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Economic Efficiency of a Community based Irrigation Water Management System in Shivalik Foothills Watershed at Village Mandhala (HP)

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ABSTRACT

During the earlier days, hilly villages used to have their own ponds, which served the community. The ponds were desilted by the community. But over the period of time, bond of the villagers over such common property is getting weak. One old silted up pond in village Mandhala (H.P.) of storage capacity 0.7 ham was renovated under an integrated watershed management project with community participation. The newly created storage capacity of 2.0 ham of the pond now irrigates 10.0 ha of land mostly for wheat crop.

A study was taken to workout production functions of wheat under rainfed and irrigated conditions. A decomposition model was developed to segregate the contribution of project infrastructures and changes in the use of inputs after the project in increasing wheat yield. The two were found as 22.4 and 77.6 percent, respectively.

The value of inputs saved under irrigation system over rainfed system in maintaining the same level of production was also worked out and was found as Rs. 1391/ha.

Key words: *Economic efficiency, Community participation, Shivalik watershed, Irrigation management system.*

INTRODUCTION

The Shivalik foothills in the state of Himachal Pradesh are marked by frequent crop failures due to erratic rainfall, lack of irrigation facilities, serious erosion problem and poor crop productivity.

Much before, during the pre independence period, many of the hilly villages used to maintain ponds on community lands to serve the needs of drinking water as well as water for cattle. These ponds used to be desilted by the community during summers when they became dry. In course of time, the practice of community desilting dwindled. The ponds silted up and became defunct. Such ponds if renovated and their capacity increased can also serve for irrigation, particularly when there is no scope for rainwater harvesting by constructing earthen dams in the watersheds.

The study relates to one such renovated pond in village Mandhala of district Solan (H.P.) which caters to the supplemental irrigation needs of *rabi* crop in the village. The pumping of water, its distribution and management is now being done by the village community.

The paper attempts to present a comparative view of economic efficiency in production of wheat under rainfed condition and under supplemental irrigation after renovation of the village pond at Mandhala. The contribution of watershed management and the specific management inputs is worked out using decomposition model.

METHODS AND MATERIAL

An old silted up pond with submergence area of 0.4 ha in village Mandhala distt. Solan, H.P. was developed under integrated watershed management project with community participation. Desiltation of the pond and raising its embankment height increased its capacity from 0.7 ha m to 2.0 ha m. Problem of leakage of old embankment was tackled by digging up centre of the embankment upto a width of nearly 3.5 m and packing that with a 1 metre thickcore wall of clay soil for a length of 60 m. Plastic sheets were also placed at vulnerable points to check the seepage.

The pond has enabled supplemental irrigation

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to about 10 ha of land, which was earlier used for rainfed farming. Main features of the pond are as follows:-

Catchment area -	4.32 ha
Capacity of the pond -	2.0 ha m
Command area -	10.0 ha
Gravity irrigated -	4.0 ha
Lift irrigated -	6.0 ha

The pond is well equipped with inlet chute structure with facility of runoff gauging through automatic stage level recorder.

To capture the effect of water management in village Mandhala a decomposition model (Thakur and Kumar, 1984) was adopted. The model measured the contribution of better water management at the first stage and contribution of various inputs at the second stage based on a survey on 34 wheat growing farms.

Indirectly estimated cobb Douglas type production functions derived from profit function formulation were used for decomposing the total difference in yields into their constituent factors like management and changes in the level of inputs.

The specifications of crop production functions under i^{th} (rainfed) and j^{th} (supplemental irrigation) conditions used in decomposition analysis were:

$$Y_i = A_i \, X_{1i}^{ai} \, X_{2i}^{bi} \, X_{3i}^{ci} \, X_{4i}^{di} \, X_{5i}^{ei} \qquad \text{..... (1)}$$

and $$Y_j = A_j \, X_{1j}^{aj} \, X_{2j}^{bj} \, X_{3j}^{cj} \, X_{4j}^{dj} \, X_{5j}^{ej} \qquad \text{..... (2)}$$

Where

Y_i and Y_j are quintals per hectare yield of wheat under rainfed and irrigated conditions.

X_{1i} and X_{1j} are seed rates (kg./ha) under rainfed and irrigated conditions

X_{2i} and X_{2j} are urea (kg./ha) applied under rainfed and irrigated conditions

X_{3i} and X_{3j} are N, P, K, fertilizer (kg./ha) applied under rainfed and irrigated conditions

X_{4i} and X_{4j} are FYM (q/ha) applied under rainfed and irrigated conditions

X_{5i} and X_{5j} are human labour (mandays/ha) under rainfed and irrigated conditions

A_i b_i......e_i and a_j, b_j.....e_j are the slope parameters of the production functions under ith and jth conditions, respectively. Corresponding to the production equations (1) and (2) the decomposition can be written as,

$$\begin{aligned} \text{Ln}\,(Yj/Yi) = & [\ln A_j/A_i] + [(a_j-a_i)\ln X_{1i} \\ & + (b_j-b_i)\ln X_{2i} + (c_j - C_i)\ln X_{3i} \\ & + (d_j - d_i)\ln X_{4i} + (e_j - e_i)\ln X_{5i})] \\ & + [(a_j \ln (X_{1j}/X_{1i}) + b_j (X_{2j}/X_{2i}) \\ & + C_j \ln (X_{3j}/X_{3i}) + d_j \ln (X_{4j}/X_{4i}) \\ & + e_j \ln (X_{5j}/X_{5i})] \qquad \text{..... (3)} \end{aligned}$$

Equation (3) brought out the total difference in per hectare wheat yield between farms under irrigated condition (after the project) and rainfed condition (before the project).

The first and second bracketed expressions on the right hand side measure the contribution of irrigation to total change in yield. The third bracketed expression measures the contribution to the changes by quantities of inputs.

The value of inputs saved under irrigation system over rainfed system (SR) *is treated as* benefit of irrigation system and is measured as

SR = {r/100} RA

Where r is the % change in output

RA is the value of input required to produce Y_i under the rainfed system.

RESULTS AND DISCUSSIONS

Farmers in Mandhala used to raise wheat on winter rainfall in absence of irrigation facility. The management inputs used by them were at low level. However, with the availability of pond water subsequent to the project, the farmers started using increased inputs for wheat production. Data on output and input used for production of wheat before and after the project (2004-05) were collected from the farmers.

A high coefficient of determination (0.962) obtained for the production function before the project under rainfed condition, indicated that the included variables explain 96.2 percent of the total variation in yield. Among the input variables, however, only x5 (human labour) contributed significantly to the sum of squares due to regression. This was because the other inputs given by the farmers were low and almost of the same level in absence of irrigation water.

A sum of regression coefficients (standarised) was tested for deviation from unity. The same turned out to be 0.98 (less than unity), indicating decreasing returns to scale.

In case of the production function estimated for the wheat yield under irrigated system, the coefficient of determination was also high at 0.912, with a variability of 91.2 percent. The regression analysis revealed that the model fitted could explain the variation in yields significantly at 5 percent level of significance. On further analysis of input variables it was found that X2 (seed rate) and X3 (urea application) led to significant increase in the yield levels when investigated through 't' test at 5 percent level of significance.

Sum of standarised regression coefficients was found to be '1.005'. This being slightly more than unity indicated increasing returns to scale.

Regressions coefficients, their 't' values, standarised regression coefficients and the coefficients of determination are shown in Table 1.

Production function under the two conditions were obtained as,

$$Y_i = 0.00028 X_{1i}^{-0.117} X_{2i}^{-0.278} X_{3i}^{0.00095} X_{4i}^{0.0090} X_{5i}^{3.106} \quad ..... (4)$$

and

$$Y_j = 0.0000042 X_{1j}^{2.761} X_{2j}^{0.341} X_{3j}^{0.0042} X_{4j}^{(-)0.0033} X_{5j}^{0.126} \quad ..... (5)$$

where all the variables are the same as defined under methods and material.

With the help of equations (4) and (5), the decomposition equation can be written as,

$$\left[l_n \frac{Y_i}{Y_j}\right] = \left[l_n \frac{.0000042}{.00028}\right] + \left[(2.761 + 0.117)) l_n X_{1i}\right]$$

Table 1: Regression Coefficients, t values, standardized regression coefficients and coefficients of determination (Number of sampled farms -34)

Particulars	Constant (A)	Seed (X_1)	Urea (kg/ha) (X_2)	NPK (kg/ha) (X_3)	FYM Fertilizer (kg/ha) (X_4)	Human (q/ha) (X_5)	R^2 Labour (Mandays)
				Rainfed Farms			
'b' values	(-) 8.153	(-) 0.117	(-)0.278	9.552E-04	0.074E-03	3.106	0.96
't' values	8.829	0.460	1.775	.184	1.484	7.238	
Standardized RegressionCoeff.	0.0	(-)0.032	(-) 0.193	0.011	0.101	1.099	
				Irrigated Farms			
'b' values	(-)12.377	2.761	0.341	4.256E-03	(-)3.29E-03	0.126	0.91
't' values	4.849	4.096	2.911	0.424	0.363	0.571	
Standardized RegressionCoeff.	0.0	0.599	0.331	0.035	(-)0.037	0.077	

$+ (0.341+0.278)\, l_n X_{2i} + (0.0042 - 0.00095) l_n X_{3i} + (-0.0033-0.0090)\, l_n X_{4i}$

$+ (0.126-3.106)\, l_n X_{5B} +$

$$\left[2.76 l_n\left(\frac{X_{1j}}{X_{1i}}\right)+0.34 l_n\left(\frac{X_{2j}}{X_{2i}}\right)+0.0042 l_n\left(\frac{X_{3j}}{X_{3i}}\right)-0.0033 l_n\left(\frac{X_{4j}}{X_{4i}}\right)+0.126 l_n\left(\frac{X_{5j}}{X_{5i}}\right)\right] \quad \ldots\ldots (6)$$

The Equation (6) decomposes the total difference in per hectare yield before and after the project. The bracketed expression on the left hand side in (6) is a measure of the percentage change in output after the project.

The first and second bracketed expression on the right hand side measures the contribution of the project benefits resulting in increased yield of wheat. The third bracketed expression measures the contribution of changes in the use of per hectare quantities of inputs after the project.

The value of inputs saved after the project (SR) is treated as benefit of the project and is accounted as,

$$SR = \left(\frac{r}{100}\right) RA$$

Where r = % change in output after the project.

This is obtained by adding the values of the first and the second bracketed expression on the right hand side of the equation (6)

RA = is the value of inputs required to produce the average yield after the project

Average of per hectare use of inputs and output before and after the project is presented in Table 2.

The decomposition analysis revealed the following

i)	Contribution of the project infrastructures in increasing wheat yield.	22.4%
ii)	Contribution of changes in the use of inputs after the project increasing wheat yield	77.6%

On assuming the following rates of inputs and output

Seed	-	Rs. 10/kg
Urea	-	Rs. 240/50kg
DAP	-	Rs. 500/50kg
FYM	-	Rs. 500/30q
Manday	-	Rs. 100/manday
Wheat	-	Rs. 700/q,

SR is calculated as Rs.1391. This shows that the values of input saved under the irrigation system over rainfed farming is Rs. 1391/- per hectare.

CONCLUSIONS

The following conclusions emerge from the study:-

(i) Development of production function of wheat under rainfed condition, before the project brought out that, human labour was the only input variable contributing significantly to the sum of squares due to regression.

(ii) After the Project, under irrigated condition seed rate and application of urea led to significant increase in yield level at 5% significant level.

(iii) Decomposition analysis of the production functions of wheat before and after the project revealed that project infrastructures led to 22.4 percent increase in wheat yield.

Table 2 : Average of per hectare use of inputs and output before and after the project

	Seed (kg/ha)	Urea (kg/ha)	NPK fertilizer (kg/ha)	FYM (q)	Labour (mandays)	Yield (q)
Before	103	64	11	12	46	8.7
After	117	137	91	64	63	21.0

Contribution of change in the use of inputs in increasing wheat yield after the project was found to be 77.6 percent.

(iv) The value of inputs saved under irrigation system over rainfed farming (before the project) for wheat crop was estimated at Rs. 1391/ha.

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