INDIA

Groundwater Sustainability and Agricultural Incentive Reform

A policy proposal to protect food sovereignty while restoring the water systems on which Indian agriculture depends

Proposed pilot: Punjab and Haryana

Prepared: 13 November 2026

Purpose: An evidence-based framework for national, state and farmer-level agreement; not a final engineering design or costed investment plan.

CORE PROPOSITION

India should first reform the water system that supports agriculture—not dismantle the production base that feeds the country. Public procurement and farmer-income safeguards must remain in place while India combines inter-basin transfers, irrigation technology, treated-wastewater reuse, local water governance and groundwater recovery. Crop-pattern change is a pre-agreed last resort, activated only by independently verified conditions.

Evidence cut-off: 13 November 2026. Figures are dated to their underlying reporting period; projections, administrative assessments and research estimates are identified separately.

1. Executive Summary

India faces a strategic contradiction: policies that helped secure domestic food production—especially public procurement, minimum support prices (MSP), irrigation expansion and subsidised farm electricity—have also reinforced production patterns that, in some north-western agricultural regions, depend on groundwater extraction above assessed annual replenishment. The resulting depletion threatens the long-term productive base that food-security policy is intended to protect.

The problem is severe but geographically uneven. The 2024 national groundwater assessment estimated extraction at 60.47% of the annual extractable resource across India. That national average masks acute regional stress: Punjab's extraction stage was 156.87%, while Haryana's was 135.96%. These are administrative assessment ratios, not a single national aquifer measurement; they must be interpreted alongside groundwater-level trends, aquifer boundaries, recharge and surface-water exchanges. [1–3]

The historical record does not support the claim that all India crossed a single sustainability threshold exactly 30 years ago. A long-term study of north-western India and central Pakistan found substantial groundwater accumulation during the twentieth century, stabilisation in the regional average between 1970 and 2000, and a loss of approximately 70 km^3 during 2000–2010 in the areas analysed. The defensible conclusion is that parts of the north-west are now drawing down a stock accumulated over earlier decades—not that every Indian region followed the same timeline. [4]

The proposed response is a sequenced, integrated programme:

- **Protect the food base:** retain reliable public procurement, MSP policy and strategic stocks for rice and wheat; do not use water reform as a pretext to withdraw farmer guarantees.
- **Substitute water sources:** expand dependable surface-water supply where basin-level analysis permits; assess inter-basin transfers; reuse treated urban and industrial wastewater without depriving downstream users or ecosystems.
- **Modernise irrigation:** apply crop-appropriate technologies—AWD and direct-seeded rice where suitable, drip and sprinkler systems for suitable crops, laser levelling, improved conveyance, smart scheduling and efficient pumps.
- **Govern water collectively:** establish aquifer- and basin-scale limits, local water-user participation, transparent measurement and independent verification, drawing lessons from Australia's Murray–Darling Basin.
- **Make incentives consistent:** retain basic farmer support while redirecting incremental public spending toward verified water-saving outcomes, infrastructure and transition-risk protection.
- **Pre-agree a last resort:** if independently verified evidence shows that the combined measures cannot restore a sustainable balance in a specific aquifer, automatically initiate a targeted, compensated crop-adjustment procedure—subject to food-security safeguards.

The recommended first step is a multi-season pilot in selected aquifer blocks in Punjab and Haryana, with matched comparison areas, independent hydrological and economic evaluation, and no automatic reduction of procurement guarantees. The pilot should test the combined system, not isolated technologies.

DECISION REQUEST

Approve a jointly governed Punjab–Haryana pilot and a national design process for a Food and Water Security Compact. The compact should bind public agencies to measurable groundwater, production, farmer-income and procurement safeguards, while defining in advance the evidence thresholds and compensation rules for any last-resort crop adjustment.

What this proposal does not recommend: a blanket ban on rice or wheat; a general withdrawal of MSP or procurement; a sudden increase in farmers' electricity bills; or permanent substitution of domestic staples with imports.

Author, Professional Background and Basis of the Proposal

Author: Dmitry Kazakov

Professional position: Independent Software & Systems Engineer

Dmitry Kazakov has worked in software development since 2006, in paid professional IT roles since 2010, and has maintained an independent engineering practice since 2015.

His professional work focuses on understanding how complex operational environments function, identifying structural constraints, and designing practical solutions that connect technical, economic and organisational requirements. This approach is grounded in systems engineering: examining not only individual problems, but also the relationships, incentives, dependencies and implementation conditions that determine whether a proposed solution will work in practice.

His policy research draws on this engineering background, alongside nearly a decade of experience engaging with political and institutional processes. His analytical work places particular emphasis on economic incentives, stakeholder interests, institutional capacity, implementation risks and the unintended consequences of policy decisions.

This proposal applies that approach to India's groundwater and agricultural sustainability challenge. It does not claim to replace the expertise of Indian agricultural scientists, hydrologists, economists or public institutions. Rather, it offers an independently developed policy and implementation framework intended to connect existing evidence, programmes and institutional capabilities into a coherent course of action.

Institutional audience: NITI Aayog, particularly its Water & Land Resources Division.

Status: Independent policy proposal. It does not represent the official position of the Government of India, NITI Aayog or any State Government.

The following sections continue the original policy proposal without alteration.

2. Scale of the Problem

2.1 National picture and regional concentration

Indicator	Latest cited value	Interpretation
India: annual groundwater recharge (2024)	446.90 billion m³	Gross annual recharge estimate; not all of it is available for extraction.
India: annual extractable groundwater resource (2024)	406.19 billion m³	After accounting for natural discharge.
India: annual groundwater extraction (2024)	245.64 billion m³	All assessed uses; national extraction stage 60.47%.
Punjab: annual extraction / extractable resource (2024)	27.66 / 17.63 billion m³; 156.87%	Extraction materially exceeds the assessed annual extractable resource.
Haryana: extraction stage (2024)	135.96%	State assessment also identifies extraction above annual availability.

The 2024 national compilation classified 751 of 6,746 assessment units (11.13%) as over-exploited, where extraction exceeds annual replenishable recharge; a further 206 units were critical. These classifications are block/mandal/taluka-level assessments and should not be confused with a direct measurement of every aquifer. [1]

2.2 Historical accumulation and depletion

MacAllister et al. (2022) analysed long-term post-monsoon groundwater observations from 1900 to 2010 across north-western India and central Pakistan. In data-sufficient areas, they estimated at least 420 km³ of net groundwater accumulation over the twentieth century. Canal irrigation played a defining role by increasing recharge. Average groundwater levels stabilised between 1970 and 2000 as above-average rainfall and the spread of tubewell irrigation exerted opposing effects. In 2000–2010, approximately 70 km³ was lost in the analysed region, associated with low rainfall and increased tubewell development. [4]

This is strong evidence that groundwater stocks can be built up by infrastructure and then depleted by extraction. It does not establish a single India-wide date at which sustainability was crossed. A credible proposal should therefore state that several north-western aquifers have been in prolonged deficit and that historical accumulation has been drawn down in affected areas; the date and magnitude must be mapped aquifer by aquifer.

2.3 Human and food-system pressure

World Bank population data show India's population rising from about 558 million in 1971 to about 1.464 billion in 2025—roughly 2.6 times higher. This expands demand for food, household water and economic activity, but population growth alone does not explain regional groundwater depletion. Crop choice, irrigation source, yields, cropping intensity, rainfall, procurement and energy pricing determine where and how that demand translates into pumping. [5]

National crop-area data also show expansion over the long run. Rice area increased from approximately 37.7 million hectares in 1969–70 to around 47.8 million hectares in 2024–25; wheat area increased from approximately 16.6 million to 31.8 million hectares. These national figures combine different agro-climatic regions and do not establish the cause of depletion in Punjab or Haryana. They do show that growth in food production involved both area expansion and productivity gains. [6]

2.4 Why the '30 years ago' claim needs careful wording

The proposition that the system was in equilibrium before the 1990s and crossed a single threshold afterwards is a useful hypothesis to test, but it is not established by the available regional historical study: its average north-western groundwater series shows stabilisation during 1970–2000. Local aquifers may have crossed their limits at different times, and national or regional averages can conceal those local transitions. The final report should not present 1990 as a proven universal breakpoint.

The policy-relevant warning is nonetheless urgent: when long-term extraction exceeds recharge, farmers and towns increasingly rely on stored groundwater. As water tables fall, pumping costs, energy use and exposure to drought rise;

some wells may fail, and shallow users can lose access before deeper users. A sustained deficit can therefore undermine both household water security and the ability to maintain crop output.

3. Economic Causes of Excessive Groundwater Extraction

The crisis is not adequately described as farmers simply 'using too much water'. It is an outcome of interacting incentives and infrastructure. The relevant unit is the regional water system: crop economics, procurement, electricity, canals, groundwater access, urban demand and hydrology.

3.1 Demographic and food-demand growth

India's population grew by approximately 906 million between 1971 and 2025. That increase raised the scale of food demand and the importance of reliable domestic grain supplies. However, the relationship between population and groundwater extraction is mediated by productivity, food loss, dietary change, trade, livestock feed, irrigation efficiency and the geographic location of production. Population is a pressure multiplier—not a sufficient causal explanation.

3.2 Expansion and intensification of cultivation

Rice and wheat area expanded nationally over several decades, while yields also rose. In the north-west, the key questions are not only how many hectares are planted, but how many crop cycles occur each year, what share is irrigated, whether water comes from canals or tubewells, and how much pumping is required per hectare and per tonne. An area increase can raise total demand even if water use per tonne falls; higher efficiency can also be offset if irrigated area or cropping intensity expands.

3.3 Procurement and price assurance

MSP and public procurement are central to the political economy of rice and wheat. The central government sets MSPs for notified crops; actual procurement is concentrated in particular crops, states and procurement systems. Punjab and Haryana are major suppliers to the Central Pool. In KMS 2024–25, government estimates placed their combined paddy procurement at about 40% of Central Pool procurement. [7]

A 2024 Nature Communications study by Chatterjee, Lamba and Zaveri finds a relationship between procurement policy, rice-area expansion and groundwater stress, estimating a substantial contribution of procurement incentives to groundwater decline in Punjab over its study period. This is an econometric estimate tied to the authors' model and period; it should be presented as evidence that procurement incentives matter, not as proof that MSP alone caused depletion. [8]

3.4 Electricity subsidies and pumping incentives

Subsidised or free agricultural electricity reduces the marginal private cost of pumping. This supports farm incomes and food production, but can weaken the price signal that would otherwise discourage additional groundwater extraction. Simply charging farmers more for electricity would shift the cost of a system-level failure onto producers and could trigger political resistance. The better policy question is how to preserve basic support while changing the marginal reward structure and investing in alternative water supply.

Punjab's 2026–27 budget analysis estimates ■7,715 crore in agricultural power subsidies within ■15,550 crore of total power subsidies. This is a budget estimate, not final audited expenditure. [9]

3.5 Infrastructure and data gaps

Canal networks can both supply irrigation and recharge aquifers through seepage; lining every canal is therefore not automatically beneficial. Water conveyance improvements must be evaluated at system scale, including downstream availability and recharge effects. Punjab's 2024 groundwater assessment recorded the addition of baseflow recharge to its estimate and requested better canal-irrigation data and improved tubewell-draft calculations—evidence that the water balance itself still requires stronger measurement. [2]

The combined diagnosis is an incentive mismatch: food policy rewards reliable output and procurement; electricity policy lowers pumping costs; infrastructure and market access shape crop choices; water policy seeks to keep extraction within renewable limits. These objectives have not been sufficiently integrated.

4. Existing Procurement, Subsidy and Water Programmes

India is not starting from zero. The proposal should strengthen, coordinate and redirect existing programmes rather than imply that no action is underway.

Policy area	What is already in place	What it currently addresses / limitation
MSP and public procurement	MSP for wheat and paddy; FCI and state agencies procure grain for the Central Pool; decentralised procurement arrangements operate in participating states.	Supports prices, procurement and public food distribution. Procurement is not a universal guaranteed purchase of every crop, quantity or farmer at every location.
Irrigation expansion	PMKSY and state irrigation programmes; canal systems and local water works.	Expands access and reliability. More irrigation access does not itself guarantee lower groundwater extraction.
Micro-irrigation	Per Drop More Crop (PDMC) supports drip and sprinkler systems. Government reported 96.97 lakh ha covered by March 2025.	Promotes farm-level efficiency, especially for suitable crops. It is not a universal substitute for rice-field water management.
River interlinking	National Perspective Plan identifies 30 links; by February 2026, feasibility reports existed for 26 and DPRs for 13; Ken–Betwa is the priority link under implementation.	Creates a planning framework for inter-basin transfer, but does not yet provide a complete north-west groundwater substitution plan.
Groundwater assessment	CGWB and state departments assess recharge, extraction and assessment units; 2024 national and state assessments are available.	Provides a baseline, but data quality, aquifer-scale monitoring, canal flows and pumping estimates need improvement.
Renewable-energy pumps	PM-KUSUM and state programmes support solarisation of agricultural pumps and decentralised solar generation.	Can reduce emissions and power costs; without pump-capacity and water-accounting safeguards, cheaper power may increase pumping.
Wastewater treatment	Urban sewage-treatment programmes and state STPs are expanding treatment capacity; reuse is developing unevenly.	Treatment capacity is not the same as safe reuse. Local water balances must identify existing downstream uses before diversion.
Local water conservation	Watershed, recharge-structure, pond restoration and community water programmes operate across states.	Can improve local recharge and resilience, but needs aquifer-based targeting, maintenance and measured additional recharge.

Procurement safeguards are politically essential. The 2020 farm-law episode demonstrated that reforms perceived as weakening mandi institutions or the practical security of MSP can generate large-scale resistance. The laws did not formally abolish MSP, but farmers feared that market restructuring could erode the system around it; the laws were repealed in November 2021 after prolonged protests. [10]

5. Stakeholder Interests and Political Constraints

Stakeholder	Core interests	Conditions for a workable agreement
Union government	Food security, inflation management, Central Pool stocks, fiscal exposure, national water strategy.	No abrupt loss of food output; transparent cost-sharing; evidence that investment reduces long-term risk.
Punjab government	Farm incomes, procurement, free-power commitments, state autonomy, water security and rural stability.	No unilateral withdrawal of procurement or electricity support; central co-financing of infrastructure.
Haryana government	Agricultural output, drinking-water security, groundwater recovery and inter-state water arrangements.	Fair allocation of surface water and transparent aquifer/basin rules.
Farmers and farm organisations	Reliable prices, procurement access, low input costs, control over farm decisions and protection from transition risk.	Voluntary adoption initially; compensation for verified losses; participation in design and governance.
FCI and procurement agencies	Reliable quality and volume, storage, movement, stock management and food-distribution obligations.	Predictable production and procurement rules; logistics and storage investment.
DISCOMs and energy agencies	Financial viability, predictable subsidy reimbursement, grid stability and pump-system modernisation.	Timely subsidy compensation and a funded transition plan.
Agri-processors and private buyers	Reliable raw material, quality standards, storage, transport and predictable commercial rules.	Long-term contracts and infrastructure; private buyers complement rather than replace public guarantees.
Local communities and downstream users	Fair access to water, drinking-water security, ecosystem flows and protection against local capture.	Representation, disclosure of allocations and enforceable safeguards.
Independent science and audit bodies	Reliable aquifer accounting, data integrity, evaluation and public trust.	Access to data, independence and authority to publish findings.

The programme must recognise that agricultural water is governed across several overlapping geographies: state boundaries, river basins, aquifers, canal command areas and local irrigation systems. A state-only model cannot manage every aquifer; a purely central model will lack local legitimacy. The proposed arrangement is therefore cooperative but accountable: national financing and food-security commitments, state implementation, local participation, and independent verification.

The proposal should not assume that farmers are a single interest group. Landowners with deep tubewells, smallholders, tenants, agricultural labourers and villages without reliable drinking water can experience the same policy very differently. Compensation and representation must account for these differences.

6. Proposed Integrated Mechanism

The proposed mechanism combines four international models with India's existing institutions and food-security commitments. The international examples are design references, not templates to copy without adaptation.

6.1 Inter-basin water transfer and planned surface-water substitution — China

China's South-to-North Water Diversion demonstrates that large-scale transfer can support regional water security. A 2025 study reported groundwater-level recovery averaging about 0.7 metres per year in the North China Plain since 2020, associated with south-to-north surface-water diversion, pumping controls and wet climatic years. The study also estimated a reduction in annual groundwater abstraction of about 12 km³ between 2005 and 2023. The recovery cannot be attributed to transfer alone. [11]

For India, the mechanism should include both direct substitution—surface water replaces groundwater pumping—and indirect substitution—transferred water supplies cities or industry, freeing local surface water for agriculture. Any proposal must establish donor-basin availability in dry years, environmental flows, downstream rights, seasonal timing, energy requirements, conveyance losses, water quality and inter-state consent. The existing National Perspective Plan is a starting platform, not proof that a transfer to Punjab or Haryana is feasible.

6.2 Crop-appropriate irrigation technology — Israel and Indian programmes

Israel's water-management experience combines precise irrigation, treated wastewater reuse, monitoring, central coordination and pricing/allocation institutions. India already supports drip and sprinkler irrigation through PDMC, with 96.97 lakh hectares reported covered by March 2025. [12]

The Indian programme should add crop-specific water management: alternate wetting and drying (AWD), direct-seeded rice (DSR) where agronomically suitable, laser land levelling, soil-moisture and weather-based scheduling, improved field channels, efficient pumps and technical extension. Drip irrigation is appropriate for many horticultural, vegetable and other crops, but is not a universal replacement for paddy irrigation. Adoption support must cover equipment, agronomy, repair, training and transition risk—not just hardware purchase.

6.3 Collective local water governance — Australia

The Murray–Darling Basin Plan uses Sustainable Diversion Limits at catchment and aquifer scales. Australia's current framework identifies 29 surface-water and 80 groundwater SDL resource units across the basin. [13] India could adapt this principle through aquifer/basin water councils involving state agencies, local bodies, farmer organisations, downstream users and independent hydrologists.

Such councils should publish water budgets, coordinate allocations, monitor extraction and oversee local recharge and infrastructure. They must not transfer the state's financial and technical responsibilities to farmers. National and state governments remain responsible for major infrastructure, scientific monitoring, enforcement safeguards and compensation.

6.4 Treated wastewater reuse — Israel-inspired, India-specific

Israel reuses more than 87% of wastewater effluent, primarily in agriculture, according to the OECD. [14] This demonstrates the potential of planned reuse, but India's cities, treatment systems, water quality, sewer coverage and distribution distances vary greatly.

India should prepare city- and basin-specific reuse plans that identify treated volumes, seasonal reliability, treatment level, salinity and contaminant risks, transport costs, and current downstream users. Reuse must be measured as a net substitution for freshwater abstraction—not counted as newly created water. If treated effluent currently sustains river flow or downstream irrigation, diverting it may merely transfer scarcity to other users. Environmental flows and public-health standards must be protected.

6.5 Groundwater recharge and restoration

Recharge structures, restored ponds, floodplain reconnection and managed aquifer recharge should be targeted to suitable hydrogeology. The objective is additional, verified recharge to the stressed aquifer—not construction counts. Water quality, clogging, saline intrusion and contamination risks require monitoring. Canal seepage may contribute to recharge in some settings; lining decisions must therefore be based on whole-system hydrology rather than a blanket assumption that all seepage is waste.

6.6 Align incentives while protecting farmer guarantees

Retain MSP and public procurement arrangements for rice and wheat during the transition. Keep the basic electricity-support commitment intact initially, while redirecting incremental public spending toward efficient pumps, metering, surface-water access, solar power with pumping safeguards, agronomic support and verified water-saving payments. Any eventual change to the subsidy structure must be negotiated, compensated and separated from procurement guarantees.

7. Comparative Table: What India Does Now and What Should Be Added

This table distinguishes existing policy instruments from the additional measures proposed in this document. 'Already in place' does not mean universally implemented or fully effective; coverage, performance and state-level delivery differ.

Area	What India already does	Additional measure proposed	Problem the additional measure is meant to solve
Groundwater monitoring	CGWB and state departments assess annual recharge, extraction and assessment units; monitoring wells and state reports exist.	Aquifer-scale, continuous public dashboard combining groundwater levels, pumping proxies, canal deliveries, rainfall, crop area and quality; independent annual audit.	Current administrative estimates can miss local drawdown, lateral flows, canal-water substitution and actual pumping. A shared water account is needed to verify recovery.
Inter-basin transfers	National Perspective Plan has identified 30 links; feasibility reports and DPRs are progressing; Ken–Betwa is under implementation.	Assess a north-western water-security portfolio: direct and indirect surface-water substitution, donor-basin stress tests, dry-year guarantees and phased transfer options.	Existing river-link planning is not yet a demonstrated plan to replace unsustainable pumping in Punjab/Haryana. Donor-basin impacts and regional fit must be established.
Canal and surface-water delivery	Existing canal networks, irrigation projects and state modernisation programmes.	Rehabilitate and selectively expand conveyance and last-mile distribution; measure deliveries to farms and net groundwater pumping displaced; protect recharge functions where useful.	Surface water may exist at basin level but fail to reach the farms or seasons where groundwater is being pumped. Infrastructure outputs need to be tied to actual substitution.
On-farm irrigation	PDMC supports drip and sprinkler; other schemes support irrigation and water conservation.	A crop-specific package: AWD/DSR for suitable rice systems; drip/sprinkler for suitable crops; laser levelling, scheduling, soil-moisture tools, efficient pumps and extension.	Existing micro-irrigation is not a complete solution for paddy or for regional aquifer depletion. Technology must preserve yield and reduce total pumping, not just water per hectare.
Treated wastewater	Sewage-treatment infrastructure and reuse initiatives are being developed; reuse varies by city and state.	Basin-based reuse contracts linking urban STPs to farms, with tertiary treatment where required, pipelines/storage, quality monitoring and downstream-flow safeguards.	Treatment capacity does not guarantee safe agricultural reuse. Reuse can displace freshwater only if current downstream users and environmental flows are protected.
Local water governance	Panchayats, water-user associations, watershed programmes and state water agencies operate in different forms.	Aquifer/basin councils with farmers, local communities, states, technical experts and downstream users; publish budgets and allocation rules.	Administrative jurisdictions do not match aquifers and basins. Local participation needs authority, data and enforceable accountability.
Energy and pumping	Agricultural electricity subsidies and solar-pump programmes support farm energy access.	Preserve basic support; add pump-capacity safeguards, water accounting, solar export incentives where feasible, efficient pump replacement and rewards for verified reduction in groundwater abstraction.	Cheap or solar electricity can unintentionally increase pumping. The reform must change the marginal incentive without imposing abrupt bills on farmers.
Procurement and MSP	MSP for notified crops; FCI/state agencies procure rice and wheat for the Central Pool; strategic food stocks support distribution.	Explicit transition covenant: no procurement rollback as a condition of water reform; publish procurement commitments and automatic buyer-of-last-resort triggers; expand alternative-crop procurement only where supply chains and demand are verified.	Farmers may reasonably fear that water reform will be used to weaken price guarantees. Without a binding safeguard, adoption and political legitimacy will fail.
Farmer risk protection	Crop insurance, income-support and state-level transition schemes exist, with varying coverage and design.	Multi-season technology-risk compensation, equipment leasing, agronomic extension and make-whole payments for verified losses caused by pilot participation.	Farmers bear the immediate risk of changing technology while benefits accrue to the wider public. Adoption will be low unless risk is shared.
Aquifer recharge	Rainwater harvesting, watershed works, ponds and recharge structures are supported by multiple programmes.	Target managed aquifer recharge to hydrogeological conditions; report verified additional recharge and water quality; maintain structures and monitor outcomes.	Construction counts are not proof of recharge. Poorly sited structures may have little effect or create quality risks.

Area	What India already does	Additional measure proposed	Problem the additional measure is meant to solve
Crop diversification	Some state programmes encourage voluntary shifts from paddy to alternative crops; MSP exists for multiple crops, but procurement is uneven.	Keep diversification as a last-resort, aquifer-specific measure; guarantee purchase, processing, storage and income protection before asking farmers to shift.	A shift without assured buyers can depress prices, damage farm incomes and create surpluses. It should be used only where the water saved is quantified and food security protected.
Imports	India uses imports and exports as part of normal trade and can adjust trade policy in exceptional circumstances.	Treat imports as a temporary contingency, not a structural substitute for domestic rice/wheat capacity; diversify suppliers and maintain strategic stocks.	Permanent import dependence can expose food security to export bans, geopolitical pressure, shipping disruption and global price shocks.

The comparative table is the implementation core of the proposal: India already has multiple relevant programmes, but they are not yet integrated into a single aquifer-level mechanism that links water substitution, technology, farmer protection, procurement and independently verified outcomes.

The Principal Added Value of This Proposal

India already has many of the policy instruments, programmes and technologies required to address groundwater depletion. The central challenge is not simply the absence of additional schemes, but the lack of a sufficiently integrated implementation framework connecting them to measurable aquifer-level outcomes.

This proposal adds that framework. It brings together groundwater monitoring, inter-basin and local surface-water substitution, canal delivery, irrigation technology, treated-wastewater reuse, aquifer recharge, energy incentives, agricultural procurement and farmer-income protection within a common system of planning, implementation and verification.

Its defining principle is to measure success by the net reduction in unsustainable groundwater abstraction and the recovery of aquifer conditions — not by infrastructure constructed, equipment distributed, hectares covered or nominal water-use efficiency alone. This also requires accounting for rebound effects, overlapping water savings and impacts on downstream users.

The framework links public investment and institutional responsibilities to independently verified results while preserving food production and farmer-income safeguards. It establishes a practical sequence: improve water availability and delivery, support technology adoption, protect farmers against transition risks, measure actual outcomes and adjust policy accordingly. More difficult changes to cropping patterns remain a pre-agreed last resort, subject to demonstrated water savings, viable markets and adequate income protection.

The proposal’s principal contribution is therefore an integrated, accountable and sequenced approach to food and water security: making existing and additional measures work together towards a common outcome, rather than treating them as separate programmes.

The following sections continue the original policy proposal without alteration.

8. Economic Rationale and Incentive Design

The proposed reform should change the economics of water use without removing the economic security that sustains food production. The target is not simply lower water use per hectare; it is a sustainable regional water balance with stable output and farm income.

8.1 Pay for verified public outcomes

Public support should be linked to a combination of measures: (i) adoption of an agronomically validated practice; (ii) measured or independently estimated reduction in groundwater abstraction; (iii) no material loss of yield or farm income; and (iv) no expansion that offsets the water saving. Payment design should avoid penalising farmers for rainfall, soil or infrastructure conditions beyond their control.

8.2 Separate income support from pumping incentives

The basic income and electricity-support architecture should not be abruptly withdrawn. Instead, new or incremental support can be redirected toward equipment leasing, pump efficiency, surface-water connection, agronomic advice, metering and performance payments. Where solar pumps are used, the design should reward sale of surplus power while preventing unregulated expansion of pumping capacity.

8.3 Keep procurement guarantees distinct from water policy

Rice and wheat procurement supports national food distribution and farmer income. It should not be reduced automatically because a pilot introduces water-saving technology or because private buyers appear temporarily. Any future procurement reform must be separately justified against food demand, buffer norms, procurement geography and farmer access. Private market development should complement the public buyer-of-last-resort role.

8.4 Avoid rebound and double counting

A field-level efficiency gain is not equivalent to aquifer recovery. If the farmer expands irrigated area, adds a crop cycle or pumps longer because water is cheaper, the regional saving can disappear. Similarly, savings from AWD, DSR, canal upgrades and improved pumps cannot simply be added: their effects may overlap. The pilot must estimate net changes in groundwater abstraction and storage.

8.5 Financing principles

The Union government should finance nationally significant transfer infrastructure, research, monitoring standards and a substantial share of capital costs. States should fund local distribution, extension and maintenance, with central transfers tied to agreed outcomes. Urban utilities and industrial water users should contribute to treatment and reuse infrastructure where they generate the wastewater. Farmers should not be charged the full cost of a public water-security transition.

9. Political Conditions for Implementation

The proposal is politically more viable if its first phase is framed as investment in agricultural resilience and national food security—not as a campaign to reduce rice or wheat cultivation.

- **Farmer consent:** farmer organisations must participate before programme design is finalised. Pilot participation should initially be voluntary, with transparent compensation rules and a grievance process.
- **Procurement firewall:** water-saving participation must not trigger loss of MSP access, procurement eligibility or electricity support. The programme should include a public commitment against using the pilot as a pretext for unilateral withdrawal of guarantees.
- **Centre–state compact:** define co-financing, data-sharing, water allocation, procurement responsibilities and dispute resolution. Punjab and Haryana must have meaningful roles in decisions affecting their aquifers and canal systems.
- **Local legitimacy:** aquifer councils must include smallholders, tenants, landless agricultural workers, villages and downstream users—not only large landowners or pump owners.
- **Independent verification:** publish baseline data, methods, annual results and uncertainty ranges. Independent scientific review is essential for any automatic trigger.
- **Visible early benefits:** prioritise reliable water deliveries, reduced pump maintenance and energy costs, agronomic support and secure procurement. Long-term aquifer recovery alone may take too long to sustain political support.

The 2020–21 farm-law protests are a warning about process as well as policy substance. The three laws did not formally repeal MSP, but farmers feared that changes to mandi and market institutions could undermine practical price security. The laws were repealed after prolonged mass protests. A water reform that appears to weaken procurement guarantees is therefore unlikely to secure trust. [10]

10. Risks and Alternative Scenarios

Risk / scenario	Potential consequence	Mitigation / decision rule
Farmers reject new practices	Low adoption; no material change in pumping.	Voluntary pilot, demonstrations, equipment leasing, extension and compensation for transition risk.
AWD/DSR causes yield or quality losses in some conditions	Lower income and resistance to scaling.	Local agronomic validation; crop-specific eligibility; multi-season risk compensation; do not mandate unsuitable practices.
Surface-water transfers are unavailable in dry years	Planned substitution fails when demand is highest.	Stress-test donor basins under drought and climate scenarios; define environmental flows and priority rules before construction.
Canal expansion does not displace tubewell pumping	Higher total water use or little aquifer benefit.	Measure farm-level deliveries and pumping; target last-mile gaps; avoid counting supply expansion as saving without substitution evidence.
Solarisation makes pumping cheaper	Rebound in groundwater abstraction.	Meter/estimate pumping, cap pump capacity in stressed blocks, reward power export and link support to aquifer plans.
Wastewater diversion harms downstream users	Water scarcity shifts to downstream farms or ecosystems.	Count existing return flows; maintain environmental flows; quality standards and downstream consultation.
Private buyers fail to absorb alternative crops	Price collapse and farm-income loss.	No large-scale diversification without procurement, contracts, processing, storage and demand validation.
Government uses water reform to reduce MSP or electricity guarantees	Loss of trust and political mobilisation.	Explicit procurement firewall and farmer safeguards in the compact; independent monitoring and public reporting.
Groundwater levels keep falling despite measures	Aquifer depletion continues; sunk costs rise.	Independent diagnosis of hydrology, climate, lateral flows and pumping; trigger targeted last-resort crop adjustment if criteria are met.
Imported food becomes a structural substitute	External leverage and exposure to global shocks.	Use imports only as temporary contingency; diversify suppliers; retain domestic capacity and strategic reserves.

Imports should remain an emergency buffer and a normal trade-balancing instrument, not the structural answer to a groundwater problem. A country of India's scale should avoid creating concentrated external dependence for staple calories where domestic production capacity can be preserved through water-system reform.

11. Pre-Agreed Automatic Last-Resort Mechanism

Crop-pattern change should be agreed in principle now, while all parties recognise the risk and can negotiate safeguards. The mechanism should activate a defined procedure automatically when objective conditions are met; it should not automatically impose a blanket crop ban.

11.1 Trigger conditions

- An independent assessment confirms a persistent negative groundwater balance for a defined aquifer or assessment unit over a specified rolling period, using a published method and uncertainty range.
- Observed groundwater-level and storage trends corroborate the accounting result; lateral flows, river–aquifer exchange, canal recharge and rainfall variability are explicitly considered.
- The agreed portfolio of technically and economically viable water-substitution, recharge, irrigation and governance measures has been implemented to a defined threshold and independently evaluated.
- The residual deficit remains material and cannot be closed without a targeted reduction in water demand.
- A crop-level water-savings assessment demonstrates that the proposed crop adjustment would produce a meaningful net reduction in groundwater abstraction—not merely a theoretical reduction in crop water requirement.
- A food-security assessment confirms that domestic supply, public stocks and nutrition needs can be protected; a funded compensation and market-access plan is ready.

11.2 What activates automatically

Once the trigger conditions are certified, the compact automatically initiates a targeted Aquifer Adaptation Plan: identify the affected blocks; set a water-deficit reduction target; offer voluntary crop-switching contracts first; guarantee purchase and processing for approved alternatives; compensate verified income gaps; and phase any mandatory restrictions only if voluntary and supply-side measures demonstrably fail and legal safeguards are met.

11.3 Safeguards

- No national or blanket prohibition on rice or wheat.
- No activation based solely on one year's rainfall, a single water-level reading or a budgetary target.
- No reduction in MSP or public procurement guarantees as an automatic consequence.
- No shift without verified water savings, guaranteed market access and compensation.
- A food-security override and a periodic review clause must permit suspension if domestic supply or strategic stocks fall below agreed safety thresholds.
- The trigger, data, independent certification, appeal process and compensation formula must be written into the compact before the pilot begins.

THE PRINCIPLE

The parties should negotiate the necessity, evidence standard and safeguards for the last resort before a crisis forces them to do so. The trigger should remove the need to reopen the political argument over whether action is required; it should not remove scrutiny over where, how much and at whose cost adjustment occurs.

12. Pilot Programme: Punjab and Haryana

12.1 Purpose and scope

Launch a 3–5 year pilot in selected over-exploited assessment units in Punjab and Haryana, chosen by aquifer condition, canal command, crop pattern, pumping intensity, social vulnerability and data readiness. Include matched comparison areas to distinguish programme effects from rainfall and other external changes. The pilot should not attempt to represent every aquifer or every farm in either state.

12.2 Workstreams

Workstream	Pilot activity	Primary output
Water accounting	Aquifer boundaries; baseline water budget; observation wells; pumping estimates; canal deliveries; rainfall; water quality; surface-groundwater exchange.	Auditable baseline and annual net groundwater balance.
Surface-water substitution	Map canal gaps; test local distribution upgrades; assess indirect urban/industrial substitution and candidate transfer links.	Measured volume of groundwater pumping displaced.
Wastewater reuse	Select suitable urban wastewater sources; test treatment quality, storage, conveyance and downstream-flow effects.	Safe, seasonally reliable reuse volume and net freshwater substitution.
Farm technology	Demonstrate AWD/DSR where suitable; drip/sprinkler for suitable crops; laser levelling, scheduling, pump upgrades and agronomic extension.	Yield, water abstraction, energy and income impacts by technology and farm type.
Energy incentives	Pilot efficient pumps, solar export models and water-accounting safeguards; preserve basic support during evaluation.	Change in pumping and energy use without higher farmer burden.
Local governance	Create aquifer councils and water-user forums; publish allocations, data and grievance decisions.	Legitimate local water plans and compliance mechanisms.
Farmer protection	MSP/procurement firewall; compensation for technology risk; equipment leasing; buyer-of-last-resort safeguards.	Stable net farm income and no loss of staple procurement access.

12.3 Evaluation indicators

Dimension	Core indicators
Hydrology	Net annual groundwater balance; water-level trend and storage proxy; extraction by source; recharge; river–aquifer exchange; uncertainty interval.
Production	Rice and wheat area, yield and total output; cropping intensity; quality; seasonal reliability.
Farmer economics	Net income by farm size and tenure; input and energy cost; compensation received; adoption and dropout rates.
Public finance	Capital and operating expenditure; subsidy cost; cost per cubic metre of verified net pumping reduction; maintenance liability.
Food security	Procurement volumes and access; Central Pool contribution; buffer-stock adequacy; retail price and nutrition impacts.
Equity and environment	Drinking-water access; downstream allocations; ecological flows; water quality; impacts on tenants, labourers and smallholders.

12.4 Scale-up rule

Scale only those interventions that independently demonstrate net groundwater savings, acceptable yield and income outcomes, affordability, environmental compliance and farmer acceptance. Do not scale a technology solely because it reduces water applied per hectare. Do not scale a transfer project until donor-basin and recipient-basin impacts are independently assessed.

13. Governance, Financing and Implementation Sequence

A National Food and Water Security Compact should coordinate the programme. It need not begin as a new constitutional body. It can initially operate as an intergovernmental agreement with a joint programme office, state-level implementation units, aquifer councils and independent evaluation.

Level	Proposed responsibility
Union government	National food-security commitments; co-financing; inter-basin planning; common data standards; FCI coordination; national safeguards and independent evaluation framework.
Punjab and Haryana	State implementation; canal and local infrastructure; agricultural extension; electricity subsidy administration; groundwater enforcement consistent with agreed safeguards.
Aquifer/basin councils	Local water budgets; user participation; seasonal allocation recommendations; local monitoring; grievance and compliance reporting.
FCI and state procurement agencies	Reliable procurement operations; storage and logistics; buyer-of-last-resort mechanisms; transparent procurement data.
Independent scientific panel	Validate baselines, trigger conditions, water-saving estimates and annual results; publish uncertainty and dissenting findings.

Indicative sequence

Period	Actions
0–6 months	Constitute joint design group; select pilot aquifers; publish data protocol; agree procurement firewall and farmer safeguards; commission baseline hydrology and farm-economics work.
6–18 months	Install/upgrade monitoring; start demonstrations and extension; identify canal and wastewater substitution opportunities; complete donor-basin and environmental screening; set pilot financing.
Years 2–3	Implement first infrastructure packages; run multiple crop seasons; pay transition-risk compensation; publish annual independent results.
Years 3–5	Evaluate net aquifer impact, yields, incomes and fiscal cost; scale successful measures; activate aquifer adaptation procedure only if trigger conditions are met.
After year 5	Extend to additional stressed aquifers; update national water and food-security compact; revise thresholds using verified results.

Costing cannot responsibly be finalised from national averages. The pilot needs a project-by-project capital and operating cost model covering transfer, canal distribution, treatment and reuse pipelines, recharge, monitoring, equipment, extension, compensation and maintenance. A common metric should be cost per cubic metre of verified net groundwater abstraction avoided or replenished, alongside food output and farmer-income impacts.

14. Conclusion and Recommended Decision

India's food-security system has delivered enormous benefits. The objective of this proposal is not to reverse those gains, reduce domestic staple production by default or shift the burden of water restoration onto farmers. It is to protect the natural capital that makes continued domestic food production possible.

The evidence is clear that groundwater stress is severe in parts of north-western India. It is also clear that the problem is not uniform across the country, and that historical claims must be made at the correct geographic scale. Population growth, crop-area expansion, procurement incentives, electricity subsidies, irrigation infrastructure and climate variability all matter; no single factor explains the crisis.

A viable response must integrate water transfers, surface-water substitution, crop-appropriate irrigation technology, wastewater reuse, collective local governance, aquifer recharge, aligned incentives and farmer-income protection. It must be piloted, measured and independently verified before national scaling.

RECOMMENDED DECISION

1. Endorse the principle that domestic food production and farmer guarantees are protected during the water transition.
2. Establish a jointly governed Punjab–Haryana pilot focused on aquifer-level recovery and verified groundwater substitution.
3. Commission feasibility studies for surface-water transfers, canal modernisation and treated-wastewater reuse, including donor-basin and downstream safeguards.
4. Create aquifer councils and a public water-accounting system.
5. Agree in advance on an automatic, compensated, aquifer-specific crop-adjustment procedure as a last resort—subject to food-security safeguards.

Strategic objective: preserve India's ability to feed its population independently for generations by restoring the water systems on which domestic agriculture depends.

Appendix A. Evidence Limits and Research Priorities

Question	What is established	What still needs to be established
When did the system cross the sustainable limit?	Long-term regional accumulation followed by depletion is documented; Punjab and Haryana currently show extraction stages above 100%.	Aquifer-specific breakpoint dates; historical pumping and recharge series; consistent boundaries and methods.
How much did population growth contribute?	Population increased about 2.6-fold between 1971 and 2025.	Quantitative decomposition of demand into population, diets, yields, trade, livestock, food loss and water productivity.
Did crop area drive depletion?	National rice and wheat area expanded; research links procurement incentives and rice expansion with groundwater stress in Punjab.	District/block-level area, crop intensity, source of irrigation, pumping and causal contribution by crop.
How much water can transfers supply?	India has an interlinking programme; China shows integrated transfer plus pumping regulation can support recovery.	Recipient/donor basin balances, dry-year reliability, route, energy, ecological and social costs for north-west India.
What is the true wastewater reuse potential?	Israel demonstrates high reuse; India has treatment and reuse initiatives.	City-by-city treated volumes, quality, seasonal match, current downstream uses, distribution costs and net freshwater displacement.
What are the net effects of irrigation technologies?	India has large PDMC coverage; AWD/DSR and micro-irrigation have context-specific potential.	Multi-season, farm-level causal evaluation of pumping, yields, incomes and rebound effects in Punjab/Haryana.
What does a crop shift save?	Alternative crops may have lower irrigation requirements in some contexts.	Aquifer-specific net water savings, market absorption, procurement cost, food/nutrition effects and income compensation.

The proposal should publish uncertainty rather than conceal it. In particular, groundwater assessment ratios are administrative estimates; water-level trends are not interchangeable with total storage; and correlations between population, crop area and extraction do not establish causation. A robust pilot is designed to close these gaps.

Appendix B. Selected Sources

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Source-use note. Official assessments are used for administrative groundwater and procurement figures; peer-reviewed studies are used for historical and causal analysis; international agency material is used for comparative institutional examples. All cross-country examples require adaptation to India's hydrology, federal structure, crop systems and political economy.

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