Impact of Watershed Development Programmes on Crop Productivity: A Decomposition Analysis

Biswajit Mondal[1], Alka Singh[2] and I.Sekar[3]

1. Scientist (Ag. Econ.), Central Soil and water Conservation Research and Training Institute (CSWCRTI), Research Centre, Bellary – 583104 (Karnataka), 2. & 3. Principal Scientist (Ag. Econ.), Division of Agricultural Economics, Indian Agricultural Research Institute (IARI), Pusa, New Delhi – 110 012, India

Corresponding author: bisumondal@rediffmail.com

ABSTRACT

Total change in production and productivity are the two important dimensions of benefits of watershed development programmes along with the conservation of land and water resources. To segregate the impact of various watershed based interventions on crop productivity a study was carried out in Bundelkhand region of Madhya Pradesh. Data were collected from 240 farmers' selected from eight watersheds and eight control villages in the region using a multi-stage random sampling technique. Analysis of data indicates that implementation of watershed development programmes led to significant differences in productivity of major crops in the sampled watersheds. Decomposition analysis of difference in returns from crop enterprises between watersheds and control villages indicates that the contribution of technological component was positive and higher than the contribution of input differentials which signifies that with the existing level of input use in the control areas, the farmers could have increased the returns from crops on implementation of watershed development programmes. This calls for a wider coverage of watershed development programmes in order to bring all the areas under land treatment activities for improving the productivity levels.

Keywords: *Bundelkhand region; Decomposition analysis; Watershed programmes*

India accords high priority to watershed based interventions as a strategy for improving livelihoods and sustainability in drought-prone areas. This goes beyond merely conservation activities in terms of construction of structures and emphasizes importance of human dimensions, strengthening local institutions, income-generating technologies and markets to improve livelihoods (*Kerr et al., 2000* and *Reddy et al., 2004*). Most watershed projects are being implemented with the twin objectives of natural resource conservation and enhancing the livelihoods of the rural poor through enhancement of production levels (S*harma and Scott, 2005*).

Various evaluation studies carried out at different watershed located in different agro-climatic conditions have shown that watershed programmes help to increase agricultural productivity besides conserving natural resources. While there are no disputes about the beneficial impact of watershed projects, one important issue that has not been answered by the researchers that how much portion of this benefit (productivity in question here) is purely due to watershed technology. If watershed technology is an improvement over control areas, then its' effects in terms of gain in productivity should have occurred in two stages. Initially, more output is made available from the existing resource base under the new production technology (in this case watershed technology). This is the efficiency component, reflected in the shift in the production function. Second, an adjustment component of technological change is evident in the movement along the new production function. This movement along the new production function follows from the efforts of the firms to adjust to disequilibrium caused by the new level of efficiency. It is worthwhile, therefore, to decompose the total difference in output into its' causative factors of the differences in the levels of input use and technological efficiency.

Decomposition method was first used in Indian Agriculture by *Bisaliah (1977)* to evaluate the effect of technical change due to introduction of Mexican wheat in Punjab farms. Subsequently, the method was used by several other workers as *Umesh and Bisaliah (1986), Lalwani (1989), Kiresur et al. (1995)* and *Kiresur and Ichangi (2011)* to evaluate the technological gap in crop as well as dairy farming. There is very scanty literature on the use of decomposition analysis to break up the output growth of watershed technology into various causative factors. Hence, it was attempted to ascertain the impact of watershed development programmes on crop productivity and dissociate the changes purely into watershed technology.

METHODOLOGY

Bundelkhand region of Madhya Pradesh state was selected for the present study. Located in a hot and semi-humid region between the Yamuna and Narmada, Bundelkhand region is backward relative to other regions of the state (Inter-Ministerial Central Team Report, 2008). Eight watersheds implemented under different types of government departments (GO) as well as non-governmental organizations (NGO) as project implementing agencies (PIAs) were selected from the region. To make a comparative study, one control village from the contiguous area of each selected watershed where no watershed development activities were carried out, was also chosen. A total of 240 sample households were chosen from the selected villages and survey was conducted during 2010-11 for detailed investigation. The primary data pertaining to the socio-economic characteristics of respondents along with the crop cultivation details were collected by personal interview of the respondents with the help of pre-tested comprehensive schedule particularly designed for the study. In absence of the benchmark data for watershed villages, input-output data from control villages were used as a proxy for the 'old technology' in the decomposition analysis.

Considering the differences in crops and their varieties among the farmers, gross returns and input usages per unit area in monetary terms were used for functional analysis. For accomplishing the task of decomposition analysis, Cobb-Douglas production function has been used as follows:

$Yi = A_i N_i^{ai} S_i^{bi} F_i^{ci} M_i^{di} K_i^{ei} E^{ui}$ ....(1)

Where,

Yi = Gross returns from crop enterprises, in Rs./ha

Ni = Human labour input, in Rs./ha

Si = Value of seed, in Rs./ha

Fi = Value of fertilizer & manures, in Rs./ha

Mi = Machine labour input, in Rs./ha

Ki = Miscellaneous capital expenses, in Rs./ha

Ai = Constant term of scale parameter

ui = Error term with zero mean and finite variance

ai, bi, ci, di, ei = Partial output elasticities of human labour, seed, fertilizer, machine labour & capital expenses, respectively.

Following the above model of production function the same for control areas and watershed areas were specified as below:

$Y_1 = A_1 N_1^{a1} S_1^{b1} F_1^{c1} M_1^{d1} K_1^{e1} e^{u1}$ ....(2)

$Y_2 = A_2 N_2^{a2} S_2^{b2} F_2^{c2} M_2^{d2} K_2^{e2} e^{u2}$ ....(3)

Definitions of variables and parameters in (2) and (3) are the same as in (1).

The decomposition equation following Bisaliah (1977) from the above production function was specified as below.

Log [Y2/Y1] = log [A2/A1] + [(a2-a1) logN1 + (b2-b1) log S1 + (c2-c1) log F1+ (d2-d1) log K1] + [a2log(N2/N1) + b2 log(S2/S1) + c2 log(F2/F1) + d2 log(K2/K1)] + (u2–u1) ....(5)

The decomposition equation (4) involves decomposing the natural logarithm of the ratio of output at watershed to the output at control areas. It is approximately a measure of percentage change in output with the introduction of watershed development programmes. The first bracketed expression on the right hand side is a measure of percentage change in output due to shift in scale parameter (A) of the production function; is attributable to the neutral component of technology. The second bracketed expression, the sum of the arithmetic changes in output elasticities each weighted by the logarithm of that input used, is a measure of change in output due to shifts in slope parameters (output elasticities) of the production function (non-neutral component of technology). The third bracketed term refers to the gap attributable to differences in the input use weighed by the slope coefficients of the productivity function fitted for watershed areas.

RESULTS AND DISCUSSION

Watershed based interventions and their impact on productivity: Different soil and water conservation activities were undertaken in the sampled watersheds as per the needs and priorities of the watershed community and their technical feasibility. Constructions of different types of gully control structures were made and runoff control measures like vegetative hedges were developed to arrest erosion/ stabilize gullies. Creation of water resources potentials was undertaken through construction of water harvesting structures of different sizes and capacities, renovation/ rejuvenation of existing structures and construction of new wells. Other types of structures like percolation tanks, well recharge pit, sunken ponds, etc, were also constructed. Horticultural plantation, afforestation and fodder development activities were also adopted on farmer's fields/ boundaries as well as on non-cultivated land for income generation, wasteland reclamation and fodder production. The cumulative effect of all the above-mentioned land-based interventions was reflected through favourable changes in various bio-physical indicators/ indices like irrigation status, cropping pattern and intensity which ultimately led to increased productivity of almost all the crops grown over the pre-project years (Table 1).

Table 1. Changes in productivity in the sampled watersheds due to watershed based interventions

Crops	Pre-project yield (kg/ha)	Post-project yield (kg/ha)	% change
Rabi crops			
Wheat	885	1447	63.50
Gram	720	932	29.44
Lentil	411	524	27.49
Mustard	448	631	40.85
Linseed	402	476	18.41
Kharif crops			
Soybean	652	918	40.80
Urad	342	395	15.50
Paddy	714	919	28.71
Arhar	499	627	25.65
Sesame	213	353	65.73

Production Response in watershed and control areas and decomposition analysis : All the estimated production functions were significant as evidenced by the significance of F-values at 1 per cent level (Table 2). A perusal of the production function estimates reveals that the coefficients of all the inputs viz., human labour (N), seed (S), fertilizer (F), machine labour (M) and capital expenses (K) were invariably positive for both watershed and control areas, but it was significant for only machine labour and capital expenses. For pooled sample also the same trend was found, with the only exception of seed and fertilizer input exerted negative influence but none of them was significant at any acceptable level of significance. As we know, in the Cobb-Douglas production function, regression coefficients are equivalent to production elasticities, it could be noticed that the production elasticities of all the inputs were invariably less than unity, thus implying diminishing marginal productivity with respect to each of inputs.

Table 3 presents the geometric mean values of various inputs and output on per ha basis in both the areas. It could be seen that the average expenditure on inputs used on the farms at control areas were higher as compared to those at watershed areas, whereas, the gross value of output of watershed farms was much higher than that of the control area's farms.

Table 2: Estimates of production function (per ha)

Variables	Regression coefficients		
	Watershed area (n=108)	Control area (n=109)	Pooled (N=217)
Human labour (N)	0.16 (0.19)	0.07 (0.25)	0.28 (0.18)
Seed (S)	0.15 (0.13)	0.01 (0.20)	-0.07 (0.13)
Fertilizer (F)	0.00 (0.14)	0.14* (0.20)	-0.11 (0.14)
Machine labour (M)	0.32*** (0.11)	0.39** (0.16)	0.40*** (0.11)
Capital (K)	0.25*** (0.08)	0.25** (0.11)	0.32*** (0.08)
Intercept	3.31* (2.67)	(1.89) 3.57*	3.48 (1.86)
R^2	0.31	0.27	0.23
F-value	9.02***	7.58***	12.94***

Figures in parentheses are the standard errors

***, ** and * indicates the coefficient are significant at 10, 5 and 1 per cent probability levels.

Table 3. Geometric mean levels of input and output (Rs./ha)

Input/ Output	Watershed area	Control area	Pooled
Human labour (N)	3034.63	2925.85	2979.74
Seed (S)	2207.75	2325.86	2266.04
Fertilizer (F)	751.51	771.56	761.47
Machine labour (M)	2671.16	2757.46	2713.97
Capital expenses (K)	482.89	451.59	466.98
Output (Y)	19442.82	14288.74	16667.74

The decomposition analysis was used to estimate the contribution of various sources to the productivity difference in terms of gross returns from crop enterprises between watershed beneficiaries and non-beneficiaries in the region and the results are presented in Table 4. The technological and input use differentials between the two areas together contributed to form the total differences of the order of 36 per cent, whereas, the technological component alone accounted for 31 per cent. This implies that with the present level of resource used by the farmers at control areas, returns could be increased by about 32 per cent if watershed programme implemented thereof. In other words, with no additional units of inputs, the existing level of production could be increased to a great extent by the implementation of watershed development programmes.

The contribution of the neutral technological component in the productivity difference was negative (-16.98 per cent) whereas the non-neutral technological component contributed positively (47.49 %) to the total difference in the gross value of output. The positive non-neutral technological component signifies that with the present level of input used in the control areas, the farmers could have increased the returns by 47 per cent on implementation of watershed development programmes provided that the efficiency levels of input use were held constant. The total contribution of differences in the levels of input use to gap in returns accounted for only 1 per cent, indicating that the returns from crops on the farms at control areas could be increased by 1 per cent, if the per hectare input use levels on these farms could be increased to the same level as on the watershed farms.

There was slight discrepancy between the observed

Table 4. Decomposition of differences in returns from crop enterprises between watershed and control areas

Sources of difference	Per cent contribution	
	Sub-total	Total
Total observed difference		36.07
Technical change		30.51
Neutral technological difference	-16.98	
Non-neutral technological difference	47.49	
Due to difference in input use level		1.49
Total estimated difference (due to all sources)		32.00

(36.07 %) and the estimated (32.00%) differences in the returns in watershed and control areas farms. This discrepancy was attributed to the random error term and exclusion of one of the important variables from the model, namely, the management input (Bisaliah, 1977; Umesh and Bisaliah, 1986; Lalwani, 1989 and Kiresur et al., 1995). However, in the present case, since the discrepancy in question was of a very low order the results of this decomposition analysis could be considered to be satisfactory.

CONCLUSION

The analysis revealed that most of the inputs for crop cultivation were used at significantly higher rate in control villages, however, the gross output were significantly higher at watershed villages. The decomposition analysis carried out to dis-aggregate the effect of various factors which caused differences in output between watershed beneficiaries and non-beneficiaries revealed that watershed technology contributed mostly for the variation. The cumulative contribution of differences in the levels of input use to the productivity gap was negligible or even negative for the selected crops. This indicates that with no additional or even with lower inputs, the existing level of production could be increased to a great extent by the implementation of watershed development programmes. This shows the vital contribution of integrated watershed management interventions in mitigating the effects of drought-induced shocks on livelihoods. Therefore, the implementation of watershed development programme needs to be extended to all the un-treated villages for all-round development of people at marginalized areas.

REFERENCES

Bisaliah, S. (1977). Decomposition analysis of output change under new production technology in wheat farming: Some implications to returns on research investment. Indian Journal of Agricultural Economics, 32 (3):193-201.

Inter-Ministerial Central Team (2008). Report on Drought Mitigation Strategy for Bundelkhand Region of Uttar Pradesh and Madhya Pradesh, Government of India.

Kerr, John, Pangare, G., Pangare, V.L. and George, P.J. (2000). An Evaluation of Dryland Watershed Development Projects in India. Environment and Production Technology Division (ETPD) Discussion Paper No.68, International Food Policy Research Institute (IFPRI), Washington. D.C.

Kiresur, V.R. and Ichangi, M. (2011). Socio-economic Impact of Bt Cotton – A Case Study of Karnataka. Agricultural Economics Research Review, 24(1): 67-81.

Kiresur V., Pandey, R.K. and Mruthyunjaya (1995). Technological change in sorghum production: An economic study of Dharwad farms in Karnataka. Indian Journal of Agricultural Economics, 50 (2):185-192.

Lalwani, M. (1989). Technological change in India's dairy farming sector: Distribution and decomposition of output gains. Indian Journal of Agricultural Economics, 44 (1):55-66.

Reddy, V.R., Reddy, G., Galab, S., Soussan, J. and Baginski, S. (2004). Participatory Watershed Development in India: Can it Sustain Rural Livelihoods? Development and Change, 35(2): 297-326.

Sharma, B.R. and Scott, C.A. (2005). Watershed Management Challenges: Introduction and Overview, In: Watershed Management Challenges: Improving Productivity, Resources and Livelihoods. Eds: B.R. Sharma, J.S. Samra, C.A. Scott and S.P. Wani, International Water Management Institute (IWMI) and International Crop Research Institute for Semi-arid Tropics (ICRISAT), Malhotra Publishing House, New Delhi. pp. 245-257.

Umesh, K.B. and Bisaliah, S.(1986). Productivity differential between small and large farms: An econometric study. Asian Economic Review, 28(3):17-33.

• • • • •