International Conference "Water, Environment, Energy and Society" (WEES–2009)
New Delhi, 12–16 January 2009

River Water Management: Policy Making and Public Intervention for Conservation of Water Quality and Quantity

Ramakrishna Nallathiga
Centre for Good Governance, Dr. MCR HRD IOA Campus
Road No. 25, Jubilee Hills,
Hyderabad - 500 033, INDIA
E-mail: krishnram_n@rediffmail.com; ramanallathiga@yahoo.co.uk

ABSTRACT: Water is a primary resource for several human activities, and rivers are a major source of water in several parts of India. River water management is an important area of natural resource management that crosses several disciplines, and in order to be effective, it requires public intervention through appropriate policy and institution. This paper first discusses the public intervention rationale and strategies, relevance of economic valuation and principles of policy making for river water management. Subsequently, the need for using this policymaking framework in the context of the critical state of Yamuna river water resource is discussed. The paper also emphasizes on a programmatic approach towards river water management using appropriate policy instruments for achieving the objectives.

Keywords: River Water Management, Water Pollution, Public Intervention, Economic Valuation, Institutional Mechanism.

INTRODUCTION

Environmental problems have been emerging across the world at various levels, to different extents and in different forms. Often, this is generally attributed to the rising human population, urbanization and economic activities. These exert pressure on environmental resources as well as result in the damages to eco-systems, upon both of which future human sustenance rests. Water resource is one such natural resource that has been coming under severe pressure, which prompts some social scientists to warn that in the coming years we may experience more wars on water at local to global levels. Riverine water resources, in particular, are increasingly becoming vulnerable to quantity decline and quality degradation due to human activities, more so in a country like India, which has as many as fourteen rivers and several cities alongside them. River water sources are increasingly coming under the threat of becoming carriers of water of extremely poor quality along several stretches, particularly along the major cities wherein the domestic and industrial wastewater enters them to a great degree.

River water uses pertain to quantitative and qualitative dimensions, but the exact quantum of them is highly diffused over space, time and users, rendering its' management complex. Although significant awareness about the state of river water has been built through concerted efforts of public, private and non-governmental organizations, the action required for the conservation of water resources has not been coming to that effect. Awareness, however, shall lead to discussion and debate concerning the issue, thereby, making people become vocal and strengthening public participation in decision-making. Therefore, even if reactionary, appropriate action has to stem from the relevant public agency through design and implementation of public policy to conserve river water. Essentially, public intervention becomes necessary when the problem domain is spread across various sections of society, disciplines of study and administering agencies.

River water resources around the world have been developed and managed for centuries to control volatile supplies of water in order to meet the demands for water quality, quantity and reliability over time (Loucks *et al.,* 1981). However, river water management calls for setting up of sound institutions and policies in order to achieve these goals. Here, both the setting up of appropriate institution (or, public intervention) and policy making assume greater importance in water resource management. With this emphasis, this paper sets out the rationale for such public institution and policy, discusses its operational principles as well as strategy and performs a case examination of the Yamuna river water. Therefore, I set out the rationale for policy based public intervention first, discuss the strategies of policy formulation next, discuss the importance of economic valuation and economic instruments in the context of policy making, and, finally, the context for management of river Yamuna water as well as the possible approach are discussed.

RATIONALE FOR PUBLIC INTERVENTION

In the case of vast subject like river water management, the concerted efforts of an organization are more fruitful than piecemeal efforts of individuals or small agencies. Although independent actions of individuals can make some difference, public intervention and policy are more effective than action at individual level for various reasons:

- First, most of the resource management problems are due to the public goods nature of environmental resources and the associated externality problems i.e., resources are shared by several and their consumption leads to some unintended effects. In the case of common property resources, in particular, externality, free ridership, and disincentives all lead to misuse of resources rather than their optimal use. Under such conditions, no incentives exist for individuals to organize their actions to avoid or minimize the externality effects of their actions. This lack of incentives may arise from institutional constraints or economic rationality.
- Second, the regulation of use and maintenance of resources as a trustee of planet earth and its eco-systems is desirable and a lack of it, quite often, leads to non-compliant or free-riding behaviour, which, in turn, exacerbates the resource degradation and decline, resulting in what is popularly known as 'Tragedy of Commons'. Therefore, sustainable resource use and management require policy making for conservation, monitoring of resources and ensuring the compliance from the behavioural changes brought-in. An exception is when monitoring and compliance are either costly or not practical, in which case getting a correct regime of property rights of environmental resource use has theoretical possibility of delivering better, given the risk of high establishment costs of monitoring (Aggarwal, 2002).
- Third, the conflicts among various user groups, over space and time, and the domination of a few can also have an adverse effect on the distribution of water resources and their equitable use. The consumptive uses (e.g., drinking and irrigation) may prevail over non-consumptive uses of river (e.g., recreation and fishing), making the wholesome value of the resource less than its potential. However, problematic situations also occur when non-consumptive uses lower or interfere with the value of water, impairing its use by others. Although upstream areas are better suited for water quality improvement, they lack incentives for action on them as the costs are not borne by down stream areas.

STRATEGIES FOR POLICY FORMULATION

When it comes to the formulation of policy in the case of river water, a multitude of factors comes in to picture. Often, policy maker is confronted by the various aspects of water management, complementing and conflicting, to be covered by the policy. Instead of allowing such confusion prevail, the policy maker needs to understand the body of policy making in order to formulate strategies. To formulate strategies, policy maker needs to pose few questions first pertaining to effectiveness, goals, monitoring, evaluation, and review of policy, which are discussed hereunder. Here, public participation of various forms is essential at all levels. The body of policy making consists of (Stonehouse *et al.,* 1997):

- Formulation of goals and objectives
- Analysis and Design of strategies
- Monitoring and Review of outcomes.

Goals

Goals are possible questions that the policy maker is concerned about in the policy. Water resources management has physico-chemical, engineering, biological, socio-economic, and even psychological dimensions. Often, professionals in these disciplines pose questions. However, given the constraints of resource scarcity, only few of these questions could be stated as goals of the policy. While setting goals, it is important to give attention to whether some questions have already been covered by other policies in order to avoid confusion that the policy may bring out. Further, a goal that transcends more than one discipline will be more effective than the one which is narrowed to a discipline. However, it has to be taken with caution that the goal is not too generic, as it becomes more difficult to assess its effectiveness at a later stage. Hence, the goal needs to transcend one discipline, but shall remain focused in structure. When there are multiple goals, they need to be prioritized to identify the key goal (s) that should be addressed first. Such prioritization can be done using various operations research methods. Finally, goals should not overlap or counteract each other, if so, some conflict resolution mechanism or goal priority setting needs to be resorted. *In the case of water resources policy, often improvement in water quality or quantity with improvement in net social payoffs is the common goal.*

Effectiveness

The effectiveness of policy will be more when it is made with little or no ambiguity i.e., when it is well specified and clearly stated. Besides statement, the effectiveness of policy is also determined by the understanding of the operational system (monitoring, evaluation, implementation, and taskforce), and there might be some inherent problems that necessitate very different approach. For example, the control of point Vs non-point source pollution (Baumol and Oates, 1975). When controlling of one or a few pollutants based on specific and identifiable sources of pollution, mostly based on the regulatory policy instruments and supplemented by litigation and penalties, is the policy objective, it is effective in case of point source pollution; and it is more difficult to do so in case of non-point source pollution. River water is confronted by both point and non-point source pollutants. Hence, the policy shall target only one of them first in order to make it effective to control water pollution. Further, the policy effectiveness can also be judged based upon how well the net social payoffs are maximized. This entails inclusion of any onsite (or private) benefits and costs, as well as offsite (or public) benefits and costs, of abatement policies. Moreover, in addition to increasing net payoffs, policy goals may be set to include attainment of social equity, societal acceptability, and administrative feasibility.

Monitoring

The issue of monitoring relates to the capacity to enforce and measure the effectiveness of the policy, which renders a pragmatic dimension to policy making. The choice of policy making also depends on the strength of monitoring. Policies that involve monitoring of pollutant in trace amounts requires considerable equipment and effort, and thus, increase the cost; whereas, the measurement of a more common representative pollutant avoids it. A typical example is reducing trace metal pollutants in water. Policy to control them would require monitoring on a large scale across the river water and its analysis, whereas the policy that aims at reduction in a parameter like BOD requires measurement at regular intervals and, thus, can be monitored effectively.

Evaluation

Evaluation refers to the assessment of policy intervention in tangible/deducible terms, so as to decide whether the policy is efficient and also economically sound. Evaluation is necessary because, public policy implementation involves public investments to be made in monitoring and execution. Benefit-cost analysis is widely used for evaluation of projects, plans, and recently policies (Chichilinsky, 1997). Thus, measurement of benefits and costs (both, onsite and offsite) becomes crucial in identifying whether the policy is effective in attainment of stated goal. Targeting conservation or abatement situations that provide best use of scarce funds (resources) also requires public benefits be carefully identified and measured for each situation. This, in turn, entails evaluation of a number of different physico-chemical, engineering and socio-economic variables using a comprehensive methodology with multidisciplinary approaches (Stonehouse *et al.,* 1997).

ECONOMIC VALUATION

An important aspect of strategy formulation is the availability of right kind of information relevant for policy and decision making with regard to water resource management. Policy makers and decision makers look at economic measures together with other technical or engineering measures before making appropriate choice. Therefore, measurement of benefits and costs of resources, both public and private, is important, which constitutes a separate discipline of economic valuation. Economic Valuation takes a careful approach towards the resource and the question of measurement in money terms; first, it undertakes a careful study of the services/ functions of rendered by the resource, and next the value of such services are assessed by various methods in literature (Figure 1 illustrates Taxonomy of values).

There is a wide range of literature on various methods of valuation of public goods (see Munasinghe, 1993), whereas private goods are measured either directly or indirectly using the prices existing in markets. Such valuation is also being used for resource accounting at the national/regional level and incorporated into GDP/ GNP measured by conventional economic accounting Country level practice of environmental accounting is explained well in Pearce (1985) and Das Gupta (1997), and a framework for India is discussed in Parikh *et al.* (1997). In principle, benefit-cost analysis of public policy shall prescribe adoption or rejection of such intervention for the conservation of resource. Some analysts prefer further extension of analysis to include sensitivity analysis and distribution analysis, which are certainly useful, as highly sensitive nature of distribution reverses results to indicate inherent inconsistencies, whereas, inequitable distribution, both spatially and cross-sectionally, may be unacceptable politically. Methods also exist for overcoming the equity and

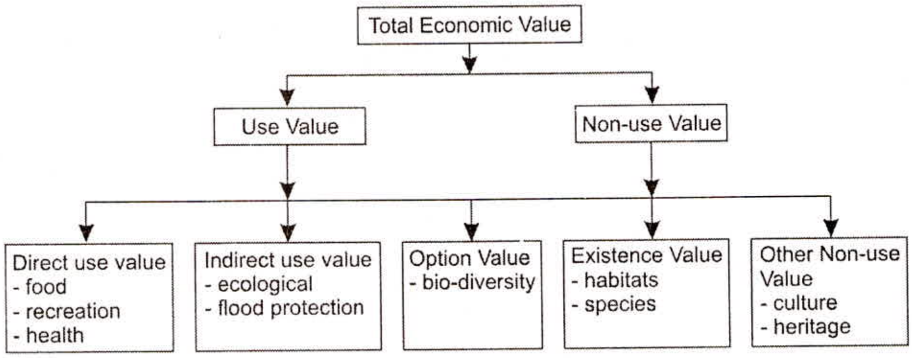

Fig. 1: Taxonomy of economic values

validity problems e.g., Kneese (1985) applies a regional sector model to an estuary bay for assessing damages to lay taxes).

While measuring benefits and costs, public benefits appear as formidable to identify and measure, more so, when public policies are aimed at improving status of water resources—qualitatively or quantitatively. This is because of many biophysical, engineering, and socio-economic attributes that affect public benefits form such improvement. The attributes include (Stonehouse *et al.,* 1997):

(a) Existing water quality, according to a well defined criteria prior to implementing abatement policy.
(b) Actual or planned uses of the water together with any standards or levels of quality associated with each use.
(c) The actual or potential number of users of water identified for each use.
(d) The extent of improvements in water quality made by the abatement policy.
(e) The value placed on the water quality improvements by the water using public, otherwise known as willingness of public to pay for water quality improvements.

ENVIRONMENTAL POLICY PRINCIPLES AND INSTRUMENTS

Principles

Public intervention becomes more needful when the current operations lack incentives to behave in an appropriate manner that shall be beneficial to society and also when there are no disincentives for doing so. For a polluting firm or city, there exists no incentive for treatment of wastewater and also there exists no disincentive for discharging it freely into river or stream. It occurs because there is a cost involved in treatment and subsequent disposal without any major problem. It may appear that it is obvious for the polluting firm/city to discharge effluents freely into river and pollute it. However, the riddle forms due to the nature of environmental gods as non-marketed goods (Baumol and Oates, 1975).

Here, the river water, or water in general, is a non-marketed good with free/open access to all, which renders it taken for granted. Hence, appropriate policy action at a broader level shall be to make it more of a marketed good. Baumol and Oates (1975) discuss various policy options for correcting such distortions in market. Pricing of water may be part of the solution, but not the only solution. The welfare implications to poor and the resistance of community need also to be considered. Hence, greater part of the market distortion can be dealt by creating incentives for right behaviour, such as levying charges on polluting firms/citizens.

This principle is chartered under "polluter pays" principle, which is widely adopted by several countries and international bodies. The design of charges, however, shall be based on the economic equilibrium of marginal abatement costs vis-à-vis marginal social benefits of abatement, so that the outcome behaviour is consistent with economic rationality (Cooper, 1981). Pricing of water shall rather more reflect the scarcity in terms of quantity of water, whereas, levying charges/ taxes shall be more appropriate to deal with qualitative degradation of water.

Policy Instruments

Taxation of public goods or bads is a policy option frequently resorted to in the case of environmental resource management. An alternative policy instrument commonly referred to in literature is permits/quotas. This is an alternative approach to the riddle due to non-marketed nature of environmental goods, which tries to establish market for these goods through institutions. This approach, takes into consideration of thresholds of resources quality and quantity, beyond which damages will take place and which may be irreversible in both technology and cost or reversible either after substantial amount of damage has taken place or involve huge costs. Thus, thresholds serve as an upper limit and can be set based on eco-toxicological or carrying capacity methods, or standards reflecting it can be set based upon several criteria identified.

Once the standards are laid down, it becomes easy for a policy maker to fix the pollution permits or quotas, which equal to the set limits to comply with standards. Subsequently, these quotas/permits can be made tradable in a market among polluters. This tradable permits mechanism fulfils the objective of environmental conservation in two ways: on one hand, it creates market for public bads such as pollution through the permits/quotas, on other hand it brings in incentives for rational behaviour on part of polluters to tradeoff the costs of pollution permits with abatement costs. An increasing demand for the permits makes them costly in the long run and thus abatement option becomes more acceptable option to firms.

CASE STUDY: YAMUNA RIVER WATER MANAGEMENT

Introduction

River Yamuna is one of the major rivers in India and also a major tributary to river Ganges, the largest river in India. Both of these rivers cater to the vital human needs of the states in North India. River Yamuna originates from Yamunotri in Himalayas to travel through the hill parts of Himachal Pradesh and Uttar Pradesh, and then passes through valley states of Haryana and Uttar Pradesh as well as the Delhi state before joining river Ganga at Allahabad. The population of the basin has grown from 51 million to 131 million at 2.4 per cent during 1950–1990 and Delhi, in particular, has grown at 4 per cent, while level of economic development in the basin is high and diverse (Narula *et al.,* 2001). Water use has risen from 1000 MCM to 4000 MCM during this period. River Yamuna has several important functions identifiable as below:

- Irrigation
- Drinking water
- Bathing water
- Fisheries
- Livestock use
- Navigation
- Aesthetics and Recreation
- Religion and Culture.

This classification of uses is analogous to the taxonomy of values identified by Munasinghe (1993) (see Figure 1). Irrigation is the major use with the net irrigated area in the basin has gone up from 47,000 sq km to 110,000 sq km during 1950–1990, although there has been a shift from traditional canal irrigation to ground water irrigation (which is replenished by river Yamuna and rains) (Narula *et al.,* 2001). Drinking water is the next most important use and the rising population discussed above reflects the rapid rise in domestic and drinking uses. Likewise, industrial use has also risen as a result of rapid rise in number of large and medium scale industries, which numbered to almost 10,000 by 1990s (Narula *et al.,* 2001). These uses are representatives of several functions that the river renders as a continuum of water. Besides acting as a supportive resource for use, river Yamuna also renders service as a sink by assimilating wastes. However, over time, river Yamuna lost several of its functions, which reduced it to almost a drain flowing through capital, thereby causing severe public health problems. In the Fifth State of India's Environment report of the Centre for Science and Environment, it was observed that the river has become more filthy, and it is a drain of waste water which chokes and dries up in summer. It further identifies that the major causes of river water pollution are urbanization, industrialization, withdrawal of water, agricultural runoff, and improper religious and social practices (CSE, 1999).

Water Quality Degradation in River Yamuna

Most of the water in the region is drawn from river Yamuna for various uses, predominantly for agriculture and drinking purposes, through various diverging canals in the upstream parts of the river basin. These uses draw good amount of water from river Yamuna. For example, the total water use in the capital, where drinking is the predominant use, was 1,027.84 mcm in 1992, which increased by almost 30% in three years to 1,330.04 mcm in 1995 (NEERI, 1997). At the same time, the total water use in the basin, where agriculture uses a majority of water, was 44,926 mcm in 1992, which rose to by 10% to 50,437 mcm in 1995 (NEERI, 1997). Such rapid rise in use by increasing drawal from river over years resulted in drastic reduction of river water to a level that the river cannot offer any services/functions.

An important observation to be made is the reduction in annual river water flow from 10 mcm/y to 5 mcm/y (CPCB 1978). The low self-purification capacity of the river Yamuna is due to the want of minimum flow in the river and discharge of heavy municipal and industrial pollution load emanating from Delhi. Even though Delhi constitutes only 2% of the catchment of the Yamuna basin, yet it contributes to about 80% of the pollution load. There are 16 drains which discharge treated and untreated waste water/sewage of Delhi into the Yamuna. The municipal sector is the main source of water pollution in terms of volume. Approximately 1,900 mld of waste water is discharged from the municipal sector and 320 mld from the industrial sector. The installed capacity for treatment is 1,270 mld. At the same time, the existing capacity for treatment is not up to the desired secondary treatment level. Thus, substantial quantity of untreated sewage and partially treated sewage is discharged into the Yamuna every day. The Najafgarh drain contributes 60% of total waste water and 45% of the total BOD load being discharged from Delhi into the Yamuna. The municipal waste water has increased from 960 mld in 1977 to 1,900 mld in 1997 (NEERI, 1997). The capacity for treatment has enhanced from 450 mld in 1977 to 1,270 mld in 1997.

The effluents flowing into the river Yamuna comprise of municipal and industrial wastes. The Central Pollution Control Board (CPCB) has been monitoring the water quality of the Yamuna at the upstream of Wazirabad and at Okhla. Upstream of Wazirabad, the Dissolved Oxygen (DO) level is 7.5 mg/l and Biochemical Oxygen Demand (BOD) level is 2.3 mg/l, whereas, downstream at Okhla, the DO level declines to 1.3 mg/l with the BOD at 16 mg/l, indicating considerable deterioration in water quality in the stretch due to discharge of sewage and industrial effluents (MoEF, 2003). The prescribed ambient water quality in terms of DO is 5 mg/l or above, and 3 mg/l or below in terms of BOD. The stretch between Wazirabad and Okhla is designated as bathing quality standard in terms of its water use.The coliform count at Wazirabad is 8,506/100 ml whereas at Okhla, it increases to 3,29,312/100 ml, as against the prescribed standard of 500/100 ml (MoEF, 2003).

Accompanied by this, there is an increase in the wastewater flows into river Yamuna. Industry is the largest polluter; strong effluents of high pollutant concentration are discharged into it, while also, agricultural farm return flows and livestock use constitute yet another major source of pollution. Wastewater discharges in the capital alone have increased from 745.03 mcm in 1992 to 835.34 mcm in 1995 (NEERI, 1997). The result is that the river no longer serves as a stream of water. The river clearly shows a declining trend of water quality measured on several parameters soon after it enters Delhi as shown in Table 1. The decline in river water flow and degradation of water quality of river flowing have effects varying from the loss of various services (including ecological services) rendered by the river in the stretch of NCT-Delhi to the negative effects on the public health due to contamination and spread of vector borne diseases.

Table 1: Water Quality in Polluted Stretch of River Yamuna

Location Parameter	*Talla (u/s Delhi)*	*Nizamuddin (Delhi)*	*Agra Canal (d/s Delhi)*
pH	8.2	7.6	7.6
DO	8.6	1.9	1.5
BOD	2.7	12.2	16.4
COD	25.6	50.2	60.9
TC	5878.0	319573.7	251568.0
FC	2529.3	220245.7	178326.0
TKN	1.1	919.0	13.4
WT	25.2	26.4	25.8
AMM	0.4	8.0	9.8

Source: MoEF (2003)

DO = Dissolved Oxygen, mg/l
FC = Fecal Foliform, no./100 ml
BOD = Biochemical Oxygen Demand, mg/l
TKN = Total Kjeldahal Nitrogen, mg/l
COD = Chemical Oxygen Demand mg/l
WT = Water Temperature, °C
TC = Total Coliform, no./100 ml
AMM = Ammonia, mg/l

The CPCB has also identified that the river flowing through capital has very low river flows and associated by it the water quality in the stretch is very poor for any direct use as evident in Table 2 by the class of existing water quality vis-à-vis desired water quality (CPCB, 1978). The board works out an ambitious project of Yamuna action plan on the similar lines of Ganga action plan. The focus, once again, is given to control of pollution by treatment of water, rather than, prevention of river water pollution.

Table 2: Water Quality in Polluted Stretch of River Yamuna

Polluted Stretch	*Existing Class of Water Quality*	*Desired Class of Water Quality*	*Critical Parameters*
Delhi to confluence with river Chambal	Partly D/E	C	DO, BOD, Coliform
City limits of Delhi, Mathura, and Agra	Partly D/E	C	DO, BOD, Coliform

Note: CPCB has adopted classification of river water quality by dividing river into few stretches (based upon criticality) and has designated best uses to them (quality below which means degradation/pollution): A—Drinking water source without conventional treatment, but after dis-infection; B—Outdoor bathing; C—Drinking water source with conventional treatment, but after dis-infection; D—Propagation of wild life; E—Irrigation, Industrial cooling and Waste disposal (the classification and criteria are shown in Table 3).

Table 3: Central Pollution Control Board (CPCB) Criteria for Designated Best Use of River Water

Parameter	*Measurement Unit*	*Threshold*	*Class A*	*Class B*	*Class C*	*Class D*	*Class E*
Dissolved Oxygen (DO)	mg/L	Min	6	5	4	4	
Bio-chemical Oxygen Demand (BOD)	mg/L	Max	2	3	3		
Total Coliform	MPN/100 mL	Max	50	500	5000		
PH			6.5–8.5	6.5–8.5	6–7	6.5–8.5	6.5–8.5
Free Ammonia	mg/L	Max				1.2	
Conductivity (μ)	mho/cm	Max					2250
Sodium Absorption Ratio		Max					26
Boron	mg/L	Max					2

Source: IWACO (1996), "Risk Assessment of the Yamuna River: Water Quality Monitoring Stations in India", Phase II, Government of India and Government of Netherlands, Rotterdam, cited in CSE (1999).

Policy Approach to River Water Management

The discussion on the state of river Yamuna points to the lack of effective public policy intervention with effective public participation. Certainly, a policy for the management of river water within the basin is completely lacking in practice. The current administrative structure, which divides the river in to stretches of respective administration of states, does not bring in co-operation in the management of river water, but leads to conflict between them.

The MoEF (2003) observed that the dry weather flow in the river Yamuna along Delhi is nearly zero. This has resulted in almost total depletion of the self cleansing capacity of the river of Wazirabad. Pollution in the Yamuna cannot be controlled fully unless a minimum flow is maintained in the river. It is mentionable that sewage treatment plants are designed for reducing the pollution in sewage to a certain economically achievable level only. The rest of the pollution is controlled by the dilution available in a water body. To maintain the water quality of the river within the bathing class standard, nearly 10 times the discharge of the fully treated municipal waste water is required.

The principal activities for controlling water pollution in Delhi are given below (MoEF 2003):

- Designing a strategy for augmentation of water resources in the upper stretches of Yamuna and for conserving water both in domestic and irrigation use (by Ministry of Environment & Forests/Governments of Uttar Pradesh/Haryana/Delhi).
- Maintaining minimum flow in the river Yamuna (by Central Water Commission/Upper Yamuna Board).
- Controlling pollution discharges in the upper stretches of the river Yamuna and the western Yamuna Canal (by Government of Haryana/Hâryana State Pollution Control Board).
- Construction of sewage treatment plants upstream of Delhi at Yamuna Nagar, Karnal, Panipat, & Sonepat, etc. (by Ministry of Environment & Forests/ Government of Haryana).
- Pumping of sewage to the full capacity of existing sewage treatment plants and regular maintenance of sewers and pumps (by Delhi Water Supply & Sewage Disposal Undertaking).
- Construction of sewage treatment plants to meet effluent treatment requirements (by Delhi Water Supply & Sewage Disposal Undertaking).
- Statutory regulation of ground water (by Ministry of Water Resources/Ground Water Board).

A river basin authority, therefore, needs to be set up by the Central government under the Central Water

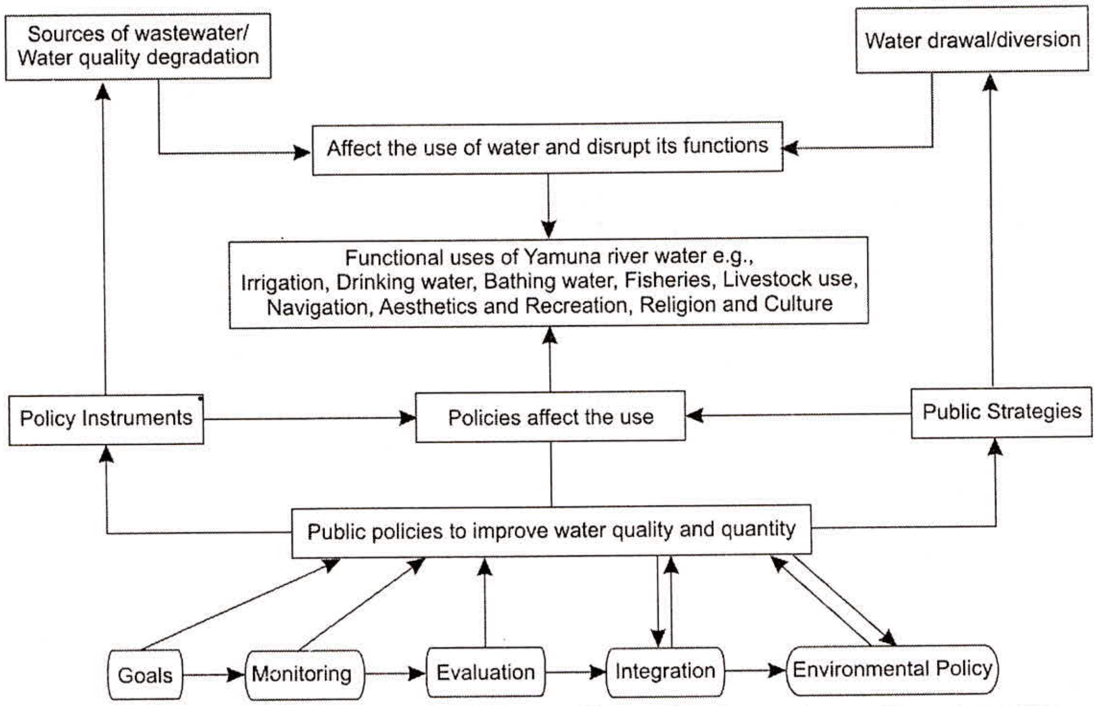

Fig. 2: Framework for public intervention toward improving river water quality and quantity

Commission to function independently to coordinate with State and Central government agencies in terms of ensuring the undertaking of the activities and monitoring the progress. The said river basin authority shall take care of the river water quality and quantity by taking a regional approach and use economic approaches to policy making with wider stakeholder participation based on the scheme outlined and discussed earlier. The authority shall, thus, formulate goals, and set objectives, evaluate various options for water management, and evaluate them and their alternatives in a benefit-cost analysis framework using economic valuation as a major tool to measure, implement action plan using various policy instruments to bring in effective action.

The key tasks for the authority shall thus be regular monitoring of water resources and review of implementation, and ensuring key stakeholder participation i.e., industry, non-governmental organization, local community and other representative groups, into the decision making at all levels. The public intervention will become true and meaningful with such action. The body and strategies of policy formulation, discussed earlier, can be applied in case of a complex task of water resources management in Yamuna river basin within the framework identified in Figure 2. The policy instruments identified above shall be used appropriately to distinguish the varying approach in case of point sources (e.g., industry) vis-à-vis non-point sources (e.g., agriculture), different taxation principles (e.g., pollution taxes or permits in case of industrial waste water, and pricing or taxation in case of domestic water consumption).

Once established, various options could be explored by the board of the authority, and economic, but efficient options to pool up resources and use them optimally in meeting the objectives shall be explored by it and implement with the help of various stakeholder groups. The setting up of such board in an integrated framework shall be a first step towards improving river water quality and quantity on part of government, while effective functioning of the board shall be brought in by various mechanisms. The present classification of river stretches based on use quality can be a first method of choice that could be expanded later on to include several other parameters.

REFERENCES

Agarwal, A. (1997). "The Challenge of the Balance: Environmental Economics in India". Proceedings of National Environmental and Economics Meeting, Centre for Science and Environment, New Delhi, India.

Baumol, W.J. and Oates, W.E. (1975). *Economics, Externalities, Public Outlays, and Quality of Life*. Prentice-Hall Publishers, New Jersey, USA

Chichilinisky, G. (1997). "The Costs and Benefits of Benefit-Cost Analysis". *Environment and Development Economics*, Vol. 2, pp. 195–221.

Cooper, C. (1981). *Economic Evaluation and the Environment*. Hoddee and Stoughton Publishing, UK.

CPCB [Central Pollution Control Board] (1978). *The Ganga basin, Part I: The Yamuna sub-basin*, Central Board for Prevention and Control of Water Pollution, New Delhi, India.

CSE (1999). *State of India's Environment: The Citizens' Fifth report—Part 1*. Anil Agarwal, Sunita Narain, and Srabani Sen (Eds). Centre for Science and Environment, New Delhi, India.

Das Gupta, N. (1997). *Environmental Accounting*, A.H. Wheeler & Co., New Delhi, India.

Kneese, A.V. (1985). *Economics and Environment*, Penguin Books, USA.

Lee, D.J. and Dinar, A. (1995). "Review of Integrated Approaches to River Basin Planning, Development and Management", *Policy Research Working Paper 1446*, The World Bank, Washington DC.

Loucks, D.P., Stedinger, J.R. and Haith, D.A. (1981). *Water Resource Systems Planning and Analysis*, Prentice Hall, Englewood Cliffs.

MoEF (2003). "White Paper on Water Pollution in Delhi", Ministry of Environment and Forests, Government of India, New Delhi (http://envfor.nic.in/divisions/cpoll/delpolln.html).

Munasinghe, M. (1993). "Environmental Economics and Sustainable Development". *World Bank Environment Paper No. 3*, The World Bank, Washington DC, USA.

Narula, K.K., Wendland, F., Bhujanga Rao, D.D. and Bansal, N.K. (2001). "Water resources development in the Yamuna river basin in India", *Journal of Environmental Studies and Policy* 4(1): 21–33.

Parikh, K., Parikh, J., Sharma, V.K. and Painuly, J.P. (1997). *Natural Resources Accounting: A framework for India*, Report prepared for Ministry of Environment and Forests, Indira Gandhi Institute of Development Research, Mumbai, India.

Pearce, D. (1985). *Blue Prints of Green Economy*, Earth scan Publishers, London, UK.

Stonehouse, P.D., Giraldiez, G. and van Vuurev, W. (1997). "Holistic policy approach to natural resource management and environmental care", *Journal of Soil and Water Conservation*, Vol. 52: 22–25.