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Impact of Water Quality on Agriculture – A Case Study of Bhima River, Karnataka, India

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ABSTRACT

A growing world population, unrelenting urbanization and increasing developmental activities have accelerated the demand for water. While the global water supply is fixed, the multisectoral demand for water has been growing over the years. Various water sources across globe like rivers, ponds, lakes and streams and wells are polluted due to anthropogenic factors. Poor quality of water adversely affects agriculture production, livestock and human health which, in turn, negatively affect agrarian economy. Health of Indian river is severely affected due to pollution from different sources and in some cases rivers have lost their genuine natural characteristics. The present study was conducted in Indi taluk of Bijapur district in Karnataka, with an objective to analyze the economic impact of river water quality on agriculture. The results revealed that river water is not suitable for irrigation in the study seasons. Decomposition model showed that in sugarcane crop the contribution of water pollution towards yield difference was 0.88 per cent. Average yield difference between polluted and non polluted villages was 3.43 tonnes/ha of worth Rs.6177.6. Average per annum veterinary expenses by the household was Rs.1710, in polluted villages which was more by 34.33 per cent compared to that in non polluted village. Hence, Government should initiate urgent effective measures to control or regulate pollution and organize awareness programmes regarding health risks by use of polluted water.

Key words: *Agriculture, Livestock, Pollution, Water quality, Health*

INTRODUCTION

Water is one of the most important resources on earth. All plants and animals must have water to survive. If there was no water there would be no life on earth. Freshwater is literally the lifeblood of agriculture. Globally agriculture uses approximately 70 per cent of the freshwater and contributes to economic growth. With growing demand for water, agriculture sector is facing twin challenges of quantity and quality of water available for agriculture production. The quality of fresh water available for agriculture is a fixed against the growing demands.

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But, with deterioration in water quality, the net availability of good quality of water for agriculture would relatively be declining. Quality of water used for various agricultural purposes not only limits agricultural production but also poses health hazards for human beings and animals. The effect of water pollution on agricultural production could include decline in product quantity and quality. Crops that have higher pollution level compared to the standard of allowable pollution levels and deterioration of agro-ecological environments like soil pollution of farmland, destruction of soil structure and groups of soil microorganisms[5]. Poor quality irrigation water can adversely affect agricultural production, which, in turn, negatively affect agrarian economy and retard improvement in living conditions of rural people[10].

According to the Water (Prevention & Control of Pollution) Act, 1974, pollution of water is defined as "Contamination of water or such alteration of the physical, chemical or biological water or such discharge of any other liquid, gaseous or solid substance into water (whether directly to indirectly) as may or is likely to create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses or to the life and health of animals or plants or of aquatic organisms".

A few studies have dealt with impact of water pollution on agriculture. Ahmad *et al*[3]. studied effect of sewage water on spinach yield in Rahim Yar Khan District, Pakistan and reported that although sewage water application increased production of leafy vegetables in the short run its continuous use badly impacted soil productivity. Paul and Nelliyat[7]. made a fish diversity study in Noyyal river of Tamil Nadu (India) and reported that the Tiruppur stretch of the river did not support any fish species due to the discharge of industrial effluents. Pullaiah[8]. studied Musi river pollution in Hyderabad (India) and reported its impact on health and economic conditions of downstream villages. Study reported that many cattle died due to pollution and the milk production was also significantly affected. Poor water quality negatively affects crop yields and production, soil health, fish population, quality of farm produce. It also adversely affects health of human beings and livestock. Thus, livelihood of farmers in negatively affected by reduced incomes and employment and increased undesirable expenditure like medical expenses. The present study, therefore, focuses on agro economic aspects of impact of river water pollution on agriculture. The objective of the study is to study the economic impact of river water quality on agriculture and livestock.

MATERIAL AND METHODS

The study was taken up in Bhima river basin which is one of the important river basins of Karnataksa. Bhima is tributary of Krishna river in South India. Its banks are densely populated and form a fertile agricultural area. Bhima flows southeast for long journey of 861 km during which many smaller rivers flow into it. Kundali, Kumandala, Ghod, Bhama, Indrayani, Mula, Mutha and Pavna are the major tributories of this river. Bhima merges into the Krishna along the border between states of Karnataka and Andhra Pradesh. Bhima River basin was purposively selected for the study in view of emerging complaints from farmers and social activists around the region regarding problems of pollution in Bhima River.

According to quality analysis done by the Karnataka State Pollution Control Board (KSPCB) in 23 rivers across the State, water from only two rivers namely the Nethravathi and Kumaradhara could be consumed with disinfection and without conventional treatment. The water in the rivers was tested for their PH value, biochemical oxygen demand, free ammonia, sodium absorption ratio, boron, dissolved oxygen, total coliforms and conductivity. The rivers were classified into A, B, C, D and E categories, based on their quality in accordance with criteria specified by Central Pollution Control Board (CPCB). The results of water quality tests of river Bhima in four locations revealed that, on average, the River fell under category C, which means the water could be only be drunk with conventional treatment followed by disinfection.

To assess the effects of water quality, the study area was divided into two clusters namely, polluted villages and non polluted villages, based on the extent of effects of river water quality. A sample of five villages on the banks of river and another five villages away from the river but with similar agro economic conditions was selected. In the next stage, using stratified random sampling method, twelve farmers from each village belonging to different farm size categories namely, large farmer (> 5 acres), medium farmer (3–5 acres), small farmer (2–3 acres)[9], and landless labourers in equal numbers were selected for data collection. Data needed for the study were collected from respondents by personal interview method using pre-tested schedule. A total of 120 sample farmers consisting of 60 from each cluster were chosen. To estimate the economic impact of river water pollution on agriculture and livestock detailed household level information regarding farming practices, crop production, yield levels, livestock, disease or other health problems of people was collected.To estimate irrigation water quality, water samples were collected from two polluted and two non polluted villages and tested for electrical conductivity (EC). Water samples were collected twice, once in pre-mansoon and second in post mansoon seasons.

Analytical tools and techniques employed

To fulfill specific objectives of the study, tabular analysis and decomposition model were used.

Decomposition Model

Production function approach

Most of the farm studies have established that Indian agriculture would approximate the Cobb-Douglas type of production function[4]. Further, constant returns to scale is empirical evidence widely observed in studies on Indian agriculture. Both these were assumed for the present study and hence the per hectare production function in the Cobb-Douglas form was specified. It was aimed to decompose the change in productivity of a principal crop (sugarcane) between water polluted villages and water non polluted villages into the impact due to polluted water used for irrigation and that due to change in use of inputs. The Cobb-Douglas form of production function was used for yield in water polluted villages and water non polluted villages. Sugarcane was chosen for the study as it was a pre-dominant commercial crop in the region in terms of acreage. Specifications of the model are as follows;

For non polluted villages

$$Y1 = a1\, X11^{b11} X12^{b12} \ldots\ldots\ldots\ldots\ldots\ldots X1n^{b1n} e \qquad (1)$$

For polluted villages

$$Y2 = a2\, X21^{b21} X22^{b22} \ldots\ldots\ldots\ldots\ldots\ldots X2n^{b2n} e \qquad (2)$$

Where,

Y1 = Gross output obtained in non polluted villages

Y2 = Gross output obtained on polluted villages

(quintal)

X3 = Human labour (man days)

X4 = Bullock labour (pair days)

X5 = Plant protection chemicals (Rs. /ha)

X6 = No. of irrigations

a1 and a2 are the intercept of non polluted and polluted villages, respectively

X1n = Independent variables in non polluted villages

X2n = Independent variables in polluted villages

For sugarcane the independent variables included,

X1 = Seeds (quintal)

X2 = Organic manure

bi = output elasticity co-efficient of i^{th} input

Taking logarithm on both sides for equations 1, and 2, ln Y1 = lna1+ b11lnX11+b12 lnX12 ………………. + b1n ln X1n _________ (3)

In Y2 = lna2+b21lnX21+b22 lnX22 ………………. + b2n ln X2n _________ (4)

Decomposition model

To identify the structural break in the production relations that defined the yield levels in water polluted villages and water non polluted villages, a dummy variable with 1 for water polluted villages and zero for water non polluted villages was introduced in the production function of Cobb-Douglas setting. The decomposition model for polluted V/s non polluted water was obtained by taking difference between equation (3) and (4).

(lnY2 – ln Y1) = (lna2 – lna1) + {(b21 lnX21 – b11 lnX11) + (b22 lnX22 – b12 lnX12) +……………+ (b2nlnX2n –b1n ln X1n) ________ (5)

(Kiresur and Ichangi,2011)

RESULTS AND DISCUSSION

Irrigation water quality

Irrigation water quality is indicated by electrical conductivity of water samples measured in mS/cm. As shown in Table 1 electric conductivity of Dhulakhed and Bhuyar river water samples and Yelgi and Hirebevnur bore well water sample was 1.76 mS/cm, 0.99 mS/cm, 0.83 mS/cm and 1.75 mS/cm, respectively which were collected on January 2014. The water samples which were found to have electric conductivity between 0.75 mS/cm and 2.25 mS/cm indicated that water quality was medium for irrigation as per Indian Standards of water quality. The electric conductivity of water samples was higher in river water compared to that in bore well water by 5.83 per cent and 41 per cent during January and April, respectively. The results indicated that first, river water in this condition was less suitable for irrigation compared to bore well water, secondly temporally river water quality was more deteriorated in April compared to January month of the year.

As discussed earlier, the productivity differentials in sugarcane were decomposed using Cobb-Douglas production function to assess the impact of water quality on crop yields. Table 2 presents sugarcane yield differences between polluted and non polluted villages. However, the difference between the yields could not be attributed to water pollution as the contribution of polluted water to decrease in yield of sugarcane was only 0.88 per cent.

As indicated in Table 2, average yield difference of sugarcane between polluted and non polluted villages was 3.43 tonnes/ha. of worth Rs. 6178. The yield difference between polluted and non polluted villages was highest between Chanegaon and Mananklagi followed by that between Shirnal and Halasangi, Dhulkhed and Yelgi, Bhuyar and Hirebevnur. Table 2 also depicts income loss due to pollution. The economic loss ranged from a lowest of Rs.4392 in case of Lachyan and Bergudi to highest of Rs.7,200 in case of Chenegoon and Manankalgi.

An assessment of physical and economic loss in livestock due to pollution was made and results are presented in Table 3. As reported by the households, the extent of death of livestock was more in water polluted villages that caused loss to the individual farmer and farming economy in region. It was observed that two bullocks in case of large farmers and two bullocks in case of medium farmers died causing an economic loss worth Rs.1, 60,000. Totally eight buffaloes died in the polluted villages whose present value was Rs.2, 54,000.Total three cows reported dead in polluted villages which were worth about Rs.65,000. In all categories of farmers total six sheep/goats died which were worth Rs.48,000.

It could be observed that average loss of livestock per household per year was more in case of large farmers (Rs.15,733) compared to other categories of farmers because livestock composition was as well as death of livestock was more in case of large farmers (Table 3). Per annum average loss per household in case of medium, small farmers and landless labourers was Rs.10,866, Rs.5,067 and

Rs.2,933, respectively. Average loss due to death of livestock per annum calculated also more in case of large farmers that was Rs. 3,147. In of case medium farmers, small farmers and landless labourers loss per annum calculated over a five year period was found to be Rs.21,773, Rs.1,013and Rs. 587, respectively.

Average veterinary expenditure per household was more in water polluted villages when compared that in non polluted villages because animals drank water from stagnant and polluted water from river (Table 4). On an average annual veterinary expenditure per house hold, across all farm categories were higher by 34.33 per cent in polluted villages when compared to those in non polluted villages. It was also observed that average veterinary expenses were more in case of large farmers because of larger livestock holding compared to other farm categories. Average veterinary expenditure in polluted villages by large farmers was Rs.3,153 which was higher by 5.16 per cent when compared to that in non polluted villages. In case of medium farmer average veterinary expenses were more in water polluted villages by 86.65 per cent when compared to that in non polluted village. In case of small farmers average expense was by about Rs. 1,553 which was 17.77 per cent higher compared to that in non polluted villages. In case of landless labourers average veterinary expenses in polluted villages were more by Rs.587 which 87.73 per cent more compared to that in non polluted villages. These higher expenditures added to the economic burden of households and adversely affected their livelihood.

The decomposition analysis (Table 5) revealed that yield of sugarcane in water polluted villages was less in non polluted villages. Yield differences due to input uses were 13.10 percent. This implied that there was sub- optimal use of inputs in sugarcane cultivation in polluted villages. However, contribution of water pollution was lower than that of input use. The water pollution depressed the productivity of sugarcane by 0.88 per cent. It can be inferred that use of lower quantities of inputs reduced yield of sugarcane in water polluted villages.

Contribution of yield reduction of sugarcane was 3.10 per cent. However, increased bullock labour, human labour, organic manure and number of irrigation on sugarcane had positive effect on yields. Negative contributions of other inputs were contributed by plant protection chemicals and seed rate.

CONCLUSION

River water in the study area was not found suitable for irrigation purposes in the study period. Average difference in income from sugarcane cultivation in polluted villages was about Rs. 6178 over the non-polluted villages. The livelihoods were affected in terms of decreased crop yields and loss in livestock and enhanced expenses on livestock health. Thus, overall findings of the study reveal that the poor quality of water negatively affected agriculture in the banks of Bhima river in Karnataka, India. The farmers were affected in terms of decreased crop yields and loss in livestock.

Policy implications

1. Since, the water quality tests results in the study were found to be above desirable limits, there is a need for continuous monitoring water quality of the rivers. The Karnataka State Pollution Control Board (KSPCB) has to expand its capabilities to continuously monitor river water quality in the state.
2. Creation of database of polluted water resources is necessary to take measures to check the polluting activities and fix responsibility.
3. The Municipalities and local government agencies, in cooperation with Pollution Control Board, should undertake a rolling program of water auditing for industries, to compile a register of industrial water usage.
4. Formulating programs using integrated waste management approach to make sure that industrial waste does not contribute to the contamination of water.
5. Capacity building of community organization and fund support for establishment of water quality testing labs at local level.

Table 1: Irrigation water quality in terms of the electrical conductivity (ms/cm)

Results	River water		Average	Borewell water		Average	Difference
	Dhulakhed	Bhuyar		Yelgi	Hirebevnur		
January 2014	1.76	0.99	1.37	0.83	1.75	1.29	0.08 (5.83%)
April 2014)	1.91	1.21	1.56	1.02	0.80	0.91	0.65 (41%)

Table 2. Yield and income losses in sugarcane crop

Villages	Yield difference (tonnes/ ha)	Income loss (Rs.)
Dhulkhed and Yelgi	3.56	6,408
Bhuyar and Hirebevnur	3.38	6,084
Lachyan and Baragudi	2.44	4,392
Shirnal and Halasangi	3.78	6,804
Chanegaon and Mananklagi	4	7,200
Average	3.43	6177.60

Table 3: Economic loss due to death of livestock due to water pollution

Category of livestock	LF	MF	SF	LL	Total
Bullocks					
Value (Rs.)	80000	80000	0	0	160000
Buffaloes					
Value (Rs.)	120000	50000	56000	28000	254000
Cows					
Value (Rs.)	20000	25000	20000	0	65000
Goat					
Value (Rs.)	16000	8000	8000	16000	48000
Total (Rs.)	236000	163000	76001	44000	519001
Average loss/ Household/year (Rs.)	15,733.33	10,866.67	5,066.73	2,933.33	34,600.07
Losses per annum calculated over the previous five years	(3146.67)	(2173.33)	(1013.35)	(586.67)	(6920.01)

Table 4. Veterinary expenditure on livestock

(Amount in Rs./ farmer/annum)

Farmer category	Non polluted villages	Polluted villages	Difference	Percent change
LF	1,033.33	3,153.33	2120	5.16
MF	400.00	1,546.67	1,146.67	86.65
SF	300.00	1,553.33	1,253.33	17.77
LL	312.50	586.67	274.17	87.73
Total	2,045.83	6,840	4,794.17	34.33
Average	511.33	1710	1,198.54	34.33

Table 5: Decomposition of total difference in productivity of sugarcane crop in polluted and non polluted villages

Sl. No	Source of difference	Percentage contribution
I	Due to polluted water	-0.88
II	Due to difference in input use	
	Seeds	-0.11
	Organic manure	0.67
	Human labour	0.36
	Bullock labour	3.24
	PPC	-0.37
	No. of irrigation	9.31
III	Total due to inputs	13.10
	Total difference in output due to all sources	12.22

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