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Contrasting Irrigation, Agriculture, Livelihood Linkages in Coastal and Non-Coastal Districts of Odisha and West Bengal

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An analysis of irrigation, agriculture, livelihood links in coastal and non-coastal districts of Odisha and West Bengal was carried out. District-wise scenario of irrigation, agriculture, livelihood and poverty revealed with the help of different indexes (value ranged from 0 to 1) developed for the study. The coastal districts of Odisha showed relatively better irrigation, agriculture and livelihood scenario as compared to non-coastal districts. While in West Bengal, districts of Gangetic plains (districts like Bardhaman, Birbhum, Hooghly, Midnapore (W), Murshidabad and Nadia) had better irrigation, agriculture and living scenario as compared to coastal districts. Six districts in Odisha showed higher irrigation and agriculture index values (>0.6) that included four coastal districts *viz.* Bhadrak, Balasore, Puri and Jagatsinghpur. Only one of three coastal districts in West Bengal showed higher value (>0.6) of irrigation and agricultural indexes. The surface water irrigation system was found predominant as groundwater irrigation contributed to about 14 per cent irrigation potential created in Odisha, while the same was 46 per cent in case of West Bengal. It is evident that relatively better groundwater development in West Bengal (40%) had lead to better irrigation and agricultural scenario in comparison to Odisha (28%) barring the coastal districts of Odisha. The links and/or missing links between irrigation resources, agriculture development, poverty and level of living were explored through correlation and linkage matrix. The indexes found to be mostly significantly correlated; however, linkages between them seemed to be more in case of poorer condition of different sectors; while betterment in one sector had not linked to betterment of other sectors in many of the districts.

(***Key words:*** *Agricultural development, Irrigation, Groundwater, Surface water, Level of living, Rural poverty*)

Irrigation resources have played a major role historically in poverty alleviation by ensuring agricultural development, expanding livelihood opportunities and employment both on and off the farm. Irrigation has played a crucial role in agricultural growth and development due to its direct (Hasnip *et al.*, 2001; Hussain and Hanjra, 2003) as well as indirect (Narayanamoorthy and Bhattarai, 2004, Narayanamoorthy, 2007) positive impact on the rural economy in India. A significant contribution (about 60%) from irrigated agriculture has always been to overall agricultural production in India (Planning Commission, 2012). Therefore, with irrigation development as one of the priority areas of India's agricultural development strategy in the successive five year plans (FYPs), irrigation potential has increased to 123 million hectare (Central Water Commission, 2012). If irrigation has the potential to produce such profound impacts on agrarian dynamism, why such impacts are not visible in eastern India, where it is needed and has the water resources to sustain intensive irrigation (Shah, 2004). Rural eastern India is still poverty stricken with narrow living options inspite of plentiful water resources. The positive impact of irrigation development could not be achieved equally across different geographical regions and unsustainable water resource development in one part is coexisting with its under-utilization in other part of the country (Narayanamoorthy, 2011). This kind of mismatch demands an analysis of irrigation, agriculture, poverty and living scenario in eastern region of India. In this backdrop, present paper analyse irrigation, agriculture, and livelihood scenario in coastal and non-coastal districts of Odisha and West Bengal.

MATERIALS AND METHODS

Different indices were constructed for assessment of district wise scenario of irrigation, agriculture, and livelihood, *viz.* Groundwater Development Index (GWDI), Irrigation Coverage Index (ICI), Composite Irrigation Index (CII), Agricultural Development Index (ADI), Level of Living Index (LLI), and Poverty Ration Index (PRI) following the methods used by Planning

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Commission for State Development Report (planningcommission.nic.in/plans/stateplan), which are usual way of indexing the variables of different units to make them unit free. Brief account of these indexes are given below:

GWDI considered district-wise gross annual draft (ha-m) out of utilisable groundwater resource (ha-m) and calculated as:

$$GWDI_j = \frac{GWD_j - \min GWD_j}{\max GWD_j - \min GWD_j} \quad (1)$$

Where, GWD_j = (gross annual draft of jth district / utilisable groundwater resource of jth district)

ICI was calculated on the basis of net irrigated area out of net cultivated area.

$$ICI_j = \frac{IC_j - \min IC_j}{\max IC_j - \min IC_j} \quad (2)$$

Where, IC_j = (net irrigated area of jth district / net sown area of jth district)

CII was calculated averaging GWDI and ICI giving equal weight.

ADI included seven indicators *viz.* % of cultivable land to total land area, % of net sown area to total cultivable area, % of gross irrigated area, cropping intensity, yield of paddy (major crop), food grain production and per ha fertilizer consumption. To depict the district-wise agricultural development disparity scenario, composite Agricultural Development Index (ADI) was constructed by 'Deprivation Method' by using seven agricultural development indicators similar to those given in the Report Planning Commission (planningcommission.nic.in/plans/stateplan).

Composite agricultural development index was calculated as:

$$ADI_j = \frac{\sum_{i=1}^{n} I_{ij}}{\sum_{i=1}^{n} I} \quad (3)$$

Where, ADI_j is the index of jth district and equal weight to all the indicators

$$I_{ij} = \frac{X_{ij} - \min X_{ij}}{\max X_{ij} - \min X_{ij}} \quad (4)$$

Where, X_{ij} is the actual value of ith indicator for jth district $\min X_{ij}$ and $\max X_{ij}$ are the minimum and maximum value of ith indicator

LLI included 14 variables *viz.* % of population above poverty line, literacy rate, per capita food grain production, yield of major crop, % of gross irrigated area, % of village electrification, women work participation rate, % of agricultural laborers to total main workers, % of cultivators to total main workers, % of industrial workers to total main workers, % of main workers to total population, percentage of urban population to total population, agricultural productivity per worker, and backward class (Scheduled Class/ Scheduled Tribe) population. To ensure the index values for the selected variables move in same direction the index value was calculated as follows:

Index values for the positive variables like literacy rate, agricultural productivity, etc were calculated as:

$$P_{ij} = \frac{Y_{ij} - \min Y_{ij}}{\max Y_{ij} - \min Y_{ij}} \quad (5)$$

While index values of the negative variables like backward class population, poverty ratio, etc were calculated as:

$$P_{ij} = \frac{\max Y_{ij} - Y_{ij}}{\max Y_{ij} - \min Y_{ij}} \quad (6)$$

Where, Y_{ij} is the actual value of ith indicator for jth district $\min Y_{ij}$ and $\max Y_{ij}$ are the minimum and maximum value of i^{th} indicator

On the basis of the index value of each selected indicator a composite index was derived giving equal weight and there by district-wise LLI value was calculated as:

$$LLI_j = \frac{\sum_{i=1}^{m} P_{ij}}{\sum_{i=1}^{m} i} \quad (7)$$

Where, LLI_j is the index of j^{th} district and equal weight to all the indicators

PRI was calculated on the basis of percentage of families below poverty line (BPL) in the district.

$$PRU = \frac{\max PR_j - PR_j}{\max PR_j - \min PR_j} \quad (8)$$

Where, PR_j = (BPL families of j^{th} district / total rural families of j^{th} district)*100

District-wise data on selected variables were taken from various secondary data sources viz. Economic Survey, Agricultural Statistics of Odisha and West Bengal, Census, BPL Survey and other published sources as available till the end of Eleventh Five Year Plan. District-wise values of different indices were calculated. Each index ranged from 0.0 to 1.0. The districts were classified under each index into five categories *viz.* very low (0.0 to 0.2), low (>0.2 to 0.4), medium (>0.4 to 0.6), high (>0.6 to 0.8) and very high (>0.8 to 1.0).

RESULTS AND DISCUSSIONS

District-wise scenario of irrigation, agriculture, level of living and poverty is presented with the help of different indices derived for 30 (including 6 coastal districts) and 18 districts (including 3 coastal districts) of Odisha and West Bengal, respectively, along with mean and standard deviation value of each index. (Table 1 and Table 2).

Irrigation scenario

A look at the district-wise irrigation scenario at the end of Eleventh Five Year Plan in Odisha revealed that the created irrigation potential out of the total potential varied among the 30 districts of Odisha. Net irrigated area out of net sown area was ranging from 4.55 per cent (Nawarangpur district) to 69.23 per cent (Puri district). Irrigation potential development was more than 50 per cent in 7 districts out of which 5 districts (Puri, Ganjam, Jagatsinghpur, Sonpur and Cuttack) had 50 per cent of cultivated area irrigated, out of which three districts were coastal districts (Puri, Jagatsinghpur and Ganjam). ICI values of 18 districts were very low to low, while that of 7 districts was high to very high, out of which Bhadrak, Puri, Ganjam and Jagatsinghpur were coastal districts and Cuttack, Gajapati and Sonpur were non-coastal districts. CII value varied from 0.004 (Malkangiri district) to 0.85 (Bhadrak and Jatsinghpur district). CII values of 20 districts were very low to low, while 7 districts were under very high to high category including six coastal districts viz. Bhadrak, Jagatsinghpur, Kendrapara, Ganjam, Balasore and Puri.

Groundwater development varied from 9 per cent (Malkangiri district) to 59 per cent (Bhadrak district). Groundwater development was less than the state's average (28%) in 18 districts. The GWDI values of 18 districts were low to very low; only for five districts the value was >0.6 i.e. high to very high, four of which were coastal districts (Bhadrak, Kendrapara, Balasore, and Jagatsinghpur districts). Rest seven districts were in medium level of GWDI value.

Groundwater development in West Bengal varied from 4 per cent (Jalpaiguri dist.) to 92 per cent (Nadia dist.). The GWDI values of nine districts were found low to very low; while four districts' values were high to very high (>0.6) including two coastal districts (South and North 24 Parganas) and two non-coastal districts (Nadia and Murshidabad). The irrigation utilization or irrigation coverage (ratio of net irrigated to net sown area) varied from 3.58 per cent (Darjeeling) to 87.55 per cent (Bankura district) with an average of 54 per cent. Eleven districts showed high to very high irrigation coverage index value (ICI>0.6), including two non-coastal districts. CII value varied from 0.01 (Darjeeling district) to 0.91 (Nadia district). CII values of five districts were low to very low (< 0.4), while that of eight and five districts each were medium (>0.4 to 0.6) and high (>0.6 to 0.8), respectively. Only one coastal district i.e. South 24 Parganas was having high CII value (0.66).

The surface water irrigation system was found predominant as groundwater irrigation contributed to about 14 and 46 per cent share of IPC in Odisha and West Bengal, respectively. However, it is evident that relatively better groundwater development in West Bengal had led to better irrigation scenario in comparison to Odisha (Ghosh *et al.,* 2014). Overall the potential utilization of groundwater irrigation system is relatively less in eastern region as compared to other regions of country due to many constraints like higher energy cost, operational cost, defunct lift points, etc (Srivastava *et al.,* 2014). In Indo-Gangetic Basin (IGB) that also covers many districts of West Bengal, energy cost and availability ranked as the top challenge to the farming (Shah *et al.*, 2006). The diesel price squeeze on small-scale irrigation is heading towards a crisis that is also visible in West Bengal, where electric tubewells are few and the ratio of rice (major crop) to diesel price has turned adverse. In crop-sharing contracts for water sales, tubewell owners claim 1/3rd to half of the total output for pump irrigation alone when they pay for diesel (Shah *et al.*, 2009).

Agricultural scenario

ADI values of 30 districts in Odisha ranged from 0.79 (Sonpur dist.) to 0.17 (Kandhamal district). Twelve districts showed medium ADI values (>0.4-0.6); while 10 and 8 districts indicated very low to low (0.0-0.4) and high (>0.6-0.8) agricultural development, respectively. The ADI values of four coastal districts *viz.* Bhadrak, Balasore, Puri and Ganjam found relatively higher as compared to most of the non-coastal districts.

ADI values of 18 districts in West Bengal ranged from 0.82 (Bardhaman district) to 0.13 (Darjeeling district). Bardhaman district had very high ADI value while eight districts showed high (>0.6-0.8) agricultural development, which included one coastal districts (East Midnapore). Six and three districts showed medium (>0.4-0.6) and very low to low (0.0-0.4) ADI values, respectively.

Rai *et al.* (2008) also reported that districts of Odisha states were in the group of maximum number of low agricultural productive districts in India. As per the agricultural status index these districts in agro-climatic zone 7 (barring coastal districts of Odisha those are in zone 11) were categorized as low; while many districts of West Bengal in agro-climatic zone 3 were medium status. Agricultural development in districts of West Bengal was found to be comparatively better than other eastern Indian states (Ghosh *et al.,* 2014) with relatively higher

Table 1. *Values of different developmental indexes in the districts of Odisha*

Sl. No.	District	GWDI[1]	ICI[2]	CII[3]	ADI[4]	LLI[5]	PRI[6]
Coastal districts							
1	Balasore	0.88	0.39	0.64	0.74	0.52	0.33
2	Bhadrak	1.00	0.67	0.85	0.73	0.58	0.52
3	Kendrapara	0.96	0.48	0.72	0.64	0.53	0.70
4	Jagatsingpur	0.86	0.84	0.85	0.75	0.53	0.90
5	Puri	0.24	1.00	0.62	0.72	0.55	0.45
6	Ganjam	0.42	0.94	0.68	0.53	0.50	0.84
Non-Coastal districts							
7	Cuttack	0.58	0.73	0.65	0.66	0.61	0.91
8	Jajpur	0.80	0.25	0.52	0.47	0.43	0.69
9	Bolangir	0.28	0.01	0.15	0.26	0.41	0.67
10	Sonepur	0.22	0.85	0.53	0.79	0.57	0.35
11	Dhenkanal	0.34	0.13	0.23	0.47	0.42	0.63
12	Angul	0.50	0.07	0.29	0.29	0.41	0.72
13	Gajpati	0.36	0.62	0.49	0.35	0.40	0.66
14	Kalahandi	0.02	0.40	0.21	0.45	0.39	0.63
15	Nawapara	0.24	0.08	0.16	0.39	0.27	0.00
16	Keonjhar	0.40	0.15	0.27	0.48	0.38	0.24
17	Koraput	0.02	0.47	0.24	0.37	0.33	0.05
18	Malkangiri	0.00	0.01	0.004	0.28	0.43	0.10
19	Nawarangpur	0.12	0.00	0.06	0.37	0.31	0.33
20	Rayagarh	0.12	0.43	0.28	0.21	0.31	0.37
21	Mayurbhanj	0.42	0.24	0.33	0.60	0.44	0.22
22	Kandhamal	0.08	0.01	0.04	0.17	0.32	0.20
23	Boudh	0.22	0.52	0.37	0.46	0.42	0.15
24	Khurda	0.48	0.31	0.40	0.54	0.56	0.72
25	Nayagarh	0.30	0.11	0.21	0.47	0.40	0.49
26	Sambalpur	0.14	0.34	0.24	0.55	0.61	0.71
27	Bargarh	0.34	0.47	0.41	0.76	0.61	0.69
28	Deogarh	0.14	0.17	0.16	0.42	0.27	0.19
29	Jharsuguda	0.44	0.09	0.26	0.38	0.54	1.00
30	Sundargarh	0.26	0.29	0.35	0.47	0.41	0.56
Max. value	1.00	1.00	0.85	0.79	0.61	1.00	
Min. value	0.00	0.00	0.004	0.17	0.27	0.00	
Mean value	0.37	0.36	0.37	0.49	0.43	0.50	
Standard deviation		0.28	0.30	0.24	0.17	0.10	0.28

Note: [1]Groundwater Development Index (GWDI), [2]Irrigation Coverage Index (ICI), [3]Composite Irrigation Index (CII), [4]Agricultural Development Index (ADI), [5]Level of Living Index (LLI) and [6]Poverty Ratio Index (PRI)

Table 2. *Values of different developmental indexes in the districts of West Bengal*

Sl. No.	District	GWDI[1]	ICI[2]	CII[3]	ADI[4]	LLI[5]	PRI[6]
Coastal districts							
1	Midnapore (E)	0.32	0.83	0.58	0.65	0.43	0.97
2	24 Parganas (N)	0.66	0.83	0.74	0.54	0.48	0.43
3	24 Parganas (S)	0.66	0.36	0.51	0.43	0.30	0.46
Non-Coastal districts							
4	Bankura	0.41	1.00	0.70	0.66	0.47	0.20
5	Bardhaman	0.36	0.79	0.58	0.82	0.58	1.00
6	Birbhum	0.34	0.89	0.62	0.72	0.46	0.12
7	Coochbihar	0.15	0.46	0.30	0.46	0.31	0.02
8	Darjeeling	0.01	0.00	0.01	0.13	0.39	0.00
9	Dinajpur (N)	0.48	0.48	0.48	0.70	0.35	0.27
10	Dinajpur (S)	0.48	0.28	0.38	0.51	0.40	0.14
11	Hooghly	0.47	0.61	0.54	0.71	0.56	0.86
12	Howrah	0.24	0.63	0.43	0.39	0.62	0.71
13	Jalpaiguri	0.00	0.29	0.14	0.34	0.31	0.52
14	Malda	0.41	0.61	0.51	0.58	0.43	0.38
15	Midnapore (W)	0.32	0.84	0.58	0.72	0.53	0.67
16	Murshidabad	0.85	0.62	0.74	0.67	0.47	0.16
17	Nadia	1.00	0.82	0.91	0.65	0.48	0.61
18	Purulia	0.06	0.47	0.26	0.42	0.34	0.14
Max. value	1.00	1.00	0.91	0.82	0.62	1.00	
Min. value	0.00	0.00	0.01	0.13	0.30	0.00	
Mean value	0.40	0.60	0.50	0.56	0.45	0.42	
Standard deviation	0.27	0.26	0.22	0.17	0.11	0.32	

Note: [1]Groundwater Development Index (GWDI), [2]Irrigation Coverage Index (ICI), [3]Composite Irrigation Index (CII), [4]Agricultural Development Index (ADI), [5]Level of Living Index (LLI) and [6]Poverty Ratio Index (PRI)

productivity of major crop paddy (about 2.5 t ha^{-1}), food grain production (15700 thousand tonne with productivity about 1.7 t ha^{-1}), cropping intensity (180%) and fertilizer consumption (145 kg ha^{-1}). While more than half of the gross sown area was found irrigated in the West Bengal, low to medium level of agricultural development in half of the districts reiterates the fact that performance of groundwater irrigation influenced the irrigation and agricultural performance.

Living and poverty scenario

Rural poverty was explored through the percentage of rural families under below poverty line (BPL) to total number of rural families. About 60 per cent of BPL rural families comprised agricultural labourers, marginal and small farmers families; it ranged from 24 per cent (Ganjam) to 90 per cent (Nawarangpur). PRI values of 10 districts were in high range (higher the value of index lower is the poverty), while 12 districts showed the very high to high poverty level with lower PRI values (<0.4). The level of living of 19 districts was found as medium (with LLI value >0.4-0.6) and of 9 districts was low (with LLI value >0.2-0.4). Sambalpur and Bargarh were the only two districts with a high LLI value.

It is revealed that overall irrigation scenario was best in Jagatsinghpur and Bhadrak districts with very high CII values (>0.80), which were mainly attributed to better groundwater development in those districts. The CII value was high (>0.60-0.80) in case of Kendrapara, Balasore, Cuttack, Ganjam and Puri districts. Irrigation coverage *i.e.* percentage of net irrigated area out of net sown area was also found to be high with very high ICI values in the districts like Puri, Ganjam, Sonpur, and Jagatsinghpur. The ICI value was high in case of Cuttack, Bhadrak and Gajapati districts. It may be concluded that groundwater irrigation was having better impact on overall irrigation scenario. The better irrigation scenario was reflected in better agricultural scenario in Balasore, Bhadrak, Jagatsinghpur, Kendrapara, Cuttack and Puri districts with higher ADI values. However, Sonpur district was found best in agricultural development. The level of living of Samabalpur district was also found to be high followed by Cuttack and Bhadrak districts. Better level of living in Cuttack district had reflected in lower poverty scenario. Jharsuguda which was one of the industrially developed districts along with Sambalpur in the state of Odisha with better living scenario had showed relatively lower poverty.

Level of living of eleven and six districts was found as medium (with LLI value >0.4-0.6) and low (with LLI value >0.2-0.4), respectively in West Bengal. PRI values of six districts were in high range (higher the value of index lower is the poverty), which included one coastal district East Midnapore. Nine districts showed relatively higher poverty level with lower PRI values (<0.4). Poverty was found highest in Darjeeling and Coochbihar districts (46 % families are BPL); however, it was lowest in Bardhaman district, where 26% families were BPL, agricultural development was found maximum. Thus, the living scenario of most of the districts in West Bengal was at medium level.

Rai *et al.* (2008) in their study on livelihood status of different agro-climatic zones in India reported that livelihood status index of agro-climatic zones 7 (Jharkhand, Chhattisgarh and Odisha are in this zone barring coastal districts of Odisha those are in zone 11) and 4 (all districts of Bihar) was categorized as low while agro-climatic zones 3 (many districts of West Bengal) was medium status. Extent of poverty was found maximum in Odisha and minimum in West Bengal having relatively low and high level of irrigation as well as agricultural performance, respectively (Ghosh *et al.*, 2014). The locational differences (upstream–downstream poverty differences in India about 11%) in poverty were more pronounced in larger irrigation systems (surface irrigation), where locational inequities in water distribution and agricultural productivity differences were also high (Hussain *et al.*, 2003). Impact of groundwater irrigation on agriculture and poverty reduction is larger (Bhattarai and Narayanmoorthy, 2003, Shah, 2004; Narayanmoorthy, 2007). Mukherji (2007) in an extensive study in West Bengal reaffirmed groundwater irrigation with numerous benefits.

Linkages between irrigation, agriculture, living and poverty

To draw relationships between irrigation resources, agricultural development, level of living and poverty, at the first step normality of CII, ADI and LLI tested using SPSS 10.0 for Windows program. As the indices values were found to be normally distributed, correlation analyses were carried out with those values. Links between irrigation, agriculture, livelihood and poverty were understood through a correlation matrix (Table 3 and Table 4). In Odisha, the correlation matrix revealed that ADI was significantly related with GWDI, ICI and

Table 3. *Correlation matrix of different indexes in Odisha*

Index	GWDI	ICI	CII	ADI	LLI	PRI
GWDI	1					
ICI	0.294	1				
CII	0.794**	0.811**	1			
ADI	0.556**	0.668**	0.763**	1		
LLI	0.503**	0.554**	0.656**	0.754**	1	
PRI	0.464**	0.287	0.467**	0.267	0.613**	1

Note: ** significant at 0.01 per cent level and * significant at 0.05 per cent level

Table 4. *Correlation matrix of different indexes in West Bengal*

Index	GWDI	ICI	CII	ADI	LLI	PRI
GWDI	1					
ICI	0.397	1				
CII	0.844**	0.827**	1			
ADI	0.499*	0.776**	0.763**	1		
LLI	0.240	0.582*	0.490*	0.475*	1	
PRI	0.140	0.410*	0.328	0.423	0.572*	1

Note: ** significant at 0.01 per cent level and * significant at 0.05 per cent level

CII, while LLI was significantly related with GWDI, ICI, CII, ADI and PRI. PRI was significantly associated with GWDI, CII and LLI; however, no association was found between PRI and ADI. In West Bengal, ADI was significantly related with GWDI, ICI and CII; while LLI was significantly related with ICI, CII, ADI and PRI. Correlation coefficient value between PRI and ICI as well as PRI and LLI was significant; however, that of PRI and ADI was not significant. Lack of significant association may be attributed to the fact of the dependence on rice as major crop (more than 80 % of total acreage and total production) that was not remunerative necessitating crop diversification towards more remunerative/high value crops.

A linkage matrix was prepared showing frequency of districts under various combinations of links between irrigation, agriculture, level of living and poverty (Table 5 and Table 6). The CII, ADI, LLI and PRI values of each district were considered to delineate the districts falling under index: high to very high (value>0.6), index: medium (value 0.4-0.6) and index: low to very low (value<0.4) with various combinations of links between the indexes. Number of districts having values of CII, ADI, LLI and PRI more than 0.6 counted under the index: high to very high within various combinations of links; similarly, the values of said indexes falling under 0.4 for the districts were counted under index: low to very low with various combinations of links. The districts with

Table 5. *Linkage matrix showing number of districts under various combinations of links between irrigation, agriculture, livelihood and poverty in Odisha*

Types of Links	Districts (No.)			
	Index: High to very high	Index: Medium	Index: Low to very low	Total
Irrigation - Agriculture	6	1	10	17
Agriculture – Livelihood	2	6	6	14
Irrigation – Livelihood	1	2	7	10
Irrigation - Poverty	4	0	10	14
Agriculture - Poverty	3	2	6	11
Livelihood - Poverty	3	4	7	14
Irrigation – Agriculture – Livelihood	1	1	5	7
Irrigation – Agriculture – Poverty	3	0	6	9
Irrigation – Livelihood - Poverty	1	0	7	8
Agriculture – Livelihood – Poverty	2	2	5	9
Irrigation–Agriculture -Livelihood - Poverty	1	0	5	6

Table 6. *Linkage matrix showing number of districts under various combinations of links between irrigation, agriculture, livelihood and poverty in West Bengal*

Types of Links	Districts (No.)			
	Index: High to very high	Index: Medium	Index: Low to very low	Total
Irrigation - Agriculture	4	2	2	8
Agriculture – Livelihood	0	2	2	4
Irrigation – Livelihood	0	5	5	10
Irrigation - Poverty	0	0	4	4
Agriculture - Poverty	5	2	1	8
Livelihood - Poverty	1	1	6	8
Irrigation – Agriculture – Livelihood	0	1	2	3
Irrigation – Agriculture – Poverty	0	1	1	2
Irrigation – Livelihood - Poverty	0	0	4	4
Agriculture – Livelihood – Poverty	0	1	1	2
Irrigation–Agriculture -Livelihood - Poverty	0	0	1	1

developmental indexes values between 0.4-0.6 were categorized under the index: medium with various links.

In Odisha, the values of CII and ADI were found more than 0.6 (index: high to very high) for six districts, less than 0.4 (index: low to very low) for ten districts, between 0.4 to 0.6 (index: medium) for one district; therefore, overall the 'Irrigation – Agriculture' link is found in 17 districts. However, it is narrowed down to 14 and 10 districts in the case of 'Agriculture – Livelihood' and 'Irrigation – Livelihood' links, respectively. The 'Irrigation – Poverty' 'Agriculture – Poverty' and 'Livelihood – Poverty' links are visible in 14, 11 and 14 districts, respectively. The 'Irrigation – Agriculture – Livelihood – Poverty' link is seen only in six districts.

In West Bengal, the values of CII and ADI were found more than 0.6 (index: high to very high) for four districts, less than 0.4 (index: low to very low) for two districts and from 0.4 to 0.6 (index: medium) for two districts; therefore, overall the 'Irrigation – Agriculture' link was found in eight districts. However, it was ten and six districts in the case of 'Irrigation – Livelihood' and 'Agriculture – Livelihood' links, respectively. The 'Irrigation – Poverty', 'Agriculture – Poverty' and 'Livelihood – Poverty' links were visible in four, eight and eight districts, respectively. The 'Irrigation – Agriculture – Livelihood – Poverty' link was seen only in one district, which was categorized under low to very low index value.

Both in case of Odisha and West Bengal, 'Irrigation – Agriculture – Livelihood – Poverty' link was seen mainly under low to very low index value. Therefore, better scenario of irrigation and agriculture in 10 (six in Odisha and 4 in West Bengal) districts could not influence the level of living in those districts showing the missing links.

CONCLUSIONS

As revealed in the present study as well as past studies, the impacts of irrigation vary across settings and the magnitude of the anti-poverty impacts of irrigation depend on a number of factors like structure of land distribution, condition of the irrigation infrastructure and its management (both groundwater and surface water), irrigation water management including allocation and distribution procedures, irrigation efficient production technologies, cropping patterns and crop diversification, support measures including information, input and output marketing. There is a need for combination of sustainable irrigation development with the development of appropriate pro-poor institutions and technologies to achieve lasting and sustainable impact on poverty.

District-wise scenario of irrigation, agriculture, living and poverty was revealed with the help of different indexes developed for the study. The differential influences of irrigation on agriculture as well as that of both irrigation and agriculture on living and poverty scenario witnessed on many districts of Odisha and West Bengal. Irrigation – Agriculture – Livelihood – Poverty links have been found more in case of poorer condition of different sectors; while betterment in one sector had not linked to betterment of other sectors in many of the districts. Thus, the study has unveiled the links and/or missing links between irrigation resources, agricultural development, level of living and poverty which would help to formulating future policies and planning for eastern India in general and Odisha as well as West Bengal in particular for better agricultural growth and visible impact on agrarian economy and livelihood.

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