ECONOMIC IMPACTS OF WASTEWATER IRRIGATION IN PUNJAB, PAKISTAN

Irfan Ahmad Baig*, Muhammad Ashfaq**, Ishtiaq Hassan***, Muhammad Ishaq Javed****, Wasif Khurshid***** and Asghar Ali******

ABSTRACT

Wastewater use has been in practice in many peri-urban areas of Pakistan. Farmers in these areas are owners of small land holdings and wastewater is available to them usually on very cheap rates or even free of cost. Due to the absence of any other cheap and reliable source of water, farmers generally rely on wastewater. But at the same time many negative externalities are also attached with this practice. Due to the contaminations and hazardous material, wastewater not only affects the soil texture and its fertility but also has bad impacts on human health. In a study conducted in the Department of Agricultural Economics, University of Agriculture, Faisalabad, Pakistan during 2009, an analysis of two situations i.e. wastewater use area and fresh water use area was carried out by using multiple economic criteria. The data on production cost and output value for four major crops i.e. wheat, berseem, sorghum and maize were collected from Chak No. 570/ JB as wastewater use area and Chak No. 219/ RB as fresh water use area. The results revealed that wastewater use has higher benefit-cost ratio in study area irrespective of the negative externalities like health risk, associated with it. Net benefit from crop production per rupee invested for wastewater irrigation returned Rs. 5.56 on an average as compared to Rs. 2.20 for fresh water irrigation. But average days of illness in wastewater area were 11.44 days per person per annum as compared to 8.04 days in fresh water area.

KEYWORDS: Wastewater; fresh water; irrigation; cost benefit analysis; Punjab; Pakistan.

INTRODUCTION

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Urban wastewater has been in use since long for crops cultivation. However, it has captured the attention of researchers and policy makers due to increasing scarcity of fresh water resources in many arid and semi-arid regions. Increasing wastewater volumes, driven by rapid urbanization, made it a low-cost alternative to conventional irrigation water. Moreover, high salinity of groundwater, and nutrient value of wastewater has increased the importance of this alleviation. Another reason might be the proximity of urban markets and the reliability of wastewater, which, unlike regular irrigation water, is not subjected to rotational schedule communities (1).

Kauser (3) has estimated that, about one-tenth of the world’s population takes food produced from wastewater. He further states that as population continues to grow, more freshwater is diverted to cities for domestic use of 70 percent returns as wastewater. So the use of wastewater is certain to increase, both in terms of areas irrigated, and wastewater volumes applied.

Wastewater can be categorized as under:-

- Domestic effluent consisting of blackwater (excreta, urine and associated sludge) and greywater (kitchen and bathroom wastewater).
- Water from commercial establishments and institutions, including hospitals.
- Industrial effluent.
- Storm water and other urban runoff.

According to an earlier study (7) the actual proportion of each constituent within any given urban population will vary due to spatial and temporal differences. It is difficult to segregate and keep the wastewater from each source separate because wastewater (especially in under developing countries) is mixing up from different sources. At final destination it will be a mixture of water from different sources and with different pollutants.

A rapidly growing population, saline groundwater, a poorly performing irrigation distribution system and recurrent droughts have led to increase water shortages. Under these conditions, use of untreated urban wastewater for agriculture has become a common and widespread practice, specifically in vegetable production. In almost all towns in Pakistan having a sewage system, wastewater is directly used for irrigation. A nationwide survey made by International Water Management Institute (IWMI), Lahore, Pakistan indicates that in Pakistan 32,500 hectares are directly irrigated with wastewater i.e. 26 percent of vegetables are being produced from wastewater. A negligible proportion of this wastewater is treated and no clear
Economic impacts of wastewater irrigation in Punjab

regulations exist for classification of crops that can be irrigated with wastewater. Vegetables are commonly irrigated by sewerage water and grown in peri urban areas because these fetch high prices in nearby urban markets (1). Further, vegetables are perishable and are grown near big cities from where these can be supplied to the market centers in a short duration. The wastewater from sewage and industry is easily available for vegetable production grown near the city centers. However, wastewater irrigation potentially bears risks that may weaken the human, natural, and social assets of the farmers and their families, making them more vulnerable to external shocks. Apart from the direct risk to health, water polluted with industrial effluents may also pollute soil and groundwater, thereby undermining the long-term sustainability of the natural resource base. An analysis of risks would help understand the actual trade-offs on the sustainability of livelihoods of urban irrigators and their families: Do the benefits outweigh the risks and negative impacts of wastewater irrigation? This is the question that needs to be addressed by conducting an economic analysis.

Whatever the benefits may be for the irrigators, policy makers must safeguard the wider public interest. Although irrigation with untreated wastewater contributes substantially to the availability of fresh vegetables, and under controlled circumstances may be environmentally acceptable and a beneficial means of waste disposal but uncontrolled wastewater irrigation can lead to both chronic illnesses and more serious outbreaks of diseases amongst irrigators and consumers. Irrigation of agricultural land with wastewater will not only increase crop production, but also will cause heavy metal concentrations and infection of farmers with pathogens (5). Policy managers and others workers in this field need clear guidance on the levels of risks associated with use of untreated wastewater if they are to assess the trade-offs that exist between costs and benefits. Some types of wastewater irrigation are probably unsustainable and may be regarded as unacceptable by most of the communities when given information. However, in the absence of guidelines specifically aimed at managing untreated wastewater irrigation, it is difficult to make informed judgments about the costs, benefits, and trade-offs, associated with different practices.

The use of wastewater for agriculture purposes in district Faisalabad is common. At least nine different sites could be identified, varying in size from a few hectares to almost 1,000 hectares (1). Common crops grown at these sites include fodder, wheat, cotton and vegetables (cauliflower, spinach and aubergine). Few of these sites have been receiving wastewater for the last 30 years.

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The present study was conducted to evaluate clean water and untreated or partially treated wastewater use in different crops production while farmers are unaware of its consequences on their health and negative impacts on soil fertility. The conventional cost-benefit analysis can discourage to invest scarce resources in wastewater treatment but economic value of potential negative effects of wastewater irrigation is expected to be very high which has been totally ignored in the analysis. Therefore, in social cost-benefit analysis these missing economic values of damages (or risks) need to be incorporated.

**MATERIALS AND METHODS**

This study was conducted in the Department of Agricultural Economics, University of Agriculture, Faisalabad during 2009. Following two types of analysis were employed to compare the benefits and costs associated with wastewater use in study area:-

(a) Comparison of performance indicators  
(b) Benefit-cost analysis associated with wastewater use

As the data were collected from two locations i.e Chak No. 219/RB and Chak No. 570/JB (Faisalabad) for one time period i.e. 2009, ‘With and without’ approach for comparison of two situations was used. Chak No. 219/RB was taken as the area that was characterized with the use of wastewater while Chak No. 570/JB with more or less similar agro-climatic conditions of Chak No. 219/RB was included as the area without wastewater (fresh water use area). The data on production cost and output value for major crops i.e. berseem, maize, wheat and sorghum were collected from both these areas. ‘With and without’ approach was used to compare the impact of any particular event or factor in many studies such as Farley (2) and Samad and Dingle (4). Total number of respondents were 125, including 72 farmers and 53 non-farmers.

**Comparison of performance indicators**

A popular method of comparing two systems is the comparison of various indicators. Since wastewater is being used in the agriculture sector, comparison of agricultural characteristics was made using well established indicators according to previous workers (2). Following indications were compared:-

1. Comparison of agricultural inputs used and its cost

*J. Agric. Res., 2011, 49(2)*
2. Comparison of gross value product (GVP) and gross margin (GM)
3. Comparison of days of illness and expenditures on health
4. Comparison of sources of irrigation

In addition to above comparisons, land holdings, source of irrigation and off-farm income status were also compared to evaluate socio-economic status of the farmers. Analysis was carried out on the data collected for four major crops i.e. wheat, berseem, sorghum and maize.

**Comparison of production cost including irrigation and fertilizer cost**

Cost of production of four major crops was compared to see the difference in pattern of input use in the areas using wastewater and fresh water. Average cost of production was calculated for all variable cost items including cost of seed, fertilizer, irrigation, mechanized operations and chemicals. Cost of labour was not included as majority of the farmers were using family labour in the area and only few were using the hired labour. Fixed costs and opportunity costs were also not included in the cost items. All costs were calculated in Rupees per hectare of the area under major crops. Average cost was calculated for valid cases only.

**Comparison of days of illness and health expenditure**

To know the extent of externalities attached with the use of wastewater, a comparison of average illness days per person and average health expenditure per person was made. Expenditure on health includes cost of medication, cost of consultation and other costs attached with treatment such as transportation, etc.

**Comparison of gross value product (GVP)**

GVP of each crop was calculated for each farm and then average GVP for both areas using fresh water and wastewater, was obtained. Comparison was made between two areas using average GVP per hectare of major crops. Average prices prevailing in the specific area was used to calculate GVP.

\[
GVP = \text{Yield} \times \text{price}
\]

Since the input requirement and output produced of all four crops was different from each other, these were dealt with separately. Comparison of overall average GVP was also made between two areas. Average GVP per hectare of the crop area was calculated for valid cases only.

**Comparison of gross margins (GM)**
Gross margins of four major crops were also estimated and compared between the two areas. Gross margins were obtained by deducting direct costs of production from the GVP.

RESULTS AND DISCUSSION

Input use and cost

Overall cost of production was relatively higher in rabi as compared to kharif season (Table 1.). The main contributors towards the cost of production were irrigation, machinery and labour in both seasons. It was analyzed that cost of seed for fresh water use area was about 3 times less (Rs.765/ha) than wastewater use area in kharif season (Rs.2525/ha) while about 45 percent lower in rabi season (Rs.1150 and Rs.1608/ha). The high cost is due to low germination of seed in the wastewater use areas, which compelled farmers to use more seed rate. Comparison of fertilizer cost showed that for fresh water use area, it was four times higher (Rs. 2355/ha) as compared to the wastewater user area in kharif season (Rs.573/ha) while about 5 times more in rabi season (Table 1). Irrigation cost was about four times more in fresh water user area in both seasons due to the use of underground water to supplement the surface irrigation. Overall machinery cost was relatively similar in both seasons but significant difference existed within kharif season for two strata that is cost of machinery is about 77 percent higher in wastewater user area (Rs.1654/ha) than fresh water user area (Rs.940/ha). This could be due to hardness of soils because of continuous use of wastewater.

Table 1. Comparison of inputs use in both seasons

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Winter season (rabi)</th>
<th>Summer season (kharif)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wastewater area</td>
<td>Fresh water area</td>
</tr>
<tr>
<td></td>
<td>Cost/ha (Rs.) Valid No.*</td>
<td>Cost/ha (Rs.) Valid No.*</td>
</tr>
<tr>
<td>Seed</td>
<td>1608 29</td>
<td>1150 20</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>573 21</td>
<td>3364 32</td>
</tr>
<tr>
<td>Irrigation</td>
<td>2154 32</td>
<td>9771 32</td>
</tr>
<tr>
<td>Machinery</td>
<td>1354 28</td>
<td>1457 23</td>
</tr>
<tr>
<td>Chemicals</td>
<td>159 25</td>
<td>251 22</td>
</tr>
</tbody>
</table>

J. Agric. Res., 2011, 49(2)
Chemical cost in fresh water use area was higher during both seasons i.e. Rs. 313 in kharif and Rs. 251 in rabi. However, it was not a significant part of total cost of inputs. Labour cost was not included in the comparison of cost of production because majority of the farmers used family labour and a few farmers used hired labour.

**Health expenditure**

Health expenditure includes all spendings on the treatment and prevention of diseases made by respondents in one year. The data (Table 2) showed the heterogeneous pattern of spending on health made by four different groups in a year. The average per capita health expenditure for the study area was Rs.3848. In case of wastewater use areas per person health expenditure was Rs.4178 as compared to fresh water used areas where it was Rs 3537. The expenditure on health was 18 percent more in case of respondents living in wastewater use areas.

Table 2. Average annual health expenditures (Rs.).

<table>
<thead>
<tr>
<th></th>
<th>Rs. /family</th>
<th>Valid No.</th>
<th>Per capita expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>27585</td>
<td>35</td>
<td>3848</td>
</tr>
<tr>
<td>Wastewater users</td>
<td>31436</td>
<td>18</td>
<td>4178</td>
</tr>
<tr>
<td>Fresh water users</td>
<td>23508</td>
<td>17</td>
<td>3537</td>
</tr>
<tr>
<td>Farmers</td>
<td>36493</td>
<td>24</td>
<td>4883</td>
</tr>
<tr>
<td>Non-Farmers</td>
<td>11468</td>
<td>11</td>
<td>1590</td>
</tr>
</tbody>
</table>

While comparing farmers and non-farmers categories, more expenditure can clearly be seen in case of farmer’s category (Rs.4883). Farmers had comparatively high income so they had higher expenditure towards health and their days of illness were less than that of non-farmers. The incidence of occurring of diseases also varied among groups.

**Days of illness**

Days of illness indicator describes the number of days lost by the family members due to health problems from their income earning jobs. Overall 75 days were lost due to illness in all families and about 10 days lost from work due to illness for every person (Table 3).

Table 3. Average days of illness.

<table>
<thead>
<tr>
<th>Avg. No. of illness days/family</th>
<th>Valid No.</th>
<th>Avg. No. of illness days/person</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>
Higher number of days were lost due to illness by wastewater users (82) and lowest by fresh water user area (69) (Table 3). Wastewater users had more incidents of diseases with longer period that could be attributed to unhygienic conditions of the area and contaminated drinking water.

Irrigation

The results revealed that ground water was about five times more costly than the wastewater but there were many negative externalities associated with wastewater use. Wastewater was a main source of land degradation and low productivity. It was estimated that 46 percent of the farmers irrigate their fields through wastewater. Conjunctive use of canal water and ground water was second mostly used source of irrigation (41%) (Table 4). A small portion of farmers (10 %) rely completely on canal water for irrigating their farms. Only 3 percent farmers were using tubewell water as a sole source of irrigation.

Table 4. Source of irrigation.

<table>
<thead>
<tr>
<th>Sources</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater</td>
<td>33</td>
<td>46</td>
</tr>
<tr>
<td>Canal water (CW)</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Conjunctive (CW+GW)</td>
<td>30</td>
<td>41</td>
</tr>
<tr>
<td>Ground water (GW)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>72</td>
<td>100</td>
</tr>
</tbody>
</table>

GVP and GM of major crops of area

Comparing the cost of production and output value, it has been concluded that although continuous use of wastewater in the area has resulted in degradation of soil quality, yet net benefits of per unit cash input are high for wastewater use areas, due to low cost of production.

While comparing cost of production, in fresh water use area, it was about 260 percent more than wastewater use area but in case of GVP per hectare fresh water use area get 27 percent higher returns (Rs.49635/ha) than the
Economic impacts of wastewater irrigation in Punjab

wastewater user (Rs.39034/ha) (Table 5). The overall gross margins per hectare in fresh water use area and wastewater use area were almost the same but net benefits per unit of total cash cost in wastewater use area (Rs.5.56) is about 250 percent higher than fresh water use area (Rs.2.20).

Table 5. Comparison of GVP and GM in both area.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Total area (ha)</th>
<th>GVP/ha (Rs)</th>
<th>GM (Rs)</th>
<th>Net benefit/unit of cash input</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wastewater area</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berseem</td>
<td>12.14</td>
<td>32164</td>
<td>22857</td>
<td>2.45</td>
</tr>
<tr>
<td>Wheat</td>
<td>29.75</td>
<td>34817</td>
<td>32325</td>
<td>12.97</td>
</tr>
<tr>
<td>Maize</td>
<td>5.32</td>
<td>13800</td>
<td>9320</td>
<td>2.08</td>
</tr>
<tr>
<td>Sorghum</td>
<td>13.86</td>
<td>18532</td>
<td>14434</td>
<td>3.52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>61.0</td>
<td>39034</td>
<td>33084</td>
<td>5.56</td>
</tr>
<tr>
<td><strong>Fresh water area</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berseem</td>
<td>7.34</td>
<td>30509</td>
<td>5970</td>
<td>0.24</td>
</tr>
<tr>
<td>Wheat</td>
<td>24.69</td>
<td>43556</td>
<td>36448</td>
<td>5.12</td>
</tr>
<tr>
<td>Maize</td>
<td>9.41</td>
<td>29353</td>
<td>20644</td>
<td>2.33</td>
</tr>
<tr>
<td>Sorghum</td>
<td>13.99</td>
<td>15104</td>
<td>6606</td>
<td>0.77</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>55.4</td>
<td>49635</td>
<td>34152</td>
<td>2.20</td>
</tr>
</tbody>
</table>

All averages were calculated as weighted except the total area.

Higher costs in fresh water use area were due to greater fertilizer use and expensive irrigation water. It was estimated that fertilizer cost for fresh water use area was about 470 percent more as compared to wastewater use area while irrigation water cost is about 250 percent more in fresh water use area compared to wastewater use area. Higher net benefits per unit of cost (Rs.12.99) was for wheat crop grown in wastewater use area as compared to fresh water use area (Rs.5.42) (Table 5). Lowest value for net benefits per unit of cost was for berseem crop grown in fresh water use area (Rs.0.24).

**CONCLUSION**

1. Overall cost of production was relatively higher in rabi as compared to kharif season. Cost of production in fresh water area was higher for all items except the seed cost which was higher in wastewater area in both seasons. Comparing the cost of production and output value, it was observed that net benefits of per unit cash inputs is high for wastewater use area.

2. The average per capita health expenditure for the study area was Rs. 3848. In case of wastewater use areas per person health expenditure was higher (Rs. 4178) as compared to fresh water used areas (Rs.3537) due to higher number of days of illness.

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3. Wastewater irrigation is cheaper than fresh water. It was found that
ground water was about five times more costly than the wastewater. It
was also estimated that 46 percent of farmers irrigate their fields through
wastewater.
4. GVP per hectare for fresh water use was 27 percent higher than
wastewater use area. The overall gross margins per hectare in fresh
water user area and wastewater user area were almost same but net
benefits per unit of cash cost for wastewater use area is higher than fresh
water use area.

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