PUBLIC AND PRIVATE IRRIGATION WATER RESOURCE MANAGEMENT: SUGARCANE CROP PRODUCTIVITY AND PROFITABILITY COMPARED

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ABSTRACT

Quantitative analysis of the yields and revenues of crops grown in the two ‘irrigation-&-drainage’ systems, being practiced along publicly-managed Kabul River Canal and privately-managed Joe-Sheikh Canal of river Kabul, was carried out, using dummy-variable econometrics analytic technique. Both differential intercept and differential slopes were included to capture the effects of the two systems mentioned. Results revealed that yields per hectare of wheat and sugarcane were relatively higher and net revenues lower in KRC command areas. However, the effects of yields on net returns were lower than that of the JSC. The results thus suggest that chances of increasing yields and net returns are higher on JSC. Second, the yields of wheat at Mid section and that of sugarcane at Head section of the KRC are lower than on that of the JSC. Hence, scope of increasing yields of wheat and sugarcane are greater at Mid and Head sections of KRC, respectively. Third, the net revenues of the two crops are relatively lower on KRC. The net revenues of wheat are especially lower at Tail and that of sugarcane in Head and Mid areas of KRC. Per kg returns seems to be positively correlated with wheat net revenues in Tail area and with that of sugarcane in Mid areas. Lowering costs of sugarcane in Mid KRC area seems to have also been correlated with higher net revenues. Fourth, the results are limited in scope, and suggest that a further detailed study for the greater understanding of the phenomenon discussed be initiated.

Key Words: Public and Private, Water Management, Sugarcane, Productivity, Profitability

INTRODUCTION

The two canals, Kabul River Canal (KRC) and Joe-Sheikh Canal (JSC), which originate from River Kabul at Warsak, provide a good opportunity for carrying out a comparative study of a publicly run irrigation and drainage system with one managed by private sector (Annexure 1). KRC irrigation system has been in operation since year 1902. Irrigation Department is managing the KRC with the help of salaried staff and a setup of rules and regulations. Water is distributed on the basis of Culturable Command Area (CCA). The scheduling of water deliveries to water channels is on a 24 hours basis, and water delivery to farmer’s fields is managed under Pakwa warabandi. The water allowance on KRC is 0.261 m$^3$/s /404.85 ha.

Joe-Sheikh Canal (JSC) dates back to Moghal Emperor Aurangzeb Alamgir ages, when JSC was dug as an inundation canal by farmers on self-help basis. Presently the Provincial Irrigation Department looks after the technical aspects and water supplies to the main canal, while further internal distribution of irrigation water is managed by farmers according to the Riwaj (customs). Riwaj allows farmers to use canal water up to their entire needs, without paying any water charges (Abiana). However, the share of cost to individual farmer is decided according to the holding and crops grown. The water allowance on JSC is 12.06 cfs per 1000 acres. JSC is 43 km long, with Cultural Command Area (CCA) of 29000 acres, compared to KRC, which is 60 km long, having CCA of 48700 acres.

This paper attempts to make a comparison of the two systems of irrigation water-resource management, being practiced at KRC and JSC commanded lands, in terms of crop production, costs of crop production and the resultant net revenues earned by growers. Sugarcane, being a major commercial crop grown in both canal commanded areas, has been selected for such a comparison.

MATERIALS AND METHODS

After selecting two canals (KRC & JSC) as research sites, interview schedule were used to collect data from a sample of 180 growers. On every canal fifteen watercourses were selected representing equally the head, middle and tail of both canals. In this regard Annexure 1 demonstrates a map showing a detailed scheme of sample selection methodology on KRC and JSC. Of the total 180 sample growers on the two canal systems,
41\% were found cultivating sugarcane crop. Simple budgeting method was employed to arrive at cost of production, total revenues and net revenues for each sugarcane grower. Yields, costs and net returns were then compared across two canals, using the following econometric dummy-variable model, suggested for such types of comparison by Gujarati (2003).

\[ Y = \beta_0 + \beta_1 D + e \]  

Where,
‘D’ represents dummy variable possessing 0 value if JSC and 1 for KRC.

Model given in (1) suggests that if yields Y (or costs C or net returns NR) are regressed on dummies with values 0 and 1, the estimated results of \( \beta_0 \) and \( \beta_1 \) would, respectively, give average values for JSC and magnitude of the values by which KRC lands differ from that of JSC. The negativity or positivity (signs) of \( \beta_1 \) and its statistical significance level would determine whether values related with KRC are less than or higher than that of the JSC.

Growers’ production and net revenues were further compared across the two canals, using detailed production and net revenue functions developed, as follows.

**Production/Yields Function**

The sugarcane growers’ total outputs/supplies (TS) are assumed to be affected by two major categories of factors employed, namely: (a) total area planted and (b) major inputs used, including labour-days employed (L), tractor-hours used (TH) and fertilizer-nutrients applied (N, P, & K). To incorporate the effect of the differences between two management systems, differential intercept dummy (CD) and differential slope dummies (AD, LD, TH, N, PD & KD) have additionally been included.

\[ TS = f(A, AD, L, LD, TH, THD, N, ND, P, PD, K, KD, DC, e) \]  

**Net Revenues Function**

Net revenue (NR) is estimated as the difference between total revenues (TR) and total cost (TC), where the latter two variables TR and TC are estimated as: \( TR = P \times Y \) and \( TC = c \times Y \) (where P = market price of output, c = cost of unit output produced and Y = output per unit area, say production per hectare). Hence, NR appears to be a function of P, c and Y. Accordingly, the sugarcane growers’ net revenues (NR) are determined by total yield (Y) in kilograms per hectare, returns per kg of sugarcane produced (RK) and cost per kg of sugarcane produced (CK). Additionally dummy variable DV was included to capture the effect of sugarcane variety, which is being produced in the study areas for sugar-cuts (Gandheries) and juice extraction and is priced at rates approximately double that of other sugarcane varieties. Effects of the differences of canals on Y, RK and CK are included through respective dummies YD, RKD and CKD, representing KRC’s cases.

\[ NR = f(Y, YD, RK, RKD, CK, CKD, DV, DC, e) \]  

In place of prices, total returns per kg of production (RK = total returns/yield per hectare) were used to incorporate the effect of all returns, including receipts from by-products and useful-wastes. CD was included as differential intercept and RKD, CKD and YD as differential slopes to capture the effects of differences between the two systems of managing irrigation water resources.

**RESULTS AND DISCUSSION**

In order to check the efficiency of the two irrigation resource management systems in practice at JSC and KRC commanded lands, comparison of yields per hectare (Y), cost of sugarcane production (C) and net revenues per hectare (NR) was made using the models specified in (1) through (3).

**Sugarcane Yields**

\[ Y = 59339.875 + 4196.274 \text{ KRC} \]  

\[ C = 33686.761 - 1105.327 \text{ KRC} \]  

\[ NR = 61487.420 - 11313.91 \text{ KRC} \]

The empirical results of the dummy-variable models (4) through (6) reveal that JSC commanded areas, on average, produce 59340 kgs of sugarcane per hectare, while KRC command areas produce 4196 kgs per hectare higher than that of JSC. However, this difference in yield is statistically not very significant; the significance level is \( \alpha = 0.154 \) against the desired level of \( \alpha = 0.05 \).

Contrary to yields, the costs of sugarcane production across JSC and KRC are about similar, while net returns are lower on KRC irrigated areas than JSC. Against the average cost of Rs.33,687 per hectare on JSC, the cost of production on KRC is lower by Rs.1,105 per hectare; the difference, however, is statistically highly insignificant, technically equal to zero. Average net returns on JSC and KRC, respectively, are Rs.61,487 and
Rs.50,174 per hectare; the two net returns differ by Rs.11,313 per hectare and the difference is statistically significant at \( \alpha = 0.136 \).

To further explore the underlying factors responsible for relatively higher sugarcane outputs, same costs and lower net returns on KRC commanded lands, production and net revenue functions were developed, again including the effects of the differences of the two canals, incorporated through dummies. The empirical results obtained and discussions thereon are made in the following paragraphs.

**Sugarcane Net Returns across JSC and KRC**

As per economic theory already explained in (3), net revenues (NR) are assumed to determine by total yield (Y), returns per kg of sugarcane produced (RK) and cost per kg of sugarcane produced (CK). Another dummy variable DV was included to capture the effect of sugarcane variety, which is produced for Gandheries and juice extraction and is sold on rates approximately double that of other sugarcane varieties. Effects of the differences of canals on Y, RK and CK are included through respective dummies YD, RKD and CKD, representing KRC’s cases, along with differential intercept DC. The estimated results are provided, as follows:

\[
\text{NR} = -54582.37 - 11374.767\text{DC} + 2927.347\text{DV} + 0.958\text{Y} - 0.304\text{YD} + 55752.931\text{RK} \\
\quad + 11168.241\text{RKD} - 57264.32\text{CK} - 8828.292\text{CKD} \\
\quad (7.729) \quad (1.536) \quad (1.249) \quad (12.065) \quad (-3.422) \quad (23.245) \quad (5.240) \quad (-11.913) \quad (-1.425)
\]

\[
\text{R}_2^2 = 0.9880 \quad \text{Adjusted-R}_2^2 = 0.987 \quad F = 680.797
\] (7)

**Sugarcane Production/Yields across JSC and KRC**

Total sugarcane outputs/supplies (TS) of growers are regressed on the respective areas planted (A & AD; where A represents area in JSC and AD dummy for KRC) and per hectare labour-days employed (L & LD), tractor-hours used (TH & THD) and fertilizer-nutrients applied (N, P, & K and ND, PD & KD). The empirical results are provided, as follows:

\[
\text{TS} = 5075.264 + 6923.607\text{DC} + 62367.061\text{A} - 20705.50\text{AD} - 11.295\text{L} - 48.154\text{LD} - 157.588\text{TH} \\
\quad + 419.761\text{THD} - 345.763\text{N} + 2199.813\text{ND} + 262.344\text{P} - 2790.155\text{PD} \\
\quad - 779.835\text{K} - 434.267\text{KD} - 44.491\text{IR} + 143.094\text{IRD} \\
\quad (0.442) \quad (0.478) \quad (27.927) \quad (-4.993) \quad (-0.288) \quad (-0.799) \quad (-0.660) \quad (1.073) \quad (-0.224) \quad (1.094) \quad (0.101) \quad (-0.778) \quad (-0.554) \quad (-0.204) \quad (-0.174) \quad (0.337)
\]

\[
\text{R}_2^2 = 0.9610 \quad \text{Adjusted-R}_2^2 = 0.951 \quad F = 95.719
\] (8)

(Note: Fertilizers/Farm Yard Manure (FYM) have been converted to their nutrients-equivalents, using the following conversion rates: Urea x 0.46 = N; DAP x 0.18 = N; DAP x 0.46 = P; FYM x 0.25 = N; FYM x 0.50 = P; FYM x 0.25 = k; Source: GoP (1997). Fertilizer Recommendations in Pakistan, Planning and Development Division, Islamabad.)

**Interpretations of Estimated Models**

The empirical results contained in the estimated models (4) through (8) reveal several important points for further consideration. First, yields per hectares are relatively higher at KRC commanded lands (Eq.4), but these higher yields do not contribute to the net revenues (Eq.7); rather, their effect on net revenues appears to have been negative and statistically significant (t = -3.422, \( \alpha = 0.001 \)). On contrary, yields contribute positively and effectively towards net revenues on JSC lands.

Second, the estimated model (8) reveals that sugarcane growers’ total production/supplies mainly depend on size of areas planted in both JSC and KRC cases. The areas (A & AD) planted are the only two statistically significant explanatory variables; all other explanatory variables carry insignificant coefficients. After taking out the effects of areas planted, there remains variations in dependent variable (TS) related to the yields per hectare, which seem to have been hardly explained by the variations in the so-called yield-affecting explanatory variables like labour-days, tractor-hours, fertilizers nutrients (N, P & K) applied and numbers of irrigation (IR), again in both JSC and KRC cases. Question ‘whether the required inputs are working or not’ needs further investigation.

Third, in spite of the fact that all yield-affecting variables are statistically insignificant, the directions of their effects are clear from the signs (+ or -) attached with the respective coefficients. The signs indicate that labour-days employed are negatively correlated with yields per hectare at both JSC and KRC; however, negative effect of labour is higher at KRC relative to JSC. The tractor-hours are negatively associated with yields at JSC
and positively at KRC. Of the fertilizer-nutrients applied, nitrogenous (N) fertilizers are negatively correlated with yields at JSC and positively at KRC; while the opposite is true for phosphatic (P) fertilizers; photashic (K) fertilizers are negatively attached with yields at both JSC and KRC lands. Numbers of irrigation (IR) are negatively associated with yields in JSC and positively in KRC areas.

Fourth, to investigate whether the above stated differential impacts and opposite-directional effects of major inputs are due to their improper and mismanaged use, calculated the mean values and differential usage of such major inputs and report the same in a comparative form, as follows.

<table>
<thead>
<tr>
<th>Mean Overall Usage</th>
<th>Mean JSC Lands Usage</th>
<th>Differential Usage JSC &amp; KRC</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour-Days (days/hectare)</td>
<td>105.53</td>
<td>89.19</td>
<td>31.82</td>
</tr>
<tr>
<td>Tractor-Hours (Hours/hectare)</td>
<td>16.08</td>
<td>17.04</td>
<td>-1.87</td>
</tr>
<tr>
<td>N-fertilizer (nutrients kg/hectare)</td>
<td>292.06</td>
<td>280.49</td>
<td>22.53</td>
</tr>
<tr>
<td>P-fertilizer (nutrients kg/hectare)</td>
<td>116.96</td>
<td>134.85</td>
<td>-34.84</td>
</tr>
<tr>
<td>K-fertilizer (nutrients kg/hectare)*</td>
<td>150.13</td>
<td>166.94</td>
<td>-32.73</td>
</tr>
<tr>
<td>Number of Irrigation (No./ha)*</td>
<td>20.34</td>
<td>24.92</td>
<td>-8.92</td>
</tr>
</tbody>
</table>

* Differential usage and related statistics have been calculated, using dummy-variable model given in (1).
* Major sources of K-nutrients’ supply are Farm Yard Manures (FYM); chemical K-fertilizers are rarely used.
* No. of time a field is irrigated: is a proxy for the quantity of water applied.

\[
R^2 = 0.9610 \quad \text{Adjusted-}R^2 = 0.951 \quad F = 88.78 \quad (9)
\]

The estimated model (8) was reproduced in (9) by incorporating the effect of sugarcane variety again reveals that sugarcane growers’ total production/supplies mainly depend on size of areas planted in both JSC and KRC cases. The areas (A & AD) planted are the only two statistically significant explanatory variables; all other explanatory variables carry insignificant coefficients.
CONCLUSION AND RECOMMENDATIONS

Results reveal that yields (Y) contribute positively to net revenues on JSC and negatively on KRC, and the effects are highly statistically significant. The empirical results of the comparative analysis of the two ‘irrigation-&-drainage’ systems being practiced along publicly-managed KRC and privately-managed JSC canals of river Kabul help us to arrive at some very interesting and thought-provoking conclusions.

First, the yields per hectare of wheat and sugarcane crops appear relatively higher on KRC commanded lands; however, the effects of yields on net returns are lower than that of the JSC. The results thus suggest that chances of increasing yields and net returns are higher on JSC. Second, the yields of sugarcane are lower at Head section of the KRC. Hence, scope of increasing yields is greater at Head sections of KRC. Third, the net revenue is relatively lower in Head and Mid areas of KRC. Per kg returns seems to be positively correlated with that of sugarcane in Mid areas. Lowering costs of sugarcane in Mid KRC area seems to have also been correlated with higher net revenues. Fourth, the results are limited in scope; these do not provide enough insight to analyze why the KRC commanded lands have not been able to yield higher net revenues while they have been producing higher yields of both crops – wheat & sugarcane. Further research aiming at to investigate in to the costs involved as well as the position of water availability and the water-logging and salinity situation in the two canal systems would help analyze the situation. This conclusion warrants recommending a further detailed study for the greater understanding of the phenomenon discussed.

REFERENCES


