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**FACTORS INFLUENCING FARMERS' WILLINGNESS TO
PROTECT GROUNDWATER FROM NONPOINT
SOURCES OF POLLUTION IN THE LOWER BHAVANI
RIVER BASIN, TAMIL NADU, INDIA**

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STRUCTURE OF PRESENTATION

- Importance of Groundwater Protection
- Objectives
- Methodology
- Study Locations
- Results
- Summary
- Conclusions



IMPORTANCE OF GROUNDWATER PROTECTION

- As a source of drinking water

In India, costs associated with mortality (in terms of avoided deaths) of water-borne diseases are estimated to be USD 3.1 to 8.3 billion in 1992 prices (Brandon and Hommann, 1995).

- Groundwater is the most important decentralised source of drinking water
- Quality of rural water supply sources is unprotected, unmonitored and unregulated



OBJECTIVES

To capture factors influencing

- (a) farmers' perceptions about groundwater quality,
- (b) farmers' willingness to protect groundwater, and
- (c) farmers' willingness to support local government to supply safe drinking water (demand for safe drinking water).



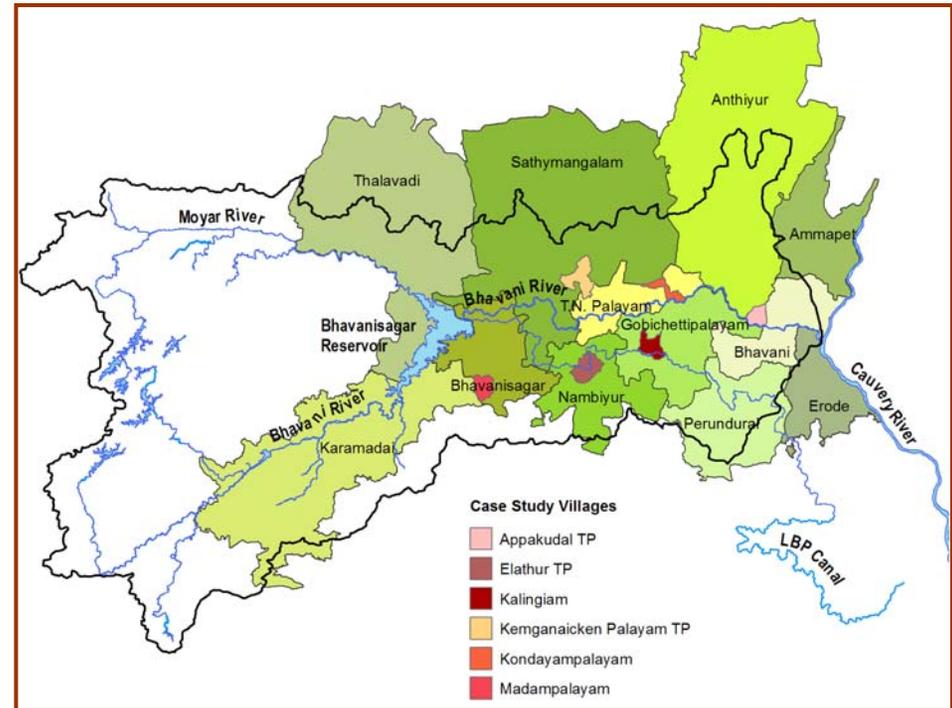
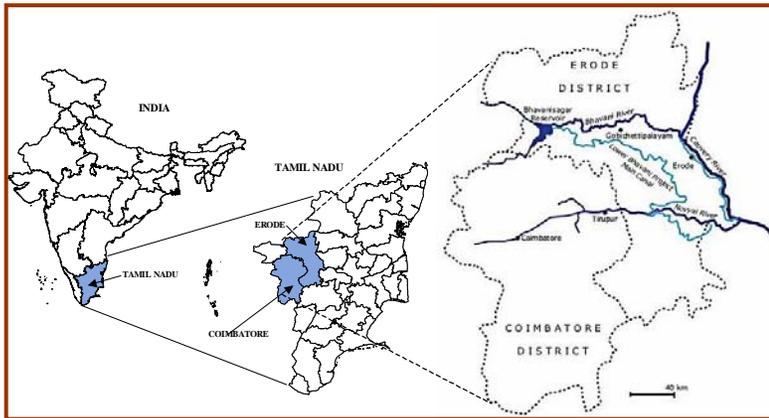
METHODOLOGY

- Collection and Analysis of Secondary Groundwater Quality Information
 - To identify nitrate affected villages in the basin
 - Source-wise, region-wise estimation of nitrogen load of the basin
- Collection of demographic information
- Primary Household Questionnaire Survey
 - 395 farm-households from 6 villages
 - Face-to-face interviews
 - Random sampling
- Estimation of econometric models (Binary Choice Probit and Multinomial Logit Estimation)



STUDY LOCATIONS

The Lower Bhavani River Basin, Tamil Nadu



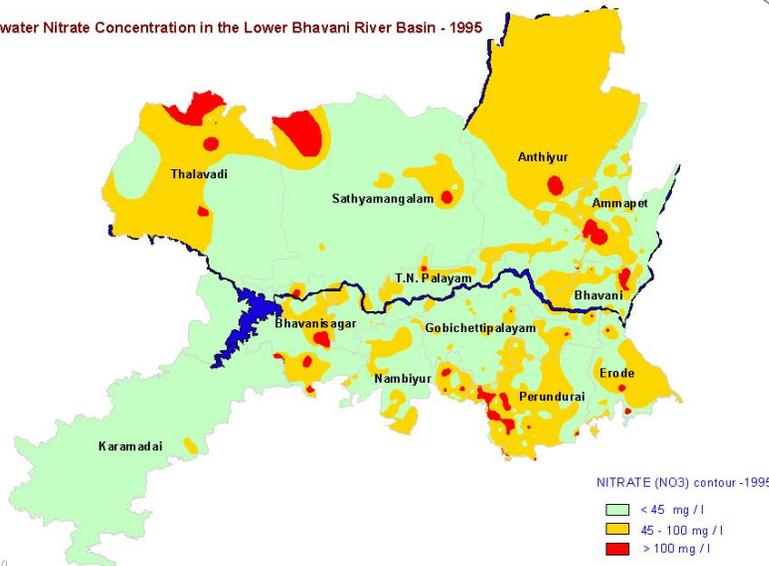
The Bhavani River is the second largest perennial river of Tamil Nadu and one of the most important tributaries of the Cauvery River



GROUNDWATER NITRATE CONCENTRATION IN THE LOWER BHAVANI RIVER BASIN

ECONOMICS OF AGRICULTURAL NONPOINT SOURCE WATER POLLUTION
- A Case Study of Groundwater Nitrate Pollution in the Lower Bhavani River Basin, Tamilnadu

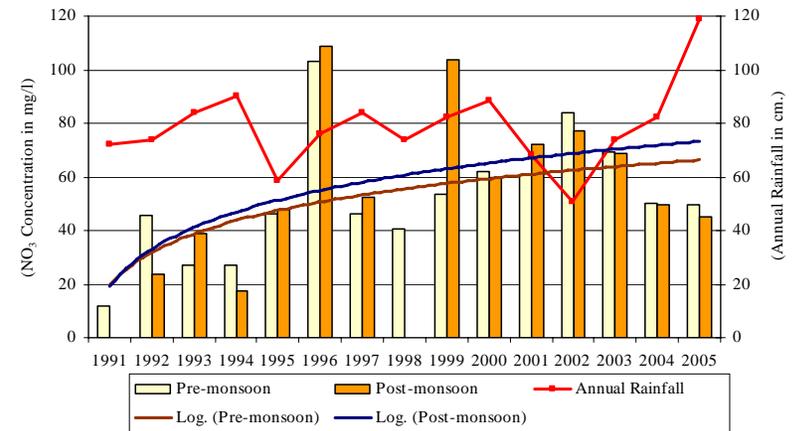
Groundwater Nitrate Concentration in the Lower Bhavani River Basin - 1995



Source : GIS / TWAD

- 33% of hand pump samples have nitrate concentration ≥ 50 mg/l and 9% of samples have nitrate concentration ≥ 100 mg/l

Temporal & Seasonal Variations of Average Groundwater Nitrate Concentration in the Study Villages (May 1991 to May 2005)

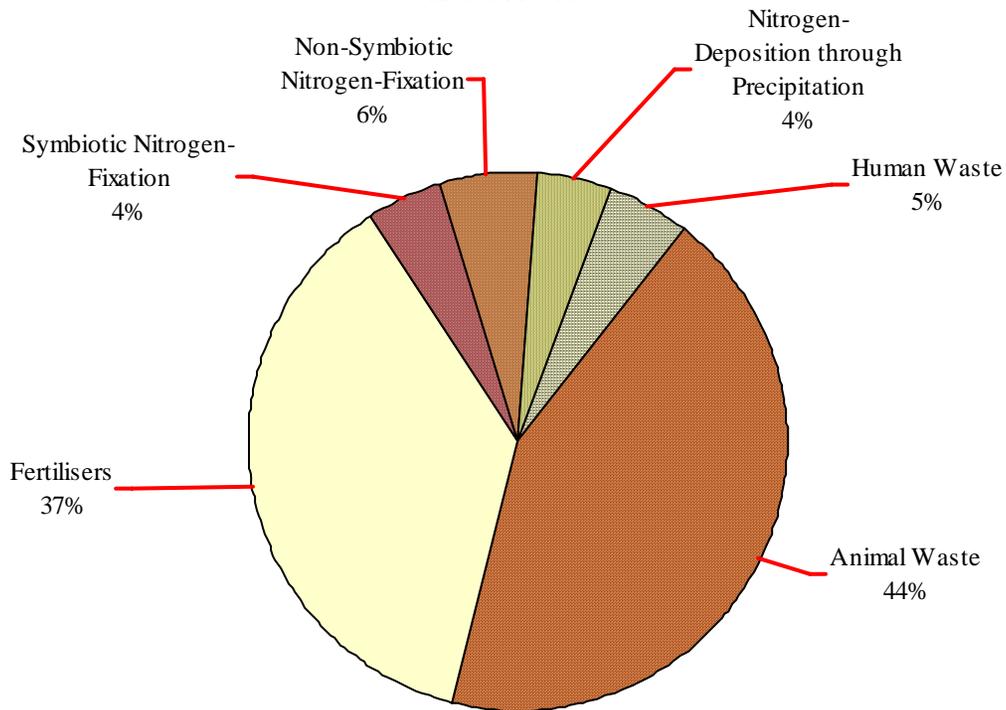


- Post-monsoon nitrate concentration is higher than pre-monsoon concentration
- Rainfall is not the only factor determining groundwater nitrate concentration



NITROGEN LOAD OF THE BASIN

Percentage Share of Sources in Nitrogen Load of the Lower Bhavani River Basin: 2001-02



Source: Mukherjee (2008)

- Estimated annual nitrate leachate in groundwater is 7.03 Kg. NO_3 /hectare
- Estimated stock of nitrate in aquifer varies from 123 to 134 Kg. NO_3 /hectare

Source: Mukherjee (2008)



SELECTION OF STUDY VILLAGES

Groundwater Nitrate Pollution in the Study Villages

Name of the Sample Location	Source(s) of Irrigation	NO ₃ Concentration (in mg/l)		% of observation having NO ₃ Concentration	
		Average	Range	>50 mg/l	> 100 mg/l
Kembanickenpalayam (KNP) (Town Panchayat)	Small dam, groundwater (open wells and bore wells) & river pumping	47.9	0 – 106	50	4.5
Madampalayam (MDP) (Village Panchayat)	Mostly rain fed and groundwater (open wells and deep bore wells)	128.7	0 – 320	77.3	54.5
Elathur (ELA) (Town Panchayat)	(LBP) canal and groundwater (open wells and deep bore wells)	34.5	1 – 120	23.1	11.5
Kalingiam (KAL) (Village Panchayat)	groundwater (open wells and deep bore wells)	24.3	0 – 134	13	4.3
Kondayampalayam (KDP) (Village Panchayat)	The Arakkankottai canal and groundwater (open wells and deep bore wells)	49.7	2.7 - 115	44	4
Appakoodal (APP) (Town Panchayat)	The Bhavani River and groundwater (open wells and deep bore wells)	50	10 – 105	53.8	3.8

Source: Census of India 2001; TWAD Board, Chennai and Primary Survey



RESULTS

- Farmers' Perceptions about Groundwater Quality,
- Factors Influencing Farmers' Willingness To Protect Groundwater, and
- Factors Influencing Farmers' Willingness To Support Local Government To Supply Safe Drinking Water (Demand for Safe Drinking Water).



FARMERS' PERCEPTIONS ABOUT GROUNDWATER QUALITY

Farmers' Perceptions about Groundwater Quality

Criteria	APP	ELA	KAL	KNP	KDP	MDP	ALL	F-stat
Do you think groundwater in your area is polluted? (GWQP) (1 if 'Yes', 0 otherwise)	0.43	0.25	0.08	0.44	0.11	0.40	0.28	9.5638*
Do you collect water due to quality your own drinking water source(s) is problematic? (CLCTWAT) (1 if 'Yes', 0 otherwise)	0.42	0.54	0.21	0.65	0.30	0.60	0.45	8.7589*
Do you purify/treat water after collection for drinking and cooking purposes? (PURIWATR) (1 if 'Yes', 0 otherwise)	0.18	0.26	0.08	0.34	0.27	0.28	0.24	3.2172*

Note: * - implies F-stat for mean equality test across the villages is significant at 0.01 level (2-tailed)

Source: Primary Survey



PERCEPTIONS ABOUT GROUNDWATER QUALITY

- Households, depending on their socio-economic characteristics, social- and information-network and the characteristics of the resource (groundwater), derive a subjective risk perceptions about their groundwater quality.
- Farmers' perceptions about groundwater quality vary across the villages and mimic the actual groundwater nitrate situation.
- Farmers' knowledge about impacts of agricultural practices on groundwater quality significantly influence their perceptions about groundwater quality.
- Farmers' knowledge about agricultural best management practices (BMPs) and their impacts on environment positively influences their perceptions about groundwater quality.



FACTORS INFLUENCING FARMERS' WILLINGNESS TO PROTECT GROUNDWATER

Factors Influencing Farmers' Willingness To Protect Groundwater

Since groundwater is a major source of drinking water in this area, it should be protected from agricultural chemicals (WTPGWQ)

$$\text{WTPGWQ} = \begin{cases} 1 & \text{if "Yes"} \\ 0 & \text{otherwise} \end{cases}$$

$$\text{Pr ob}(\text{WTPGWQ} = 1) = \Phi(x'\beta)$$

where, Φ is the cumulative distribution function of the standard normal distribution, and

$$x'\beta = \beta_0 + \beta_1 \text{age} + \beta_2 \text{edu} + \beta_3 \text{pclandh} + \beta_4 \text{eap} + \beta_5 \text{reside} + \beta_6 \text{bpercept} + \beta_7 \text{agriprac} \\ + \beta_8 \text{fmember} + \beta_9 \text{appl/ela} + \beta_{10} \text{knp/kal} + \beta_{11} \text{mdp/kdp}$$



WILLINGNESS TO PROTECT GROUNDWATER

- Farmers from comparatively high groundwater nitrate contaminated villages correctly perceive (subjective) their groundwater quality and they are willing to protect groundwater as compared to farmers from less affected villages.
- Farmers' knowledge about impacts of agricultural practices on groundwater quality significantly influences their perceptions about groundwater quality and willingness to protect groundwater.
- Memberships in social participatory institutions and sources of agricultural information significantly influence farmers' perceptions about groundwater quality and their willingness to protect groundwater.



FACTORS INFLUENCING FARMERS' WILLINGNESS TO SUPPORT LOCAL GOVERNMENT TO SUPPLY SAFE DRINKING WATER

Factors Influencing Farmers' Willingness To Support Local Government to Supply Safe Drinking Water

Since you collect drinking water due to quality of your own drinking water sources are problematic, will you support local government to supply water from alternative safe sources or to set up state-of-the-art water treatment plant, by contributing, supporting and taking initiative? (WTSGOVCW)

$$WTSGOVCW = \begin{cases} 1 & \text{if Yes} \\ 0 & \text{otherwise} \end{cases}$$

$$Pr ob(WTSGOVCW = 1) = \Phi(x'\beta)$$

where, Φ is the cumulative distribution function of the standard normal distribution, and

$$x'\beta = \beta_0 + \beta_1 age + \beta_2 edu + \beta_3 eap + \beta_4 pcincact + \beta_5 proenv + \beta_6 childn + \beta_7 puriwatr + \beta_8 gwqp + \beta_9 wtpgov + \beta_{10} dwqos + \beta_{11} dwqphp + \beta_{12} dwqsw + \beta_{13} sdwcw + \beta_{14} sdwohp + \beta_{15} sdwphp + \beta_{16} sdwssp + \beta_{17} sdwwti + \beta_{18} app / ela + \beta_{19} klp / knp + \beta_{20} kdp / mdp$$


WILLINGNESS TO SUPPORT LOCAL GOVERNMENT

- Demand for safe drinking water varies across the villages, based on the variations of socio-economic characteristics of the sample households and groundwater quality.
- Farmers from villages having higher concentration of groundwater nitrate, are willing to protect groundwater and reluctant to support local government.
- Irrespective of sources of drinking water, farmers are willing to support local government.
- Farmers' perceptions about their groundwater quality influence their willingness to support local government.



SUMMARY

- The issue of groundwater pollution from nonpoint sources is a growing concern not only for a relatively water scarce country like India, but also for water abundant countries around the world.
- The role of stakeholders and their voluntary participation in agro-environmental management in general and water resources conservation/management in particular is a new area of research, at least for a developing country like India.



CONCLUSIONS

- The decision to cooperate in collective action is an individual's decision where his/her economic motives, socio-economic background play a crucial role. Apart from individual specific factors, social connectivity (social capital) and factors like information/consultation sources play a crucial role in his/her decision.
- Depending on socio-economic characteristics, social- and information-network and the characteristics of the resource (alternative sources and quality of drinking water), farmers' derive a subjective risk assessment of their groundwater quality.
- Any groundwater quality protection programme from nonpoint sources of pollution should take into consideration the site characteristics and socio-economic characteristics of the stakeholders.
- Farmers' perceptions about groundwater quality influence their willingness to protect groundwater either individually or collectively.



Thank You

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