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# **Irrigation governance and the performance of the public irrigation system across states in India**

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**Abstract** An irrigation governance index is constructed based on a comprehensive set of indicators for 20 major states of India from 2001-02 to 2015-16. Its influence on the performance of the public irrigation system is analysed. The index is also estimated separately for three dimensions of governance: institutions and regulatory mechanism; participation and accountability; and service delivery. There are large inter-state variations in the governance scores and changes in their ranking over time. Massive public investments in major and medium irrigation and creation of related infrastructure have not yielded adequate outcomes measured by the net area irrigated by canals, percentage of irrigation potential utilized and gap in irrigation potential created and utilized. The results from the panel regression model show that good irrigation governance significantly improves the performance of the public irrigation system, which in turn can contribute to enhance agricultural productivity.

**Keywords** Public investment, irrigation potential, governance

**JEL classification** Q1, Q28, Q150, H410

## **1 Introduction**

Irrigation is an important input in catalysing the use of improved seeds and fertilizers. It has received significant policy attention in India, and its irrigation sector has been important in developing agriculture. A large amount of capital has been invested in constructing a massive network of canals across all the states in India to develop irrigation facilities. Even where the economic criterion of benefit-cost of irrigation projects was not in favour, irrigation facilities were developed to alleviate drought-induced famines (Gulati et al. 1994; Easter & Liu 2005).

The role of irrigation in accelerating agricultural productivity and reducing poverty is well established in the literature (Evenson et al. 1999; Hussain & Hanjra 2004; Bhattacharai & Narayananamoorthy 2012; Bathla et al. 2019). The area irrigated by canals has increased considerably from 7.2 million hectares (ha) in 1950-51 to 16.2 million ha in 2014-15 (Government of India 2017), but the effectiveness of public capital

expenditure on major and medium irrigation projects – and the returns – have varied by location and have always been a matter of concern. Projects have suffered from time over-runs and cost escalation, and some projects have been abandoned. Recovering the cost of investment has been a contentious issue, and there have been environmental externalities (Government of India 1992; Gulati et al. 1994; Easter & Liu 2005).

As per the Central Water Commission, 5,264 large dams are in operation in India, of which 2,069 are in Maharashtra; each is over 25 years old. The operations and maintenance of irrigation dams are neglected, leakages persist and management practices are poor; and all these have always been attributed to the insufficiency of funds generated from water, which is priced low (Government of India 1992). Poor operations and maintenance of systems has affected water use efficiency, which is evident from the low utilization of the irrigation potential created. And recurrent dam failures pose safety risks such as floods and loss of lives.

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The conventional model of irrigation development is based largely on the system of state command and control, but the state-led governance of the irrigation system has limitations and it does not adequately address the issues of social and environmental equity (Gandhi & Namboodiri 2009; Narayanan et al. 2014). Alternative models of governance – such as participatory irrigation management and community-based management with well-defined rights and greater decentralization of responsibilities to users – have been experimented with (Parthasarathy 2004; Swain & Das 2008; Shah 2016), but the evidence on their impact on the performance of irrigation systems is mixed.

Of late, emphasis has been laid on improving public irrigation system<sup>1</sup> governance and dam management practices.<sup>2</sup> An improvement in governance is likely to improve the utilization of the irrigation potential created and lead to an improvement in agricultural productivity (Narian 2000; Kumar et al. 2001; Kumar 2010; Shah 2019).<sup>3</sup> However, little evidence is available on the status of irrigation governance at the macro level and changes therein over time. This paper makes a modest attempt to construct an irrigation governance index (IGI) based on select indicators. It attempts also to analyse the influence of the IGI on the performance of the public irrigation system.

## 2 Governance and development: a brief review

‘Governance’ may be understood to be the traditions and institutions by which authority is exercised (Kaufmann et al. 1999). It may include the process by which governments are selected, monitored and replaced; a government’s capacity to formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions. Good governance is considered to be broader than institutions and include the people, the state and their interactions (United Nations Development Programme 2014). Good governance is important in promoting economic growth and

improving developmental outcomes such as per capita income, literacy, conservation of natural resources and reducing poverty, among others. Interest in good governance has been increasing among researchers, academicians and policy planners.

The mechanisms that promote good governance are transparency, democratic institutions and effective public services. Its processes may include the quality of participation, which includes the involvement of the most vulnerable sections of society and the poorest, and the accountability of institutions to the public and other stakeholders. The outcomes of good governance are a healthy and peaceful society and the delivery of public services. Bad governance leads to corruption, poor and inefficient implementation of programmes, weak social norms and increased social and political conflict over the access and use of resources (Keuleers 2004).

The concept of governance, and the indicators that measure it, vary by context and sector. Managing natural resources such as land, water and forests is a complex task, and it requires diverse stakeholders to coordinate multi-level decision-making with integrity. Rules and regulations are needed for effective management and participation in programmes and irrigation schemes and for fulfilling dimensions of governance such as accountability, participation, transparency and cooperation. Some rules represent fairness and equity; others are aimed at the sustainable use of resources. Together, these rules influence economic performance (Tortajada 2010).

Several studies consider the impact of overall governance, the rural infrastructure and health indicators on economic performance and social outcomes. Irrigation governance indicators have been developed (Kaufmann et al. 2009; Tortajada 2010). An economic freedom index of the states in India has been constructed to demonstrate how economic governance differs between them (Debroy and Bhandari 2012).

<sup>1</sup> Some states have initiated several measures to increase the area under irrigation. Telangana, for instance, has initiated the Kakatiya project to complete projects faster, revive traditional water bodies, and construct cost-effective and eco-friendly rain-water storage structures.

<sup>2</sup> The Dam Safety Bill, 2018 seeks to build a legal and institutional framework to ensure the proper inspection, surveillance and operations and maintenance of dams. Many states are advised to implement the provisions of the Bill.

<sup>3</sup> There are several institutional issues in water management. The four major issues are sectoral, segmented nature of institutions and their supply-side focus; multiplicity of functions of different line agencies; poor water resource monitoring; and centralized planning.

This index is based on the size of government; legal structure and security of property rights; and regulation of business and labour. The index shows that economic freedom is directly correlated with the wellbeing of citizens. It also shows that economically freer states perform better on per capita growth, employment, sanitary conditions and attracting investment. The agriculture sector is hardly free from government intervention, and dismantling controls and regulations in both output and input markets and reforming public irrigation would improve agricultural growth (Gulati 2012).

To gauge human development outcomes through development expenditure, 22 indicators are used to measure the governance index for the state of Madhya Pradesh (Bhanumurthy et al. 2016). Governance is measured along the political, legal and judicial, administrative, economic and social dimensions. A weak administrative index appears to be the main constraint in improving human development outcomes in the less developed districts. A disaggregated analysis suggests that districts with lower human development achievements need to prioritize only in one or two dimensions of governance, mainly administrative governance. Prioritizing governance dimensions should help reduce the divergence in development outcomes. Development expenditure alone is not sufficient in achieving human development outcomes, but better governance indicators improve the effectiveness of public expenditure.

To examine the role of governance, Rajkumar and Swaroop (2008) measure the level of corruption and the quality of bureaucracy to determine the efficacy of public spending in improving human development outcomes in the selected countries. They find that the quality of governance empirically explains the differences in the efficacy of public spending. In countries where governance is good, public health spending lowers child mortality rates more, and public spending on primary education becomes more effective in improving educational attainment.

Manjunath and Kannan (2017) prepared a district-level rural infrastructure index encompassing economic, social and institutional indicators to analyse their effect on agricultural development in the Indian state of Karnataka. Using district-level data for 30 years and employing an infrastructure availability and utilization

framework, the study finds agricultural productivity growth to be positively and significantly related with rural infrastructure. The effect of infrastructure utilization on productivity growth seems to exceed that of infrastructure availability. The analysis of the spatial convergence of agricultural productivity growth shows that, over time, land productivity across districts converges. The analysis identifies priority areas and suggests that there is an urgent need to make investments in irrigation and other rural infrastructures and their utilization for agricultural development.

To enable effective water management in the face of growing scarcity, the National Institute for Transforming India (NITI) Aayog (2018) developed a Composite Water Management Index. The index explains how states have progressed on water issues over time, and it identifies high performers and under-performers. Amid large inter-state variations in the index scores, most states (60%) score below 50%, and they need to improve water management practices. The high performers are Gujarat, Madhya Pradesh, Andhra Pradesh, Karnataka and Maharashtra, while the poor performers include Jharkhand, Haryana, Uttar Pradesh, Bihar, Odisha and Goa. The poor performing states are also the most populous, which poses serious food security risks. The scores improved significantly in a year with hardly any change in the ranking of states.

Clearly, governance is seen from various angles at different scales, but few studies have looked into the indicators of water governance and/or public irrigation, and hardly any study has analysed the governance of India's irrigation sector. This study is perhaps the first to construct an IGI based on a comprehensive set of 16 indicators and link it with the performance of the public irrigation system.

### **3 Data and methodology**

Identifying proper, adequate indicators of governance is a challenge. Reliable information is not adequately available; therefore, indicators are defined narrowly, and aggregating them into a single measure for examining the quality of governance turns out to be inappropriate at times. It is useful to unbundle governance into its constituent dimensions, as that helps to identify the nature and type of failure of governance and introduce the appropriate policy reforms. To develop the IGI across 20 major Indian

states from 2001-02 to 2015-16, we use the following indicators, each linked directly or indirectly to the irrigation sector and its infrastructure.

*Receipts from public irrigation:* Receipts from public irrigation are assumed to have a positive relationship with irrigation performance. Improved collection of water user fee helps improve the administration of the canal system and the supply of water to farmers. The enhanced revenue could be used to maintain and repair canals. Revenue receipts from major, medium and minor irrigation are used at 2011-12 prices. This variable is expressed as receipt per hectare of net sown area (in rupees).

*Rural teledensity:* Rural teledensity, measured by the number of telephones per 100 individuals, is assumed to have an indirect or direct relationship with irrigation performance across states. If there is a better communication system, farmers can access current knowledge about the adoption of water-saving technology and the efficient use of water, and they can coordinate water release and canal maintenance better with the government department.

*Rural roads:* Better road networks enable proper monitoring and enforcement of water management rules and regulations and help improve irrigation productivity. This indicator, represented by road length in km per lakh population, is a combination of district and village roads and roads constructed under the Jawahar Rozgar Yojana and Pradhan Mantri Gram Sadak Yojana.

*Electricity charges in agriculture:* It is assumed that a higher electricity tariff encourages farmers to maintain the canal network properly and improve the efficiency of water use.

*Numbers of energized irrigation pump sets:* Availability of pump sets is another important indicator of irrigation performance because most of the acreage is not irrigated by canals under the public irrigation system. In non-canal areas, farmers depend on either rainfall and/or groundwater but mostly on groundwater because rainfall is uncertain. Farmers also use lift irrigation to irrigate their fields and depend on pump sets for lifting water from canals.

*Water rate of flow irrigation:* Charging the appropriate rate for water is important for managing the irrigation system as it can improve the recovery of the investment

in public irrigation and, by reducing the water used per unit of output, it can help in the efficient use of the public irrigation system.

*Revenue and capital expenditure on public irrigation:* Revenue expenditure is incurred in running irrigation departments and maintaining services. Capital expenditure is incurred in creating assets (reservoirs) and on tractors and machinery used to construct dams/canals. We use the revenue and capital expenditure per hectare of net sown area at 2011-12 prices.

*Irrigation potential created under the Accelerated Irrigation Benefit Programme (AIBP):* Irrigation potential created under the AIBP is another important indicator of the performance of irrigation.

*Private (farm households') investment in irrigation:* If farmers invest in irrigation and manage it by constructing and cleaning field channels, regular water flow is maintained and water use efficiency improves.

*Electricity consumption in agriculture:* The dependence on groundwater for irrigation purposes has increased over time. Electric pump sets are mainly used to extract groundwater for irrigation. Therefore, electricity used for agriculture is considered as a proxy for the utilization of irrigation pump sets.

*Net area irrigated by public canals and tanks:* This indicator is directly related to the performance of the public irrigation system.

*Net area irrigated by tube wells and other wells:* This variable is another largely under the farmers' domain although many state governments have started investing in minor irrigation systems.

*Net area irrigated by sources other than canals, groundwater, tanks and wells, termed as 'other sources'*

*Cropping intensity:* Increasing the availability of water enables double or triple cropping.

*Irrigation potential utilized:* It is a vital indicator of irrigation performance. Higher the gap between irrigation potential created and utilized, lower will be the performance of irrigation.

*Stages of groundwater development as per the usage/ extraction of water*

Data on these variables were compiled from various published sources (see table A1 in the appendix). The selected variables were grouped into three dimensions

of governance as per the UNDP (2004): institutions and regulatory mechanisms, participation and accountability and service delivery. The min–max method of normalization was adopted<sup>4</sup> using the following formula.

$$\text{Scaled value of indicator } (S_i) = \frac{X_i - \text{Minimum value } x}{\text{Maximum value} - \text{Minimum value}}$$

Principal component analysis (PCA) is used to generate weights. The PCA creates a new set of variables out of a given set of variables ( $X_j, j=1, 2, 3, \dots, k$ ). These variables are called principal components ( $P_i$ ), which are linear components of  $X_j$  and can be represented as:

$$P_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \dots + a_{1k}X_k$$

$$P_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + \dots + a_{2k}X_k$$

$$\dots$$

$$P_k = a_{k1}X_1 + a_{k2}X_2 + a_{k3}X_3 + \dots + a_{kk}X_k$$

where  $a_s$  are loadings chosen such that the first principal component captures the maximum possible proportion of the total variation in all  $X_j$ . The first principal component accounts for the maximum possible proportion of the variance of the set of variables, the second principal component accounts for the maximum of the remaining variance, and so on. In this paper, the first component is used as a weight since it has the

maximum variance of all the components. The composite IGI has been constructed by multiplying the weight with scale-free variables such as

$$\sum W_{it} X_{it}$$

where  $W_{it}$  is the weight of the  $i^{\text{th}}$  variable at  $t^{\text{th}}$  time.  $X_{it}$  is the scale free  $i^{\text{th}}$  variable at  $t^{\text{th}}$  time. Finally, to see the effect of irrigation governance on the performance of public irrigation, a panel regression model is specified as follows.

$$Y_{it} = \alpha_i + \beta x_{it} + u_{it}$$

where  $y_{it}$  is the irrigation performance indicator measured as the gap between irrigation potential created and irrigation potential utilized,  $x_{it}$  is the vector of explanatory variables – IGI, rainfall and proportion of area under non-food crops and  $u_{it}$  is the error term. A correlation analysis is also carried out to examine the relationship between the performance of irrigation with three different dimensions of governance.

#### 4 Trends in irrigation governance index

Figure 1 shows the weighted average scores of IGI at all India from 2001-02 to 2015-16.

The variables area irrigated by tubewells/other wells, stages of groundwater development and consumption of electricity for agriculture purpose attained the maximum score – above 0.8. This implies that groundwater utilized for irrigation influences the value

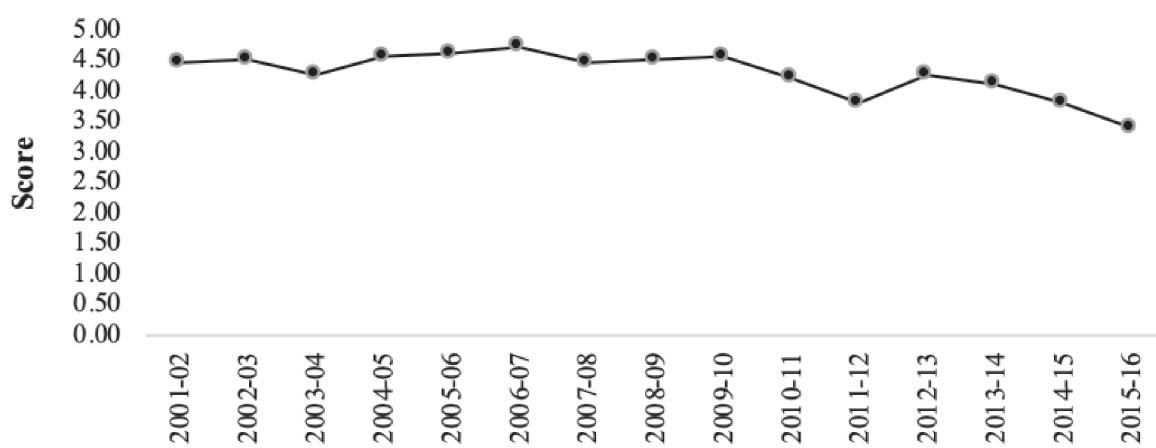


Figure 1. All India irrigation governance index from 2001-02 to 2015-16

<sup>4</sup> Different units were used to measure variables, which were normalized to remove scales and make them unit-free. The min–max method allows values of indicators to lie between 0 and 1, which is a useful property and has an effect on the composite indicator.

of the IGI much more than the public sources of irrigation. The IGI increased slightly from an initial score of 4.46 to 4.70 and subsequently fell to 3.4. This implies that irrigation governance has declined consistently despite increased outlays on irrigation and other reform initiatives.

There are several problems: dam construction has a long gestation period; there are environmental constraints; and maintenance and cost recovery are poor. The rehabilitation of displaced people is a challenge. These problems are aggravated by the ineffective management in the supply and use of irrigation water, which results in the deterioration of irrigation infrastructure, wastage and inequalities in distribution to users (Vaidyanathan 1991; Gandhi & Namboodiri 2009).

In the 1950s, public canals irrigated 39.8% of the net irrigated area; by 2014-15, that share had fallen to

23.7%. That is a direct consequence of poor governance, and it puts the onus on farmers to install tube wells and withdraw the already depleted groundwater reserves to meet crop water demand.

Figure 2 depicts the state-wise IGI for TE 2003-04 and TE 2015-16.

During early 2000, the top performers on the IGI were Gujarat, Haryana, Maharashtra, Tamil Nadu, Andhra Pradesh, Rajasthan and Punjab. Towards the end of TE 2015-16, Punjab, and Rajasthan were at the top of the index, followed by Haryana, Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu. The worst performing states in both periods were mainly the hilly states – Jammu and Kashmir, Himachal Pradesh and Uttarakhand, along with Assam and Jharkhand. These states depend on piped water for irrigation. Among the worst performers, Assam and Jharkhand frequently face natural calamities.

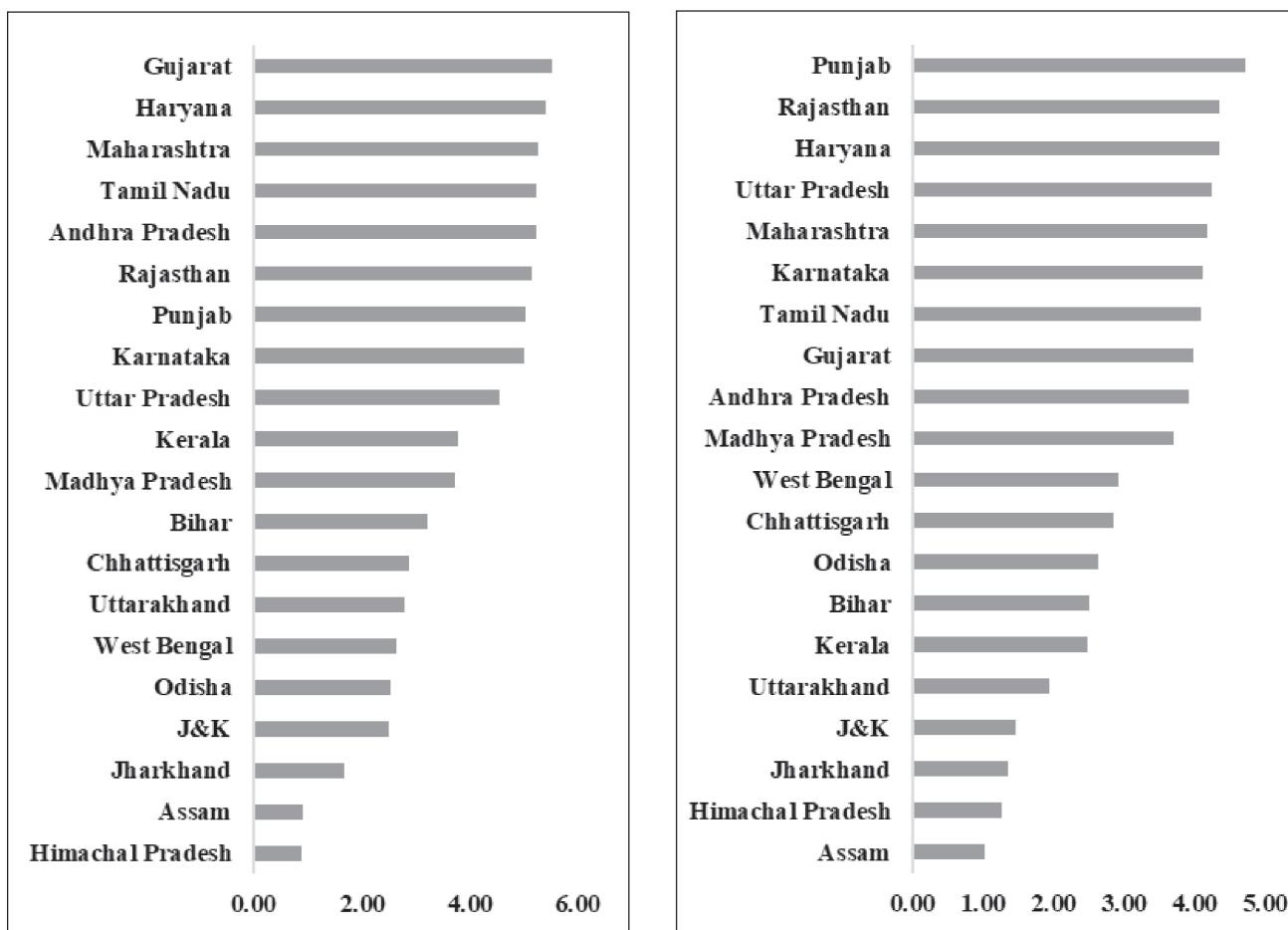


Figure 2. Irrigation governance index TE 2003-04 and TE 2015-16

**Table 1. State-wise status of irrigation governance**

Level of irrigation governance	TE 2003-04	TE 2009-10	TE 2015-16
High	Gujarat Haryana Maharashtra Tamil Nadu Andhra Pradesh Rajasthan Punjab Karnataka Uttar Pradesh	Tamil Nadu Rajasthan Maharashtra Punjab Haryana Andhra Pradesh Gujarat Karnataka Uttar Pradesh	Punjab Rajasthan Haryana Uttar Pradesh Maharashtra Karnataka Tamil Nadu Gujarat Andhra Pradesh Madhya Pradesh
Medium	Kerala Madhya Pradesh Bihar	Madhya Pradesh Kerala Chhattisgarh Odisha West Bengal	West Bengal Chhattisgarh Odisha Bihar
Low	Chhattisgarh Uttarakhand West Bengal Odisha J&K Jharkhand Assam Himachal Pradesh	Bihar Uttarakhand J&K Jharkhand Himachal Pradesh Assam	Kerala Uttarakhand J&K Jharkhand Himachal Pradesh Assam

Note: SD = standard deviation; Mean ( $\pm$ ) 0.50\*SD.

Broadly, the states have ranked the same on the IGI during TE 2003-04, TE 2009-10 and TE 2015-16, but the least performing states have slipped; their scores varied between 0.88 and 2.87. In the case of good performers, scores varied between 3.71 and 4.73 during TE 2015-16 (see table 2 in the Annex). The ranking of the states on the governance index changed over the period. Punjab's ranking improved from seventh to first, Rajasthan's from sixth to second, and Odisha's from sixteen to thirteen but Gujarat slipped from first to eighth and Andhra Pradesh from fifth to ninth position.

Table 1 describes the level of irrigation governance as high, medium and low, and groups states into each category based on the mean score ( $\pm$ ) 0.50 \* standard deviation. The governance scores vary across the states from 2001-02 to 2015-16. During TE 2003-04, irrigation governance was high in nine states, medium in three states and low in the remaining eight states

but, during TE 2015-16, it was high in ten states, medium in four states and low in six states.

Among the 10 states where the level of irrigation governance was high in TE 2003-04, Madhya Pradesh progressed considerably. The other nine states are Gujarat, Haryana, Punjab, Karnataka, Maharashtra, Rajasthan, Tamil Nadu, Andhra Pradesh and Uttar Pradesh. The level of irrigation governance was medium in Bihar, Kerala and Madhya Pradesh during TE 2003-04 and low in Assam, Odisha, Jharkhand, Chhattisgarh and West Bengal. The progress was commendable in Madhya Pradesh and Odisha. By TE 2015-16, irrigation governance improved and became high in Madhya Pradesh and it improved from low to medium in Odisha.

The IGI is bifurcated into three broad dimensions – institutions and regulatory mechanism; participation and accountability; and service delivery – and scores are estimated (tables 2a, 2b and 2c). During TE 2003-

**Table 2a. Dimension 1 of IGI: institutions and regulatory mechanism**

State	TE 2003-04	Rank	State	TE 2015-16	Rank	Change in rank TE 2015-over TE 2003-04
Maharashtra	0.80	1	Maharashtra	0.84	1	(0)
Gujarat	0.79	2	Karnataka	0.72	2	(+ 2)
Kerala	0.72	3	Odisha	0.70	3	(+ 4)
Karnataka	0.70	4	Andhra Pradesh	0.69	4	(+ 1)
Andhra Pradesh	0.66	5	Gujarat	0.68	5	(- 3)
Rajasthan	0.66	6	Rajasthan	0.65	6	(0)
Odisha	0.64	7	Madhya Pradesh	0.63	7	(+ 3)
Haryana	0.63	8	Assam	0.63	8	(+ 7)
Uttar Pradesh	0.55	9	Chhattisgarh	0.63	9	(+ 10)
Madhya Pradesh	0.54	10	Kerala	0.61	10	(- 7)
Himachal Pradesh	0.53	11	Uttar Pradesh	0.60	11	(- 2)
Tamil Nadu	0.52	12	West Bengal	0.60	12	(+ 5)
Punjab	0.49	13	Punjab	0.58	13	(0)
Jammu & Kashmir	0.47	14	Jammu & Kashmir	0.58	14	(0)
Assam	0.42	15	Bihar	0.52	15	(+ 3)
Uttarakhand	0.42	16	Himachal Pradesh	0.49	16	(- 5)
West Bengal	0.41	17	Haryana	0.49	17	(- 9)
Bihar	0.36	18	Tamil Nadu	0.46	18	(- 6)
Chhattisgarh	0.32	19	Jharkhand	0.43	19	(+ 1)
Jharkhand	0.21	20	Uttarakhand	0.42	20	(- 4)

**Table 2b. Dimension 2 of IGI: participation and accountability**

State	TE 2003-04	Rank	State	TE 2015-16	Rank	Change in rank TE 2015-over TE 2003-04
Andhra Pradesh	0.81	1	Gujarat	0.80	1	(+ 2)
Karnataka	0.81	2	Karnataka	0.77	2	(0)
Gujarat	0.79	3	Andhra Pradesh	0.75	3	(-2)
Haryana	0.77	4	Maharashtra	0.70	4	(1)
Maharashtra	0.76	5	Madhya Pradesh	0.65	5	(10)
Punjab	0.68	6	Himachal Pradesh	0.60	6	(10)
Uttar Pradesh	0.66	7	Haryana	0.56	7	(-3)
Rajasthan	0.65	8	Tamil Nadu	0.55	8	(+1)
Tamil Nadu	0.63	9	Punjab	0.53	9	(-3)
Jammu & Kashmir	0.57	10	Uttar Pradesh	0.49	10	(-3)
Kerala	0.52	11	Odisha	0.48	11	(+7)
Uttarakhand	0.51	12	Rajasthan	0.46	12	(-4)
Bihar	0.51	13	Uttarakhand	0.45	13	(-1)
Chhattisgarh	0.49	14	Jharkhand	0.39	14	(+3)
Madhya Pradesh	0.48	15	Chhattisgarh	0.37	15	(-1)
Himachal Pradesh	0.34	16	Jammu & Kashmir	0.36	16	(-6)
Jharkhand	0.31	17	Kerala	0.36	17	(-6)
Odisha	0.28	18	West Bengal	0.28	18	(+1)
West Bengal	0.24	19	Bihar	0.25	19	(-6)
Assam	0.17	20	Assam	0.21	20	(0)

**Table 2c. Dimension 3 of IGI: service delivery**

State	TE 2003-04	Rank	State	TE 2015-16	Rank	Change in rank TE 2015-16 over TE 2003-04
Punjab	0.82	1	Uttar Pradesh	0.84	1	(+ 2)
West Bengal	0.79	2	Punjab	0.82	2	(- 1)
Uttar Pradesh	0.76	3	Rajasthan	0.81	3	(+ 2)
Haryana	0.73	4	West Bengal	0.78	4	(- 2)
Rajasthan	0.72	5	Madhya Pradesh	0.75	5	(+ 5)
Andhra Pradesh	0.67	6	Haryana	0.74	6	(- 2)
Karnataka	0.66	7	Karnataka	0.69	7	(0)
Tamil Nadu	0.64	8	Bihar	0.66	8	(+ 3)
Odisha	0.64	9	Tamil Nadu	0.65	9	(- 1)
Madhya Pradesh	0.62	10	Andhra Pradesh	0.61	10	(- 4)
Bihar	0.59	11	Gujarat	0.61	11	(+ 2)
Kerala	0.58	12	Odisha	0.60	12	(- 3)
Gujarat	0.58	13	Chhattisgarh	0.57	13	(+ 2)
Uttarakhand	0.55	14	Uttarakhand	0.56	14	(0)
Chhattisgarh	0.48	15	Maharashtra	0.56	15	(+ 1)
Maharashtra	0.46	16	Kerala	0.54	16	(- 4)
Jammu & Kashmir	0.43	17	Jammu & Kashmir	0.43	17	(0)
Assam	0.40	18	Assam	0.40	18	(0)
Himachal Pradesh	0.36	19	Himachal Pradesh	0.36	19	(0)
Jharkhand	0.31	20	Jharkhand	0.35	20	(0)

04, Maharashtra, Gujarat, Kerala, Karnataka and Andhra Pradesh ranked high on the dimension of institutions and regulatory mechanism, and Karnataka, Odisha, Chhattisgarh and West Bengal made considerable progress over time.

Under the second dimension, participation and accountability, the five best performing states during TE 2003-04 were Andhra Pradesh, Karnataka, Gujarat, Haryana and Maharashtra. By TE 2015-16, Gujarat and Maharashtra took precedence in place of Andhra Pradesh and Haryana. Madhya Pradesh improved its rank from 15<sup>th</sup> during TE 2003-04 to 5<sup>th</sup> during TE 2015-16, Himachal Pradesh from 16<sup>th</sup> to 6<sup>th</sup>, and Odisha from 18<sup>th</sup> to 11<sup>th</sup>. Madhya Pradesh and Odisha allocated a massive amount of resources towards public irrigation during the 2000s.

With respect to the third dimension of the IGI, service delivery, Punjab, West Bengal, Uttar Pradesh, Haryana and Rajasthan have taken a lead. Jammu and Kashmir, Assam, Himachal Pradesh and Jharkhand are way behind on irrigation outcomes such as increase in area

under irrigation and cropping intensity, reflecting poor governance compared to other states.

#### 4.1 Relationship between irrigation governance and the performance of the public irrigation system

The performance of the public irrigation system can be captured through the gap between irrigation potential created and irrigation potential utilized and/or utilization of irrigation potential created. These two variables are therefore dropped from the IGI and a new index (based on 14 indicators) is constructed for the purpose. The scores are similar to those in the first index (table 3, Annex). During TE 2003-04 the five top performers on the IGI were Tamil Nadu, Haryana, Gujarat, Maharashtra, Tamil Nadu and Andhra Pradesh. During TE 2015-16, Punjab and Haryana were at the top followed by Rajasthan, Uttar Pradesh and Maharashtra. In both periods, the least performing states were Assam, Himachal Pradesh, Jharkhand, Odisha and Jammu and Kashmir. Odisha has improved considerably and it is no more among the five worst performing states.

It is hypothesized that improving irrigation governance leads public irrigation to perform better. Improvement in public irrigation is represented by the gap between the irrigation potential created and irrigation potential utilized, which is expected to reduce. Datta and Das (2008) consider the irrigation potential created as a proxy for the supply of irrigation water and the irrigation potential utilized as proxy for the demand for irrigation water. Improvement in public irrigation is deemed important in reducing the gap and in helping to expand potential. It also has implications for the allocation of scarce public resources to the different sectors of the economy.

Between TE 2003-04 and TE 2015-16, the gap between irrigation potential created and irrigation potential utilized has increased in each state, with a somewhat modest increase in Assam, Haryana, Himachal Pradesh, Kerala, Odisha, Punjab, Tamil Nadu and Uttarakhand (table 3). It is the highest (more than 22 lakh ha) in Andhra Pradesh, Gujarat and Maharashtra, followed by Bihar, Madhya Pradesh and Uttar Pradesh between 10 lakh ha and 21 lakh ha and below 10 lakh ha in the remaining states.

The log of absolute gap between irrigation potential created and irrigation potential utilized is regressed on the independent variables such as log of IGI, log of rainfall and the proportion of the non-food grain area to the total sown area. The proportion of the non-food grain area to the total sown area is taken to capture the extent of crop diversification. The fixed effects model was chosen over the random effects model based on the Hausman test statistic (table 4).

The results reveal that the coefficient of the governance index is negative and statistically significant. This implies that an improvement in irrigation governance leads to a reduction in the gap between the irrigation potential created and utilized. The effect of rainfall turned out to be positive but statistically insignificant. However, the effect of the proportion of the area under non-food grains on reducing the gap between the irrigation potential created and utilized is highly significant. Perhaps higher returns from non-food crops enable farmers to pay water charges regularly and maintain the canal properly.

Overall, the results indicate that reforms that enable good governance in the irrigation sector will go a long

**Table 3. Gap between irrigation potential created and irrigation potential utilized (000' ha)**

State	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16
Andhra Pradesh	320.93	355.60	1559.10	1674.82	2244.09
Assam	84.30	91.70	245.10	260.31	334.45
Bihar	1031.13	1064.10	1239.60	1261.73	1363.00
Gujarat	306.60	395.10	1806.40	1950.63	2647.91
Haryana	283.43	300.40	313.10	317.25	333.45
Himachal Pradesh	6.83	7.30	22.30	24.01	31.80
Jammu & Kashmir	12.10	12.70	145.00	157.15	217.82
Karnataka	437.43	518.00	633.70	636.27	695.05
Kerala	68.93	78.10	124.30	130.41	157.73
Madhya Pradesh	676.17	758.60	1333.10	1400.28	1713.73
Maharashtra	1151.33	1181.10	1815.60	1878.85	2186.64
Odisha	74.60	95.70	268.70	287.95	379.27
Punjab	61.63	64.20	173.90	183.93	234.36
Rajasthan	279.77	335.50	641.00	641.00	810.90
Tamil Nadu	3.80	5.70	21.40	22.99	30.82
Uttar Pradesh	1840.43	1972.60	1463.70	1441.59	1294.64
West Bengal	172.87	181.20	327.80	342.32	413.45
Chhattisgarh	179.80	188.80	321.10	334.70	400.36
Jharkhand	142.67	152.00	284.90	298.72	365.18
Uttarakhand	96.90	97.90	97.90	98.12	98.82

Source: Annual Reports of Central Water Commission, Government of India.

**Table 4. Results based on fixed effects model**

Dependent variable: Log gap between irrigation potential created and irrigation potential utilized

Independent variables	Coefficient	Std. error
Log irrigation governance index	-0.999***	0.215
Log rainfall	0.004	0.175
Proportion of non-food grain area to total area sown	-0.450***	0.207
Constant	8.126 ***	1.39
<i>R</i> -squared	0.084	
<i>F</i> (3, 277) Prob> <i>F</i>	8.42*** 0.00	
No. of observations	300	
Hausman test statistic	Chi 2(3) = 6.44 Prob>chi2 = 0.092	

Note: \*\*\*Significant at 1% level.

**Table 5. Correlation between dimensions of governance and irrigation performance (TE 2015-16)**

	% Irrigation potential utilized	Rainfall	% Non-food area	Institutions and regulatory mechanism	Participation and accountability	Service delivery	Overall governance index
% Irrigation potential utilized	1						
Rainfall	-0.077	1					
% Non-food area	0.056	0.303**	1				
Institutions and regulatory mechanism	0.231*	-0.189	0.311**	1			
Participation and accountability	0.016	-0.434***	0.254**	0.439***	1		
Service delivery	0.508***	-0.469***	0.103	0.265**	0.143	1	
Overall governance index	0.534***	-0.586***	0.310**	0.567***	0.509***	0.781***	1

Note: \*\*\*, \*\* and \* indicate level of significance at 1%, 5% and 10%.

way in improving the utilization of irrigation potential, efficiency of water use and the allocation of resources. As regards the impact of the three dimensions of the IGI on the performance of public irrigation, a correlation analysis is done taking the percentage of irrigation potential utilized as the performance indicator. The results for TE 2015-16 indicate a positive relationship only with institutions and regulatory mechanism and service delivery (table 5). The results are consistent with the findings obtained from the regression analysis.

## 5 Conclusions

An IGI is developed in each of the 20 major states to empirically test its relationship with the performance

of the public irrigation system. It is hypothesized that an improvement in irrigation governance would lead to an improvement in the performance of the public irrigation system across the states. The IGI was based on 16 selected indicators from 2001-02 to 2015-16 and it was also estimated separately for three broad dimensions of governance: institutions and regulatory mechanism; participation and accountability; and service delivery. The principal component method was used to get the weights to construct the index.

Findings reveal that irrigation governance at the national level hardly improved between 2001-02 and 2015-16. However, large differences in the scores were observed and also variations in the ranking of states as per the three dimensions of governance. During TE

2015-16, Punjab, Rajasthan, Uttar Pradesh, Madhya Pradesh, and Odisha made significant strides in the development and management of public irrigation systems. The poor performers in IGI were Kerala, Uttarakhand and Bihar. Four states—Assam, Jharkhand, J&K and Himachal Pradesh remained at the bottom, which could be explained by hilly terrain, dependence on rainfall, less public intervention and recurrence of floods. Among major states, Maharashtra, Karnataka, Odisha, Andhra Pradesh and Gujarat had relatively better institutional and regulatory mechanisms compared to other states. From the perspective of participation and accountability, Gujarat, Karnataka, Andhra Pradesh, Maharashtra and Madhya Pradesh held prominence. In case of service delivery aspect of governance, Punjab, Rajasthan, Madhya Pradesh, West Bengal and Uttar Pradesh occupied top position.

Notably, massive public investments in major and medium irrigation and creation of related infrastructures do not commensurate with the outcomes, seen through net area irrigated by public canals, irrigation and cropping intensities and gap in irrigation potential created and utilized. Empirical results confirm that good irrigation governance significantly improves the performance of public irrigation systems in each state. Two dimensions of governance – institutions and regulatory mechanism, and service delivery showed positive correlation with irrigation performance, implying potential to enhance efficiency and agricultural productivity.

## Acknowledgement

This paper is drawn from the ICAR-NIAP funded project entitled 'Irrigation Investments, Governance and Agricultural Outcomes: A State Level Analysis'. The authors are grateful to Dr. Suresh Pal and Dr. P.S. Birthal for their critical comments and suggestions.

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Annex Table 1. List of indicators and data sources

Sl. No.	Governance dimensions	Variables name	Unit	Data sources
1		Irrigation Receipts in Major, Medium & Minor Irrigation	At 2011-12 price, Rs /ha	Annual report of Comptroller and Auditor General (CAG) of India <a href="https://cag.gov.in">https://cag.gov.in</a>
2	Institutions and Regulatory Mechanism	Rural teledensity	Per 100 Individual	The Indian Telecom Services Performance Indicators, Telecom Regulatory Authority of India <a href="https://main.trai.gov.in">https://main.trai.gov.in</a>
3		Length of Rural Roads	Kilometres Per One Lakh of Population	<a href="http://www.mospi.gov.in">http://www.mospi.gov.in</a> Agriculture Statistics at a Glance, MOA&FW, GOI
4		Electricity Tariff for Agriculture	Paisa/kwh	<a href="http://www.morth.nic.in/">http://www.morth.nic.in/</a> Agricultural Research Data Books ICAR, <a href="https://icar.org.in">https://icar.org.in</a>
5		Numbers of Energized Pump Set	Numbers	
6		Water Rate Flow	Rs	Central Water Commission, Government of India
7		Revenue & Capital Expenditure in Major, Medium & Minor Irrigation & CAD	Rs/ ha at 2011-12 Price	Annual report of Comptroller and Auditor General (CAG) of India <a href="https://cag.gov.in/">https://cag.gov.in/</a>
8	Participation and Accountability	Year-Wise Irrigation Potential Created by Major and Medium Irrigation Projects under Accelerated Irrigation Benefit Programme	000' ha	Central Water Commission of India, Annual Report <a href="http://cwc.gov.in">http://cwc.gov.in</a>
9		Private Investment in Irrigation	Rs/ha	NSS AIDIS (situation assessment survey), GOI.
10		Consumption of Electricity for Agricultural Purposes / Ratio of average electricity cost to tariff of electricity in Agriculture (paisa/kwh)	Kwh/ha	Agricultural Statistics at Glance, Ministry of Agriculture and Farmers' Welfare, Government of India
11		Net Area Irrigated by Canals & Tanks	000 ha	Ministry of Agriculture & Farmers' Welfare, Government of India
12		Net Area Irrigated by Tubewells & Other wells	000 ha	Ministry of Agriculture & Farmers' Welfare, Government of India
13	Service Delivery	Area Irrigated by Other Sources of Irrigation	000 ha	Ministry of Agriculture & Farmers' Welfare, Government of India
14		Cropping Intensity	Ratio	Ministry of Agriculture & Farmers' Welfare, Government of India
15		Percentage of Irrigation Potential Utilized	Percentage	Central Water Commission of India, Annual Report <a href="http://cwc.gov.in">http://cwc.gov.in</a>
16		Stages of Ground Water Development	Percentage	Report of Dynamic Ground Water Resources of India, CGWB

**Annex Table 2. Irrigation water governance index from 2001-02 to 2015-16 based on 16 indicators**

State	TE 2003-04	TE 2009-10	TE 2015-16
Andhra Pradesh	5.25	5.12	3.92
Assam	0.91	1.02	1.03
Bihar	3.23	2.94	2.51
Gujarat	5.54	5.00	3.98
Haryana	5.40	5.16	4.35
Himachal Pradesh	0.88	1.46	1.27
Jammu & Kashmir	2.51	1.97	1.46
Karnataka	5.00	4.79	4.11
Kerala	3.78	3.69	2.50
Madhya Pradesh	3.73	4.11	3.71
Maharashtra	5.25	5.36	4.18
Odisha	2.54	3.12	2.64
Punjab	5.05	5.21	4.73
Rajasthan	5.16	5.43	4.36
Tamil Nadu	5.25	5.45	4.10
Uttar Pradesh	4.55	4.70	4.26
West Bengal	2.65	3.01	2.93
Chhattisgarh	2.87	3.32	2.86
Jharkhand	1.68	1.48	1.37
Uttarakhand	2.79	2.20	1.95
All India based on 20 States (weighted average)	4.40	4.57	3.77

Source: Authors' estimates.

**Annex Table 3. Irrigation water governance index based on 14 indicators**

State	TE 2003-04	TE 2009-10	TE 2015-16
Andhra Pradesh	5.01	4.84	3.52
Assam	0.79	0.95	1.03
Bihar	3.18	2.82	2.30
Gujarat	5.20	4.84	3.49
Haryana	5.20	5.06	4.11
Himachal Pradesh	1.02	1.94	1.68
Jammu & Kashmir	2.17	1.93	1.38
Karnataka	4.65	4.43	3.50
Kerala	3.50	3.59	2.28
Madhya Pradesh	3.80	3.88	3.28
Maharashtra	5.13	5.12	3.77
Odisha	2.04	2.63	2.03
Punjab	4.58	4.64	4.24
Rajasthan	4.75	4.97	4.00
Tamil Nadu	5.27	5.20	3.58
Uttar Pradesh	4.16	4.19	3.81
West Bengal	2.32	2.60	2.68
Chhattisgarh	2.28	2.95	2.52
Jharkhand	1.63	1.68	1.26
Uttarakhand	2.70	2.18	1.71

Source: Authors' estimates.

