

## Summaries

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### **Environment development linkages: modelling a wetland system for ecological and economic value**

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The nature of human well-being derived from eco-system services depends on their availability as determined by the natural environment and demands for these services created by human populations. While the former is determined by physical and ecological factors, a series of behavioural and institutional factors determine the demands that humans make on eco-systems. Bringing the two sets of factors into a common analytical framework is important in order to understand better the linkages between ecological systems and economic value obtained from them and to devise appropriate policies for managing eco-systems.

However, such an undertaking raises methodological and conceptual problems. One instance of the emergence of such problems is in the context of interpreting values attached to such services. The literature on economic valuation typically focuses on use value in the short run, whether within or outside the market. Ecologists, however, are more concerned with ecological values which provides an underlying long-run notion of value in a more general sense. This paper investigates the nature of the link between these two aspects of value in the context of Keoladeo National Park, a wetland in Northern India, which has also been designated as a Ramsar site.

Section 2 places the issue in the context of the literature on economic valuation of wetlands and sets up a schematic representation of economic activity and the ecological structure of the Keoladeo National Park (KNP). The section notes that traditional approaches to economic value obtained from wetlands can be divided into static and dynamic ones. Static approaches that estimate consumers' or producers' surplus, assuming constancy of stocks of natural capital, ignore inter-temporal processes that determine ecological functioning. Alternatively, the production function approach can be incorporated into inter-temporal models of renewable resource use in which the ecological function affects the rate at which a renewable resource increases and thereby impacts off-take from it. Such

models depict long-run equilibrium of the resource in terms of values for effort put into extraction and resource stocks. Further, most models treat wetland areas as being a proxy for stocks and they are treated as having a similar impact on harvest rates as the amount of effort put in. This paper argues that a distinction needs to be made between short-run factors (such as effort) impacting the accrual of value utility or income from wetlands or other eco-systems and the longer-run slowly changing factors (such as area) that impact ecological functioning of eco-systems and well-being accruing from them. The latter are studied better by modelling ecological aspects of the system and using scenario analysis. We illustrate this in the context of amenity value accruing from the KNP.

Section 3 gives a brief overview of the national park being studied and its ecological characteristics. Sections 4 and 5 set up a dynamic simulation model to study alternative long-run scenarios with respect to ecological health and the resulting economic value derived from the park under alternative scenarios. These scenarios are extrapolated on the basis of a model structure linking aspects of the park's ecology through equations derived from past data and observation. The dynamic model is divided into modules to capture the effect of driving variables, exogenous pressures and other significant ecological variables on 'state variables', water storage, biomass, birds and, subsequently, income derived from the park. Relationships between different variables derived from historical data and information are used to set up alternative scenarios that simulate the effect of changes in key variables which capture the influence of exogenous factors. Important among them are decrease in water inflow into the park due to increased requirements of agriculture in the catchment and a change in indices of ecological diversity. In this section, we also report results from an alternative approach used to estimate economic value through the setting up of travel cost-based demand functions for tourism-related services.

Section 6 derives conclusions obtained from a study of the scenarios and the linkages between economic and ecological value. The simulations point towards a critical dependence of economic value (direct and indirect income derived from the park) on ecological health indices. Elasticities obtained vary from 0.6, 0.7 to 1.5 or even 1.7 in two scenarios. However, as biotic pressure increases and the wetland becomes less attractive as an eco-system, the values of the elasticities decrease to a range varying from 0.04 to 0.124. A non-linearity is to be seen in the degree of impact of an increase in ecological health indices on tourist traffic.

Benefits to be had from improved maintenance for ecological conservation are more per unit of effort at higher levels of conservation. Simultaneously, results from a conventional travel cost model reveal low elasticities with respect to costs incurred by visitors. Together, these results indicate:

- with the present profile of visitors to KNP, visitation rates are not responsive to private costs incurred;
- however, direct and indirect income obtained from the park is more responsive to ecological health indices, measured as given above;

- this responsiveness or elasticity with respect to ecological health is more at higher values of the indices, indicating thereby that once efforts at conservation increase attractiveness of the park above a certain level, the impact may be cumulative and returns in terms of income may rise more than proportionately.

## **Economic policy instruments for controlling vehicular air pollution**

RITA PANDEY

As the trends in air quality in most Indian cities show deterioration, there is a general emphasis on identifying and adopting measures that are more efficient in controlling the continuing deterioration of the environment than those which have been tried so far in the country. This has focussed attention on more innovative approaches, such as economic instruments. Estimates indicate that health incidences and the corresponding cost of air pollution in India are the highest in Delhi. As the transport sector is the largest contributor to air pollution in Delhi, this paper assesses the feasibility of fiscal measures to contain emissions from automobiles in Delhi.

In this paper a number of technological options have been evaluated for controlling air pollution in Delhi. These options include conversion of petrol and diesel powered vehicles to Compressed Natural Gas (CNG) or switching to new CNG vehicles; switching to four stroke two- and three-wheeler vehicles; retrofitting (electronic ignition system, leaner carburetor, continuously regenerating trap (CRT) and catalytic converter (CAT)); and periodic inspection and maintenance. These technological options have been analysed quantitatively according to their effectiveness in emission reduction and associated net costs per weighted ton of emission reduction. Analysis of emissions of both petrol and diesel powered passenger cars is also undertaken with a view to identifying measures to internalise the cost of emissions from diesel powered cars.

The analysis in the paper identifies a number of technical options that could be win-win solutions. The analysis also brings out that there is a case for the adoption of fiscal measures to contain emissions from automobiles to improve the environmental quality in Delhi. In order to induce motorists to adopt technological options the paper suggests the following measures: (1) An annual 'emissions' tax based on the average damage due to emissions of different types of vehicles should be levied.

Vehicles running on CNG should be exempt from the annual 'emissions' tax. (2) Owing to low utilisation rate of school buses, CNG retrofitment does not appear to be a cost-effective option for them. This paper recommends a subsidy for conversion of school buses to CNG. (3) Higher excise duty on diesel powered passenger cars coupled with an annual 'emissions' tax. (4) Government funding for further research and development of CRT technology for making it commercially viable.

## **Cost–benefit analysis of cleaning the Ganges: some emerging environment and development issues**

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There are multiple benefits from cleaning rivers, the most important fresh water resources on the globe. Cleaning of the Ganges, the most important river in India, provides benefits to people who stay near the river or visit the river in the form of recreation and health benefits that are called user benefits. Also it provides benefits to Indians and foreigners who are not visiting the river but gain welfare by merely knowing that the Ganges is clean. These are known as non-user benefits arising out of people's preferences for the bio-diversity the Ganges supports, altruistic view about the welfare of fellow citizens living in the river basin, and the religious significance of the river. The other beneficiaries from cleaning the Ganges include fishermen (increased fish production), farmers (irrigation and fertilizer benefits), and unskilled labourers (employment).

The Ganga Action Plan (GAP) with the objective of achieving the bathing water quality throughout the river is an example of how environmental federalism works in a federal country. The central and three provincial governments and the private sector in India share the cost of GAP. The estimates of investment cost and operation and maintenance costs of the GAP at 1995–1996 prices during the period 1985–1986 to 1996–1997 incurred by the government are respectively given as Rs. 7,657.37 million and Rs. 480.26 million. The annual cost of effluent treatment by the water polluting industries in the Gangetic basin is estimated as Rs. 370.11 million.

Estimates of user and non-user benefits of cleaning the Ganges to the Indian public are obtained using the contingent valuation method of valuation. Health benefits of river users are obtained using cost of illness method and using survey data of river users. Irrigation and fertilizer

benefits to farmers are obtained using the data from the farm household survey. However, fisheries benefits could not be estimated due to lack of data. The social cost–benefit analysis of the program to clean the Ganges shows that it has net present benefits worth Rs. 4,147.51 million at 1995–1996 prices with a benefit–cost ratio of 1.68 at a 10 per cent rate of discount. Cleaning the Ganges benefits both rich and poor. Those receiving user and non-user benefits belong to higher income classes while the unskilled labourers, farmers, health beneficiaries, and fishermen belong to lower income classes in the Indian economy. If the income distribution effects of the GAP are taken in to account in the estimation of social benefits, the present value has increased to Rs. 5,696.26 with a benefit–cost ratio of 2.21.

## **Valuing health damages from water pollution in urban Delhi, India: a health production function approach**

PURNAMITA DASGUPTA

Water pollution affects human health in several ways. Ensuring adequate supplies of safe water is of paramount importance for health considerations. Among the major Indian metropolises Delhi has experienced the highest demographic growth during the past fifty years. Such rapid urbanization creates pressures for provision of adequate water supply of an acceptable standard.

Diarrhoeal diseases are endemic in Delhi, with the problem becoming particularly acute during the summer and monsoon months. Questions of both adequacy and quality of the water supply available to the household for drinking purposes have attained crucial importance in this setting. At the theoretical level, diarrhoeal diseases are directly attributable to the ingestion of contaminated water or food and its causes therefore involve both the household and the public sector as a provider of public goods such as water and sanitation services.

The present study conducts an objective assessment of the health damages incurred by urban households by adopting a health production function approach. A model for valuing the damages from contaminated water supplies, based on the theory of utility maximizing consumer behaviour was developed for estimating the probability of illness for a household. A household derives utility from the consumption of all non-health-related goods and leisure while deriving disutility due to illness. The time spent

ill is modelled as a function of the time spent on defensive activities and the household's exposure to contamination. The household maximizes its utility subject to a budget constraint. At the margin, the wage loss ( $w$ ) corresponding to the unit increase in time spent on defensive activities, must equal the net gains (in terms of non-health consumption expenditure and reduced sick time) from the increase in time spent on defensive activities.

The specification appropriate for the model is based on binary observed dependent variables and the model is estimated as a bivariate probit specification. The estimation provides an estimate for the predicted probability of observing illness in a household. This probability measure is subsequently used along with data on illness to derive treatment cost and the wage-loss arising from the illness. Thus, a measure of the opportunity cost of illness is obtained. The monetization of health losses borne by households reporting diarrhoeal illness provides a useful measure for valuing the benefits from improving water supplies. The results obtained on the cost of illness lead in turn to policy implications for the water sector.

The data for the estimation exercise were collected through a primary survey of 603 households in urban Delhi. To complement the dataset, water samples were also collected from the field and laboratory tested as an integral part of the study.

## **Comparing the cost effectiveness of market-based policy instruments versus regulation: the case of emission trading in an integrated steel plant in India**

RITA PANDEY AND GEETESH BHARDWAJ

There is a growing consensus amongst economist and policy makers that for the environmental policy to be effective there is a need to supplement the traditional command and control type of regulation with economic instruments. The main reasons for this move lie in the existing evidence on the growing levels of environmental degradation suggesting that the command and control type of regulation has not proved to be very effective in inducing the polluters to adopt pollution prevention and control and that the economic instruments are generally more cost effective. Intuitively, cost effectiveness results from lower total abatement costs through a shift of the burden of abatement from high to low cost abaters.

Tradable permits for pollution control is one such economic instrument. Tradable permit systems can be of two types. The first type is inter-plant trading which allows emission trading among existing plants in a specified geographical area. The second type is that of intra-plant trading which allows different discharge points of a large firm to trade emissions among themselves. The latter offers the firm the option of reducing pollution loads beyond discharge limits at one or more discharge points and crediting it to other discharge points so that the pre-determined level of environmental standards or pollution reduction is met at a lower cost. This study attempts to design an intra-firm emission trading scheme for suspended particulate matter (SPM) in an integrated steel plant in India. Specifically we examine the costs of meeting the target emission standard for SPM for stationary sources of SPM in a steel plant, under the current regulatory system and the system of emissions trading among the emission sources under the common ownership, using the bubble concept.

A conceptual model has been developed to examine the compliance costs under an intra-plant emission trading system for a non-uniformly mixed assimilative pollutant. The model incorporates the number of emission sources, the concentration of pollutants emitted at each source, the marginal cost of abatement for each source, the transfer coefficient that relates emission at each source with the impact on ambient air quality, and the desired ambient air quality target. The model is applied to an integrated steel plant in India. Results of this study demonstrate that the emission trading is more cost effective than the existing regulatory system. Further, intra-plant trades would result in 4.7 per cent saving to the plant while securing an improvement in ambient air quality in the studied geographical area. These point towards the need to implement intra-plant trading in identified integrated steel plants in India.