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Employment generation potentials in the implementation of a rural drinking water supply program: evidence from India's Jal Jeevan Mission

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ABSTRACT

Policymakers in India are finding it challenging to generate adequate employment to meet the requirements of growing population. An avenue consistently used is to invest in large-scale public infrastructure projects. In 2019, the Jal Jeevan Mission (JJM) was launched with the aim of providing potable drinking water to every rural household in India. Underscoring the large investments in infrastructure development, the mission holds significant potential to create employment. The evidence base of studies assessing the effect of rural development programs on employment was weak. Against this backdrop, we assessed the employment generation potential of JJM at various phases of its implementation. We utilized secondary and scheme-level primary data across states of India and used the input-output model and ratio method to assess employment prospects. Our results suggest that JJM has the potential to generate an average of 5.99 million person-year of direct and 22.25 million person-year of indirect employment during the construction phase, and 1.11 million person-year of additional direct employment annually during the maintenance phase. Our study highlights the spillover effects of public investments in the form of employment generation and indicates that the impact of JJM is likely to be substantial once the program is complete and operational.

Key words: Employment generation, Jal Jeevan Mission, Rural drinking water supply

HIGHLIGHTS

- Our study highlights the spillover effects of public investments in the form of employment generation.
- The Jal Jeevan Mission (JJM) has the potential to generate an average of 5.99 million person-years of direct and 22.25 million person-years of indirect employment during the construction phase.
- During the operation and maintenance phases, JJM has the potential to generate 1,118,749 person-years of additional direct employment annually.

1. INTRODUCTION

With the unemployment rate hovering at 8% and youth unemployment at 10%, Indian policymakers are incessantly exploring avenues to generate employment (CMIE, 2024; ILO, 2024). The task has been challenging as it requires creating employment for the current unemployed persons as well as 7–8 million newer young people joining the labour force every year (ILO, 2024). The role of large-scale infrastructure developmental programs/schemes can have catalyzing multifaceted effects on direct and indirect employment generation

(Parikh *et al.*, 2018; Bennett, 2019; Ngulube, 2022; Nourelfath *et al.*, 2022). With poor rural infrastructure, the slightest improvement in basic facilities like roads, electricity, telecommunication, housing, health, water, and sanitation can have a significant impact on economic development and human well-being in India (Ghosh, 2017). The year 2019 was a watershed year in the history of drinking water supply in rural India with the launch of a large-scale rural development program, the Jal Jeevan Mission (JJM). This program aims at providing tap water connection to individual households (HHs) with the provision of 55 L of potable water per capita on a daily basis. Since its launch in 2019, the program has managed to cover 3/4th of rural HHs in the country. Some of the primary objectives of the program are to provide a regular supply of adequate quantity of potable water to prevent deaths and illness due to waterborne diseases, eliminate drudgery in accessing drinking water, and improve the health and productivity of people in rural areas. One of the distinct features of the mission is to focus on service delivery rather than just creating infrastructure. Moreover, with the scope of decentralized governance and a greater community engagement, the mission holds significant potential for spillover effect in generating employment in various phases of its implementation.

The past literature throws light on the impact of infrastructure development (access to basic amenities such as drinking water, toilet facilities, electricity, and housing) on economic indicators such as Gross Domestic Product (GDP) per capita (Munnell, 1990; Sahoo *et al.*, 2010; Dwivedi, 2017). Development activities in the construction sector are mostly reported to have a strong positive effect in addressing the problem of cyclical unemployment (Ball, 1965). Furthermore, the program-based approach of public work was stressed above the project-based approach in many developing countries due to its longer-term nature and ability to address the unemployment problem (Thwala, 2008). Ascribing to the benefits of the program-based intervention approach, India has implemented several developmental programs that had either intentionally or unintentionally accelerated employment generation in the country (Nayak & Hazarika, 2019). Studies assessing the employment generation potential of government policies were highly skewed towards the schemes related to housing, roads, health, and education (Ball, 1965; Strassmann, 1976; Tipple, 1994). However, it is crucial to note that the construction and maintenance of water supply schemes, when locally managed, possess the potential of creating jobs at the lowest economic level where unemployment tends to be high with lower skill levels (Wall, 2023). For instance, under the JJM, the creation of infrastructure such as functional household tap connections (FHTCs), water storage tanks, and water treatment plants provides direct employment to labourers for construction activities and laying pipelines, whereas skilled workers such as engineers, valve men, pump operators, and managerial staffs are directly employed for proper execution of the schemes. Similarly, the maintenance of the scheme also requires several types of skilled manpower, such as watermen, pump/valve operators, supervisors, and watchmen, to regularly inspect and ensure uninterrupted service delivery. So far, the literature provides sparse evidence on how quality drinking water facilities can lead to better health, higher labour supply, and productivity (Asit *et al.*, 2005; Kremer *et al.*, 2011; Devoto *et al.*, 2012), but no proper evidence of employment generation as an effect of implementation of rural water supply program. Against this backdrop, our study aims to assess the employment generation potential of the JJM program in the construction as well as operation and maintenance phases of its implementation.

1.1. Structure of employment generation under JJM

As per JJM operational guidelines, schemes can be categorized into Single Village Scheme (SVS) and Multi Village Scheme (MVS) and can be implemented depending on factors such as geographical terrain, population density, availability of water sources, water quality, and the feasibility of infrastructure implementation in a specific region. For the construction of such schemes in villages, tenders are awarded to private entities, ensuring the completion of infrastructure creation within stipulated timelines. After the construction phase, a part of the schemes is centrally managed under the state departments but is often contracted out to private entities under a 5-year agreement (Government of India, 2019). The JJM helps generate both direct and indirect employment in its two phases: construction and operation and maintenance (O&M). The employment requirement during the construction phase is expected to be larger than the annual O&M. However, this may not hold true in the long run as the employment generated in the construction phase is one-time and depends upon various factors such as scheme size, nature of the scheme (retrofit/new), availability of manpower, and topographic conditions, whereas employment at the O&M phase is more likely to be permanent. In each of these phases, direct employment may vary based on the type of schemes (MVS or SVS) and the nature of the schemes (retrofitted or newly constructed). However, indirect employment is generated in the production, storage, transportation, and distribution of materials needed for JJM directly or indirectly. Direct materials are pipes, valves, metres, construction equipment, etc., whereas indirect materials are steel and other raw materials that are used to make pipes, valves, metres, etc. The conceptual structure of employment generation is illustrated in Figure 1.

2. METHODOLOGY

We estimated employment potentials under JJM using two different methods. First, we utilized the input–output (IO) model to estimate the overall employment potential (direct + indirect) during the construction phase. Subsequently, using the ratio method, we estimated the direct employment potential in different phases of the implementation of JJM schemes. Furthermore, we also estimated the partial indirect employment generated during the construction phase, which involves the production, storage, and transportation of materials using the ratio method. We did not attempt to compute the indirect employment created during the O&M phase

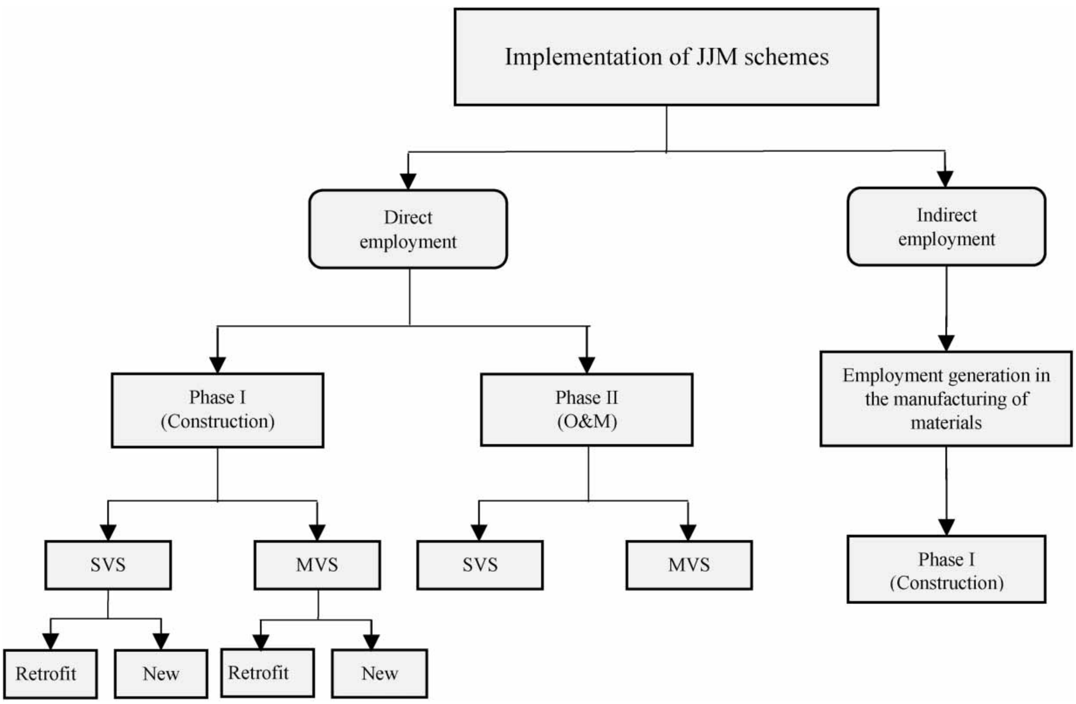

Fig. 1 | Structure of employment generation under JJM. *Note*: i) Authors' depiction ii) MVS: Multi Village Scheme, iii) SVS: Single Village Schemes.

and other induced employment due to data constraints. To make this study nationally representative, we used data from selected states across the country and estimated the employment potential of other states using cluster analysis.

2.1. Data and variables

We utilized the IO table published by the Asian Development Bank (Asian Development Bank, 2023) to derive the Leontief inverse matrix. Since rural drinking water supply (RDWS) is not identified as one of the industries in the current IO table, we created a synthetic industry to study the impact of investments in JJM. The output created under piped drinking water is already a part of identified industries in IO tables and we constructed the industry 'RDWS' as an aggregate of identified industries. For the creation of the synthetic industries, we used data from 11 tenders across four states (Karnataka, Odisha, Himachal Pradesh, and Kerala). The contracts belong to different phases of the scheme and range from tender values of INR 0.4–5 million. These contracts were obtained from the e-procurement portal of each of these individual states. Each line item in the tenders was studied and classified under an identified industry. The combined sum of costs of all the contracts was used to calculate the percentage contribution of the existing identified industries to the synthetic industry. The breakdown of the share of the synthetic industries is summarized in Supplementary Table 1.

The demand vector is generated by multiplying the total likely investment in JJM with the share of the component industries (Supplementary Table 2). The likely investment is computed by multiplying the sample average expenditure per HH and the total number of HHs to be covered.

The employment output ratios have been derived for the seven major industries laid out in the national income accounting data. Since the industry-wise allocation of GDP was not available, we used the percentage allocation of Gross Value Added (GVA) calculated for the year 2022–2023 and applied it to the GDP data. We believe that this is the closest estimate possible since the GDP of a country is net taxes added to GVA.

The total worker population for the country stood at 508,265,520 at the end of 2022. This was derived by multiplying the worker population ratio (WPR) for the year 2021–2022 with the total population (age >15 years) estimated by the World Bank for 2022. The WPR is calculated based on the Periodic Labour Force Survey carried out by the National Sample Survey Organisation every year. The worker population is further allocated to the eight major industries as per the allocation of GDP and the GDP per worker is computed (Supplementary Table 3). We then mapped these eight employment output ratios to 35 industries in the IO table based on their correspondence, as indicated in Supplementary Table 4.

For estimating the direct employment generation under JJM schemes, we considered the total employment generated and the total number of HHs covered at the scheme level from the data collected from various states. For cluster analysis, various state-level parameters related to demography and water availability were collected from the Economic and Political Weekly Research Foundation (EPWRF) – India Time Series (EPWRF, 2023). Finally, the employment-to-HH ratio normalized to 100 HHs was calculated.

2.2. Sampling and clustering of JJM schemes

For the direct employment estimation, we collected scheme-level data from various states. For this, we selected one highest scoring (best performing) district from each region of all major states based on the Jal Jeevan Survekshan report of December 2022 (Government of India, 2022). We listed all the completed schemes in the selected district and requested the JJM directors of the respective states to provide scheme-level information. A data format with a list of sample districts and a list of completed schemes ($n = 854$) was shared with the respective states. Details of sample districts and number of schemes are given in Supplementary Table 5. The data format included questions related to the scheme characteristics and employment type, such as nature of the scheme (new/retrofitting), category of the scheme (SVS/MVS), phase of implementation (construction/O&M), number of villages covered, number of population and HHs covered, estimated cost of the scheme, total water supply capacity, service-level capacity, and a set of questions related to employment types. Furthermore, we reached out to eight contractors from Tamil Nadu and four contractors from Karnataka and interviewed them using the same sets of questions. For the sake of robustness, we considered employment units as 'person-years of employment', which takes into account both the number of persons employed and the amount of time each person dedicated. Since the program is currently under implementation, the total number of completed schemes was dynamic in nature. Due to this, we received surplus data from 1,067 schemes.

For the clustering of schemes, we considered state-level parameters such as population density, river length per 1,000 population, water body area per 1,000 population, groundwater availability per 1,000 population, and WPR of casual labour per 1,000 population to generate the clusters. We used '*K*-means' clustering and employed Calinski–Harabsaz (CH) pseudo-*F* statistics to plot the elbow chart. The CH pseudo-*F* assesses the sum of squared distance within the cluster and compares it to the un-clustered data, taking into account the number of clusters (Halpin, 2016).

The values of CH pseudo-*F* are then plotted against the number of clusters (k) to identify the kink/elbow point on the curve, which denotes the optimal number of clusters (k), which is 4 in our case (Supplementary Figures 1 and 2). As the fourth cluster had only one state, i.e., Arunachal Pradesh, we clubbed it with the third cluster, which had other major northeastern states. The three clusters of the states are presented in Tables 3 and 5. Furthermore, due to the unavailability of data, we did not include Union Territories (UTs) in our cluster analysis; however, we created a separate group for UTs for which employment is estimated using national average ratios.

2.3. Analytical tools

2.3.1. Leontief IO model

We utilized the Leontief IO model to estimate the overall employment potential, which includes direct and indirect employment generation during the construction phase. The IO model in our study was adopted from Garrett-Peltier's study, in which the impact of additional investments in the renewable energy industry was estimated on employment (Garrett-Peltier, 2017).

The total output of an industry can be expressed as

$$X = Y + AX \tag{1}$$

where X is the total output, Y is the final demand, and A is the IO matrix for the economy. AX gives the output produced by different industries, which is used as input in the production process in other industries. This equation can be simplified to obtain the total output of any industry as below:

$$\begin{aligned} X &= (I - A)^{-1} Y \\ \text{Thus,} \quad \Delta X &= (I - A)^{-1} \Delta Y \end{aligned} \tag{2}$$

$(I - A)^{-1}$ is called the total requirement table or the Leontief inverse.

To derive the impact on employment, we arrive at an employment requirement matrix (E_r) from the Leontief inverse matrix and the employment requirements coefficient matrix (E), where E is a diagonal matrix indicating the employment output ratios (number of people employed/ total output) for each industry. The matrix E_r helps us estimate the number of jobs generated, both directly and indirectly, at any level of planned output.

Therefore, employment requirement (E_r) can be estimated as $Er = E \times (I - A)^{-1}$ and employment generated (E_g) as

$$E_g = E \times X = E \times (I - A)^{-1} Y$$

Since $E_r = E \times (\mathrm{I} - A)^{-1}, \quad E_g = E_r \times Y$

Hence, additional employment generated can be computed as

$$\Delta E_g = E_r \times \Delta Y \tag{3}$$

We estimate the employment generated by JJM investments using Equation (3). We generated the employment requirements coefficient matrix (E) by computing the ratio of employed persons to output for each component industry of drinking water supply, which is then used to arrive at the employment requirement matrix (E_r).

2.3.2. Ratio method

2.3.2.1. Direct employment. The employment to HH ratio representing *employment generated per HH* was computed using a sample of schemes from selected states. Subsequently, the estimated ratios were utilized to extrapolate the results at the state and national levels. As we know the total number of HHs to be covered under JJM, we consider 'HH' as the unit of estimation. This method is used for direct employment estimation in both construction and O&M phases.

As the first step, direct labour employment is estimated for each scheme i in a state j as follows:

$$\mathrm{DLE}_{ij} = \frac{\mathrm{TLE}_{ij}}{\mathrm{HH}_{ij}} \tag{4}$$

where DLE_{ij} is the direct labour employment per HH for sample scheme i in state j, TLE_{ij} is total direct labour employment in the sample scheme, and HH_{ij} is number of HHs to be served in the scheme i in state j.

In the second step, the average of DLE_{ij} for the sample states is computed to obtain the state average ratio DLE_j. This state ratio was used to compute the potential employment likely to be generated in the state j (PE_j).

$$\mathrm{PE}_j = \mathrm{DLE}_j \times \mathrm{THH}_j \tag{5}$$

where THH_j is the total number of HHs to be covered under JJM in the state j.

To compute the potential employment in states other than the sample states, we computed the average DLE in each cluster and used it to compute employment in states other than the sample states within the respective clusters.

The same approach is followed in the O&M phase to estimate the employment generation potential utilizing scheme-level sample data.

2.3.2.2. Indirect employment. To assess the indirect employment in the construction phase, we first estimate the budget amount utilized towards materials (B_m) from the total JJM budget (B). For this purpose, we use a sample of public tender documents and the questionnaires filled in by a sample of contractors. The estimate was further disaggregated to specific materials (k) like high-density polyethylene (HDPE) pipes, steel, valves, etc., and then multiplied the aggregate budgeted amount for materials (B_m) with the share of individual material (Sk) obtained from the sample to arrive at the budget amount that will be spent on individual material (BmM_k). That is,

$$\mathrm{BmM}_k = \mathrm{Sk} \times B_m$$

We computed output generated per employment of each industry (average value of output generated by an employed person) and then arrived at the employment generated due to the additional demand of the input materials used for JJM schemes by multiplying it by BmM_k. The total indirect labour employment estimated through this method is partial as it captures only the first stage of indirect employment.

3. RESULTS

3.1. Summary statistics of sample schemes

Tables 1 and 2 show the summary statistics of the scheme and their characteristics. A total of 1,067 scheme-level data were collected, among which 81 schemes belonging to Assam and Goa and 69 schemes from other states were dropped after screening for outliers and population coverage of at least 20 HHs and 100 people. As a

Table 1 | Summary statistics of sampled schemes under JJM.

	MVS ($n = 385$)			SVS ($n = 532$)		
Parameter ($n = 917$)	Mean (SD)	Min	Max	Mean (SD)	Min	Max
Total manpower	25.97 (81.57)	0.1	1,155	3.70 (6.25)	0.08	83.5
Number of villages	9.32 (20.82)	1	212	1.01 (0.18)	1	5
Population coverage	15,874.46 (61,247.9)	112	894,119	1,093.68 (1,668.68)	106	27,807
HH coverage	2,676.94 (8,524.73)	30	99,486	278.49 (492.60)	20	6,160
Water supply capacity (MLD)	1.85 (3.76)	0.01	34.82	0.49 (1.33)	0.004	9.2
Estimated cost per capita (INR)	8,445.68 (10,542.92)	67.48	81,801.7	7,549.21 (8,956.36)	19.44	58,284.88

Notes: (i) MLD, million litres per day; (ii) 56 MVSs from Punjab, Kerala, Uttarakhand, and Gujarat were reported covering single villages.

Table 2 | Characteristics of sampled schemes under JJM.

Scheme characteristics	% of schemes ($N = 917$)
Types of schemes	
MVSs	41.98
SVSs	58.01
Nature of schemes	
Retrofitting	76.18
New	23.81
Phases of implementation	
Construction	72.08
O&M	27.91

Note: Proportions for nature of schemes are calculated from a small sample scheme ($n = 550$).

final consideration, we included 917 schemes, out of which 58.01% are SVSs, 41.98% are MVSs, and 72.08% are from the construction phase and 27.91% are from the O&M phase. Furthermore, among the schemes from the construction phases, 76.18% were retrofitted and 23.81% were new schemes.

The scheme coverage statistics show that on average, the total manpower employed under an MVS is 26 and SVS is around 4; total villages covered for MVS and SVS are 9 and 1 with an average population of 15,874 and 1,093 people and 2,677 and 278 HHs, respectively. The average water supply capacity per MVS and SVS is 1.85 and 0.49 MLD (million litres per day) with an average per capita cost of INR 8,445 and 7,549, respectively.

3.2. Employment generation under the construction phase of JJM schemes

The IO model estimates the direct and indirect employment potential across both MVS and SVS schemes. The total estimated investment under JJM was obtained by multiplying the sample average cost of HH connection and the total number of rural HHs to be covered. The estimated overall employment generated at the construction phase obtained from the IO model is 28,248,478 person-years for the total estimated investment of INR 7.80 trillion under JJM (Supplementary Table 4).

The construction industry has the highest employment potential at 13,942,573 person-years followed by the machinery and basic metals industry. This is due to the nature of the water treatment plants and distribution networks, which require heavy investments in constructing large tanks, large amounts of iron and steel pipes, etc. The construction industry has 49% contribution to employment generated but only a 35% contribution to the increased output, as the employment intensity of the industry is higher than the overall average.

Whenever investments in large infrastructure projects are made, there is a multiplier effect on the economy. In the construction phase, the employment used while constructing the infrastructure is considered direct employment under JJM, the employment generated to produce the materials used in the construction is the first stage of indirect employment, and the employment generated in producing raw materials for the first stage is the second stage indirect employment, and so on. Using the IO model, we get the aggregate employment potential across multiple stages. To break this down into the direct employment potential and the first stage of indirect employment, we used the ratio method.

3.2.1. Direct employment potential in the construction phase of JJM

The direct employment generated under the construction of schemes at the state and national level is provided in Table 3. Overall, JJM has the potential to generate 5,993,154 person-years of direct employment in the construction phase of the water supply schemes. The highest ratio of employment generation in the construction phase was in Maharashtra (6.31 per 100 HH) followed by Tamil Nadu (4.40 per 100 HH), whereas the ratios of employment generation for Andhra Pradesh (0.4 per 100 HH) and Gujarat (0.6 per 100 HH) are the lowest. This variation is mainly due to the differences in the type and nature of the schemes.

3.2.2. Indirect employment potential in the construction phase of JJM

To calculate the indirect employment generated by JJM, we have attempted to estimate the breakup between spending on materials and labour. The average proportion of material cost across all the sources was 72%, which is indicative of the total tender budget used on physical materials, the breakdown of which is summarized in Appendix 5. Considering the output from these industries is generated at the average productivity of employed persons in India (Supplementary Table 6), the indirect employment generated in the first stage stands at 7,734,620 person-years during the construction phase of the mission. The employment generated in specific industries is summarized in Table 4. The remaining 14,520,704 person-years of employment, out of the total indirect employment of 22,255,324 person-years (overall employment in construction phase – direct employment in construction phase), is generated in the production of inputs used in manufacturing of materials required in the first stage.

Table 3 | Estimated direct employment per 100 HHs in the construction phase of implementation in different states.

Clusters (representative states)	States	No. of rural HHs	Employment in construction phase (per 100 HHs)	Total direct employment – construction phase
C1 (Tamil Nadu, Uttar Pradesh, Kerala)	Tamil Nadu	1250806	4.40	552235
	Uttar Pradesh	26619580	4.01	1067445
	Kerala	7068719	1.77	125116
	West Bengal	18393602	3.42	629061
	Bihar	16629997	3.42	568746
C2 (Punjab, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Jharkhand)	Punjab	3425723	1.97	67487
	Gujarat	9118449	0.60	54711
	Maharashtra	14673332	6.31	925887
	Karnataka	10117551	2.61	264068
	Andhra Pradesh	9517861	0.40	38071
	Jharkhand	6120293	4.13	252768
	Telangana	5398219	2.39	129017
	Rajasthan	10530458	2.39	251678
	Chhattisgarh	5009375	2.39	119724
	Madhya Pradesh	11979642	2.39	286313
	Haryana	3041314	2.39	72687
	Tripura	741945	2.39	17732
	Odisha	8863154	2.39	211829
C3 (Uttarakhand)	Uttarakhand	1494265	2.52	37655
	Assam	6802443	2.52	171422
	Goa	263013	2.52	6628
	Himachal Pradesh	1708705	2.52	43059
	Jammu and Kashmir	1909457	2.52	47078
	Mizoram	133329	2.52	3360
	Nagaland	366001	2.52	9223
	Meghalaya	635032	2.52	16003
	Manipur	451566	2.52	11379
	Arunachal Pradesh	230275	2.52	5803
UTs	Andaman and Nicobar Islands	62037	2.53	1569
	Dadra and Nagar Haveli and Daman & Diu	85156	2.53	2154
	Chandigarh	N/A	N/A	N/A
	Delhi	N/A	N/A	N/A
	Lakshadweep	13370	2.53	338
	Puducherry	114969	2.53	2908
Total				5,993,154

Notes: (i) Jammu and Kashmir is considered as a state which includes rural HH of UT Ladakh; (ii) estimates for Sikkim, Chandigarh, and Delhi could not be presented due to unavailability of data.

3.3. Direct employment potentials in the O&M phase of JJM

As shown in Table 5, by 2019, there were 32,362,838 rural HHs with FHTC; furthermore, a total of 162,217,522 HHs were planned to be covered under JJM. At the national level, JJM is potentially generating 1,325,919 person-years of employment in the O&M phases; out of which 1,118,749 person-years of employment can be ascribed to the JJM period (after 2019).

Table 4 | Employment generated in industries supplying raw materials for JJM.

Product manufactured	Additional employment generated
Cement	1,354,066
Steel/GI pipes	621,246
Pumps/sluice valves	1,105,943
HDPE pipes	1,352,796
Diesel	73,035
Ductile/cast iron pipes	2,121,591
Valves	1,105,943
Total	**7,734,620**

Note: Authors' calculation.

3.4. Skilled and unskilled employment generation under JJM

To estimate different types of employment, we created two categories: (i) skilled labour employment and (ii) unskilled labour employment, estimated as a part of direct employment using the ratio method. The unskilled labour employment includes helpers/watchmen and labourers, while the skilled labour employment takes into account the remaining positions. In some cases, data did not reveal the type of employment. We included them under unskilled employment.

Our result suggests that JJM has the potential to generate 2,620,783 person-years of skilled labour employment (43.72%) and the remaining 3,372,371 person-years of unskilled labour employment at the national level in its construction phase (Supplementary Table 7). Meanwhile, in the O&M phase, JJM has the capacity to generate a total number of 729,156 person-years of skilled (65%) and 389,593 person-years of unskilled labour employment annually (Supplementary Table 8).

4. DISCUSSION

In this paper, we attempted to understand the structure and potential for employment generation under the JJM. The JJM, although currently in its final implementation phase and approaching its deadline to achieve 100% coverage, has several intended and unintended spillover effects. While the intended effects can be measured in terms of enabling access to safe drinking water and health benefits, the unintended spillover effects can be seen in terms of employment creation. This potential in employment generation was estimated in two different phases of its implementation. The overall employment generation potential under JJM in its construction phase was estimated to be 28,248,478 person-years for the total investment of JJM. The estimated direct employment likely to be generated in the construction phase is 5,993,154 person-years. Subsequently, using a deductive approach, we show that out of the remaining 22,255,324 person-years of indirect employment, 7,734,620 person-years is associated with the manufacturing of materials utilized in the construction of JJM schemes. Unlike the construction phase, where employment is temporary or created for a stipulated period, the O&M phase generates employment that is perpetual in nature. During the O&M phase, the total potential employment generation is estimated to be 1,325,918 person-years. However, this figure cannot be attributed to the JJM completely because of previously existing drinking water supply schemes and manpower affiliated to them. To address this issue, we segregated the FHTC coverage into the 'pre-JJM period' (till 2019) and the 'JJM period' (2019 onwards). As of August 2019, 16.63% of rural HHs were provided with FHTCs, and 83.37% (i.e., 162,217,522 FHTCs) of rural HHs

Table 5 | Estimated direct employment per 100 HHs in the O&M phase of implementation in different states

Clusters (reference state)	States	No. of rural HHs	No. of rural HH to be covered in the JJM period (2019–2024)	Employment in the O&M phase (per 100 HHs)	Total direct employment – O&M phase	Total direct employment post-JJM period – O&M phase
C1 (Tamil Nadu)	Tamil Nadu	12550806	10376744	0.65	81580	67449
	Uttar Pradesh	26619580	26110597	0.65	173027	169719
	Kerala	7068719	5415333	0.65	45947	35200
	West Bengal	18393602	18211856	0.65	119558	118377
	Bihar	16629997	16313988	0.65	108095	106041
C2 (Punjab, Gujarat, Maharashtra, Karnataka, Andhra Pradesh)	Punjab	3425723	1747165	0.79	27063	13803
	Gujarat	9118449	2602191	0.36	32826	9368
	Maharashtra	14673332	9829500	0.89	130593	87483
	Karnataka	10117551	7665436	0.64	64752	49059
	Andhra Pradesh	9517861	6480530	0.56	53300	36291
	Jharkhand	6120293	5775128	0.74	45290	42736
	Telangana	5398219	3829918	0.74	39947	28341
	Rajasthan	10530458	9627674	0.74	77925	71245
	Chhattisgarh	5009375	4690159	0.74	37069	34707
	Madhya Pradesh	11979642	10613577	0.74	88649	78540
	Haryana	3041314	1274951	0.74	22506	9435
	Tripura	741945	718136	0.74	5490	5314
	Odisha	8863154	8555884	0.74	65587	63314
C3 (Uttarakhand)	Uttarakhand	1494265	1363953	0.75	11207	10230
	Assam	6802443	6691132	0.75	51018	50183
	Goa	263013	63919	0.75	1973	479
	Himachal Pradesh	1708705	946002	0.75	12815	7095
	Jammu and Kashmir	1868193	1332577	0.75	14011	9994
	Mizoram	133329	123859	0.75	1000	929
	Nagaland	366001	355413	0.75	2745	2666
	Meghalaya	635032	647016	0.75	4763	4853
	Manipur	451566	425646	0.75	3387	3192
	Arunachal Pradesh	230275	207479	0.75	1727	1556
UTs	Andaman and Nicobar Islands	62037	33490	0.75	465	251
	Dadra and Nagar Haveli and Daman & Diu	85156	85156	0.75	639	639
	Chandigarh	N/A	N/A	N/A	N/A	N/A
	Delhi	N/A	N/A	N/A	N/A	N/A
	Lakshadweep	13370	13370	0.75	100	100
	Puducherry	114969	21463	0.75	862	161
Total					1,325,919	1,118,749

Notes: (i) Jammu and Kashmir is considered as a state which includes rural HH of UT Ladakh; (ii) estimates for Sikkim, Chandigarh, and Delhi could not be presented due to unavailability of data.

are targeted to be covered by JJM. This distinction has led to an estimation of 1,184,899 person-years of employment in the O&M phase under the JJM period. Assuming the sample we have used is representative and free from bias, these estimates help us to understand the extent of employment likely to be generated due to JJM and indicate that the impact of JJM is likely to be substantial once it is properly completed and made operational. A detailed outline of employment potentials at different levels of implementation of JJM is presented in Figure 2.

Although it is difficult to assess the long-term impact of the JJM at this point of time, the program has a huge scope for short-term evaluation as there are no proper studies assessing the immediate and intermediate effects of JJM. The present literature indeed provides some evidence related to the conceptual framework of JJM (Sarkar & Bharat, 2021; Bongirwar & Dahasahasra, 2022; Singh *et al*., 2023) and its crude coverage (Wescoat *et al.* 2022). However, there are no proper studies assessing the ground-level impact of the program except one which assessed the social, health, and economic impacts with the help of a primary survey in rural regions of Karnataka and found significant positive effects of JJM (Premalatha, 2023).

4.1. Strengths and limitations

Our study has several caveats. First, the program is still in its implementation phase, and the total number of schemes at any point of time was dynamic; hence, it was difficult for us to draw a sample of schemes with minimum frame error. Moreover, this is one of the impeding factors that constrained us from estimating employment separately for different scheme types (MVS/SVS) and nature (new/retrofitting). Second, our study does not capture the induced employment effect in the indirect employment creation due to the unavailability of data. Furthermore, due to data constraints, indirect employment estimation was considered only for construction phases. Third, although we estimated skilled and unskilled employment, the availability of data did not permit us to assess the quality of work and identify the beneficiaries at the ground level. Nevertheless, to the best of our knowledge, our study is a novel attempt to assess the potential positive gain due to the implementation of a publicly funded rural water supply program.

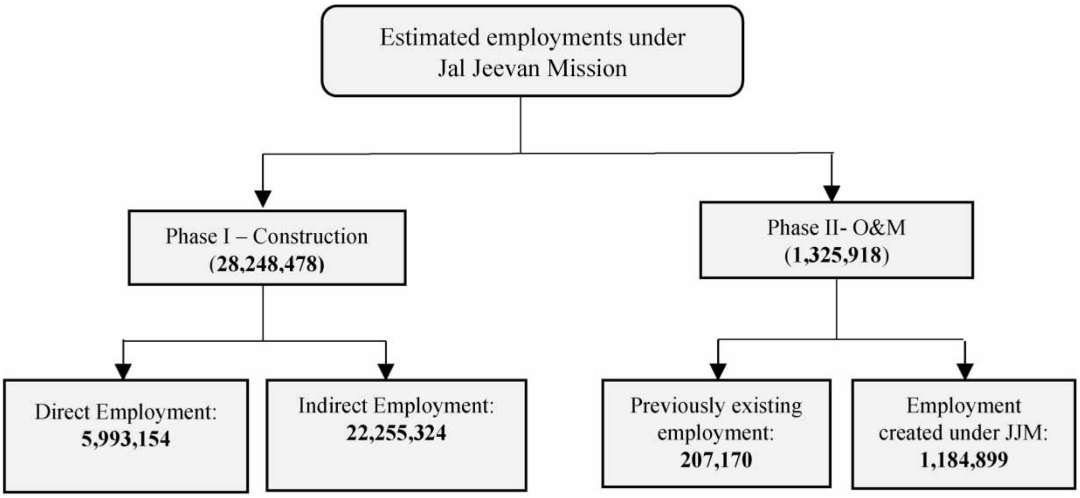

Fig. 2 | Average annual employment generation potential in different phases of implementation of JJM. *Note*: The indirect employment of 22,255,324 represents the overall indirect employment, out of which 7,734,620 is the 1st stage employment and the remainder (14,520,704) can be considered as employment in subsequent stages.

5. CONCLUSION

To encapsulate, the study findings reveal a significant impact of the JJM in terms of creating employment in the economy. Being rolled out as a national-level program, the mission aims not only to make access to safe drinking water easy but also to emerge as an opportunity hub creating short-term as well as long-term employment. We estimated the total employment likely to be generated due to the implementation of JJM. Our findings call for the attention of policymakers towards the proper execution of schemes in the post-implementation phase, elucidating the provision of manpower requirements in the operational guideline. Moreover, components such as decentralized governance and community involvement have to be given priority, which will play a vital role in making employment creation in the maintenance phase long withstanding.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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