Externalities Due To Sand Mining And Distillery Effluent In Water Streams Of India

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Introduction[♠]

Water is an important requirement for human life. It is a nature's gift to human race. The availability of adequate water in terms of both quantity and quality is essential for human existence. People recognized the importance of water quite early from a quantity viewpoint. In India, 56 percent of the area is irrigated from groundwater sources and the rest 44 percent is irrigated from surface water source (Central Groundwater Board, 2002). Thus, the future potential for irrigation exists largely through groundwater, due to high transaction costs involved by surface water irrigation in terms of rehabilitation, reclamation of saline / alkaline soils, compensation to lands submerged and high distribution cost.

Sand mining has two crucial impacts on water supply: First, it inhibits the riverbed's ability to hold groundwater. The recharge of groundwater is directly related

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[♠] Authors have submitted some photographs showing polluted water, rashes on animals and others along with this paper, photographs are available on www.rcssindia.org/jgeon This paper is presented in fifth annual partners meet of IWMI-TATA conference(International Water Management Institute) held at Anand,Gujrat on 8-10,March,2006.

to soil type. The fine sand allows water to seep without evaporation. Secondly, it reduces the flow of the water into local tanks. Sand mining effectively lowers the level of the riverbed below the level of the local tanks. In developing countries, unscrupulous exploitation of sand has affected channel form, bridges and riparian habitats and also resulted in lowered water table (UNEP, 1990). Sand bed has cushioning effect in retaining the moisture during the monsoon season and aiding in recharging of shallow as well as deep aquifer (Department of Mines and Geology, GOK, 2001).Contractors and some riparian farmers are found mining the sand in the study area and all riparian farmers are experiencing the effect in terms of groundwater depletion – a classic case of unidirectional externality.

Hemalatha, A.C (2004) assessed the externalities due to sand mining, results indicate that, sand mining contributed to 59 percent of the total income followed by agriculture (35 percent) in sand mining area, while in Non sand mining area, agriculture contributed to 60 percent of the income followed by livestock (11 percent).

In this study, in addition to these effects of sand mining, the effect of distillery unit letting its effluents in lagoons leading to groundwater pollution in the sand mining area, has been analysed. Distilleries are agro based industries producing ethyl alcohol for industrial uses. In the process, spent wash effluent of the by-product is stored in unlined lagoons, which has already polluted groundwater for irrigation and potable purposes affecting the prospect of agriculture, health and environment. Varuni (2003) assessed the externalities due to distillery effluent groundwater pollution. Researcher reported that, the medical expense per month per family was about Rs 166 in distillery effluent polluted village while it was Rs. 45 in control village.

Use of poor quality water is a slow poison for all forms of life, as it increases salinity, ion toxicity and infiltration problems in soil. These affect crop production and reduce farm income. Of late, water quality issues from point and non-point sources are increasingly causing environmental concern as groundwater serves many purposes including drinking water for humans and livestock. Groundwater contamination results in chronic health problems due to infected drinking water. Corrosion and chemical reaction from domestic and industrial waste reduces the productivity of irrigated lands and hence the quality of the output (Behera and Reddy, 2002).

Distilleries are one of the most important agro based industries producing ethyl alcohol for industrial and potable uses. They also assume importance due to growing use of alcohol in many sectors. However, their environmental degradation effects is in terms of generating large volume of foul smelling and brown coloured wastewater known as spent wash is a matter of concern. Distillery effluent is characterized by its extremely large volume of waste, foul odour, dark coffee color

and highly biodegradable character, dissolved solid content that presents significant disposal or treatment problems (Fertilizer News, 1996).

METHODOLOGY

The study area was purposively chosen to value the economic losses to farmers due to the twin effect, i.e. due to use of groundwater affected by the distillery effluent and groundwater depletion due to sand mining in Gauribidanur taluk of Kolar district. Groundwater quality from irrigation wells of sample farms was examined. It was found that groundwater quality was seriously affected in irrigation wells due to distillery pollution. The most desirable electrical conductivity (EC) should be below value of one. However for irrigation wells in SM & DEPA, the EC of groundwater is 3.4 decisiemens per meter of groundwater as against Control area with 0.5 decisiemens per meter of groundwater. The pH of groundwater exhibited low variability, varying from 6.6 in SM & DEPA to 7.3 in Control area. There is however, a significant variation in chlorine, sulphates, sodium, potassium, calcium and magnesium between SM & DEPA and Control area. This indicates that groundwater, is severely affected in irrigation wells located in SM & DEPA. The quality tests of groundwater from wells in SM & DEPA have indicated that pH, EC and sodium concentration exceeded the threshold limits of irrigation **(Table 3)**

Crops and cropping pattern

The soil types vary from sandy-to-sandy loam with kharif as the major cropping season. The crop activity is restricted for kharif season on dry lands, while four to five crops are grown using well irrigation water. Maize and Ragi occupies a major part of the rainfed agriculture, while maize, sunflower, groundnut, mulberry, ragi and vegetables are the most commonly cultivated crops in groundwater-irrigated lands.

Sampling

Data was collected from simple random sampling using structured schedules. For this study, a sample of 30 farmers owning wells affected by ground water quantity and quality depletion due to sand mining and distillery effluent was selected. In order to make a comparative analysis, 30 farmers owning wells affected only by ground water quantity depletion due to sand mining and 30 farmers owning wells which are

not affected by ground water quality and quantity depletion were also selected for this study. Thus, over all sample comprised of 90 farmers using groundwater irrigation.

Method of Analysis

Measures of central tendency were employed to analyze data pertaining to size of holding, gross irrigated area, returns from crops and well investments.

Well age and well life

The life and age of wells are estimated using 'life tables' approach as in statistical theory. 'Age' of irrigation well refers to wells that are functioning' at the time of collection of field data (2004) and well life refers to totally 'failed' and 'abandoned' wells after these have worked for sometime, including initial failures. . The age of the well was estimated as the year 2004 minus the year of well construction or sinking or drilling. The well life was estimated as year of well failure minus the year of construction/ sinking/drilling. All those wells that suffered from initial failure obviously have zero life.

Cost of irrigation well

Groundwater is being extracted from three types of irrigation wells in sand mining areas, 'sand mining and DEPA' (SM & DEPA) and control area, Viz., the Dug Well (DW), the Bore well (BW) and the Filter Point Well[1] (FPW). In costing well historic cost of well including cost of divining, drilling/ digging/casing at the time of construction is compounded at two percent from the year of construction to year 2004 for all wells. This was done to estimate the total investment made by farmers in all wells from their beginning at 2004 prices. An interest rate of two per cent represented the rate of inflation in the cost of well components like drilling, lining, casing, pump set and accessories.

Amortized cost of irrigation well

[1] The filter point well is a tubular structure piercing through the sand portion of the sand bed with a blank and slotted pipe surrounded by a gravel pack. Usually the filter point wells are dug near the riverbed or within the stream. Due to sand mining, filter point wells are quickly affected.

The amortized cost of well represents the annual fixed cost component of irrigation water. The amortized cost varies with the type of well, status of the well, year of construction, average age of well and interest rate chosen.Amortized cost[2] refers to apportioning initial investment on irrigation well over the average life period of irrigation well at the specified discount rate. The amortized cost of well represents the annual fixed cost component of irrigation water. The amortized cost varies with the type of well, status of the well, year of construction, average age of well, and interest rate chosen.

Amortized cost of irrigation well = [amortized cost of well + amortized cost of pump set and accessories + amortized cost of conveyance + annual repair and maintenance cost of pump set and accessories]

Amortized cost of well = [(Compounded cost of well)*(1+i) ^{AL}*i] / [(1+i) ^{AL}-1]

Where, AL = Average life of wells.

Compounded cost of well = [(well cost)*(1+i) $^{(2004\text{-year of construction})}$.

Amortized cost of pump set and accessories =

{[(Sum of compounded cost of pump set +pump set house + electricity at current price)*(1+i) ^{15}*i] / [(1+I) ^{15}-1]}

The working life of pump set and pump set house is assumed to be 15 years.

Amortized cost of conveyance

= [(Compounded cost of conveyance pipe used)*(1+i) ^{10}*i] / [(1+i) ^{10}-1]

The working life of conveyance pipe is assumed to be 10 years. The usual mode of conveyance is through PVC pipes.

Water use in each crop

[2] Amortized cost refers to apportioning initial investment on irrigation well over the average life period of irrigation well at the specified discount rate. In this study, social discount rate of 2 percent is considered. Life period of irrigation well refers to the average of the age of functioning wells and life of non-functioning wells. Average life period refers to the mean number of years of well life considering both life and age of irrigation wells.

The number of acre-inches of groundwater extracted for each crop in each season and for perennials = (Frequency of irrigation per month)*(number of months of crop)*(number of hours to irrigate the crop area)*(average yield of well in GPH) / 22611

Cost of irrigation

Cost of irrigation per acre- inch =
[Total amortized cost of irrigation / total acre-inches of GW used]

Cost of irrigation is then apportioned to include individual crops according to the proportion of water used in each crop by multiplying the cost per acre-inch of water with the number of acre-inches of water applied.

Externality cost

Negative externality = AP MINUS APF
Amortized cost per well (AP) =Total amortized cost of all wells/Total number of wells
Amortized cost per functioning well (APF) = Total amortized cost of all wells/Total number of functioning wells
Proportion of well failure = Number of failed wells / Total number of wells
Net return per acre-inch of GW used= Total net returns/Total GW used
Net returns per rupee of irrigation cost
= Net return per acre inch of GW used / Irrigation cost per acre inch of GW used.

Effect of distillery effluent groundwater pollution on health

Gastrointestinal problems, Skin allergies, headache, vomiting sensation, irritating eyes, fever and stomach pain frequently affects farmers in the 'sand mining and DEPA'. Avertive expenditure on health included treatment cost, cost of medicine. Human health externality is calculated as the difference between the health expenditure per capita in control village and 'sand mining and DEPA'.

Farm animals cannot be controlled in their free movements, free grazing and consumption of water available in ponds, streams. Cattle were seen drinking the distillery effluent groundwater. According to farmers this has resulted in increased livestock mortality, poor health, and reduced milk yield. Animal health externality is the difference between the health expenditure per animal in control village and DEPA.

Estimation of transaction cost of drinking water

Estimated number of women-days spent in fetching potable water per year is worked out considering the time spent on fetching potable water per day. The imputed cost is calculated by multiplying the number of women-days spent in fetching potable water per year considering a wage rate of Rs. 30 per day. The transaction cost is the difference in the imputed cost between the normal and affected.

Estimation of Pigouvian tax for sand miners and distillery

The Pigouvian tax for sand miners is calculated based on the negative externality per well due to intense sand mining above the permitted level affecting lateral and vertical movement of water through groundwater recharge. The negative externality is then extended to cover the total number of affected wells to obtain the aggregate externality for all wells affected by sand mining. This then is distributed over the total sand extracted per year to obtain an estimate of Pigouvian tax per tonne of sand extracted.

The Pigouvian tax for distillery is calculated based on the negative externality per acre due to distillery effluent polluting groundwater aquifers with seepage from spent wash lagoons. This is aggregated for the total area affected and apportioned over the volume of rectified spirit produced per year to get an estimate of Pigouvian tax per litre of rectified produced.

RESULTS AND DISCUSSION

Sources of income of the farmers

There has been a discernible shift in source of income from Control area to SMA and SM & DEPA. Agriculture is the main source of income in Control area, contributing to 77 percent of income. In SMA, agriculture contributes to 43 percent, while in SM & DEPA it contributes to 26 percent. Correspondingly, even though the farmers were affected by the negative external effects of sand mining and distillery pollution, they could not bear the transaction cost of settling the dispute unitedly. Thus, the SMA and SM& DEPA farmers resorted to cooperating with sand miners and polluters. Thus the income from sand mining contributed to 39 percent of total income in SMA and 59 percent in SM&DEPA (**Table 1**).

Table 1: Sources of income of sample farmers affected by sand mining/ distillery effluent in Gauribidanur taluk, Karnataka, 2004

(Rs./ farm / year)

Source of income	SMA		SM&DEPA		Control area	
Agriculture	45194	(43)	25609	(26)	76340	(77)
Livestock	7256	(7)	4822	(5)	8076	(8)
Sand mining	41067	(39)	58075	(59)	0	(0)
Others	11733	(11)	10667	(11)	14452	(15)
Total	105250	(100)	99173	(100)	98868	(100)

Note:

SMA: Groundwater farmers located in sand mining area.
SM&DEPA: Groundwater farmers located in both sand mining and distillery Effluent polluted area.
Control area: Groundwater farmers located away from sand mining and distillery Effluent polluted area.

* Figures in the parentheses are percentages to the total.
* Others include incomes from salaried persons, petty shops business, contractor, milk vendor and tractor driver.

Change in cropping pattern before and after pollution

The area under sugarcane was drastically reduced due to the closure of sugar industry .In sand mining and distillery effluent polluted area there is discernible change in cropping pattern due to ground water pollution. The gross cropped area under sugarcane (25 percent), paddy (2.4 percent), ragi (1.2 percent) and arecanut (1.2 percent) were reduced to zero at present. This area is now distributed for tomato and groundnut. These crops consumed much lower groundnut water compared with sugarcane and paddy.

Before the distillery effluent pollution, sugarcane (26.5 percent) was the major crop followed by sunflower (14.8 percent) and mulberry (13.6 percent). But after pollution, mulberry (32 percent) occupied major share followed by maize (25.4 percent) and sunflower (11.8 percent). The area under maize increased from 5.8 percent to 20.4 percent at present and the area under mulberry increased from 13.6 percent to 32 percent at present, giving an indication that mulberry and maize are relatively insensitive to distillery pollution than other crops **(Table 2).**

Economics of groundwater irrigation

Considering all the wells in SMA, SM & DEPA and Control area, proportion of well failure is higher in SM & DEPA (38 percent) compared to SMA (28 percent)

and Control area (13 percent). This is due to negative externality induced by sand mining on groundwater recharge and distillery effluent polluted groundwater on repair of pumpsets and accessories. The groundwater extracted per well was 28 percent lower in SMA and SM & DEPA over Control area (159 acre inches). The impact of poor groundwater quality is reflected in net returns per acre, lower by 50 percent in SM & DEPA (Rs.3439) and 21 percent in SMA (Rs.5482) compared with Control area (Rs.6932).

The externality cost involved in drilling of additional wells due to initial and premature failure was 113 percent higher in SMA (Rs.4763) and 272 percent higher in SM & DEPA (Rs.8325) compared with Control area (Rs.2236). The net return per rupee of irrigation cost is lower by 42 percent in SMA (Rs.2.15) and 72 percent in SM & DEPA (Rs.1.05) compared with Control area (Rs.3.71) (**Table 4**). Amortized cost per functional well was higher by 6 percent in sand mining area (Rs.17011) and 35 percent in 'SM &DEPA' (Rs.21644) compared with Control area (Rs.16023), amortized cost of irrigation per acre inch of groundwater was higher by 46 percent in SMA (Rs.147.5) and 89 percent in SM & DEPA (Rs.191) as compared with Control area (Rs.101) and amortized cost per acre of GIA was higher by 36 percent in SMA (Rs.2546) and 76 percent in SM & DEPA (Rs.3267) as compared with Control area (Rs1870).

Negative externality due to sand mining activity and distillery effluent

Due to sand mining activity, net return per well is lower by Rs. 22771 over Control area, and net return is lower by Rs. 1450 per acre over Control area. The net return per acre inch of groundwater is lower by Rs. 55 over Control area and net return per rupee of irrigation cost lower by Rs. 1.56 over Control area (**Table 5**).

Table 2: Cropping pattern on sample farms before and after groundwater pollution in 'sand mining & distillery effluent polluted area' in Gauribidanur taluk, Karnataka, 2004

Crops	Before pollution		After pollution	
	GCA (acres)	NCA (acres)	GCA (acres)	NCA (acres)
Kharif				
Maize	18 (5.5)	18 (7.6)	43 (20.4)	43 (27)
Chilies	8 (2.4)	8 (3.4)	1 (0.5)	1 (0.6)
Paddy	12 (3.7)	12 (5)	0 (0)	0 (0)

Groundnut	11 (3.4)	11 (4.6)	4 (1.9)	4 (0)
Rabi				
Tomato	31.5 (9.2)	31.5 (13.2)	26 (12.3)	26 (16.4)
Ragi	4 (1.2)	4 (1.7)	0 (0)	0 (0)
Sunflower	32 (9.8)	32 (13.4)	23 (10.9)	23 (14.5)
Paddy	8 (2.4)	8 (3.4)	0 (0)	0 (0)
Summer				
Groundnut	16 (4.9)	16 (6.7)	20 (9.5)	20 (12.6)
Maize	8 (2.4)	8 (3.4)	10.5 (5)	10.5 (6.6)
Sunflower	14 (4.3)	14 (5.9)	2 (0.9)	2 (1.3)
Annuals				
Mulberry	42 (12.8)	14 (5.9)	67.5 (32)	22.5 (14.2)
Banana	37 (11.3)	18.5 (7.8)	14 (6.6)	7 (4.4)
Sugarcane	82 (25)	41 (17.2)	0 (0)	0 (0)
Perennials				
Areca nut	4 (1.2)	2 (0.8)	0 (0)	0 (0)
Total	327.5 (100)	238 (100)	211 (100)	159 (100)

Note:

1) SM & DEPA: Groundwater farmers located in both sand mining and distillery Effluent polluted area.

*GCA: Gross Cropped Area, NCA: Net Cropped Area

Figures in the parentheses are percentages to the total.

Table 3: Comparison of Ground water quality parameters in 'sand mining & distillery effluent polluted area' and Control area in sample farms of Gauribidanur taluk, Karnataka, 2004

Category	pH	E.C	Cl	So_4	Na	K	Ca	Mg
		dsm^{-1}	ppm					
Control area	**7.3**	**0.5**	**90**	**35**	**45**	**7.8**	**7.6**	**20**
SM & DEPA	**6.6**	**3.4**	**860**	**215**	**160**	**15.6**	**610**	**42**
Normal standards	**6.5-8.5**	**1**	**25**	**150**	**NA**	**NA**	**75**	**30**

* Done by the researcher with the help of Department of Soil Science & Agriculture ***Chemistry***.

Note:

1) SMA: Groundwater farmers located in sand mining area.
2) SM&DEPA: Groundwater farmers located in both sand mining and distillery Effluent polluted area.
3) Control area: Groundwater farmers located away from sand mining and distillery Effluent polluted area.

E.C: Electrical conductivity, Cl: Chlorine, So_4: Sulphates, Na: Sodium, K: Potassium, Ca: Calcium, Mg: Magnesium, NA: Not Available, Ppm : parts per million. dsm^{-1}: decisiemens per meter

The net return per irrigation well in SM & DEPA is lower by Rs. 36605 over Control area, net return per acre lower by Rs. 3493, net return per acre inch of water lower by Rs. 171, net return per rupee of groundwater cost lower by Rs. 2.66. The distillery pollution effluent has reduced the net return per well by Rs. 13,834 over SMA, the net return per acre is lower by Rs. 2043, net return per acre inch of water lower by Rs. 116.5, net return per rupee of groundwater cost lower by Rs. 116.5 and net return per rupee of groundwater cost lower by Rs.1.1. Thus while both distillery pollution and sand mining activities have harmed the sustenance of farmers, distillery pollution should attract greater Pigouvian taxation compared with sand mining activity. (**Table 5**)

Impact on Net returns

Net return per rupee of irrigation cost and net return per acre of gross irrigated area is lower for farmers located closer to the lagoon and higher for the farmers located away from the lagoon irrespective of distance from river / sand stream. This is because of use of poor quality groundwater for irrigation **(Table 6).** Net return per

rupee value of groundwater is lower for farmers proximal to lagoon (Rs 0.61 & Rs 0.71), while it was higher (Rs. 1.38 & Rs.1.61) for the farmers distant from the lagoon.

Impact on productivity of crops

The immediate farm effect of poor quality groundwater irrigation is the declining crop productivity. The SM &DEPA farmers realized lower productivity as compared to SMA and Control area due to the effect of distillery effluent polluted groundwater. The productivity of maize (20.2 quintals per acre) mulberry (2.8 tonnes per acre), sunflower (6.1 quintals per acre) and tomato (17.6 tonnes per acre) was lower by 23, 22, 36 and 26 percent respectively in SM &DEPA compared with Control area **(Table 7)**

Table 4: Access to Groundwater resource for irrigation in sand mining, 'sand mining & distillery effluent polluted area' and control area from all wells in Gauribidanur taluk, Karnataka 2004

Particulars	**Sand mining area**	**Sand mining & DEPA**	**Control area**
Total number of wells	50	52	43
Number of functional wells	36	32	37
Number of failed wells	14	20	6
Proportion of well failure (percent)	28	38	13
Proportion of Non functional to functional wells (percent)	39	62.5	16
Gross irrigated area (acres)	240.5	212	317
Gross irrigated area per functional well (acres)	6.68	6.62	8.56
Groundwater extracted per well (acre inches)	115	113	159
Groundwater extracted per acre (acre inches)	17.26	17.07	18.5
Total GW extracted and used	4152	3618.5	5892.5
Irrigation cost per acre inch of groundwater used (Rs.)	147.5	191	100.61
Net returns per functional well (Rs.)	36620	22786	59391
Net returns per acre (Rs.)	5482	3439	6932
Total net return (Rs.)	1318318	729139	2197467
Total amortized cost (Rs.)	612389	692609	592856
Amortized cost per acre (Rs.)	2546	3267	1870
Amortized irrigation cost per well (considering all wells) (Rs.)	12248	13319	13787
Amortized cost per functioning well (Rs.)	17011	21644	16023
Negative externality per well (Rs.)	4763	8325	2236
Net return per acre inch of groundwater used (Rs.)	318	201.5	373

Net returns per rupee of irrigation cost (Rs.)	2.15	1.05	3.71

Note**:** wells include open wells, Filter point wells and bore wells

1) Negative externality= Amortized cost per functioning wells over amortized cost per well.
2) Amortized cost per well =Total amortized cost of all wells/Total number of wells
3) Amortized cost per functioning well = Total amortized cost of all wells/Total number of functioning wells
4) Proportion of well failure = Number of failed wells divided by Total number of wells
5) Net return per acre-inch of groundwater used= Total net returns/Total groundwater used
   Net returns per rupee of irrigation cost = Net return per acre inch of groundwater used/Irrigation cost per acre inch of groundwater used (Rs.).

How health was affected due to sand mining and distillery pollution

In SM & DEPA, sample farmers were suffering from various diseases due to exposure to distillery effluent polluted groundwater. It was observed that most of the diseases such as skin allergy, dermatitis and stomach pain, vomiting sensation, head ache, irritating eyes, lungs infections and weakness. Due to foul smell from the distillery unit were due to the exposure to distillery effluent polluted groundwater. Due to this, additional expenditure on health care per annum per family increased was estimated at Rs.1423 (**Table 8**).

Table 5: Negative externality to Groundwater resource for irrigation in sand mining, 'sand mining & distillery effluent polluted area' from all wells in Gauribidanur taluk, Karnataka 2004

Sl. No.	Differential Negative externality	Sand mining area over control	Sand mining & DEPA over control	DEPA
1.	Differential Net return per functional well (Rs.)	-22771	-36605	-13834
2.	Differential Net return per acre (Rs.)	-1450	-3493	-2043
3.	Differential Irrigation cost per acre inch of ground water used (Rs.)	46.5	90	43.5
4.	Differential Amortized irrigation cost per well (Rs.)	988	5621	4633
5.	Differential Amortized irrigation cost per acre (Rs.)	676	1397	721
6.	Differential Net return per acre inch of groundwater used (Rs.)	-55	-171.5	-116.5
7.	Differential Net return per rupee of irrigation cost (Rs.)	-1.56	-2.66	-1.1
8.	Differential Water yield (GPH)	-229.5	-411	-181.5
9.	Differential Average age (Years)	-2.98	-4.04	-1.06

*Note:*Differential Negative externality is obtained as the difference between economic parameters in sand mining area (SMA) over control area and SM &DEPA over Control area.
Loss due to poor groundwater quality is expressed as the difference between SM &DEPA over SMA.

Table 6: Net return per acre-inch of groundwater and net return per rupee of irrigation cost in 'sand mining & distillery effluent polluted area' of Gauribidanur taluk, Karnataka, 2004

Distance of irrigation wells from the lagoon in Meters

Distance of well from the sand mining area in Meters	Farmers with wells located upto 800 meters from Lagoon (near to lagoon)			Farmers with wells located beyond 800 meters from Lagoon (far from lagoon)		
	No.	Net return per acre inch of groundwater used (Rs.)	Net return per rupee of irrigation cost (Rs.)	No.	Net return per acre inch groundwater used (Rs.)	Net return per rupee of irrigation cost (Rs.)
Farmers with wells located upto 800 meters from river (near to river)	8	162	0.6	5	204	1.38
Farmers with wells located beyond 800 meters from river (far from river)	7	181	0.71	10	237	1.61

Note: SM&DEPA: Groundwater farmers located in both sand mining and distillery Effluent Polluted area

No: No. of farmers with wells in the respective category

Table 7: Productivity of crops of sample farms in Gauribidnur taluk, Karnataka, 2004

Particulars	SMa	SM & DEPA	Control area
Crops (qtls/acre)			
Maize (qtls/acre)	21.4	20.2	26.3
Paddy (qtls/acre)	21.2	18.1	26.7
Sunflower (qtls/acre)	8.2	6.1	9.8
Groundnut (qtls/acre)	14.1	12.5	16.2
Chilies (qtls/acre)	8.9	7.2	10.2
Areca nut (qtls/acre)	0	0	4.8
Crops (tonnes/acre)			
Tomato (tonnes/acre)	19.1	17.6	23.8
Cucumber (tonnes/acre)	31.7	18.9	32.4
Marigold (tonnes/acre)	4.2	0	0
Mulberry (tonnes/acre)	3.3	2.8	3.6
Banana (tonnes/acre)	11.8	9.4	13.4

Note:

1) *SMA: Groundwater farmers located in sand mining area.*
2) *SM&DEPA: Groundwater farmers located in both sand mining and distillery Effluent polluted area.*

Control area: Groundwater farmers located away from sand mining and distillery Effluent polluted area.

Table 8: Nature of ill effects and associated costs on human and livestock health in'sand mining & distillery effluent polluted area' in Gauribidanur taluk, Karnataka, 2004

Sl. No.	Particulars	Nature of problem	Additional cost on health/year /family (Rs)
1	Human health	Skin allergy, vomiting, eyes irritation, stomach pain, head ace and fever	1423
2	Animal health	Dehydration, skin infection and edema	841.1

Note:

1) SM&DEPA: Groundwater farmers located in both sand mining and distillery Effluent polluted area.

Dairy is one of the main sources of income in rural areas. Since all the local water sources were polluted, dairy animals in the village were enduring with health hazards. Livestock were grazing on lands irrigated by distillery pollution affected groundwater and also drank that water. About 13 cattle died after continuous feeding on distillery effluent polluted groundwater over the years. In addition, there was reduction in milk productivity. The major health problems affecting cattle were dehydration, skin infection and edema entailing additional expenditure on cattle per annum per farm at Rs. 841 (**Table 8**).

Table 9: Estimation of transaction cost in fetching potable groundwater in both'sand mining & distillery effluent polluted area' in Gauribidanur taluk, Karnataka, 2004

Sl. No.	Particulars	SM & DEPA	Control area
1	Average distance travelled (kms)	0-1.2	0-0.3
2	Average time spent per day (minutes)	90	15
3	Estimated number of women days spent per year (Rs.)	68.43	6.84
4	Imputed cost of women labor (Rs.)	2052.9	205.2
5	Transaction cost (Rs.)	1847.7	

Note:

1) *SM&DEPA: Groundwater farmers located in both sand mining and distillery effluent Polluted area.*
2) *Control area: Groundwater farmers located away from sand mining and distillery effluent polluted area*

Table 10: Environmental effects of groundwater pollution in 'sand mining and distillery effluent polluted area' in Gauribidanur taluk, Karnataka, 2004

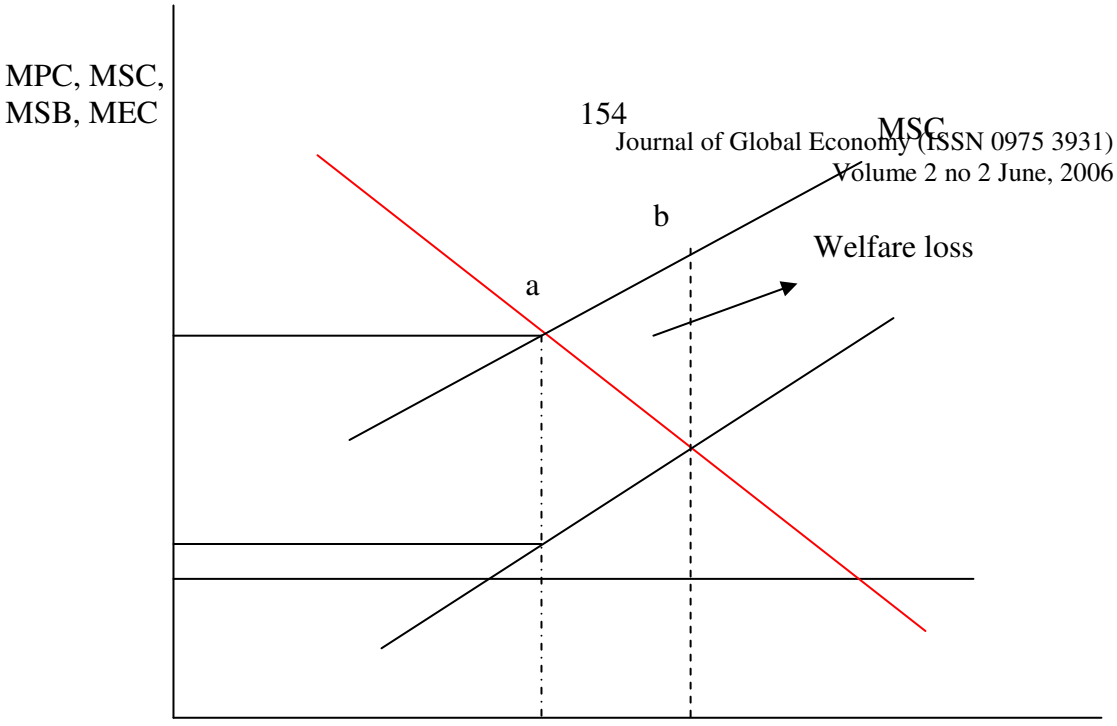
Sl. No.	Particulars	Impact
1	Soil structure and texture	Hardening of soil
2	Water holding capacity	Low
3	Fertility of soil	High NPK resulting in profuse vegetative growth, excess weed problem

4	Agricultural productivity	Low
5	Land value	Market value of land reduced by 32 percent
6	Drinking water	As distillery effluent groundwater was not potable, women were forced to walk 1 to 2 kms away from their home to fetch good quality water for potable purpose.

Table 11: Additional Costs incurred on coping mechanisms in 'sand mining and distillery effluent polluted area' in Gauribidanur taluk, Karnataka, 2004

Sl. No.	Particulars	Additional costs (Rs.)
1	Additional expenditure on seeds per acre	272
2	Additional cost of farm yard manure per acre	963
3	Additional Drilling charges per well	3456
4	Additional Repair of pump set per well	2311

Fig. 1: Negative externality on groundwater due to mining of sand from river streams and pollution from distillery spentwash



Transaction costs in fetching potable groundwater

Transaction cost is estimated as the number of women days lost while procuring potable water from distant places as potable water sources nearby are affected by distillery affluent pollution. This is the value of extra labor invested per day being Rs.1848 per year (**Table 9**) for fetching potable water. The negative externality of sand mining and pollution from distillery resulting in over production (inefficiency) and welfare loss (Fig 1) suggests that the Pigouvian Tax of Rs. 27.75 on each tonne of sand extracted above y* be imposed on sand miners such that his MPC=MSC = ad. This market failure results in the welfare loss equal to abc. Further, the estimated pigouvian tax of Re. 0.90 per litre of rectified spirit produced above y* should be imposed to internlize the negative externality.

Environmental effects of groundwater pollution

In the polluted area, there was ecological disruption due to irrigation using distillery effluent polluted groundwater. Hardening of soil structure due to high deposition of salts leading to reduction in water holding capacity was observed in affected areas **(Table 10).** This lead to water logging reducing fertility of land and crop productivity. The land value fell by 32 percent when compared with Control area.

Additional costs on coping mechanism

Farmers in the SM & DEPA are incurring additional costs on seeds, farmyard manure, drilling charges and repair of pumpset. Additional seeds were sown due to poor germination percentage due to use of distillery effluent polluted groundwater. Additional farmyard manure of one to two tractor loads per acre is applied to neutralize the effect of distillery effluent polluted groundwater. Additional drilling charges are incurred by farmers due to intense sand mining, which lead to reduction in groundwater levels in the SMA. Farmers were incurring additional cost on repairs to pumpsets as pumps were corroded due to deposition of salts on the pumpsets **(Table 11).**

Implications

Groundwater is crucial resource for farmers in tropical India who eke out their living as the rainfall is scanty with no perennial source of irrigation. Irrigation wells in the riparian areas of Uttara Pinakini river basin are continuously threatened due to sand mining which in turn has seriously depleted the groundwater table. This has led to high proportion of well failure in this region. Currently sand extraction is permitted up to three feet by with remittance of royalty of Rs. 45 per truckload of sand to the Department of Mines and Geology. With poor monitoring from the Mines and Geology Department, sand miners however are excavating even up to 40 feet in Uttara pinakini stream though the permissible limit of sand extraction is upto three feet depth from the surface. In addition, the study area is also affected by groundwater pollution caused by the distillery effluent released by distillery unit. Both these are negative externalities affecting agriculture production system, soil health and health of human beings and livestock.

The estimated negative externality per irrigation well was Rs. 8325 per year. There are about 10000 irrigation wells located in the riparian areas of the Gowribidanur river stream where sand mining is actively being undertaken. Thus, the

total estimated negative externality is Rs.8,32,50,000. The sand extraction in the study area is around 500 truckloads per day or 10000 tonnes of sand per day (@ 20 tonnes per truck load[3]). This works to 3,00,0000 tonnes per year for 300 working days from 1,50,000 trucks. The Pigouvian tax to be imposed is Rs. 8,32,50,000 distributed over 3,00,0000 tonnes, which works to Rs.27.75 per tonne or Rs.555 per truckload. In order to conserve the sand resources along the riparian areas, the environmental cost of Rs 555 per truckload should be imposed to internalize the pressure on this natural resource in the market price of sand.

Due to distillery effluent pollution the affected farmers are incurring a loss of Rs. 2043 per acre. They incur an additional expenditure of Rs. 1848 per family towards fetching potable water, Rs. 1423 per family towards extra expenditure on health maintenance and Rs. 841 per family towards additional expenditure on livestock health totaling Rs. 4112 per year. For 250 families this works to Rs.10,28,000. With the total area of 1485 acres affected in the study area, the total loss suffered on account of sand mining and distillery pollution externality is Rs.30,33,855.

The negative externality due to distillery effluent pollution is Rs.40,61,855 per year. The distillery is manufacturing 15,000 litres of rectified spirit per day or 45,00,000 litres per year. With a sale price of Rs. 30 per litre, distillery earns a revenue of Rs. 4,50,000 per day or Rs. 13.5 crores (Rs. 13,50,00,000) with 300 days of operation. Thus, distributing the negative externality of Rs. 40, 61,855 on 45,00,000 litres per year gives raise to a Pigouvian tax of 90 paise per litre of rectified spirit. It is desired that the State Pollution Control Board and the State Department of Mines and Geology will come to the rescue of the affected farmers and human beings in the study area by framing suitable institutions and in addition impose the pigouvian tax to discipline both sand miners and distillery effluent polluters.

ACKNOWLEDGEMNT

It was my privilege to have ***Dr.P.G.Chengappa****, Consultant, International Food Policy Research Institute (IFPRI) as the chairman of my Advisory Committee. I thank him profusely for his inspiring, subtle guidance, prodigious help, invaluable support and constant encouragement throughout my research period .I would like to place on record my deep sense of gratitude to my teacher* ***Dr.M.G.Chandrakanth****, Professor, Department of Agricultural Economics, UAS, Bangalore for showing keen interest and being a great source of inspiration during this research programme. I feel immense pleasure in expressing my deep sense of*

[3] Each truckload accommodates around 350 to 400 cubic feet of sand.

*gratitude and profound indebtedness to **Dr.R.S.Deshpande,** Professor and Head, ADRT Unit, ISEC, Bangalore for giving constructive suggestions. I express my sincere thanks to all the farmers who have helped me in providing useful data for my research work and **Mr.D.A.Chowdappa**, Environmentalist who spared his valuable time for my study.I am very much grateful to NATP (TOE in NRE), New Delhi for the financial assistance provided to me in the form of Junior Research Fellowship*

–A. Manjunath

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