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Adapting Agricultural Water Resources Management for a Changing Climate

Pathways to Climate-resilient Agriculture

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Image: CEEW/Kongkanika Neog

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The authors

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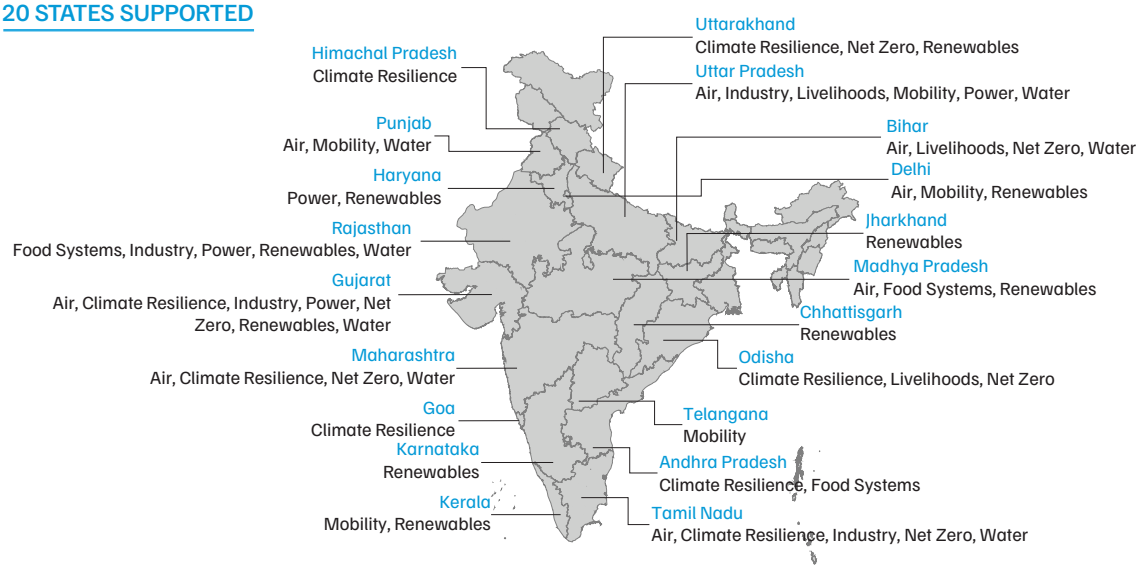
NATIONAL/INTERNATIONAL

2011 | National Water Resources Framework
2014 | 175 GW renewables target
2015 | International Solar Alliance
2016 | PM *Ujjwala Yojana*
2017 | *Saubhagya* Schemes
2019 | Climate Vulnerability Index
2021 | Net Zero by 2070
2022 | Mission LiFE
2022 | National Bioenergy Programme
2022 | E-waste (Management) Rules
2023 | G20 Green Development Pact
2023 | National Green Hydrogen Mission
2024 | Green Steel Taxonomy
2024 | PM *Surya Ghar Yojana*
2025 | National Critical Mineral Mission
2025 | Rajya Sabha guidelines on crop residue burning
2025 | National Adaptation Plan

STATE

2022 | Rajasthan Organic Farming Mission
2022 | Jharkhand Solar Policy
2022 | Uttar Pradesh *Vidyut Sakhi* programme
2023 | Rajasthan Green Hydrogen Policy
2023 | Uttarakhand Solar Policy
2024 | Net-zero roadmaps for Bihar & Tamil Nadu
2025 | Green Odisha Initiative
2025 | Maharashtra Climate Action Plan 2.0
2025 | 50 Heat Action Plans (GJ, OD, MH, TN)
2025 | Delhi Clean Air Action Plan
2025 | Delhi EV Policy 2.0

20 STATES SUPPORTED



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Executive summary

The agricultural sector is the largest consumer of water globally, accounting for 70 per cent of water withdrawals; in India, it accounts for an even higher share–76 per cent of the country's total water use (Chaturvedi et al. 2020). In India, agricultural water management faces complex challenges in terms of water supply and demand, the agricultural market, and fragmented water governance. Despite surface irrigation investments, Indian agriculture heavily relies on groundwater due to its decentralised ease of access (supply-side) and is plagued by low water productivity (demand-side) and skewed incentives favoring water-intensive crops (market-side). Further, interconnected issues related to water, food, and energy require an integrated governance approach to manage these challenges effectively. In this context, implementing integrated water resources management (IWRM) principles in agriculture has the potential to strengthen water governance by valuing, and managing water in a holistic way (Meran, Siehlow, and von Hirschhausen 2020). Traditionally, IWRM does not account for the impacts of climate change; instead, it takes a 'long-term approach' and assumes 'stationarity'–i.e., that natural systems are stable over time and past patterns in water availability and climate can predict future conditions (Ludwig, van Slobbe, and Cofino 2014). With climate change, this assumption no longer holds; there are "large uncertainties in future projection" and water availability is expected to change (Ludwig, van Slobbe, and Cofino 2014, 236).

Image: iStock

Integrating climate change considerations into agricultural water management would enable India to develop synergistic approaches that simultaneously improve water-use efficiency in agriculture and enhance resilience against climate change impacts.

In this regard, principles of climate change adaptation (CCA) include several critical dimensions that can enable the effective implementation of IWRM, taking into account the impacts of climate change. It requires integrating climate adaptation into socioeconomic and environmental policies and actions, by involving political, social, economic, and administrative entities, as well as stakeholders such as local communities, civil society organisations, and public and private sectors, through a "country-driven, gender-responsive, participatory and fully transparent approach" (UNFCC 2022). .

The IWRM framework promotes coordinated processes that integrate various disciplines, resources, policies, and stakeholders through a scientific approach and democratic water management governance. This framework is optimal for the integration of CCA due to their shared goals, such as sustainable development, public participation, and social justice. The 2030 Agenda for Sustainable Development further highlights the importance of IWRM for achieving the United Nations' Sustainable Development Goals (SDG), particularly SDG 6 and Target 6.5, which calls for the implementation of IWRM at all levels, including across borders, by 2030.

This report analyses the status of policy narratives of 16 policy instruments from India and 6 from other countries where IWRM plays a prominent role in agricultural water management. These are Australia, China, France, Netherlands, Spain, and Saudi Arabia. The Indian case is explored at the national as well as the state level, covering policies from Bihar and Odisha.

The analysis focuses on the following IWRM and CCA goals assessed through 16 sub-elements and 59 keywords to understand key narratives and draw valuable lessons from the selected policy instruments.

- **Integrated approach**: Incorporates multi-sectoral, multi-disciplinary, and multi-level governance, achieving integration across sectors, uses, demands, the environment, and people
- **Climate change considerations**: Integrates climate action by assessing risks and implementing adaptation, and mitigation measures—especially those that are adaptation-led—within the water resource management framework
- **Environmental sustainability**: Protects water resources and associated ecosystems
- **Economic efficiency**: Maximises benefits for the largest number of users by optimising the available financial and water resources, considering pricing as well as social and environmental costs and benefits
- **Social equity**: Ensures equal accessibility to adequate quantity and quality of water for all users, especially marginalised and poorer groups, to support human well-being

Figure ES1. Policy analysis across 16 policies from national and subnational cases

Source: Authors' compilation

Key findings

Our findings indicate that the narratives in the water management policies chosen emphasise integration. The uniqueness of the subnational policies is their focus on community-driven integration and water-led climate adaptation in the agricultural sector, while national-level policies place a greater emphasis on mitigation. Environmental sustainability, participatory water management, and social equity are common themes; we found a marked emphasis on marginalised groups and gender roles in Indian policies. We recognise the need to prioritise these goals given the particular context of the region while also offering practical strategies and lessons applicable across various settings, promoting cross-country learning and collaboration.

Figure ES2. IWRM and CCA elements provide a lens through which to analyse national and subnational level policies

IWRM & CCA key elements	National-level policies	Subnational-level policies
 **Integrated approach**	• An integrated approach to water management is a fundamental aspect of the primary objectives and action plans of most countries	• An integrated approach is common to all policies while there is limited focus on IWRM in all state policies and plans
 **Climate change considerations**	• Most national water management policies integrate climate change considerations	• Adaptation is focused in the state action plan on climate change (SAPCCs) but missing in water policies • Mitigation co-benefits is acknowledged in some cases
 **Environmental sustainability**	• Environmental sustainability is a primary focus in all national policies. Additionally, given the nature of the selected policies, water is the central theme across all of them	• Strong focus on water across all policies • Linkage to soil also acknowledged • Forests are recognised only in the Odisha SAPCC
 **Economic efficiency**	• The economic implications of water for national development, and the economic value of water, is a primary consideration for a majority of the selected policies	• Income and livelihood generation is a consistent theme across most policies. • Agricultural productivity is a common focus in the states' agriculture policies and SAPCCs but finds no mention in water policies.
 **Social equity**	• Several policies were highly responsive to creating a participatory governance structure	• Gendered impact is discussed across all policies • Vulnerable and marginalised groups are mentioned but detailed plans for their inclusion are missing • Participatory water management and capacity building are the focus of most policies and plans

Source: Authors' analysis

Key recommendations

We suggest the following key policy recommendations based on the analysis:

- Review and redesign policy instruments to address the gaps identified in this report, ensuring they are aligned with and effectively contribute to IWRM and CCA goals
- Consider IWRM and CCA principles or an integrated approach for holistic governance and coherent policies
- Emphasise the importance of adaptation strategies with mitigation as a co-benefit in addressing climate-related risks to water resources
- Integrate water productivity interventions and highlight their benefits in water-related and agricultural policies
- Highlight water tariffs and pricing mechanisms as an essential means to promote efficient water use and incentivise conservation efforts
- Incorporate a gender perspective into water management policies to address gendered impacts of climate change
- Set up committees that bring together policy makers involved in agriculture, climate policy, and water management at both the national and subnational levels in India

IWRM and CCA principles can guide holistic governance and coherent policy making.

The study covers selected policies, while there is scope for future research to include a comprehensive range of policies across various sectors. A more comprehensive approach should incorporate policies that target different points in the agricultural value chain and recognise the interrelations between IWRM and CCA goals and sub-outcomes for a more holistic perspective.

Image: iStock

1. Introduction

Agriculture consumes significant water globally, accounting for 70 per cent of water withdrawals (FAO 2017). In India, its share of water withdrawals is even higher, at 76 per cent (Chaturvedi et al. 2020). Agricultural water management in India is complicated by water supply and demand, agricultural markets, and various governance considerations. From the supply-side perspective, groundwater has become farmers' most sought-after irrigation source despite India making significant surface irrigation infrastructure investments over the decades. Currently, 40 percent of water used for irrigation comes from groundwater sources (Qin et al. 2024). Even among 23.14 million minor irrigation schemes in India, almost 95 per cent are schemes drawing groundwater (Ministry of Jal Shakti 2023), a climate-vulnerable resource (Pandian 2023). From a demand perspective, Indian agriculture has low water productivity driven by low water-use efficiency. A Council on Energy, Environment and Water (CEEW) study from 2020 finds that if agricultural practices such as micro-irrigation and mulching are implemented, and policy reforms like water auditing and volumetric pricing are adopted, almost 20 per cent of irrigation water can be saved in 2030 following a moderate water-saving strategy. It further argues that, by 2050, up to 47 per cent of irrigation water can be saved if a rigorous water-saving strategy is followed (Chaturvedi et al. 2020). From a market perspective, even though minimum support prices (MSPs) have been set for 22 crops (MoAFW 2024), in practice, only crops like wheat, rice, and sugarcane are assured procurement (Tiwari 2020), creating highly skewed incentive structures in favour of these water-intensive crops. Finally, agricultural water governance is plagued by resource nexus challenges, wherein the governance of water, food, and energy inevitably conflict. These issues necessitate a holistic and integrated governance approach (Orimoloye 2022).

In this context, integrated water resources management (IWRM) can be an effective framework for structuring agricultural water management. "Integrated Water Resources Management (IWRM) is a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment." (GWP 2011). IWRM aims to balance the three pillars of "social equity", "economic efficiency", and "environmental sustainability" (Ben-Daoud et al. 2021). The IWRM framework presents a holistic approach that aims to integrate resource issues (like land and soil; surface water and groundwater), various disciplines and stakeholders, policies, and bottom-up and top-down approaches (Biswas 2008).[1] It promotes coordinated processes that unite various stakeholders, use scientific data and tools for sound judgment, and emphasise democratic governance.

Traditionally, IWRM does not take into account the uncertainties posed by climate change present today.

Although IWRM has guided water management for decades, its effectiveness as a comprehensive land and water-use management tool, particularly in the agricultural sector, is gradually receiving greater recognition (Roy, Oborne, and Venema 2009). One of the first and commonly cited examples of IWRM is from 1933, when the Tennessee Valley Authority (TVA) was created to oversee multiple functions, including navigation, flood control, power production, erosion control, recreation, and public health (Meran, Siehlow, and von Hirschhausen 2020). The TVA initiative incorporated many aspects of what is now known as IWRM, emphasising comprehensive planning for natural resource use while balancing economic, social, and environmental goals. During the International Conference on Water and the Environment (ICWE) in Dublin, Ireland, the concept was formally included in the Dublin Statement on Water and Sustainable Development, and it was subsequently adopted on 31 January 1992. The Dublin Statement highlighted the mismanagement and scarcity of global water resources, which posed further threats to sustainable development, environmental protection, human health and welfare, food security, industrial growth, and ecosystem stability. It introduced four guiding principles that now serve as the foundation of IWRM (SIWI 2020).

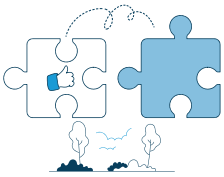
The four guiding principles that form the foundation of IWRM (SIWI 2020) are:

- Freshwater is a finite and vulnerable resource, essential to sustain life, development, and the environment.
- Water development and management should be based on a participatory approach, involving users, planners, and policy-makers at all levels.
- Women play a central role in the provision, management, and safeguarding of water.
- Water has an economic value in all its competing uses and should be recognized as an economic good.

Since IWRM provides comprehensive solutions for sustainable development, its application is especially relevant in resource-dependent sectors like agriculture, where water supply and quality, land management, and women's participation are crucial (Roy, Oborne, and Venema 2009).

1. Biswas (2008) identifies 41 such elements which require integration for IWRM to be implemented.

Traditionally, IWRM does not take into account the uncertainties posed by climate change present today. IWRM takes a 'long-term approach' based on 'stationarity'. This assumes that natural systems are stable over time and past patterns in water availability and climate can predict future conditions (Ludwig, van Slobbe, and Cofino 2014). However, with climate change, this assumption no longer holds, and there are "large uncertainties in future projection" (Ludwig, van Slobbe, and Cofino 2014, 236). This lack of stability gives rise to new uncertainties in managing physical systems and different stakeholders' behaviours. Recently, water management policies and practices has begun focusing on acknowledging and managing these uncertainties to improve decision-making (Ludwig, van Slobbe, and Cofino 2014).



The integration of CCA with IWRM for agricultural water management offers opportunities to share insights and support both approaches.

Climate change adaptation (CCA), therefore, becomes a crucial framework to be integrated into water management, particularly agricultural water management. It refers to "adjusting practices, processes and capital in response to the actuality or threat of climate change, as well as responses in the decision environment, such as changes in social and institutional structures or altered technical options that can affect the potential or capacity for these actions to be realized" (Adger, et al. 2007).

The approval of Agenda 2030 for Sustainable Development by the United Nations in 2015 established a comprehensive framework for global sustainable development efforts (Sam Kutesa et al. 2015). Within this framework, IWRM and CCA are recognised as crucial components contributing to SDGs. Specifically, IWRM aligns with SDG 6, which aims to ensure the availability and sustainable management of water and sanitation for all, while CCA aligns with SDG 13, which focuses on taking urgent action to combat climate change and its impacts. In the context of SDG 6, target 6.5 emphasises the implementation of IWRM at all levels by 2030, including through transboundary cooperation where appropriate (Giupponi and Gain 2017). Jonch-Clausen (2007) suggests that IWRM should be made a focal point in adaptation policies just as how clean energy is emphasised in mitigation efforts.

Several dimensions are critical to enable the effective implementation of IWRM. These dimensions are:

- **Enabling environment**, which encompasses relevant laws, policies, and strategies;
- **Institutions and participation**, which includes political, social, economic, and administrative institutions that support IWRM;
- **Management instruments**, which refers to tools and activities that assist decision-makers in making informed choices; and
- **Financing**, which pertains to the budgets and financial resources allocated to IWRM initiatives.

A significant component of the enabling environment is policy instruments, comprising **national, state, and local-level laws and policies** that constitute the "rules of the game" and are critical to driving change on the ground level (GWP and INBO 2009; World Water Council 2023).

Similarly, several dimensions drive the effective implementation of CCA. It requires the integration of adaptation into socioeconomic and environmental policies and actions and emphasises the engagement of political, social, economic, and administrative entities and stakeholders, including local communities, civil society, and public and private sectors, through a "country-driven, gender-responsive, participatory, and transparent approach" (UNFCCC 2022).

Both CCA and IWRM aim to promote sustainable development and share key objectives like public participation, information sharing, and social equity (He 2013; GWP-C 2015). The integration of CCA and IWRM into agricultural water management could offer valuable opportunities for sharing insights and exchanging knowledge, especially regarding how these approaches can support one another.

This report assesses subnational policies of India and key national policies globally to collate learnings on how IWRM and CCA can be integrated with water management in agriculture.

While the SDGs and other similar global agendas have established priorities and provide direction, policy instruments, such as laws or plans, guide the implementation of various concepts like IWRM and CCA through well-defined text. Hence, a systematic assessment of current policies is necessary. This is the first step toward understanding the applicability and utility of IWRM and CCA in agricultural water management. In this report, we investigate broader sectoral policies, laws, and plans. However, we refer to them as 'policies' to align with international conventions and facilitate effective communication with global research, policy, and practice communities.

Based on the outlined goals of IWRM and CCA (mentioned in Table 1), this report systematically assesses subnational policies in India and key national cases in the global context to collate learnings on how IWRM and CCA can be integrated in water management in agriculture.

Our objectives are as follows:

- How do the selected national and subnational policy instruments integrate IWRM and CCA in agricultural water management?
- What key learnings can be drawn from these national and subnational policy instruments for incorporating IWRM and CCA into agricultural water management?

2. Methods

The report employs narrative analysis to understand IWRM and CCA narratives in the selected policy instruments and highlights recommendations for future policy action (Rose 2004). It examines significant policies from seven countries, including India. These cases reflect a global water governance reform paradigm and offer valuable insights for integrating IWRM and CCA into agricultural water management. In addition, we analyse subnational Indian policies from two Indian states. We hope that this analysis would enable cross-learning at different levels regarding the policy initiatives of other countries without focusing on their differences (Fritsch and Benson 2019; Rose 2004).

2.1 Study design

We employ a framework (detailed in Table 1) that integrates IWRM principles and CCA goals to assess agricultural water management. This framework provides a structured approach for evaluating how effectively policies align with these combined IWRM and CCA goals. By systematically organising and prioritising these goals, the framework aids in identifying strengths, gaps, and areas for improvement, supporting better decision-making and promoting integrated, sustainable water resource management. We developed the framework by defining and describing five common goals for IWRM and CCA based on their definitions, identifying elements within each key goal, and establishing keywords for each.

Table 1. The IWRM and CCA goals assessment framework has five key goals

Key goals	Description	Elements	Keywords
Integrated approach	Draws from multi-sectoral, multi-disciplinary, multi-level governance, and multi-stakeholder perspectives and achieves integration across various dimensions: use, demand, the environment, and people (ENTIRE 2014)	integrated, IWRM	integrated, IWRM
Climate change considerations	Integrates climate action in the form of assessing risks and carrying out adaptation and mitigation activities within the water resource management framework (Ludwig, van Slobbe, and Cofino 2014)	adaptation, mitigation, risk	adaptation, resilience, adapt, climate change, mitigation, emission, sequestration, carbon capture, greenhouse gas, GHG, risk
Environmental sustainability	Protects water resources and associated ecosystems (Conradin 2019)	sustainable resource management, water, soil, forest, energy	water, soil, microbial, land, forest, non-timber forest products, timber, resource management, resource use, resource efficiency, efficiency, conservation, energy
Economic efficiency	Maximises benefits for as many users as possible while making the best use of the limited available water and financial resources. This includes price as well as social and environmental costs and benefits (GWP 2024)	income, productivity, water as an economic good	income, profit, returns, productivity, economic, tariff, pricing
Social equity	Ensures equal access to adequate quantity and quality of water for the sustenance of human wellbeing, for all users, especially those that are marginalised and poorer user groups (GWP 2024)	gender, other interest groups, participatory	gender, women, woman, female, scheduled caste, SC, scheduled tribes, ST, small holder, marginal farmer, minority group, small farmer, marginal, small-scale producer, poor, indigenous, rural, equity, farmer producer organisation, FPO, water user association, WUA, cooperative, self-help group, SHG, participatory

Source: Authors' compilation

Note:
"Goal- Responsive" indicates that the primary objective of the policy directly aligns with the respective goal;
"Goal-driven" applies when the goal is explicitly mentioned within the policy, even if it is not a central priority;
"Goal-aware" is used when the goal is only briefly acknowledged or referenced, without substantive emphasis
"Goal-blind" refers to cases where there is little to no recognition of the goal within the policy

Next, for policy analysis, we used NVivo, a qualitative data analysis software. The keywords defined in Table 1 were used to code the information to identify policy priorities to understand their alignment with the goals. Substansive reading of the policies were carried out to critically extract learnings for the integration of IWRM and CCA into agricultural water management.

By including policies from 2001 onwards, we analyse how climate change considerations have been progressively integrated into water management policies over time.

2.2 Selection of policy instruments for narrative analysis

We selected policy instruments for this IWRM and CCA analysis that were introduced between 2001 and 2024. This timeframe was selected because the year 2000 marked the adoption of the Millennium Development Goals (MDGs) by the United Nations with commitment by all member states, which brought increased global attention to water resource management and sustainable development. Given the overlapping concerns between IWRM principles and the MDGs, 2001 is a relevant starting point for examining how these principles were incorporated into policy. From the early 2000s, there was growing recognition globally of the impact of climate change and the need for adaptation strategies. By including policies from 2001 onwards, we can analyse how climate change considerations have been progressively integrated into water management policies over time.

For national case studies

To select national policy instruments from other countries, we used the SDG 6.5.1 reporting portal. SDG 6.5.1, which measures the degree of IWRM, is a well-documented and monitored SDG. Progress against this indicator is measured on a scale of 0 to 100 ('implementation not yet started' to 'fully implemented'). We sourced this data from the IWRM Data Portal maintained by the UNEP-DHI Centre on Water and Environment in partnership with the United Nations Environment Programme (UNEP) and the Global Water Partnership (GWP).

The portal hosts more than 190 national reports on SDG indicator 6.5.1 (reported across three years – 2017, 2020, and 2023). We used data from the latest round of reporting in 2023. The data primarily comprised self-reporting on IWRM implementation assessed through a survey questionnaire filled by a National SDG 6.5.1 focal point during a national workshop. Finally, UNEP aggregates, assesses, and verifies the data, which is then hosted on the portal.

Using the scores from 2023, which covered 183 countries, we identified 47 countries that performed 'high' and 'very high' in IWRM implementation. These 47 countries are grouped based on the geographic regions defined under the United Nations Statistics Division (UNSD) into the following seven SDG regions: Sub-Saharan Africa, Northern Africa and Western Asia, Central and Southern Asia, Eastern and South-Eastern Asia, Latin America and the Caribbean, Oceania, and Europe and Northern America. We selected high-performing countries with the most agricultural land in each region: **Australia, India, China, France, and Saudi Arabia**. Using our discretion, we added two other countries from the UNSD SDG region of Europe and Northern America, **Spain and the Netherlands**, which are known for their exemplary water management. Both these countries have high-performing IWRM programmes and more than 50 per cent of their total land is agricultural land.

Table 2 provides context regarding IWRM implementation categories, future water stress in 2030 under the business-as-usual (BAU) scenario, and existing climate change impacts. Next, for each of these countries, we selected the primary water policy instrument as reported in their SDG 6.5.1 reports (Table 2).

Table 2. Countries with high-performing programmes and the impact of climate change highlight the need to integrate IWRM and CCA to promote sustainable agricultural water management

Country	IWRM implementation category, 2023	Agricultural land (% of total land (World Bank 2021)	Future water stress in 2030 under the BAU scenario[2] (Luo et al. 2015)	Climate change impacts	Policies selected for analysis
Australia	High	47	High	A warming climate, year-to-year rainfall variability, increase in the intensity of rainfall, increase in extreme fire weather, increased sea surface temperatures, sea-level rise, reduction in snow depth, reduction in rainfall in some parts, decrease in the number of tropical cyclones (Climate Change in Australia 2021)	National Water Initiative, 2004 (Australian Government 2004); Water Act, 2007 (Australian Government 2007); National Groundwater Strategic Framework, 2016–26 (Australian Government 2016)
China	High	55	High	Increased frequency of heatwaves, glacier retreat, strong warming in the northern regions, significant reduction of cold days in winter, frequent extreme droughts, increased risk of summer flooding, decreased wheat yields, longer potential growing seasons (Piao et al. 2010)	The Water Law of the People's Republic of China, 2002 (Government of China 2002)
France	Very high	52	Medium to high	Reduced summer stream flows, decline in snow mass (Dayon et al. 2018), increasingly frequent and severe heat waves, greater precipitation variability, increased exposure to cyclones (IEA 2022)	Law on Water and Aquatic Environments 2006 (Government of France 2006; Chiu 2019; ICID n.d.)
India	High	60	High	Extreme heat, changing rainfall patterns, increasing droughts, overexploited groundwater, glacier melt, sea-level rise, water stress (World Bank 2013)	*National Water Policy, 2012* (Ministry of Water Resources 2012); *Draft Water Resource Framework Bill, 2016* (Ministry of Water Resources 2016)

2. According to Luo et al. (2015), water stress is the total annual water withdrawals (municipal, industrial, and agricultural) expressed as a percentage of the total annual available surface water and groundwater. Higher values indicate more competition among users.

Country	IWRM implementation category, 2023	Agricultural land (% of total land (World Bank 2021)	Future water stress in 2030 under the BAU scenario[2] (Luo et al. 2015)	Climate change impacts	Policies selected for analysis
Netherlands	High	53	Medium to high	Increase in extreme temperatures, higher precipitation on the coasts, frequent heavy showers, increased water temperatures and earlier growth of blue algae, sea-level rise, soil salinisation (PBL Netherlands Environmental Assessment Agency 2012)	Delta Programme, 2024 (Government of the Netherlands 2023)
Saudi Arabia	High	80	Very high	Reduced precipitation, high evapotranspiration and loss of soil moisture, increased wind speeds in some regions, higher surface runoff, reductions in deep aquifer recharge (Chowdhury and Al-Zahrani 2013)	National Water Strategy, 2030 (MEWA 2019)
Spain	Very high	52	High	Warmer temperatures and reduced precipitation, reduction in total water resources, decrease in runoffs, high water stress (Estrela et. al. 2012)	Water Law, 2001 (Ministerio de Medio Ambiente 2001)

Source: Authors' compilation

For subnational case studies

For this report, we delve into policy instruments from two states – Bihar and Odisha. Both these states, situated in Eastern India, count among the top ten climate-vulnerable states in terms of climate sensitivity and adaptive capacity (Mohanty and Wadhwan 2021; IIT Mandi, IIT Guwahati, and IISc 2020). These states are predominantly agrarian, with 77 per cent of the population engaged in agriculture in Bihar and 60 per cent in Odisha (Jeet, Ahmed, and Kumari 2020; Government of Odisha 2019). The average landholding size in both states (0.4 hectares in Bihar and 0.9 hectares in Odisha) is below the national average (1.08 hectares) (MoAFW 2019), indicating the dominance of small and marginal farmers. In Odisha, 62 per cent of the farmland relies on monsoon rains, despite 21 droughts and 33 rainfall deficits recorded over 50 years, including a severe drought in 2015, which affected 27 of 30 districts (Das and Mishra 2017). Similarly, Bihar faces erratic weather, with 19 districts recording a 20–53 per cent rainfall deficit in 2024. As India's most flood-prone state, 73–76 per cent of Bihar's area and 28 of 38 districts are at flood risk (Khan 2024).

Table 3. Bihar and Odisha exhibit high vulnerability across multiple dimensions, including climate change, livelihoods, health, and environment

Indicators	Source	Bihar (%)	Odisha (%)
Population engaged in agriculture	Jeet, Ahmed, and Kumari (2020); Government of Odisha (2019)	76	60
Average land holding size	Government of Odisha (2020b)	0.39 ha	0.95 ha
Districts with high exposure to climate change	Rao et al (2019)	78	10
Districts with high vulnerability to climate change	Rao et al (2019)	3	47
Districts with high historical hazards	Rao et al (2019)	22	30
Districts with high future hazards	Rao et al (2019)	84	87
Districts with high intensity of climate change risk	Rao et al (2019)	62	63
Stunting	MoHFW (2021)	43	31
Wasting	MoHFW (2021)	23	18
Underweight	MoHFW (2021)	41	30
All women aged 15-49 years who are anaemic	MoHFW (2021)	64	64
Area with low nitrogen	MoAFW (n.d.)	59	84
Area with low phosphorus	MoAFW (n.d.)	2	25
Area with low potassium	MoAFW (n.d.)	2	9
Area with organic carbon deficiency	MoAFW (n.d.)	32	56
Stage of groundwater development*	Central Ground Water Board (2024)	46	48

*The stage of ground water development is a ratio of annual groundwater extraction and net annual groundwater availability in percentage.

Source: Authors' compilation

The policy instruments selected for our deep-dive analysis include each of these states' primary water, agriculture, and climate change policy instruments. We selected the water policies in each state as they serve as their foundational documents on water governance. Further, given our focus on agricultural water management, we selected each state's major agriculture policy instruments—the *Fourth Agriculture Roadmap, 2023*, in Bihar and the *Samrudhi Agriculture Policy, 2020*, in Odisha. Finally, we selected both states' state action plans on climate change (SAPCC). In 2009, the central government directed the state governments to draft SAPCCs in line with the *National Action Plan on Climate Change* (NAPCC) (Gogoi 2019). Both Bihar and Odisha subsequently developed their SAPCCs. The details of all the selected policy instruments are provided in Table 4.

Table 4. Six policy instruments covering water, agriculture, and climate change were selected from Bihar and Odisha

State	Policies selected for analysis	Primary policy objective
Bihar	*Bihar State Water Policy, 2010*	Establish a "benign water and sanitation policy" to foster social, political, economic, and environmental harmony through integrated, multidisciplinary approaches, emphasising water security (Government of Bihar 2010)
Bihar	*Bihar State Action Plan on Climate Change, 2015*	"Build resilience through development" (Government of Bihar 2015)
Bihar	*Fourth Agriculture Roadmap 2023–28*	Address agriculture challenges to promote food and nutritional security, inclusive development, priority-based public and private investments, fostering convergence between stakeholders, etc. (Government of Bihar 2023)
Odisha	*State Water Policy of Orissa, 2007*	Establish the fundamentals of equitable and judicious use of water for human welfare, the survival of life, and sustained and balanced state growth (Government of Orissa 2007)
Odisha	*Samrudhi Agriculture Policy, 2020*	Sustainably harness agricultural potential to consistently improve farmers' welfare and income while ensuring nutritional security (Government of Odisha 2020)
Odisha	*Odisha State Action Plan on Climate Change, 2021–30*	Based on current and future vulnerabilities, identify and prioritise adaptation/mitigation strategies and refine region-specific action plans (Government of Odisha 2021)

Source: Authors' compilation

3. Results

This section presents the key findings on best practices and learnings derived from analysing national policy instruments, and subnational policy instruments focusing on the states of Bihar and Odisha. The results are categorised into two main areas: first details the best practices and learnings identified within national-level policy instruments, examining their overarching design, implementation effectiveness, and impact scalability. Second offers a deeper, analysis of the subnational policy instruments in Bihar and Odisha, highlighting successful, context-specific approaches, and drawing transferable lessons regarding policy adaptation, local governance effectiveness, and stakeholder engagement within varied state contexts.

3.1 Best practices and learnings in national-level policy instruments

This section provides a comprehensive summary of our analytical findings regarding selected national-level policy instruments. Our assessment specifically evaluates the extent to which these instruments demonstrate an integrated approach, integrate climate change considerations, uphold principles of environmental sustainability, optimize for economic efficiency, and promote social equity.

At what water governance scale do these seven countries operate?

Water governance varies by region and context, but understanding its scale is crucial. Table 5 provides an overview of how different countries manage their water resources, listing key governmental agencies and their scale of operation. Studying these governance structures can shed light on various approaches to handling water issues and promoting sustainable, integrated water management techniques for adaptive agriculture worldwide.

Table 5. Most of the high-performing IWRM countries use river basins as their unit for water management

Country	Who governs water? National/federal/state/provincial governments and their roles	Scale of governance[3]
Australia	In Australia, the national government sets policies and leads legal reform for sustainable and productive water resource management. However, state and territorial governments handle water management within their own regions. Several organisations, including the National Water Grid Authority and the Murray–Darling Basin Authority, share the responsibility of administering water resources (Australian Government 2022).	State; river basin
China	Chinese water governance combines unified management across governance levels and sub-sectors, wherein the Ministry of Water Resources and provincial and municipal authorities oversee various aspects of water management. China's central government essentially controls and supervises the country's water resources. The Changjiang Water Resources Commission and the Yellow River Conservancy Commission are two of the seven significant river and lake basin commissions that China has established to monitor the management of water resources in its largest river and lake basins (Li et al. 2020; He 2020)	River basins; administrative regions
France	At the federal level, the Ministry for the Ecological and Solidarity Transition engages in negotiations at the European and international levels, drafts national laws and regulations, and ensures its enforcement. Basin-level organisations help gather data, plan, collect fees, and provide financial support to local authorities and project managers. Local governments, businesses, farmers, and associations are responsible for making investment decisions related to water management (Ministry for the Ecological and Solidary Transition, International Office for Water, and French Water Partnership 2019).	River basins
India	In India, at the national level, the Ministry of Jal Shakti (formerly the Ministry of Water Resources) is in charge of creating and carrying out water-related policies and programmes. State governments also have jurisdiction over water resources within their respective states. River basin organisations (RBOs) have been established through specific acts (e.g., the Brahmaputra Board), tribunal rulings under the *Inter-State Water Disputes Act (1956)*, and state agreements (e.g., the Upper Yamuna Board). However, most RBOs operate with a top-down, bureaucratic structure, lack stakeholder participation, and are plagued by political resistance and funding shortages, all of which hinder their effectiveness (Raju and Taron 2019).	State

3. Scale of governance here refers to the level at which water management happens, not limited to policy-making.

Country	Who governs water? National/federal/state/provincial governments and their roles	Scale of governance[3]
Netherlands	Responsibility for water management in the Netherlands is vested with the Rijkswaterstaat or the Directorate-General for Public Works and Water Management (the executive branch of the Ministry of Infrastructure and Water Management). This body is responsible for the management of major water bodies, such as the sea and rivers, while district water boards manage regional waters, such as canals and polder waterways. The provinces are responsible for translating the national water policy into regional measures. Under the Soil Protection Act 1951, the responsibility of managing groundwater quality is also vested with the provinces (Government of Netherlands 2013; Government of Netherlands 2015).	River basins; district water boards
Saudi Arabia	Environmental, water, and agricultural matters come under the purview of the Ministry of Environment, Water and Agriculture (MEWA). It provides irrigation water through wells and dams, manages irrigation and drainage-related projects, and plays a vital role in distributing irrigation water to encourage the efficient utilisation of these resources (Fanack Water 2021).	Central
Spain	In Spain, water governance is complex and involves multiple authorities at different levels of government. The Ministry for the Ecological Transition and the Demographic Challenge (Ministerio para la Transición Ecológica y el Reto Demográfico, MITECO) formulates the national water policy and oversees its implementation (Smart Water Magazine 2024). At the regional level, autonomous communities manage intra-regional river basins for irrigation and water allocation; regulate mineral waters, thermal springs, and fishing; oversee infrastructure development; and implement environmental protection legislation at the basin level (López, Martín and Alcácer 2008; Font and Subirats 2010).	River basins

Source: Authors' compilation

Further, we assessed how well national water policy instruments align with IWRM and CCA goals. The aim is to gain a deeper understanding of how diverse policy instruments follow IWRM and CCA principles on a global level. Figure 1 illustrates whether the policies are goal-blind (red), goal-aware (light orange), goal-driven (green), or goal-responsive (blue).

Figure 1. All policies are geared towards achieving environmental sustainability as a goal

Country and policy instrument	Integrated	Climate change	Environmental sustainability	Economic efficiency	Social equity
Australia - National Groundwater Strategic Framework 2016-2026	🔵	🔵	🔵	🟢	🟢
Australia - National-water-initiative 2004	🔵	🔵	🔵	🔵	🔵
Australia - Water act 2007	🟢	🟢	🔵	🔵	🔵
China - Water Law 2002	🔵	🔴	🔵	🔵	🔵
France - Water Law 2006	🔵	🟢	🔵	🔵	🔵
India - Draft Water Resources Framework Bill 2016	🔵	🟢	🔵	🔵	🔵
India - Water Policy 2012	🟢	🔵	🔵	🔵	🟢
Netherlands - Delta Programme 2024	🔵	🔵	🔵	🔵	🔵
Saudi Arabia - National Water Strategy 2030	🟢	🟢	🔵	🔵	🟠
Spain - Water Law 2001	🟢	🟢	🔵	🟢	🟢

🔴 Goal blind 🟠 Goal aware 🟢 Goal driven 🔵 Goal responsive

Source: Authors' analysis

The following are our major findings from the analysis:

- **Australia's National Water Initiative, 2004, and the Netherlands' Delta Programme, 2024, could be regarded as examples of model policies** that prioritise holistic or integrated management of water resources. Both this policies feature policy designs that are responsive to various IWRM and CCA elements.

- **Most policies prioritise an integrated approach**. These policies prioritize many key components of integrated management, even if they are not explicitly labeled as IWRM.

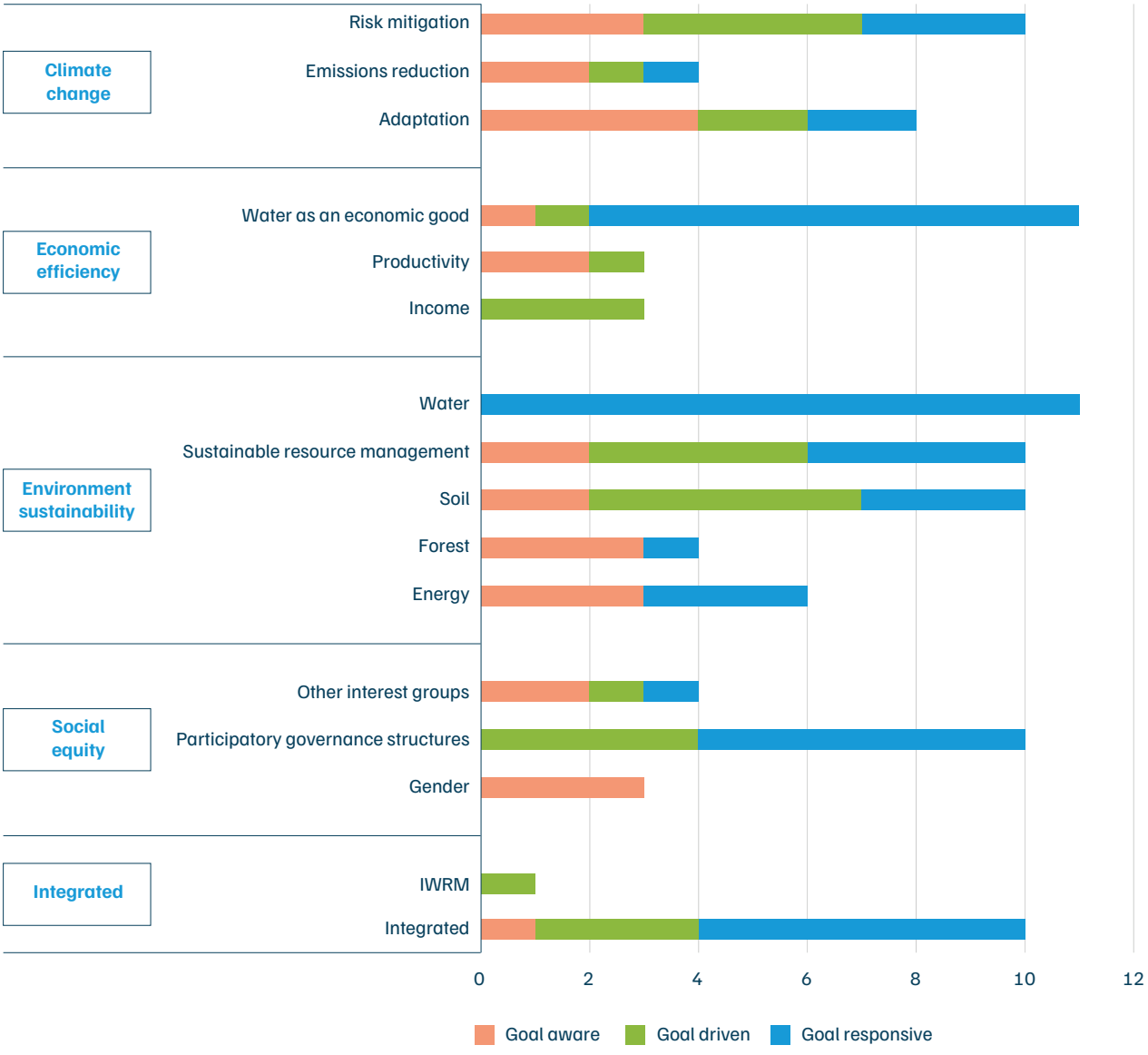
- **Climate change is an important priority in several national policies.** While the China Water Law 2002 does not acknowledge climate change in its policy, it does note environmental and water-related disasters.

- **Environmental sustainability emerges as a prevalent and crucial goal across the national water policies analysed**. Countries have recognised the need to balance economic development with environmental conservation, thereby emphasising the need to manage natural resources effectively.

- **All national water policies prioritise economic efficiency as a critical goal.** They hinge on the understanding the water is a critical imperative for economic development.
- **Social equity remains a significant goal across the national water policies analysed.** Policies assessed indicate the need to address fairness and inclusivity in water resource management frameworks, especially in areas with pronounced socio-economic differences.

In this section, we look at each objective to identify best practices and learnings within the selected policy instruments. We also assess the number of policies classified as goal-aware, goal-driven, and goal-responsive (Figure 2).

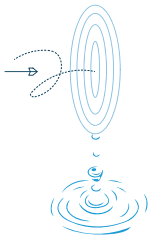
Figure 2. Multidimensional lens is essential to examine the policy instruments to IWRM and CCA principles



Source: Authors' analysis

Integrated approach

- **An integrated approach to water management is fundamental to the primary goals and action plans of the selected policies,** as seen in Australia's National Groundwater Strategic Framework, 2016–2026, and National Water Initiative, 2004, as well as in the selected policies of China, France, and the Netherlands. France mandates the use of a "management plan established at the scale of a coherent hydrological unit" for operations and maintenance of rivers, canal and any water body. Australia's Water Act, 2007, outline action points to actively incorporate integrated methods for management of "environmental waters". The Delta Programme of Netherlands recommends Integrated River Management that integrates science with policy, encourages multi-stakeholder involvement and recognised multi-sectoral demand management.



An integrated approach to water management is fundamental to the primary goals and action plans of the national policies.

Best practice

- **Australia's National Water Initiative, 2004**, recognises the need to create consolidated water accounts to support water entitlement systems. This includes creating systems to integrate the accounting of groundwater and surface water and consolidating groundwater aquifers and streamflow data. This data is integrated into national water budgets, highlighting bottom-up solid data consolidation. States and territories take the lead in identifying locations where aquifers and surface water are closely connected.

Climate change considerations

- **Most national water management policies take climate change into consideration**. The Netherlands' Delta Programme, 2024, considers all three subgoals—adaptation, emission reduction, and risk—as part of its core objective. Australia's National Groundwater Strategic Framework, 2016–2026, and National Water Initiative, 2004, particularly take a risk assessment-based approach towards understanding climate change. Both Saudi Arabia and France recognise risk as a climate consideration and have developed strategies driven towards addressing it.

Best practice

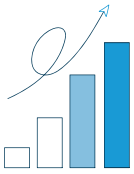
- **The Netherlands' Delta Programme, 2024**, introduced the Spatial Adaptation programme, which aims to make the Netherlands water-resilient and climate-proof. The programme primarily emphasised soil and water resilience. It recommends conducting stress tests, holding risk dialogues, creating implementation agendas, exploiting synergistic opportunities, encouraging and facilitating access to knowledge, and having a robust response mechanism for emergencies.

Environmental sustainability

- **Given the nature of the selected policies, water is a central theme for all of them**. However, only China, France, and Spain's plans highlight water as an environmental resource in relation to the larger ecology, emphasising sustainable resource management. Most of the national policies, such as those of China, Spain, the Netherlands, and France, draw strong connections between water and soil, particularly in relation to land use, thereby laying out plans for soil conservation and efficient irrigation. Besides brief acknowledgements in Australia's Water Act, 2007, and France's Water Law, 2006, Spain's Water Law, 2001, is the only national policy delineating core action plans for water and forestry.

Best practice

- **Spain's Water Law, 2001**, emphasises the relation between water and forestry. Spain has several plans and strategies for the integration of hydrological and forest restoration works. These linkages affect water planning in terms of water use, soil and irrigation, and other agricultural uses (Rodríguez and Suárez 2017).



When it comes to economic efficiency, most of these policies view water as an economic good.

Economic efficiency

- **The economic implications of water for national development and the economic value of water** are primary considerations in most of the selected policies—the national policies of the Netherlands, France, China, Saudi Arabia, and Australia's Water Act, 2007, and National Water Initiative, 2004—and a primary consideration of Spain's Water Law, 2001. When it comes to economic efficiency, most of these policies view water as an economic good.

Best practice

- France's 2006 Water Law emphasises the "user-pays" and "polluter-pays" principles mandated by the EU Water Framework Directive. The law achieves this by reinforcing a system which levy fees on water abstraction and pollution. Furthermore, it recommends water use to economic rationality, as seen in provisions that require compensation to be paid to hydraulic concession holders only if new regulations disrupt the economic balance of their contract.

Social equity

- **Recognising water as a community resource that must be accessible to all**, the national policies of the Netherlands, France, and China, as well as Australia's two policies, were found to be highly responsive to the goal of creating a participatory governance structure, while Spain's Water Law, 2001, also outlines actionable strategies for the same.

Best practice

- **In China's Water Law, 2002**, ownership of small water bodies is assigned to collectives, be it ponds managed and owned by rural collective economic organisations or reservoirs by agricultural collective economic organisations.

3.2 Best practices and learnings from subnational policy instruments: Bihar and Odisha

We analysed how various policy instruments in Odisha and Bihar align with the goals of IWRM and CCA. Figure 3 illustrates whether the policies are goal-blind (red), goal-aware (light orange), goal-driven (green), or goal-responsive (blue).

Figure 3. All the selected policies were geared towards achieving environmental sustainability as a goal

State policy instruments	Integrated	Climate Change	Environmental Sustainability	Economic Efficiency	Social Equity
Bihar - Agriculture Roadmap, 2023	●	●	●	●	●
Bihar - SAPCC, 2015	●	●	●	●	●
Bihar - Water Policy, 2010	●	●	●	●	●
Odisha - SAPCC, 2021–2030	●	●	●	●	●
Odisha - Water Policy, 2007	●	●	●	●	●
Odisha - Samrudhi Agriculture Policy, 2020	●	●	●	●	●

● Goal blind ● Goal aware ● Goal driven ● Goal responsive

Source: Authors' analysis

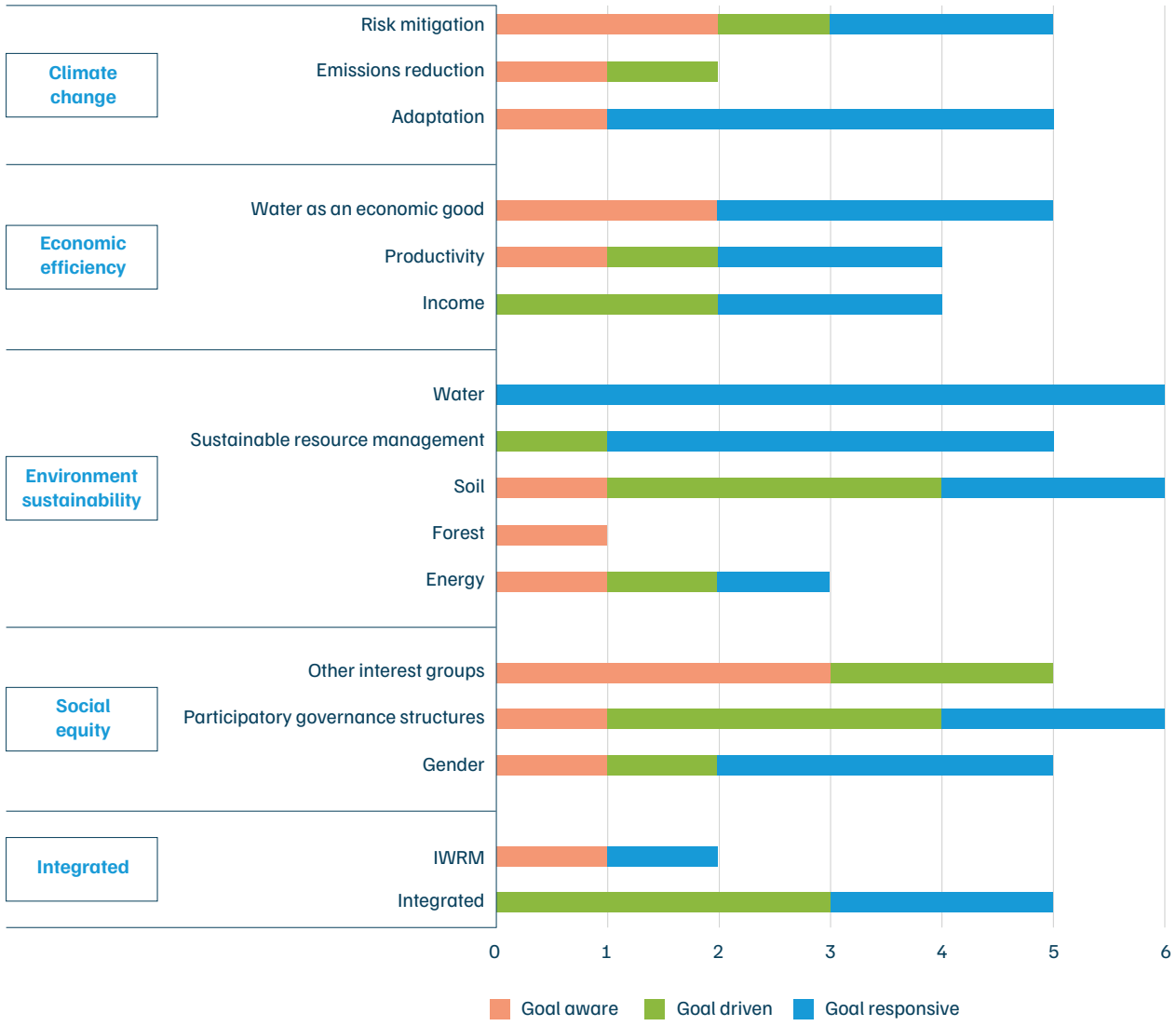
The following are our major findings from the analysis.

- **Odisha's *Samrudhi Agriculture Policy, 2020*, stands out as a model policy** as it actively addresses all goals. The state's water policy is focused on fewer goals, leading to a discrepancy in how different departments within the state government prioritise these goals.
- **Integrated approaches, as defined in Table 1, are a prominent theme in most policies**. Many of these policies concentrate on either integrating the management of farming systems or establishing more robust participatory structures.
- **Both states' water policies overlook climate change concerns**. They fail to adequately address adaptation strategies. Transforming these policies is crucial, as effective water management is especially vital in areas prone to extreme weather, which stands to significantly impact agriculture and related activities.
- **All the selected policies prioritise environmental sustainability**. However, to ensure sustainability, it is essential to analyse if the various resources are being managed as a nexus or in isolation.
- **Economic efficiency is a priority across all policies.** Income, productivity and tariff structuring are common aspects discussed in the policies.
- **Social equity is sufficiently highlighted across all policies.** Focus on gender and other marginalised groups are a common theme. Participatory management of resources is also referred to in some policies.

We delved further into each objective to explore best practices and learnings from subnational policy instruments related to agriculture, water, and climate change. Additionally, we analysed the proportion of policies categorised as goal-aware, goal-driven, and goal-responsive, as illustrated in Figure 4.

Both Bihar and Odisha's water policies fail to adequately address adaptation strategies, despite being highly vulnerable to extreme climate conditions.

Figure 4. All policies are goal-responsive towards the sub-element 'water'

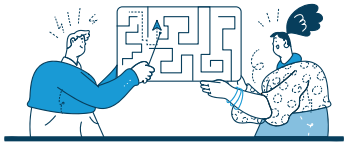


Source: Authors' analysis

Integrated focus

- **Most of the policies and plans analysed advocate for an integrated approach to resource management**. Bihar's *Water Policy, 2010*, advocates for an integrated approach that shifts away from engineering-centric solutions to embrace local community-led water management. The state's SAPCC emphasises inclusive, sustainable, and climate-resilient growth and development. It promotes integrated watershed management and holistic water policies to effectively address climate change challenges. The state's *Agriculture Roadmap, 2023*, proposes a detailed soil and water conservation plan, showcasing a commitment to an integrated approach. The *Odisha SAPCC, 2021–2030*, however, stresses the need for livelihood-centric integrated watershed development in rainfed regions. It introduces initiatives like the *Odisha Integrated Irrigation Project for Climate Resilient Agriculture (OIIPCRA)* and integrated farming systems (IFS).

- **There is a limited focus on IWRM in Bihar and Odisha policies and plans**. Bihar's *Water Policy, 2010*, emphasises training across various fields within the water sector, including IWRM. The *Odisha SAPCC, 2021–2030*, emphasises the need for IWRM approaches but also recognises the lack of institutional expertise to undertake the same as an adaptation option. It further aims to mitigate rising water demand and scarcity by adopting IWRM as the primary approach to water resource management. The plan also encourages studying the impact of climate change by developing a water database through IWRM studies. This involves consolidating all water-related activities under a single multidisciplinary organisation, the river basin organisation (RBO), in collaboration with the Department of Water Resources.



Bihar's SAPCC enshrines adaptation as the "predominant philosophy" and a component of the climate response strategy.

Climate change considerations

- **Adaptation is a significant focus in the SAPCCs as well as in Odisha's Agriculture Policy, 2020, and Bihar's *Agriculture Roadmap, 2023***. Bihar's SAPCC enshrines adaptation as the "predominant philosophy" and a component of the climate response strategy (Government of Bihar 2015, 21). The Bihar *Agriculture Roadmap* promotes climate-resilient agricultural practices that could improve yield and soil health and reduce the environmental footprint of agriculture. The Bihar *Water Policy, 2010*, highlights how resilience to droughts in the most vulnerable areas should be tackled using community-based initiatives. Odisha's SAPCC recognises IWRM and CCA as useful strategies while recognising the need for improved institutional capacity and coordination. The plan recognises implementation of critical climate change related water sector activities like expanding the hydrometry network, increasing water-use efficiency, undertaking water audits, benchmarking, monitoring, and better pricing mechanisms. It stresses the importance of investing in the adaptation of sectors vulnerable to climate change, like water and agriculture. Odisha's *Samrudhi Agriculture Policy, 2020*, emphasises the conservation of water resources and their efficient use in the face of climate change.

- **Mitigation as and when it is a co-benefit to adaptation is acknowledged in Bihar's *Agriculture Roadmap* and Odisha's SAPCC**. Bihar's *Agriculture Roadmap* highlights the potential for emission reduction through zero-tillage practices. The Odisha SAPCC highlights interventions such as hydropower, improved water-use efficiency, and system of rice intensification (SRI)[4] that help build adaptation capacity, and have mitigation as co-benefit.

- **Climate risks for water resources are well-recognised in some policies and plans**. Bihar's SAPCC recognises the risks posed by climate change and emphasises the need to implement suitable measures to address the effects on its water resources. It also recommends reviewing sectoral strategies through the lens of vulnerability and risk. In Odisha, the *Water Policy, 2007*, talks about drought risk, while the SAPCC specifically details plans for disaster risk management.

4. System of rice intensification, or SRI, is a climate-smart agroecological methodology for increasing the productivity of rice and other crops by changing the management of the plant, soil, water, and nutrients.

Environmental sustainability

- **There is a strong focus on water in all the policies, including Bihar's *Agriculture Roadmap, 2023*, *Odisha's Samrudhi Agriculture Policy, 2020* and the SAPCCs**. Bihar's *Agriculture Roadmap* highlights the positive impact of climate-resilient agricultural practices on water resources. Further, it emphasises the importance of watershed development and water conservation for agricultural water management. The SAPCCs of both states also significantly focus on water resources. Odisha's *Samrudhi Agriculture Policy, 2020*, focuses on the need to improve water use efficiency.

- **Linkages between soil and water are acknowledged across all policies and plans, with a few delving into a plan of action for soil conservation**. Bihar's water policy identifies links between water and land. At the same time, the *Agriculture Roadmap* emphasises soil and water conservation through community participation, including promotion of creation of district-level soil fertility maps with panchayats and villages as units. Bihar's SAPCC recommends implementing agroforestry, integrated watershed management and water harvesting through check dams, and renovation of existing ponds to minimise soil and water loss. Odisha's *Water Policy, 2007*, emphasises collecting soil quality data and implementing soil conservation measures to prevent reservoir sedimentation as part of catchment treatment measures. The state's *Samrudhi Agriculture Policy* highlights the importance of participatory watershed management for soil conservation. The Odisha SAPCC acknowledges the role of water management in maintaining soil moisture and emphasises soil health management through the promotion of organic farming and conservation agriculture.

- **The importance of forests in water management is recognised only in the *Odisha SAPCC, 2021–2030***. The plan suggests tree planting and integration of forest management for improved watershed and water resource management. The plan recommends sustainable and scientific management of forests and optimisation of forest resources management.

- **Energy, its use, and its nexus with food and water are highlighted in a few policies and plans**. Bihar's *Agriculture Roadmap* highlights the positive impact of climate-resilient agricultural practices on energy usage. The state's SAPCC highlights cross-sectoral water-use competition between other sectors and energy and promotes improving energy pricing and water pump efficiency. Odisha's *Samrudhi Agriculture Policy* recommends the use of solar-powered irrigation.

Economic efficiency

- **Income and livelihood generation is a consistent theme across most policies**. Bihar's *Agriculture Roadmap* highlights the income generation potential of interventions like zero tillage, while the SAPCC recommends incorporating poverty, equity, and livelihood concerns for all sectors. It also recognises the income generation potential of allied activities like horticulture and fisheries. Neither of the state's water policies mentions income and livelihood generation. Odisha's *Samrudhi Agriculture Policy* focuses significantly on livelihoods and income by emphasising the need to consistently increase funding for agriculture. Similarly, the Odisha SAPCC highlights existing schemes critical for income and livelihood generation.

Neither of the state's water policies mentions income and livelihood generation.

- **Agricultural productivity is a common focus in the states' agriculture policies and SAPCCs, but it finds no mention in the water policies. Water productivity is not mentioned in any of the policies and plans**. However, Bihar's *Agriculture Roadmap* highlights the importance of soil and water conservation for agricultural productivity. The state's SAPCC recommends ensuring adequate water input supply and resource renovation and enhancement to enhance agricultural productivity. The Odisha SAPCC mentions agricultural, forest, and livestock productivity. The *Samrudhi Agriculture Policy* recommends reforming the wasteful methods of irrigation and techniques of production to improve agricultural productivity.

Other than Australia, water productivity is rarely mentioned across national and subnational policies.

- **Water tariffs, pricing, and cost recovery are prominently highlighted in the water policies, while the agriculture policies do not mention the same**. Bihar's *Water Policy* highlights the high service cost, low-cost recovery, and subsequently low expenditure on operation and maintenance (O&M) for water services. The policy considers differential pricing (for agricultural, industrial, commercial, and municipal water use), volumetric pricing, and affordability. Water metering is another critical pricing element highlighted in the policy. Odisha's *Water Policy* also proposes basing pricing on principles of financial sustainability. It recommends the full recovery of O&M costs, differential pricing, and pricing based on the polluter pays principle. Both the SAPCCs mention pricing—Bihar in the context of water tariffs under the *National Water Mission* and Odisha in the context of pricing being a critical aspect of increasing water-use efficiency.

Social equity

- **The gendered impact of policies and climate change, and women's participation in agriculture, are some critical elements discussed across most policies**. Bihar's *Agriculture Roadmap* emphasises the role of women farmers in inclusive development. Bihar's *Water Policy*, in turn, acknowledges the impact of water risks on women. Their representation in Village Water and Sanitation Committees (a sub-committee of the *Gram Panchayat* that manages village water supply and sanitation programs) is also encouraged. The Bihar SAPCC details a gender-mainstreaming process involving the use of gender-responsive language, empirical analyses of implementation plans, gender-focused monitoring and evaluation, audits, and capacity building. Similarly, the Odisha SAPCC outlines a gender policy framework and gender mainstreaming checklist, acknowledging that the effective participation of women in adaptation planning is critical. Its *Samrudhi Agriculture Policy* emphasises the collection of gendered data during monitoring. Odisha's Water Policy does not mention gender.

- **Other vulnerable and marginalised groups are acknowledged in some of the policies and plans, but detailed plans for their inclusion in water resource management are lacking**. Bihar's *Agriculture Roadmap* recommends zero-tillage practices, which could provide better net returns for small and marginal farmers. The Bihar *SAPCC* recognises the disproportionate impact of climate change on the poor, women, children, and the elderly and encourages integrating their concerns through equitable planning. Bihar's *Water Policy* addresses the concerns of vulnerable and marginalised groups by recommending equitable planning at a micro, watershed level. Odisha's *Samrudhi Agriculture Policy* recommends that special attention be paid to rain-fed farmers by creating separate avenues to address their concerns. The Odisha SAPCC simply acknowledges the impact of climate change on small and marginal farmers and SC/ST farmers.

- **Participatory water management and capacity building are the focus of most policies and plans.** Bihar's *Agriculture Roadmap* highlights community participation in irrigation management. The Bihar SAPCC focuses on capacity building for women and men to implement participatory schemes at the village level. The plan also recommends partnerships and collaborations with panchayati raj Institutions and gram panchayats to develop participatory and gender-just adaptation plans. The plan also encourages participatory research by partnering with civil society and the use of participatory quantitative and qualitative methods. Bihar's Water Policy proposes a paradigm shift from engineering-based solutions to community-based participatory solutions through community empowerment to enable bottom-up decision-making with top-down technical support. Odisha's *Water Policy* also recommends a participatory approach to water management, including participatory irrigation management (PIM). The policy highlights the *Orissa Pani Panchayat Act, 2002* (now the *Odisha Pani Panchayat (Amendment) Act, 2014*) (Government of Odisha 2015), which provides a legal framework for farmers to participate in irrigation management and irrigation management transfer (IMT). The policy also encourages the participation of non-governmental organisations (NGOs) in generating awareness regarding water conservation and PIM. Odisha's *Samrudhi Agriculture Policy* also encourages participatory water security management.

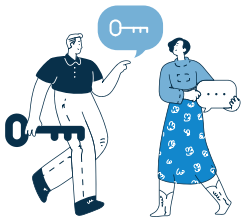
Bihar's SAPCC recommends partnerships with panchayati raj institutions and gram panchayats to develop participatory and gender-just adaptation plans.

4. Key takeaways and discussion

The following section highlights the overall findings from the analysis:

- **Both national and subnational policies recognise the need for an integrated approach to water management**. At the sub-national level, policies such as the Odisha *Samrudhi Agriculture Policy* address various dimensions; however, national policies could further integrate aspects of climate change and IWRM. However, the level of emphasis and implementation varies across different policies and contexts. At the subnational level, integration is often linked to community participation and resource management, while national-level policies focus more on combining surface water and groundwater management, as seen in Australia's National Water Initiative, 2004 where consolidated water accounting is encouraged.

- **Subnational policy instruments primarily focus on adaptation within the agricultural sector and acknowledge the potential impacts of climate change**. Though a mitigation-focused approach can lead to emission reduction and carbon sequestration as co-benefits, India's strategic focus in the agricultural and water sectors emphasises adaptation and not mitigation. Policies such as Bihar Agriculture roadmap, and Odisha SAPCC have accounted for both mitigation and adaptation, while policies. On the other hand, some national-level policy instruments also treat mitigation as one of the core principles, while risk is a common climate consideration across most policy instruments as seen in the water laws of Saudi Arabia and France.



It is important to recognise that the IWRM and CCA goals are highly context-specific.

- **All the national and subnational-level policy instruments that we analysed strongly focus on environmental sustainability, including a prominent focus on soil as a critical resource related to water**. The recognition of forests as an essential component of the hydrological cycle is missing in the Indian states' policy instruments, except the *Odisha SAPCC, 2021–2030*, while being prominently featured as a strategy in Spain.

- **In both national and subnational-level policy instruments, incomes and livelihoods were in focus**. In contrast, water productivity was rarely mentioned, except in the selected Australian policies. Among the subnational policy instruments, water tariffs were highlighted only in the water policies, while agriculture and climate change policies failed to mention them. Water tariffs and pricing are highlighted in national-level policy instruments.

- **Participatory water management is a common theme across all policies–both in the national and subnational cases**. The Indian policy instruments focused on minority groups, such as small and marginal farmers and other marginalised groups. Such a focus is missing in the national-level cases. The gendered impact of climate change and women's role and participation in agriculture and water management is a common theme across Indian policy instruments. However, national-level policy instruments hardly discuss or address gender.

A narrative analysis of national and subnational policy instruments with a focus on IWRM and CCA goals highlights some important insights.

1. Context-specific nature of IWRM and CCA goals: It is important to recognise that the IWRM and CCA goals are highly context-specific. This means that factors such as institutional structures, capacities, and local conditions can influence whether these efforts succeed or fail. A bottom-up approach that enhances participatory mechanisms for local communities and institutions would help enable smooth and efficient implementation. For example, Australia's National Water Initiative (NWI, 2004) allows for local and bottom-up responses in water trading, and Odisha's Water Policy (2007) relies on bottom-up approach of empowering local water user groups (Pani Panchayats). This study examined how the policies are designed and not how they are implemented. Future studies can evaluate the implementation of these policies within their respective local contexts.

2. Scope and limitations of the study: The study is limited by the number of policies analysed. To provide a better understanding, future research should look at a wider range of policies across different sectors—agriculture, water management, and climate change. It should also consider policies that target different stages of the value chain, from production to consumption, for a more holistic perspective.

3. Interconnectedness of the outcomes: While our study focuses on individual outcomes related to agriculture, water, and climate change, it is important to recognise the interconnectedness of these sub-outcomes. For example, community participation in decision-making can positively impact income generation, support sustainable agricultural practices, and improve resilience to climate change. Future studies should explore these connections better to achieve policy goals.

4. Learning from global experiences: To broaden the scope of analysis, looking at what worked in other countries and identifying lessons and strategies could be useful. Learning from global agricultural and climate change policies can help us find best practices and encourage a collaborative learning environment across countries, which can then be contextualised for specific use cases.

The way forward

In conclusion, while this analysis sheds light on important aspects of incorporating IWRM and CCA goals in policies related to agriculture, water, and climate change, there are still several unexplored avenues for further research and action. Adopting a holistic and broad approach that includes more international case studies can lead to a comprehensive understanding of the connections between agriculture, water, and climate change as well as help develop solutions for different states across India, based on their respective contexts.


Image: iStock

5. Recommendations

The following section presents a series of targeted, actionable recommendations across three critical domains: policy and governance, technological and infrastructure investment, and farm-level and community practices. These recommendations are designed to foster the principles of IWRM and CCA, promoting water-use efficiency, and secure equitable water access for the agricultural sector in the face of a rapidly changing climate. Successful adaptation requires not just incremental adjustments, but a strategic, coordinated transition supported by enabling policy frameworks and significant investment in both modern and nature-based solutions.

- **To effectively bridge the identified gaps, state-level policy tools must be revisited to ensure relevance and goal responsiveness**: Bihar and Odisha's water policies require updates to reflect the current and projected risks posed by climate change. Their SAPCCs should be periodically reviewed and revised as per NAPCC guidelines. The periodicity of revisions can be every 2-5 years (CEEW and IWMI 2024). These updates should focus on creating policies that can shift and adapt to changing climate, development trajectory, and societal needs. For instance, integrating the latest science on water mediated disasters like drought, floods and extreme weather events, and respective strategies for climate-smart water management. Ecosystem-based adaptation strategies with recognition of the role of natural systems in water regulation and disaster risk reduction is crucial for a water secure future. To further strengthen sustainable water, efficient irrigation needs to be promoted, groundwater recharge needs to be enabled, and conservation practices need further penetration.

Regular evaluation and monitoring mechanisms should be designed to measure how well existing policies are working so that adjustments can be made where needed, keeping the broader objectives in mind. This is where robust monitoring, evaluation and learning frameworks with tracking continual improvements are needed with timely adjustments and course corrections. The evaluation process needs to be made publicly available with stakeholder engagement in the review process.

- **Adopt IWRM principles or other integrated approach for holistic governance and coherent policies**: This is crucial not just for water policies but also for agricultural and climate change policies. An integrated approach enabled through strengthening cross-sectoral representation in decision-making by inviting perspectives from key stakeholders from relevant departments and extending community participation with inclusion of the most vulnerable and affected section. Integration across different areas can help balance various water uses, manage demand effectively, and align policies with environmental and social sustainability, in addition to economic sustainability.

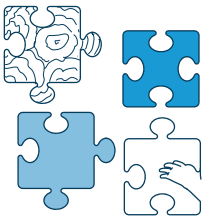
- **Emphasise adaptation strategies for managing climate-related water risks that also provide mitigation benefits as co-benefits**: Policies should integrate emission reduction and carbon sequestration into agricultural water management to showcase the climate advantages of adaptation efforts, particularly methane reduction associated with agriculture and allied sectors. Highlighting these development co-benefits can help policymakers secure support for adaptation initiatives while also advancing broader climate mitigation goals in order to transition to climate resilient pathways.

- **Integrate water productivity interventions into water and agriculture policies, emphasising their advantages**: Acknowledging the close link between water resources and agriculture will enable policymakers to create pragmatic solutions. This can be enabled through water footprint assessment through the agriculture products and processes, inter-state virtual water flows to identify hotspots of unsustainability. Holistic strategies that strengthen both systems while sharpening their ability to bounce back to equilibrium from an unsustainable stage.

- **Promote water tariffs and flexible pricing systems to encourage efficient use and incentivise conservation**: This could involve creating flexible pricing schemes tailored to the needs of different users, as seen in the case of certain states of India like Maharashtra and Haryana established through the water resources regulatory authorities. This was also seen in various policies in our analysis. In doing so, water can be regulated in a systematic, time-bound, and well-informed manner to meet conservation targets and generate stable revenue to build and maintain water systems for the present and future

- **Include a gender perspective in water management policies by acknowledging how climate change affects men and women differently and ensure women have a role in agriculture and water resource management**: This would mean introducing gender-responsive strategies that address gender disparities and promote equality. Gender-mainstreaming frameworks in Bihar and Odisha's SAPCCs can serve as useful examples of best practices on this front. This needs capacity building to understand the broad gender spectrum, and legal, socio-cultural aspects of gender mainstreaming. Inclusion of gender perspective also necessitates creating sex -disaggregated database for effective assessment over time and space.

- **Set up committees that bring together policy makers involved in agriculture, climate policy, and water management at both the national and subnational levels in India**: Such committees can build on the 'Core Group of Secretaries' to integrate key priorities and associated expertise, thereby ensuring that policies and strategies are holistic and account for the interdependencies between systems while preventing inefficiencies. They would be crucial for helping in alignment of goals, avoiding trade-offs in policies, and enabling co-financing, technical knowledge to achieve multiple objectives.



Emphasising adaptation strategies that yield mitigation co-benefits, integrating water productivity interventions, and implementing flexible water tariffs are vital steps towards sustainable water management.

To effectively bridge the identified gaps in water governance, the analysis of how well national and subnational policies are aligned with IWRM and CCA goals highlights opportunities for transitioning towards a comprehensive and adaptive approach. A key insight is that policy goals are prioritised differently depending on their scale, mandates, and specific contexts. To substantiate, Indian state-level policies often focus on community-driven adaptation within the agricultural systems, while national policies globally tend to emphasise mitigation and broader environmental sustainability.

Policy action towards bridging the gaps would require attention in the entire policy process covering updation of the existing national and state water policies to reflect current and projected climate risks, and also ensuring their periodic review and revision. Policies must adopt an integrated approach, fostering cross-sectoral collaboration and broad stakeholder participation, including vulnerable communities. Emphasising adaptation strategies that yield mitigation co-benefits, integrating water productivity interventions, and implementing flexible water tariffs are vital steps towards sustainable water management. Furthermore, embedding a gender perspective and establishing inter-ministerial committees at both national and subnational levels will ensure holistic policy formulation, resource alignment, and conflict avoidance. Ultimately, robust monitoring, evaluation, and learning frameworks, with public transparency and community engagement, are essential to ensure continuous improvement and the long-term resilience of India's water resources in a changing climate.

To enable this, future research must broaden its scope to continuously integrate the evolving scientific understanding of water resources and climate change, alongside tracking the dynamic policy landscape for time-sensitive assessments. Furthermore, policy research would greatly benefit from exploring best practices and case studies from other relevant geographies to inform adaptive water resources management for a changing climate and growing farms.

Acronyms

BAU	business as usual
BIPP	*Biotechnology Industry Partnership Programme*
BMGF	Bill & Melinda Gates Foundation
CCA	climate change adaptation
FPO	farmer producer organisation
GHGs	greenhouse gases
GWP	Global Water Partnership
ICID	International Commission on Irrigation and Drainage
ICWE	International Conference on Water and the Environment
IISER	Indian Institute of Science Education and Research
INBO	International Network of Basin Organizations
IWRM	integrated water resources management
MDGs	Millennium Development Goals
MEWA	Ministry of Environment, Water, and Agriculture (Saudi Arabia)
MITECO	Ministerio para la Transición Ecológica y el Reto Demográfico (Ministry for the Ecological Transition and the Demographic Challenge, Spain)
MSP	minimum support price
NAPCC	*National Action Plan on Climate Change*
NFHS	*National Family Health Survey*
NGO	non-governmental organisation
O&M	operation and maintenance
OIIPCRA	*Odisha Integrated Irrigation Project for Climate Resilient Agriculture*
PIM	participatory irrigation management
RBO	river basin organisation
SAPCC	*State Action Plan on Climate Change*
SC/ST	Scheduled Caste/Scheduled Tribe
SDG	Sustainable Development Goal
SHG	self-help group
SRI	System of Rice Intensification
TVA	Tennessee Valley Authority
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division
WUA	water user association

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