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Water- Crops- Milk Interdependence: A Case Study of Odisha

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ABSTRACT: Discerning the interdependence between water, crops and milk production in a study conducted for30 districts of Odisha, district wise three factors namely, irrigation, crop output and milk output were estimated. Positive correlations of 0.86 between irrigation and crop output, 0.81 between irrigation and milk output and 0.69 between crop and milk output were observed, all the correlation values are significant at 1 per cent level. Analysing district wise matching three factors, it was observed that highest association of dataset existed between the factors of irrigation and crop output; in comparison to other two sets. The multiple regression analysis of two independent variables (irrigation and crop output) on the milk output, clearly indicated that irrigation had a strong positive association with milk output and the shift in milk output was affected due to irrigation factor only.

Keywords: irrigation, crop output, milk output, correlation, linear regression, interdependence.

INTRODUCTION

It has been a truism that agriculture is keenly associated with availability water. Rationalizing further, productivity gains in crops can be realized with effective use of water. Elucidating the issue of 'productivity gains', it has been an established fact that the net sown area of India has not increased over time, hence raising the cropping intensity is the only viable option left to garner more production per unit area of land. The provision of controlled water (irrigation) is the principal input for improving cropping intensity (Rosegrant and Perez 1997; Ringler *et al.,* 2000; Hussain and Hanjra 2004; Lipton *et al.,* 2005). The effective utilization of water leads to higher crop production and productivity, thereby triggering total biomass production in an area, which acts as one of the inputs for milk production. Though this interlinkage between water-crops-milk looks obvious; but there is limited research findings and knowledge resources to underpin this fact.

Objectives. The study was carried out for the state of Odisha with the following objectives:

— Evaluate the correlation between the district wise area under irrigation with that of the value of total crops / value of milk produced and the correlation between the district wise value of total crops and value of milk produced

— Rank and match the performance of districts of the state with respect to irrigation potential created, value of crops and value of milk

— Draw evidences on water-crops-milk interdependence.

METHODOLOGY

In order to accomplish the objectives of this research study, the methodology draws from the seminal works on 'meta-analysis' carried out by Alston *et al*. (2000); McConnell and Eric Keys (2005); Holmgren and Merkel (2017); Satish (2007) on "Rural Infrastructure and Growth: An Overview". The study took into cognizance two published reports of secondary origin of Government of Odisha publications available on public domain on the three parameters of all 30 districts of Odisha; firstly, gross area under irrigation (including all sources of irrigation), Department of Water Resources, 2015-16, Govt. of Odisha available on www.dowrodisha.gov.in; secondly, on the value of all crops put together in current price and thirdly, on the value of milk in current price, Directorate of Economics and Statistics, 2020, Odisha available on www.desorissa.nic.in/pdf/value-output-report(final).pdf.

Purposively, the district-wise data on irrigation, the value of the all crops and the value of milk, of all 30 districts were collated for the year 2015-16; as the data on value all crops and milk were only available till 2015-16. In order to bring comparable parity among these numbers, the district-wise data on gross area under irrigation, the value of the all crops and the value of milk were divided with total area of the respective district (available on

http://districts.nic.in/districts.php?sid=OR), so as to arrive at district-wise 'factor' of irrigation, 'factor' of value of all crops and 'factor' value of milk per square kilometre. In order to measure the strength of the linear relationship between two variables, the correlation analyses of district-wise gross area under irrigation and value of all crops; district-wise gross area under irrigation and value of milk and that of, district-wise value of all crops and value of milk were evaluated using the formula as given hereunder;

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(xi - \bar{x})^2 \sum(yi - \bar{y})^2}}$$

Further, the districts were ranked from 1 to 30 based on the factors of irrigation, factors of crop output and factors of milk output separately, wherein rank 1 was highest and rank 30 was the lowest amongst the districts. The districts ranking from top 1 to 10 are clubbed as 'top' range, the districts ranking from 10 to 20 are put under 'middle' range and the rest districts ranking from 20 to 30 positions are grouped under 'low' range with respect to three parameters under study. Thereafter, the matching of all the districts with respect to their 'ranges' *viz.,* top, middle and low between all three parameters under study were conducted to arrive at matching of ranges in the districts.

In addition, to arrive at conclusive evidence, the study chalked out two separate linear regression analyses of factor milk with that of irrigation and factor of milk with that of crops; wherein the 'factor' of milk was construed as the dependent variable and other two factors namely irrigation and crops were considered as independent variables. The multiple regression analysis was carried out using the formula as given hereunder;

$y=a+b_1x_1 +b_2x_2$

where, b_1= Coefficient for independent factor x_1 (irrigation), b_2 = Coefficient for independent factor x_2 (crop output), and y = Dependent factor (milk value), a = intercept constant

RESULTS AND DISCUSSION

The data on district wise gross area irrigated, total value of crops, total value of milk and area of the respective districts were collected from three different sources, collated and presented in Table 1. The district wise factors of irrigation, factor of crop output and factor of milk output were calculated by dividing the gross area irrigated/the total value of crops/the total value of milk with respective area of the district, respectively and presented in Table 1.

Table 1: District wise Gross Area Irrigated (Thousand Ha.), Total Value of Crops (in Rs. Lakh) and Total Value of Milk (in Rs. Lakh), Area of District (in Sq. Km)and calculated Factor of Irrigation, Crop Output and Milk Output.

Sr. No	District	Gross Area Irrigated [a] '000 Ha	Total Value of Crops [b] (in Rs Lakh)	Total value of Milk [b] (in Rs. Lakh)	Area of Dist[c] in Sq KM	Factor of Irrigation	Factor of Crop output	Factor of Milk output
1.	Anugul	137.068	131936	14444	6232	0.022	21.170	2.317
2.	Balasore	296.403	181938	49017	3634	0.081	50.065	13.488
3.	Bargarh	315.111	206985	21344	5837	0.054	35.460	3.656
4.	Bhadrak	202.028	169295	12000	2505	0.080	67.582	4.790
5.	Bolangir	174.913	187816	23678	6575	0.026	28.565	3.601
6.	Boudh	102.983	70179	7102	3098	0.033	22.653	2.292
7.	Cuttack	290.580	150606	64159	3932	0.073	38.302	16.317
8.	Deogarh	52.476	46727	4363	2781	0.018	16.802	1.568
9.	Dhenkanal	215.953	139238	22564	4452	0.048	31.275	5.068
10.	Gajpati	44.493	89588	10481	3850	0.011	23.269	2.722
11.	Ganjam	388.464	233724	39133	8070	0.048	28.962	4.849
12.	Jagatsingpur	136.418	112754	31805	1759	0.077	64.101	18.081
13.	Jajpur	218.636	100642	32622	2888	0.075	34.848	11.295
14.	Jharsuguda	34.825	40417	4370	2081	0.016	19.421	2.099
15.	Kalahandi	334.828	192928	18612	7920	0.042	24.359	2.350
16.	Kandhamal	56.015	163234	5766	8021	0.007	20.350	0.718
17.	Kendrapada	220.369	113905	19589	2644	0.083	43.080	7.408
18.	Keonjhar	165.108	223028	14886	8240	0.020	27.066	1.806
19.	Khurda	154.986	131751	23945	2887	0.053	45.635	8.294
20.	Koraput	207.327	204455	16417	8807	0.023	23.215	1.864
21.	Malkangiri	136.880	100942	10074	5791	0.023	17.430	1.739
22.	Mayurbhanj	310.696	227642	29216	10418	0.029	21.850	2.804
23.	Nawrangpur	101.669	138753	5131	5294	0.019	26.209	0.969
24.	Nayagarh	104.593	98301	7537	3890	0.026	25.270	1.937
25.	Nuapada	116.120	77922	10366	3408	0.034	22.864	3.041
26.	Puri	265.872	147608	33788	3051	0.087	48.380	11.074
27.	Rayagada	104.800	148790	15313	7584	0.013	19.618	2.019
28.	Sambalpur	146.585	115306	9889	6702	0.021	17.204	1.475
29.	Sonepur	165.323	142920	11439	2284	0.072	62.574	5.008
30.	Sundergarh	174.826	176897	15729	9712	0.018	18.214	1.619

Sources:

a. www.dowrodisha.gov.in; b. www.desorissa.nic.in/pdf/value-output-report(final).pdf; c. http://districts.nic.in/districts.php?sid=OR

The three numbers of correlation coefficients calculated between district-wise factors of irrigation and crop output; district-wise factors of irrigation and milk output; district-wise factors of crop output and milk output, are presented in Table 2.

The positive correlations were indicative of the fact that linear relationships between these factors did exist. However, the correlation between crop output and irrigation; it was the highest (0.862), and the correlation between crop output and milk output was the lowest (0.691) amongst the three factors.

The district wise rank and range based on the factors of irrigation, crop output and milk output are presented in Table 3.

Table 2: Correlation Matrix- Factors of irrigation, crop output and milk output.

Correlation Matrix	Factor of Irrigation	Factor of Crop Output
Factor of Crop Output	0.862**	
Factor of Milk Output	0.812**	0.691**

**Significant at 1% level

Table 3: Ranking and range of Districts based on factors of Irrigation, crop output and milk output.

Sr. No.	District	Rank based on			Range based on		
		Factor of Irrigation	Factor of crop output	Factor of milk output	Factor of Irrigation	Factor of crop output	Factor of milk output
1.	Anugul	21	23	18	L	L	M
2.	Balasore	3	4	3	T	T	T
3.	Bargarh	9	9	12	T	T	M
4.	Bhadrak	4	1	10	T	T	T
5.	Bolangir	16	13	13	M	M	M
6.	Boudh	15	21	19	M	L	M
7.	Cuttack	7	8	2	T	T	T
8.	Deogarh	25	30	27	L	L	L
9.	Dhenkanal	11	11	8	M	M	T
10.	Gajpati	29	18	16	L	M	T
11.	Ganjam	12	12	11	M	M	M
12.	Jagatsingpur	5	2	1	T	T	T
13.	Jajpur	6	10	4	T	T	T
14.	Jharsuguda	27	26	20	L	L	M
15.	Kalahandi	13	17	17	M	M	M
16.	Kandhamal	30	24	30	L	L	L
17.	Kendrapada	2	7	7	T	T	T
18.	Keonjhar	23	14	25	L	M	L
19.	Khurda	10	6	6	T	T	T
20.	Koraput	20	19	23	M	M	L
21.	Malkangiri	19	28	24	M	L	L
22.	Mayurbhanj	17	22	15	M	L	M
23.	Nawrangpur	24	15	29	L	M	L
24.	Nayagarh	18	16	22	M	M	L
25.	Nuapada	14	20	14	M	L	M
26.	Puri	1	5	5	T	T	T
27.	Rayagada	28	25	21	L	L	L
28.	Sambalpur	22	29	28	L	L	L
29.	Sonepur	8	3	9	T	T	T
30.	Sundergarh	26	27	26	L	L	L

T- Top range, M-Middle range, L-Low Range

Firstly, comparing the range based on factors of irrigation with that of crop output, it was observed that out of 30 districts, the range matched for 23 districts as against a mismatch in rest 7 districts. Secondly, comparing the range based on factors of irrigation with that of factor of milk output, it was found that out of 30 districts, the range matched for 22 districts as against a mismatch in rest 8 districts. Thirdly, comparing the range based on factors of crop output with that of factors of milk output, it was observed that the range matched in 19 districts as against a mismatch in rest 11 districts. Thus, analysing these set of three results, it may be construed that the relatively highest conjunction and association of data does exist between the factors of irrigation and factors of crop output; in comparison to other two sets.

Multiple regression analysis of district wise independent factors *viz.*, factors of irrigation and crop output on the dependent variable milk output; the analysed values are presented in Table 4.

Table 4: Regression coefficients, standard errors and significance level of factors of milk output to the factors of irrigation and crop output in multiple regression analysis

Variables	Coefficients	Standard error	t-value	Significance
Factor of irrigation	**151.727**	**39.890**	**3.804**	**0.000**
Factor of crop value	-0.011	0.070	-0.154	0.874
Intercept constant	-1.098			

Multiple R = 0.812, R square = 0.660,
MSS of Regression = 208.16, MSS of error = 7.940
The multiple regression equation obtained is as follows:
Factor of Milk (y) = -1.098 + 151.727 -0.011 = 150.618
The dependent variable observed R Square value of the multiple equation of 'milk output' to the 'irrigation' is significant and positively associated. The significance of P value for the coefficient of factor of irrigation, one of the independent variables, indicates a strong positive association with the milk output. It clearly revealed that the shift in milk output was significantly affected due to the changes in factor of irrigation.

Using plot level production data from a nation-wide survey in India, Jin *et al*. (2012) reported strong and significant impact of irrigation on agricultural productivity, which is in consonance with the present study. However, Narayanamoorthy *et al.* (2015) reported that both univariate and multivariate regression results showed a declining trend of irrigation coefficient over time, one might not be able to firmly say that the role of irrigation in determining the value of agricultural output had reduced over time, as this could have happened due to acceleration in the productivity of crops cultivated in the rainfed/less irrigated districts. Similarly, Rajan and Shah (2020) reported the impact of irrigation on India's mixed crop-based dairy production system that the rain-fed areas account for 47%of the total value of milk output, whereas area underground water irrigation and surface water irrigation account for 38% and 15%, respectively. Of all the different irrigation modes, groundwater irrigated areas have the most efficient bovine herd for milk production. This has a broad agreement with the present study.

CONCLUSIONS

Verily water is the principal input for triggering development in agriculture and allied sectors. The study was undertaken for the state of Odisha with an overarching goal of reinforcing the apparently obvious fact that water elicits agricultural growth including milk production. The hypothesis that provision of water through the irrigation systems is the prime mover for higher crop production and productivity. In turn, the generation of increased bio-masses including crop residues in a locality do provide an opportune environment for triggering milk production. Though this well-stated fact of organic linkage does appear obvious, but hardly there was any evidence to reaffirm the interdependence of water, crops and milk in a particular locality. An attempt was made by the authors to collect secondary information from two different sources of Government of Odisha publications available on public domain for all 30 districts of the state; firstly, gross area under irrigation (including all sources of irrigation), secondly, on the value of all crops put together in current price and thirdly, on the value of milk in current price and conduct a meta-analysis.

Comparing the positive correlation coefficients between the three factors under study clearly indicated that highest correlation was estimated between factors of irrigation and crop output and the lowest was observed between factors of crop output and milk output. Further, 'matching' of district performances based on rank and range of the districts with respect to the three parameters under study, there was a strong indication in majority of the districts that provision of irrigation water triggered crop outputs and simultaneously served as a pathway for milk output in the district. The multiple regression analyses reinforced these evidences that the regression equation of 'milk output' as a dependent variable to the 'irrigation' as an independent variable is more reliable than the equation of 'milk output' as dependent variable to the 'crop output' as an independent variable. Hence, considering the above empirical evidences, the policy makers and planners need to comprehend the organic linkage between water-crops-milk as an interdependent continuum; however, more precisely water-led crop output and water-led milk output, for ushering in development in a region/ state.

REFERENCES

Alston, J. M., Marra, M.C., Pardey, P. G. and Wyatt, T. J. (2000). Research returns redux: a meta-analysis of the returns to agricultural R&D. *Australian Journal of Agricultural and Resource Economics*, *44*(2), 185-215.

Holmgren, J. and Merkel, A. (2017). Much ado about nothing? - A meta-analysis of the relationship between infrastructure and economic growth. *Research in Transportation Economics, 63*, pp. 13-26

Hussain, I. and Hanjra, M. (2004). "Irrigation and Poverty Alleviation: Review of the Empirical Evidence." *Irrigation and Drainage, 53* (1), 1–15.

Jin, S., Yu, W., Jansen, H. G. P. and Muraoka, R. (2012). The impact of Irrigation on Agricultural Productivity: Evidence from India. Selected Poster prepared for presentation at the *International Association of Agricultural Economists (IAAE) Triennial Conference,* Foz do Iguaçu, Brazil, 18-24 August, 2012.

Lipton, M., Litchfield, J. and Faures, J. M. (2005). The Effects of Irrigation on Poverty: A Framework for Analysis" *Journal of water Policy, 5,* 413-427.

McConnell, William J., and Eric Keys (2005). "Meta-analysis of agricultural change" Seeing the forest and the trees: Human–environment interactions in forest ecosystems pp. 325-353.

Narayanamoorthy, A., Alli, P. and Suresh, R. (2015). Is the Role of Irrigation in Agricultural Output Declining in

India ?: A District-Wise Study at Six Time Points. *Ind. Jn. of Agri. Econ., 70*(3).

Rajan, A. and Shah, T. (2020). Impact of Irrigation on India's Dairy Economy. Agriculture (2020), *10,* 53.

Ringler, C., Rosegrant, M. and Paisner, M. (2000). Irrigation and Water Resources in Latin America and the Caribbean: Challenges and Strategies. EPTD Discussion Paper 64. Washington, D.C. International Food Policy Research Institute (IFPRI).

Rosegrant, M. and Perez, N. (1997). Water Resources Development in Africa: A Review and Synthesis of Issues, Potentials, and Strategies for the Future. EPTD Discussion paper 28. Washington, D.C. International Food Policy Research Institute (IFPRI).

Satish, P. (2007). Rural Infrastructure and Growth: An Overview. *Ind. Journal of Agri. Econ., 62*(1).

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