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Valuation of groundwater protection: A state level analysis in India

Arnab Roy

Ph.D. Scholar, Department of Agricultural Economics, University of Agricultural Sciences, GKVK, Bengaluru

E-mail: royarnab_94@rediffmail.com

Abstract: The benefits of groundwater protection are estimated to assess the non-marketed benefits associated with increased protection of the groundwater resource, as compared to purification of groundwater for drinking water purposes. As of April 2015, the water resource potential or annual water availability of the country in terms of natural runoff (flow) in rivers is about 1,869 Billion Cubic Meter (BCM)/year. However, the usable water resources of the country have been estimated as 1,123 BCM/year. According to some estimates, it accounts for nearly 80 per cent of the rural domestic water needs, and 50 per cent of the urban water needs in India. Therefore, the evaluation of ground water quality and impact of polluted groundwater on environment and health has drawn attention of the researchers. The present paper is also an attempt on such study. The pollution level of ground water in India and its effect on environment and vicinity area have been studied in the present paper.

Key Words: non-marketed, natural runoff, hedonic pricing, contingent valuation,

Introduction

The crucial role groundwater plays as a decentralized source of drinking water for millions rural and urban families cannot be overstated. According to some estimates, it accounts for nearly 80 per cent of the rural domestic water needs, and 50 per cent of the urban water needs in India. Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies. Increase in overall salinity of the ground water and/or presence of high concentrations of fluoride, nitrate, iron, arsenic, total hardness and few toxic metal ions have been noticed in large areas in several states of India. Ground water contains wide varieties of dissolved inorganic chemical constituents in various concentrations as a result of chemical and biochemical interactions between water and the geological materials through which it flows and to a lesser extent because of contribution from the atmosphere and surface water bodies. Ground water in shallow aquifers is generally suitable for use for different purposes and is mainly of Calcium bicarbonate and mixed type. However, other types of water are also available including Sodium-Chloride water. The quality in deeper aquifers also varies from place to place is generally found suitable for common uses. . The purpose of this paper is to describe problems and possibilities with economic valuation of risk reductions, and to illustrate how different valuation perspectives affect the extent of investigations. An economic decision analysis model is presented for integrating the valuation of health, ecological, and other risks into one assessment. The decision model can be used on the societal level for cost-benefit analysis, but also for evaluating the cost-efficiency of different investigation and remediation alternatives.

Extent and Impacts of Groundwater Contamination and Pollution

The incidence of fluoride above permissible levels of 1.5ppm occur in 14 Indian states, namely, Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal affecting a total of 69 districts, according to some estimates.Some other estimates find that 65 per cent of India's villages are exposed to fluoride risk

Table 1: State-wise Status of Groundwater Resources (2010)

No	State	Billion Cubic Metres (BCM) Annual Replenishable Groundwater Resource	Net Availability	Net Draft	Stage of GW Development (Net Draft/Net Availability*100)
1	Andhra Pradesh	36.50	32.95	14.90	45
2	Assam	27.23	24.89	5.44	22
3	Bihar	29.19	27.42	10.77	39
4	Chhattisgarh	14.93	13.68	2.80	20
5	Gujarat	15.81	15.02	11.49	76
6	Haryana	9.31	8.63	9.45	109
7	Jammu and Kashmir	2.70	2.43	0.33	14
8	Jharkhand	5.68	5.25	1.09	21
9	Karnataka	15.93	15.30	10.71	70
10	Kerala	6.84	6.23	2.92	47
11	Madhya Pradesh	37.19	35.33	17.12	48
12	Maharashtra	32.96	31.21	15.09	48
13	Orissa	23.09	21.01	3.85	18
14	Punjab	23.78	21.44	31.16	145
15	Rajasthan	11.56	10.38	12.99	125
16	Tamil Nadu	23.07	20.76	17.65	85
17	Uttar Pradesh	76.35	70.18	48.78	70
18	Uttarakhand	2.27	2.10	1.39	66
19	West Bengal	30.36	27.46	11.65	42
20	Other states	7.67	7.03	0.86	12
Total		432.42	398.70	230.44	58

Source: CGWB (2006).

High levels of salinity are reported from all these states except West Bengal and also the NCT of Delhi, and affects 73 districts and three blocks of Delhi. Iron content above permissible level of 0.3 ppm is found in 23 districts from 4 states, namely, Bihar, Rajasthan, Tripura and West Bengal and coastal Orissa and parts of Agartala valley in Tripura. High levels of arsenic above the permissible levels of 50 parts per billion (ppb) are found in the alluvial plains of Ganges covering six districts of West Bengal.

Presence of heavy metals in groundwater is found in 40 districts from 13 states, viz., Andhra Pradesh, Assam, Bihar, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal, and five blocks of Delhi. Ground water development is a ratio of the annual ground water extraction to the net annual ground water availability. It indicates the quantity of ground water available for use.

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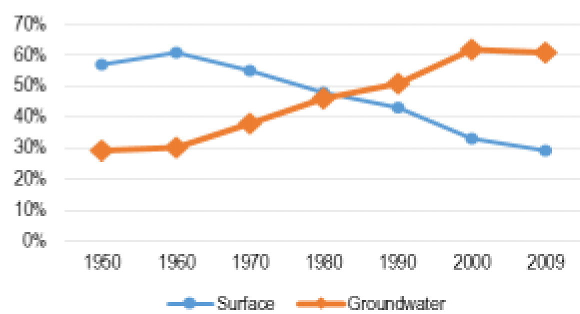
Table 2: Comparative status of level of ground water development in India in the past 20 years

Level of ground water development	Explanation	% of districts in 1995	% of districts in 2004	% of districts in 2009	% of districts in 2011
0-70% (Safe)	Areas which have ground water potential for development	92	73	72	71
70-90% (Semi-critical)	Areas where cautious ground water development is recommended	4	9	10	10
90-100% (Critical)	Areas which need intensive monitoring and evaluation for ground water development	1	4	4	4
>100% (Over-exploited)	Areas where future ground water development is linked with water conservation measures	3	14	14	15

Sources: Central Ground Water Board; PRS.

Of all these sources, ground water constitutes the largest share. Wells, including dug wells, shallow tube-wells and deep tube wells provide about 61.6% of water for irrigation, followed by canals with 24.5%. Over the years, there has been a decrease in surface water use and a continuous increase in ground water utilization for irrigation.

Figure : Increase in ground water utilization for irrigation



The dependence of irrigation on ground water increased with the onset of the Green Revolution, which depended on intensive use of inputs such as water and fertilizers to boost farm production. Incentives such as credit for irrigation equipment and subsidies for electricity supply have further worsened the situation.

It has been pointed out that nearly 60% of all districts in the country have issues related to either availability of ground water, or quality of ground water, or both.

Table 3: States and districts affected by geogenic contamination in groundwater

Geogenic contaminants	Number of affected states	Number of affected districts
Arsenic	10	68
Fluoride	20	276
Nitrate	21	387
Iron	24	297

Source: Central Ground Water Board; PRS.

Issues in Tackling Groundwater Contamination and Pollution

The first step towards evolving measures to prevent and cure groundwater quality deterioration is generating reliable and accurate information through water quality monitoring (WQM) to understand the actual source/cause, type and level of contamination. However, there are a few observation stations in the country that cover all the essential parameters for water quality and hence the data obtained are not decisive on the water quality status. Secondly, WQM involve expensive and sophisticated equipments that are difficult to operate and maintain and require substantial expertise in collecting, analyzing and managing data. Since water technology is still not advanced in India, it is very likely that the available data is less reliable. The existing methodology for WQM is inadequate to identify the various sources of pollution. Integration of data on water quality with data on water supplies, which is very important from the point of view of assessing water availability for meeting various social, economic and environmental objectives, is hardly done. And finally, in the absence of any stringent norms on water quality testing, results can change across agencies depending on sampling procedure, time of testing, and testing instruments and procedure.

Economic Valuation of Ground Water

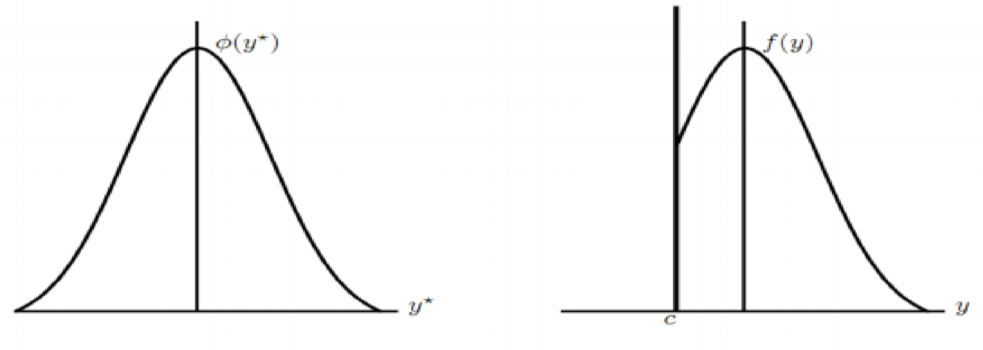
Since the 1960s economists have developed a variety of techniques for assessing the value of nonmarket goods and services, not priced and traded in markets. While most applications are to natural resources and environmental assets, the concepts and methods of nonmarket valuation extend to a range ofgoods not usually traded in markets. The ability to assign values to such goods and services has improved the accuracy of benefit-cost analysis. Inclusion of economic values for some important (and previously ignored) classes of environmental services enables benefit-cost assessments to reflect more fully the consequences of natural resource policies and regulations. The first application of techniques developed specifically for valuing nonmarketed commodities involved the travel cost method (TCM), Hotelling proposed in 1946 as a means of valuing visits to national parks. The travel cost method, in its numerous variants, has been used extensively to assess the value of a commodity used directly by the consumer, namely outdoor recreation. Refinements of the travel cost method and the development of new techniques, such as the contingent valuation method (CVM) and hedonic price method (HPM)In the Contingent Valuation (CV) survey, the respondents are provided with this information directly, and they are asked to choose how much they would pay for groundwater protection. In the Choice Experiment (CE) survey the respondents are asked to choose between alternatives where the levels of drinking water quality, surface water quality and price are varied systematically.

In the contingent valuation literature, Ordinary Least Squares (OLS) regressions are commonly used to estimate a WTP model from responses to an open-ended question. However, if the sample is censored it is not appropriate to use OLS. A censored value can be defined as follows. Let y^* be a normally distributed variable with mean μ and variance σ^2 . An observed variable is censored below if:

$$y = c \text{ if } y^* < c \text{ and } y = y^*$$

otherwise.where c is a given constant. This is illustrated in the following figure:

Figure: Normal Variable y* and Censored variable y



During the fieldwork, various zones in the city reported that tap water services were interrupted for at least two weeks before the interview. Given that a number of WTP observations have a zero value (protests for the unreliable water supply), the sample is censored. Therefore, the proper model for assessing the WTP is a Tobit model.

In the CE survey, the indicator levels are designed so as to approach the descript.

Table 1. WTP-results from CE and CV.

	CE	**CV**
Naturally clean groundwater	1853	698
Very good conditions for plant and animal life	1120	
Total	2973	

Groundwater governance framework

The main findings related to groundwater governance are:

Even though the 1998 National Water Policy (NWP) and the 2002 amended version do not have statutory status, and thus cannot be legally enforced, they are the outcome of intensive political discussions and so state governments could find them useful in developing their own water policies. Agriculture, energy, water supply, and many other sectoral policies influence groundwater use and pollution, but they are difficult to reform. It is clear that groundwater management falls under the jurisdiction of the states and to this effect the central government has circulated since 1970 a model groundwater bill. Regretfully, only a few states have formally adopted it. Nevertheless, the two main legal drawbacks (the resource being assumed to follow the right to land and the absence of groundwater legislation at the central level) have been sorted out by: The Supreme Court and High Court rulings have affirmed the government's right and obligation to protect groundwater under the right to life guaranteed by the Constitution.

Legislative and Policy Framework

This implies that state legislative assemblies can make laws on the subject. In order to provide broad guidelines to state governments to frame their own laws relating to sustainable water usage, the central government has published certain framework laws or model Bills. In 2011, the government published a Model Bill for Ground Water Management based on which states could choose to enact their laws. As recommended in this policy, the government published a National Water Framework Bill in 2013. The Model Bills and National Water Policy address the governance of ground water under the public trust doctrine.

Institutional Framework

Within the central government, the Ministry of Water Resources, River Development and Ganga Rejuvenation is responsible for the conservation and management of water in the country. The Ministry of Rural Development also implements certain programmes related to ground water management. In addition, the Ministry of Environment, Forests and Climate Change is partially responsible for the prevention and control of pollution, including water pollution, and ground water contamination. In addition, there are four major central institutions that address issues related to ground water.

Conclusions

The main conclusions of this study are: Large variation of acceptable risk levels in different sectors of society has been noted. The acceptable risk levels for contaminated sites are low compared to other types of risks, e.g. health risks to workers or residential health risks. The present Indian approach of comparing measured contaminant concentrations to guideline values, rather than quantification of the actual risk level, does not correspond very well to economic valuation of risk reduction. Risk should preferably be defined as a measure of lack of knowledge and its consequence, instead of as a frequency determined in a deterministic way. A comprehensive World Bank study concluded that high-level policy reform in the shape of regulatory measures, economic instruments, or tradable groundwater extraction rights is simply not a credible way forward. Taking quantitative and qualitative aspects together, it would appear that a total of 347 districts (59% of all districts in India) are vulnerable in terms of safe drinking water in India. This is a matter of serious concern, requiring a new approach.

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