total organic nutrient supply, produced similar yields as the wholly organic plots, and surpassed the inorganic plots; the former brought a profit of Rs. 53,200 per hectare higher than the latter (a single research-station trial).[37] Long-term ICAR trials also indicate disadvantage arising from using nitrogen alone in the absence of organic matter.[23]

Step 2: Taper in stages, tied to input supply. Sikkim cut chemical-input subsidies by 10 per cent a year from 2003 and banned them in 2014, yet only 5 per cent of its 2010-14 mission spending went on training, and most produce was not sold as organic;[39] Sri Lanka's overnight ban of 2021 shows the cost of skipping the taper.[35] Each subsidy step-down should be conditional on local bio-input supply.

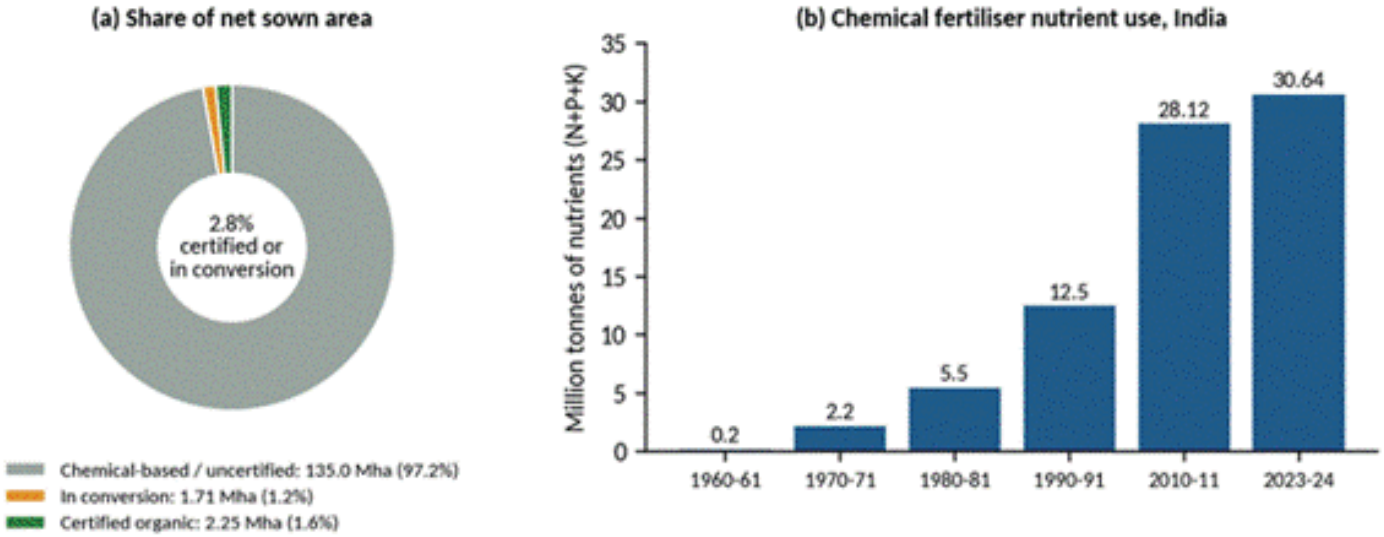
Step 3: Establish local inputs and know-how. The National Mission on Natural Farming aims to establish 10,000 bio-input resource centres, 2,000 demonstration farms and 30,000 Krishi Sakhis in 15,000 clusters;[28] the system's effectiveness rests on the number of centres that actually function, on tested inputs, and on handholding, not on reach.

Step 4: Address the income gap. PKVY brings Rs. 31,500 per hectare across three years for inputs, certification, and training. PGS-India supplies affordable domestic certification, and certifying larger areas can reduce conversion time from two to three years to a few months.[38] The annual support is about Rs. 10,500 per hectare, which is slightly less than the Rs. 11,554 hidden cost listed in Table A3. That means carbon, or ecosystem payments (Section 4) and premium-price market connections[36] are required to fully bridge the gap.

Step 5: Scale by evidence. To put it into perspective, profits from natural farming in Andhra Pradesh increased twofold without reduction in yield.[34] Sequencing by context is the author's draw: integrated nutrient management first in high-intensity states such as Punjab and Haryana, and full organic or natural conversion first where fertiliser use is already low, advancing only when yields and incomes are verified.

Appendix: Figures and Tables

Figure A1. (a) Area under organic versus chemical-based farming in India, and (b) growth of chemical fertiliser nutrient use.



Sources: (a) APEDA NPOP 2024-25 (certified 2.25 Mha, in conversion 1.71 Mha); net sown area 138.99 Mha, 2023-24 provisional.[29,18] Years differ slightly. "Chemical-based/uncertified" is the remainder and includes uncertified low-input and natural-farming plots.
(b) Economic Survey 1996-97 (1960-61 to 1990-91);[19] Lok Sabha reply 2016 (2010-11);[20] RBI (2023-24).[18]

Table A1. Global fertiliser structure: producers, traders and exposure

Nutrient	Main producers	Trade and dependence
Nitrogen (ammonia, urea)	China, Russia, US, India; Gulf states (Qatar, Saudi, Oman) lead urea exports	Gas-based; Gulf supplies about 34% of seaborne urea. Brazil, India, US are major importers
Phosphate	China (over one-third), Morocco, US, Russia, India	China, Morocco, Saudi Arabia, US supply about 79% of DAP/MAP trade (IFA, 2019); India imports DAP and about 90% of phosphate rock
Potash	Canada, Russia, Belarus (about two-thirds of output and reserves)	About 75% of output is traded. India has no reserves; US import reliance 94% (2024)
All nutrients	China, Russia, US, India, Canada: over 60%; China about 25%	Trade is 10-15% of N and P output; Russia about one-fifth of global trade

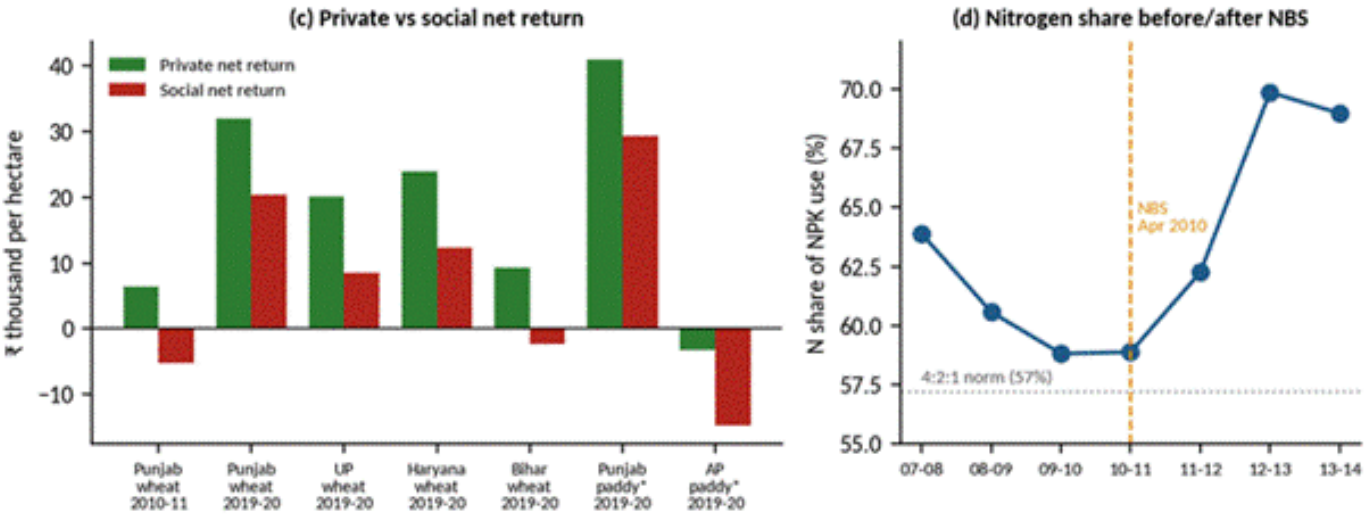
Sources: Farmdoc daily;[5] USDA FAS;[6] IFA;[33] WTO analysis;[10] CEEW.[8]

Table A2. India's fertiliser production, use, imports and manufacturing emissions, 2022-23

Product	Output (Mt)	Imports (Mt)	Use (Mt)	CO_2 (Mt)	Import-dependent inputs
Urea	28.5	10.2	35.7	16.2	Gas about 60% imported (sector)
DAP	4.35	6.7	10.4	2.5	Rock phosphate about 90%; ammonia 80-90%
NPK/complex	10.0	5.6	15.6	6.1	Ammonia, phosphoric acid; potash 100%
All fertilisers	49.4	22.4	67.6	about 25	0.58 t CO_2 per tonne produced

Sources: CEEW,[8] based on DoF Annual Report 2023 and FAI Fertiliser Statistics 2023. Output/imports/use include products not shown separately (SSP, ammonium sulphate).

Figure A2. (c) Private versus social net return by state, crop and year; (d) nitrogen share of total NPK use around the 2010 NBS reform.



Sources: (c) author's calculation from CACP/DES cost and price data, NBS notifications, IPCC Tier[1], Menegat et al.1 and US EPA;[30] *paddy cells are illustrative.
(d) Chand and Pavithra.[22] 4:2:1 norm equals about 57% N.

Table A3. Private and social net return by state, crop and year (₹ per hectare)

State	Crop	year	Yield (q/ha)	Price (₹/q)	C2 cost	Private net	Social net	Gap % private
Punjab	Wheat	2010-11	46.93	1,120	46,226	6,336	-5,218	182.4
Punjab	Wheat	2019-20	50.08	1,925	64,503	31,901	20,347	36.2
Uttar Pradesh	Wheat	2019-20	34.32	1,925	45,954	20,112	8,557	57.4
Haryana	Wheat	2019-20	46.87	1,925	66,321	23,904	12,350	48.3
Bihar	Wheat	2019-20	29.85	1,925	48,208	9,254	-2,301	124.9
Punjab	Paddy*	2019-20	65.17	1,815	77,422	40,862	29,308	28.3
Andhra Pradesh	Paddy*	2019-20	39.77	1,815	75,364	-3,182	-14,736	n/a

Social net = private net - ₹11,554 per hectare (fiscal pass-through plus GHG cost at US$51/tCO$_2$e, fixed recommended dose). *Wheat dose applied to paddy; methane excluded. Unweighted mean wheat gap about 90%.

Table A4. Fertiliser intensity and implied fiscal exposure

State/year	N+P+K (kg/ha)	Implied exposure (₹/ha)	Ratio to all-India 2021-22
All-India, 2019-20	133.4	2,010	0.55
All-India, 2021-22	146.7	3,630	1.00
Bihar, 2019-20	245.3	3,695	1.02
Haryana, 2021-22	210.1	5,198	1.43
Punjab, 2021-22	253.9	6,283	1.73
Punjab, 2022-23	223.0	14,072	3.88

Source: State consumption from Rajya Sabha and Lok Sabha replies; NBS rates from Department of Fertilisers; author's calculation.

Table A5. Segmented regression of national nitrogen share, 1971-72 to 2013-14 (Newey-West, 2 lags)

Term	Coefficient	HAC std. error	p-value	Reading
Pre-1992 trend	-0.24 pp/yr	0.10	0.022	Gradual decline
1992 level jump	+7.16 pp	0.99	<0.001	P&K decontrol shock
Slope change from 1992	-0.40 pp/yr	0.13	0.002	Decline resumed
2010 level jump	-0.71 pp	0.73	0.33	No immediate jump
Slope change from 2010	+4.42 pp/yr	0.48	<0.001	Reversal after NBS

Source: Author's estimation on the series in Chand and Pavithra.[22] Only four post-2010 observations; no control group, so other national shocks cannot be fully ruled out.

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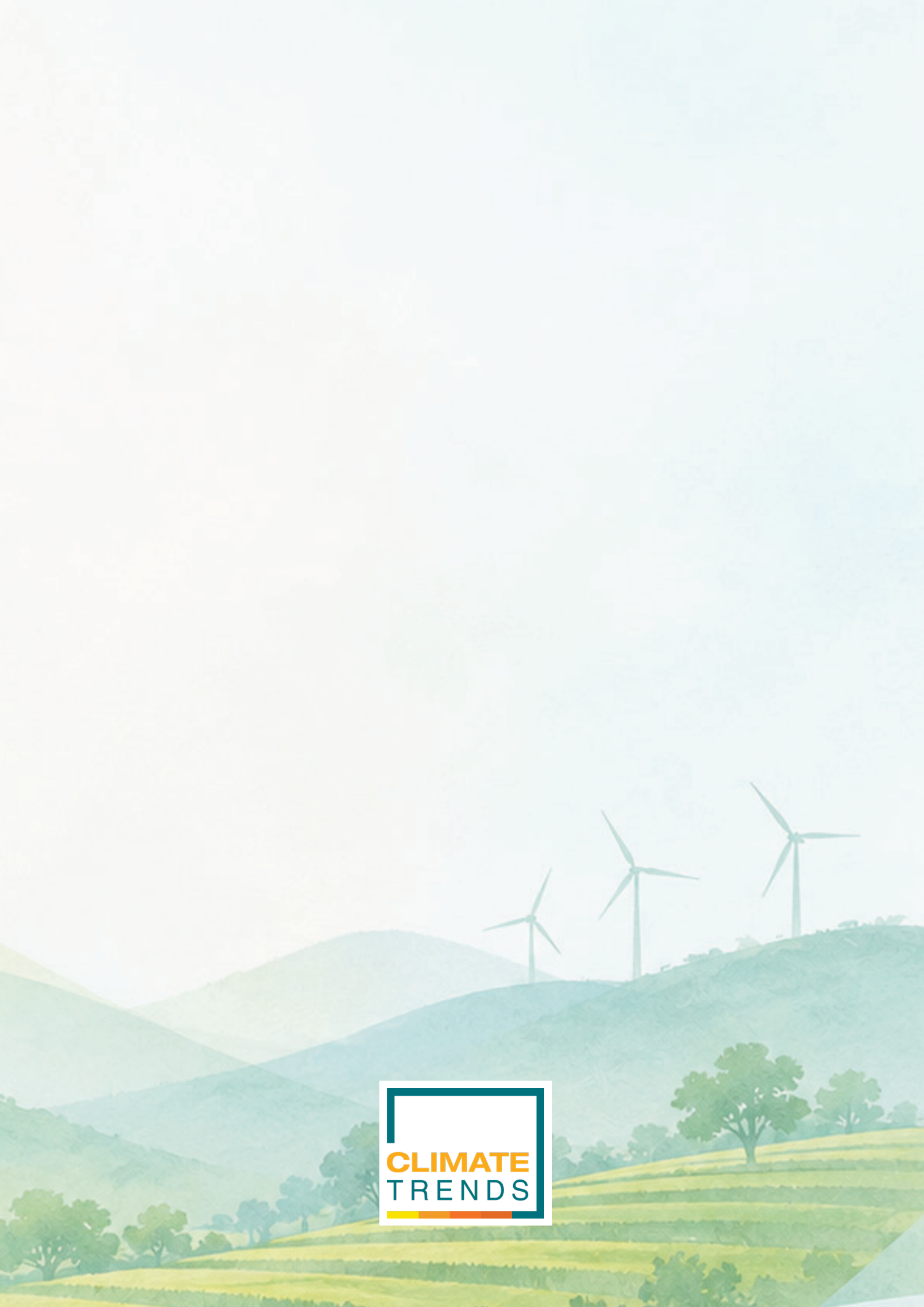
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