IRRIGATION POLICY & WATER MANAGEMENT: INDIA VS. DEVELOPED CONTRIES- A BRIEF REVIEW

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ABSTRACT

India irrigates the world's second-largest cropland, sustaining over half of its agricultural output and rural livelihoods. Yet, the irrigation economy faces persistent inefficiencies: high conveyance and evaporation losses, poor cost recovery from surface irrigation systems, pervasive electricity subsidies that encourage over-pumping, and growing groundwater depletion hotspots across key basins. At the same time, India's institutional arrangements for water allocation and pricing remain fragmented across states, with limited integration of data, metering, and accountability mechanisms.

In contrast, developed jurisdiction such as Australia's Murray–Darling Basin (MDB), the western United States, Israel, and the EU/Spain demonstrate varying but effective combinations of statutory frameworks, volumetric water pricing, advanced metering, water markets or user associations, and well-developed wastewater reuse programs. These systems reveal how coherent legislation, economic incentives, and digital infrastructure can jointly improve water-use efficiency, equity, and sustainability.

This review synthesizes evidence from 25 key studies and policy documents to compare water laws, subsidy designs, and distribution efficiency across these contexts. It distils actionable design lessons for India cantered on four reform priorities: (i) expanding metering and incentive-based management, (ii) channelling targeted capital support for on-farm water-use efficiency, (iii) modernizing canal networks with performance-based operations and maintenance frameworks, and (iv) establishing robust groundwater governance with transparent data and regulatory oversight. Citations are embedded and fully clickable to facilitate reference and policy uptake.

INTRODUCTION

Water scarcity is emerging as one of the defining challenges of the 21st century, particularly in agriculture. India's irrigation sector, which supports nearly 55% of its gross cropped area, is heavily dependent on unsustainable groundwater extraction, with states like Punjab, Haryana, and Gujarat reporting critical declines in water tables. The National Water Policy (2012) and Draft River Basin Bill (2018) acknowledge these challenges, but implementation gaps remain vast. Electricity subsidies for pumping encourage excessive water use, while investments in micro-irrigation adoption remain below potential.

In contrast, developed nations have transitioned towards more sustainable and efficient water management practices. For instance, Australia's Murray–Darling Basin has pioneered water markets and cap-and-trade mechanisms, allowing reallocation of water to high-value crops and ensuring ecological flows. The United States, through laws such as the Sustainable Groundwater Management Act (2014), mandates basin-level planning and volumetric water accounting. Israel has set global benchmarks with near-universal drip irrigation adoption and reuse of more than 90% of its treated wastewater. Similarly, the European Union's Water Framework Directive (2000) enforces cost recovery for water services and promotes integrated river basin management.

This review compares India's irrigation laws, subsidies, and distribution efficiency with these global practices to provide a structured understanding of what works and what can be adapted. By identifying gaps and opportunities, it contributes to ongoing debates on achieving sustainable water management while ensuring food security and farmer welfare in India.

1. Background & Scope

Irrigated agriculture accounts for the majority of consumptive water use in India; enhancing allocation, pricing, and infrastructure efficiency is therefore central to water security and farm incomes. We compare India with developed benchmarks where reforms have emphasized metering, water rights and markets, reuse, and cost recovery. Core questions: (a) What do laws enable? (b) How do subsidies shape behavior? (c) What distribution efficiencies are achieved?

2. Legal & Governance Frameworks

India

- National Water Policy (NWP) 2012: recognizes water as an economic good, advocates demand management, volumetric supply, and improved cost recovery, but operationalization has been uneven. National Water Management
- River Basin Management Bill (draft, 2018) would create statutory basin authorities for coordinated allocations still pending. PRS Legislative Research+1
- Groundwater: the Model Groundwater (Sustainable Management) Bill argues for community-based aquifer management and separation of land & groundwater rights; adoption varies by state. IELRCNational Water Management

Developed comparators:

- Australia (MDB): Water Act 2007 and Basin Plan 2012 set sustainable diversion limits and enable transparent water markets (entitlements & allocations), complemented by buy-backs and on-farm efficiency grants. Murray-Darling Basin Authority+1
- U.S. (West/California): Prior appropriation water rights; the Sustainable Groundwater Management Act (SGMA, 2014) requires local GSAs and sustainability plans. Water.ca.gov+2Water.ca.gov+2
- EU/Spain: The EU Water Framework Directive (WFD) mandates cost recovery and incentive pricing (Article 9) within river-basin plans; Spain layers national irrigation modernization and strong water user associations. EUR-LexLegislation.gov.uk
- Israel: Highly centralized allocation, universal metering, volumetric pricing, and world-leading wastewater reuse for irrigation (often ~90%). PMC

3. Subsidy Systems & Incentive Design

India (irrigation & energy)

- Capital subsidies for micro-irrigation under PMKSY/PDMC & earlier NMMI have scaled drip/sprinkler adoption; recent PDMC 2023 guidelines standardize implementation and finance. Pradhan Mantri Kisan Samman Nidhi+1Cold Chain Development
- Micro-Irrigation Fund and operational guidance under PMKSY. PDMCPradhan Mantri Kisan Samman Nidhi
- Energy: large electricity subsidies for pumping documented to spur groundwater extraction and shift cropping toward water-intensive crops; policy options include direct benefit transfer (DBT) and feeder solarization (PM-KUSUM). IISDKatrina K. Jessoe+1Sustainable Energy for All | SEforALL
- PM-KUSUM: capital support for standalone pumps, grid-connected solarization, and decentralized plants; guidelines and extensions through 2026 detail modalities and targets. TGERCMinistry of New and Renewable Energy+1Press Information Bureau

Developed comparators

- U.S.: USDA-NRCS EQIP & related programs fund irrigation improvements (piping, drip/sprinkler conversions, scheduling); Reclamation's WaterSMART supports districts' conveyance modernization. Natural Resources Conservation Service+1
- Australia (MDB): large public outlays for infrastructure modernization and buybacks; ongoing reform of water markets following the ACCC inquiry (2019–21). Water Library+1DCCEEW
- EU/Spain: WFD's cost-recovery principle and CAP co-financing steer modernization; OECD shows most OECD countries have increased farm water charges but often still below full economic cost. OECD+2OECD+2

4. Efficiency of Water Distribution & On-farm Application

- **Canal & on-farm efficiency (India)** remains constrained by seepage, poor maintenance, and non-volumetric delivery, while micro-irrigation is expanding. NITI Aayog synthesizes typical field application efficiencies of ~35–40% (surface), ~60–70% (sprinkler), and ~80–90% (drip) mirrored internationally. *(See Figure 1.)* NITI Aayog
- **Micro-irrigation adoption (India)**: technical potential ≈ 69.5 Mha vs achieved ≈ 13–14 Mha by ~2021; closing this gap requires financing, after-sales service, and electricity reform for groundwater sustainability. *(See Figure 2.)* NITI Aayog

- **Reuse & non-conventional water**: Israel's integrated model high reuse share for irrigation and desalination reduces freshwater pressure; EU is scaling reuse under 2020/741 and Mediterranean programs; India can expand safe reuse linked to agriculture. PMC

5. Synthesis: what works, where, and why

Metering + volumetric pricing (Israel, many EU regions, parts of U.S.) drive behavioral response; cost recovery funds O&M and modernization. Property-right clarity and markets (MDB) enable flexible reallocation while capping total take. Targeted capex subsidies (U.S. EQIP; India PDMC) accelerate technology adoption but should be paired with incentive-compatible energy pricing to lock in water savings rather than rebound extraction. Basin governance matters when canals, groundwater, and environmental flows interact (MDB Plan; SGMA). Murray-Darling Basin AuthorityWater.ca.gov Natural Resources Conservation ServiceEUR-Lex

6. Figures

Figure 1. Typical field application efficiency by method surface (~37%), sprinkler (~65%), drip (~90%).
Source: compiled from Indian and international guidelines synthesized in NITI Aayog (2023). NITI Aayog

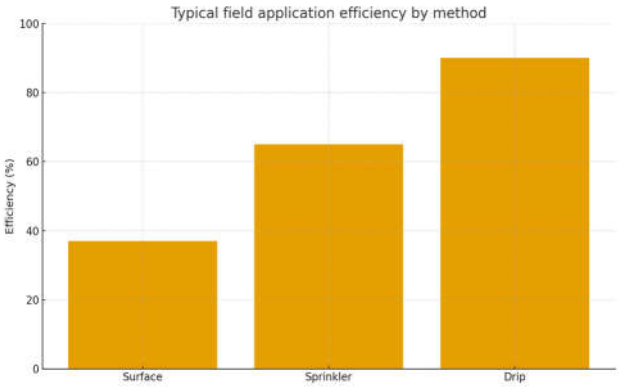
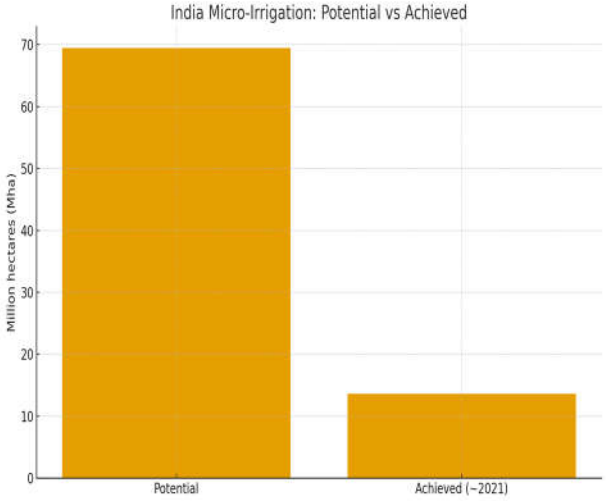


Figure2: India Micro-Irrigation: Potential vs Achieved potential ≈ 69.5 Mha; achieved ≈ 13.6 Mha.
Source: NITI Aayog (2023). NITI Aayog



Figures embedded above show irrigation efficiency by method and India's MI potential vs achieved.

7. Policy Comparison Snapshot

· **India**: NWP 2012 envisages volumetric supply/cost recovery; PDMC subsidizes micro-irrigation; electricity subsidies remain large; early moves on DBT and feeder separation; groundwater governance uneven. National Water ManagementPradhan Mantri Kisan Samman NidhiIISD

· **U.S.**: rights-based allocation, SGMA for groundwater; EQIP/WATER-SMART co-finance efficiency; pricing varies by district. Water.ca.govNatural Resources Conservation Service

· **Australia (MDB)**: binding diversion limits, strong water markets, public investment in efficiency, continuing reforms post-ACCC. Murray-Darling Basin AuthorityWater Library

· **EU/Spain**: WFD Article 9 on cost recovery; widespread modernization and basin planning; reuse growth. EUR-Lex

· **Israel**: universal metering, volumetric pricing, near-universal drip, very high wastewater reuse. PMC

8. Comparative Findings

· **Laws & rights**: Binding caps (MDB) and rights **administration** (U.S. prior appropriation; SGMA for groundwater) help align diversions with sustainability; the EU WFD hard-wires cost recovery & basin economics**;** India's NWP lays intent but needs enforceable basin authorities and groundwater rights reform. Murray-Darling Basin AuthorityWater.ca.govEUR-LexNational Water Management

· **Subsidies**: **Targeted capex** (EQIP/PDMC) works best when paired with volumetric pricing/metering**;** untargeted energy subsidies expand extraction (India evidence), undermining physical savings from micro-irrigation. Natural Resources Conservation ServicePradhan Mantri Kisan Samman NidhiKatrina K. Jessoe

· **Distribution efficiency**: Modernised canals + pressurized, metered on-farm delivery (Israel, parts of Spain/U.S.) achieve higher application efficiency than open channels with non-volumetric supply. India's MI gap is the biggest "low-regret" opportunity but requires service ecosystems and energy pricing reform. NITI Aayog

9. Policy Design Checklist for India

1. **Metering & volumetric service** in canals and *all* new MI projects; couple with tiered pricing and service-level guarantees. (WFD/Israel practice.) EUR-Lex
2. **Targeted subsidies + O&M financing**: keep capital support for MI and canal lining, but ring-fence O&M cost recovery**;** performance-linked grants to irrigation departments/water user associations. (OECD guidance.) OECD
3. **Energy reform for groundwater**: move toward DBT, feeder separation/solarisation (PM-KUSUM), and progressive tariffs to reduce over-pumping. TGERCSustainable Energy for All | SEforALL
4. **Basin governance**: advance the River Basin Bill; publish allocative plans with caps and environmental flows; pilot intrastate trading/leases with safeguards, drawing on MDB lessons. PRS Legislative ResearchMurray-Darling Basin Authority
5. **Scale reuse** for peri-urban irrigation with quality standards and pricing incentives (EU/Israel playbook). PMC

10. Limitations & Future Research

State-level heterogeneity in India is large (canal vs. groundwater economies). Many programs (PM-KUSUM feeder solarization, PDMC 2023) are mid-implementation; rigorous, multi-state impact evaluations will sharpen understanding of water *savings vs. shifting*. Comparative metrics (e.g., leakage, cost recovery, reliability) should be standardized across canal commands to benchmark progress.

LITERATURE REVIEW

1. The National Water Policy 2012, issued by the Government of India, Ministry of Water Resources: it stresses on water scarcity, mismanagement, and climate change impacts, and calls for integrated river-basin management. It prioritizes drinking water, sanitation, food security, and ecological needs, while promoting conservation, efficiency, fair pricing, legal reforms, and community participation for sustainable and equitable water use.

2. The River Basin Management Bill (Draft, 2018) by PRS Legislative Research: it proposes the creation of statutory river basin authorities for coordinated planning and management of inter-state rivers. It emphasizes basin-level governance through mandatory data sharing, preparation of basin plans, and mechanisms for dispute resolution among states. The Bill seeks to improve irrigation allocation, ensure equitable water use, and promote integrated, scientific, and cooperative river basin management in India.

3. The PRS Bill Track Summary on the River Basin Management Bill by PRS Legislative Research: it outlines the Bill's procedural status, key provisions, and fiscal implications. It highlights clauses on establishing river basin authorities, mechanisms for dispute resolution, basin-level planning, and data sharing, while also noting the financial requirements for implementation. The summary serves as a concise

reference for tracking the Bill's legislative progress and understanding its broader context.

4. The Model Bill to Regulate Ground Water Development (2016) by Y.B. Kaushik, Central Ground Water Board: it reviews India's overdependence on groundwater, issues of over-extraction, depletion, and quality decline, and traces the evolution of groundwater regulation from 1970 to 2011. It proposes permits, borewell registration, rainwater harvesting, penalties, and a multi-level institutional framework, but notes weak state implementation due to poor infrastructure, manpower, and data. It stresses groundwater as a public trust, need for stronger regulation, participatory management, and integration with overall water resources.

5. The Model Groundwater (Sustainable Management) Bill, 2017 by Philippe Cullet (IELRC): it proposes a shift from permit-based regulation to a rights-based, sustainable framework, treating groundwater as a public trust. It emphasizes the right to water, community participation, decentralization, equity, and ecological protection, aiming for inclusive and sustainable groundwater governance in India

6. The article *Water Policy in India: A Review* by K.M. Singh, R.K.P. Singh, M.S. Meena, and Abhay Kumar (2013): It highlights India's growing water scarcity caused by rising demand, mismanagement, and pollution. It stresses inefficiencies in irrigation, overuse of groundwater, and unequal access, calling for a strong National Water Policy focused on conservation, efficiency, and equitable distribution to ensure long-term water and food security.

7. The India Policy Review by the International Environmental Law Research Centre (IELRC): it critically examines India's water governance, stressing sustainability, equity, decentralization, and ecological protection. It reviews key reforms like the Model Groundwater Bill 2017 and highlights challenges of over-extraction, pollution, and climate impacts.

8. Operational Guidelines of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY): PMKSY presents it as an integrated scheme focused on expanding irrigation, improving water use efficiency, and ensuring "Har Khet Ko Pani" and "Per Drop More Crop." Studies highlight its convergence of multiple programs, promotion of micro-irrigation, watershed management, and rejuvenation of traditional water bodies. With decentralized planning through District and State Irrigation Plans, ICT-based monitoring, and geo-tagging, PMKSY is seen as a holistic initiative to conserve water, enhance productivity, and secure sustainable rural livelihoods.

9. The Revised PDMC Operational Guidelines 2023 by the Government of India, Ministry of Agriculture & Farmers Welfare: it focuses on improving agricultural water-use efficiency through micro-irrigation, cluster-based planning, digital monitoring, and convergence with other schemes, aiming to ensure sustainable irrigation and higher farmer income.

10. The NMMI Guidelines by the Government of India, Ministry of Agriculture: it outlined the pre-PMKSY framework for promoting drip and sprinkler irrigation through subsidies, focusing on water-use efficiency, cost reduction, and productivity, and serving as the basis for later PMKSY reforms.

11. The Micro Irrigation Fund (MIF) Operational Guidelines, 2025 by the Government of India, Ministry of Agriculture & Farmers Welfare: it provides a framework for States/UTs to access NABARD-supported funds for expanding micro-irrigation through top-up subsidies and innovative projects, aiming to boost water-use efficiency, crop productivity, and farmer income under PDMC–PM-RKVY.

12. The report on "Efficiency of Micro-Irrigation in Economizing Water Use in India" by ICAR–National Institute of Agricultural Economics and Policy Research (NIAP), submitted to NITI Aayog (2019): it analyzes adoption in Punjab, Maharashtra, Gujarat, and Andhra Pradesh, showing water, energy, and fertilizer savings, yield and income gains, but also challenges of financing, awareness, and uneven implementation, stressing stronger policies and institutions for scaling up.

13. The PM-KUSUM Guidelines by the Government of India, Ministry of New and Renewable Energy (MNRE)L: it outlines support for decentralized solar plants, 17.5 lakh standalone solar pumps, and solarization of 10 lakh grid-connected pumps. The scheme targets clean energy for irrigation, reduced subsidy burden on DISCOMs, and additional farmer income through surplus power sales.

14. The Office Memorandum on "Development of Solar Parks and Ultra Mega Solar Power Projects" (2023) by the Government of India, Ministry of New and Renewable Energy (National Solar Mission Division): it announces an extension of the Solar Park Scheme timeline up to FY 2025–26 (31st March 2026) without

additional financial implications. This extension allows continued development of large-scale solar infrastructure under the National Solar Mission to accelerate renewable energy deployment.

15. The booklet *PM-KUSUM: A New Green Revolution* issued by the Ministry of Information and Broadcasting, Government of India: It presents the scheme as a major step to solarize agriculture through small solar plants, standalone pumps, and feeder solarization. Literature notes its role in reducing diesel use, cutting subsidies, providing farmers reliable power, boosting incomes, creating rural jobs, and supporting climate goals, making it a key reform linking renewable energy with farmer welfare.

16. The report "India's Energy Transition: Electricity Subsidies" (2021) by the International Institute for Sustainable Development (IISD): it analyzes India's electricity subsidies, mainly for agriculture and low-income households, noting benefits but also fiscal stress, inefficiency, and water-energy misuse. It recommends better targeting, transparency, and integration with renewables for sustainable reform.

17. The report "Powering Irrigation: A Review of Electricity Policies for Groundwater Management in India" (2019) by the Bharti Institute of Public Policy, Indian School of Business: it analyzes how electricity subsidies drive groundwater overuse, causing depletion and inefficiency, and suggests reforms like DBT, smart metering, and solar pumps for sustainable water-energy management.

18. The paper *Can Electricity Pricing Save India's Groundwater?* by Ram Fishman, Upmanu Lall, Vijay Modi, and Nikunj Parekh (2016): it evaluates a Gujarat pilot offering farmers rebates for reduced electricity use. While participation was high, it had little effect on groundwater or power use, showing voluntary metering is feasible but insufficient without deeper reforms.

19. The report "Direct Delivery of Power Subsidy to Agriculture in India" by Mohinder Gulati (SE4All) and Sanjay Pahuja (World Bank Group): it analyzes how free power drives groundwater overuse and utility losses, and proposes direct subsidy delivery via segregated feeders, smart metering, and ICT tools to improve service, accountability, and efficiency without removing farmer support.

20. The report "Sustainable Management of Water Resources in Agriculture" (2010) by Kevin Parris, OECD: it reviews OECD countries' experiences in agricultural water use, highlighting efficiency gains, rising groundwater dependence, and climate risks. It recommends stronger institutions, cost-reflective pricing, integrated policies, and better data to ensure sustainable and equitable water management in agriculture.

21. The report "Water and Agriculture: Sustainability, Markets and Policies" (2006) by the OECD: it reviews how irrigation, groundwater use, and farm practices affect sustainability, and evaluates tools like pricing, subsidies, and tradable rights. It stresses integrated water management, better institutions, and policy alignment to balance farm productivity with conservation.

22. The EU Water Framework Directive (2000/60/EC, consolidated 2014) by the European Union: it sets a framework for protecting all water bodies, aiming for "good status" via river basin management, ecological protection, pollution control, cost recovery, and public participation, making it the foundation of EU water policy.

23. The Murray–Darling Basin Plan by the Murray–Darling Basin Authority: it sets Sustainable Diversion Limits, allocates environmental water, and uses water trading markets to balance farming, community, and ecological needs, ensuring sustainable management under climate and extraction pressures.

24. The "Murray–Darling Basin Water Markets Inquiry: Final Report" (2021) by the ACCC: it reviews Australia's water markets, highlighting transparency gaps, risks of manipulation, and inequities for small farmers, and recommends stronger governance, clearer rules, and better data to ensure fair and sustainable outcomes.

25. The EQIP Factsheet by the USDA Natural Resources Conservation Service (NRCS): it explains how the program offers technical and financial support for farmers to improve soil, water, and air quality, enhance irrigation efficiency, and build resilience, with special support for underserved groups through higher payments and dedicated funds.

CONCLUSION

India's water governance is shifting toward integrated, sustainable, and decentralized management, with policies like NWP 2012, PMKSY, and groundwater bills addressing scarcity, equity, and efficiency. While micro-irrigation, renewable energy schemes, and subsidy reforms offer potential, weak implementation, institutional gaps, and socio-political challenges limit impact. Global experiences such as the EU Water Framework Directive, Australia's Murray–Darling Basin Plan, and U.S. EQIP highlight the importance of strong institutions, pricing mechanisms, and incentive-based approaches. Overall, India must strengthen regulation, ensure equity, and adopt integrated water–energy policies to secure sustainable resource use.

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3. PRS Bill Track Summary (RBM Bill) — Procedural status, key clauses and fiscal implications; handy for legislative context. PRS Legislative Research

4. Model Groundwater (Sustainable Management) Bill — Advocates aquifer-based management and community participation; foundational for tackling energy-groundwater nexus. National Water Management

5. Cullet & Gupta (IELRC) review of India's water law — Critical assessment of reforms and human right to water implications; clarifies legal tensions around pricing. IELRC

6. Water Policy & Acts Mapping (NWM) — Catalogues state/central instruments and their coverage; quick reference for legal inventories. Welcome to CUTS CITEE |

7. India Water Partnership Policy Review (2024) — Comparative notes on basin planning and coordination; links Indian directions to global practice. Australian Water Partnership

8. PMKSY Operational Guidelines — Program design for convergence, AIBP, watershed, and PDMC; clarifies implementation architecture. Pradhan Mantri Kisan Samman Nidhi

9. PDMC (Micro-Irrigation) Operational Guidelines 2023 — Current rules for drip/sprinkler subsidies, fund flow, beneficiaries; core for subsidy design. Pradhan Mantri Kisan Samman Nidhi

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13. MNRE PM-KUSUM Guidelines & portal — Components A/B/C, eligibility, CFA structure; aligns irrigation energy with clean supply. TGERCMinistry of New and Renewable Energy

14. PM-KUSUM extension notice (to 2026) — Confirms timelines/targets; important for program evaluation windows. Ministry of New and Renewable Energy

15. PIB PM-KUSUM booklet (2023) — Summarizes achievements, state roll-out, feeder solarisation cases. Press Information Bureau

16. IISD (2020) *Unpacking India's Electricity Subsidies* — Quantifies the size and structure of electricity subsidies, transparency gaps, and fiscal risks; anchors energy-water debates. IISD

17. Badiani & Jessoe (JED; working/related papers) — Causal evidence that lower ag-power prices increase groundwater extraction and shift cropping; key elasticity estimates. Katrina K. Jessoe+1

18. Fishman et al. (field experiments/policy paper) — Explores metering/DBT approaches to align incentives and reduce over-extraction. Quadracci Sustainable Engineering Lab

19. SE for all/Prayas (DBT for ag-power) — Design blueprint for direct power-subsidy delivery compatible with efficiency incentives. Sustainable Energy for All | SEforALL

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