Chapter -1

Introduction

*Water: A "Valuable" Natural Resource for the Well-being of Mankind*

Growth of economic activity and population all over the developing world has created concomitant pressure on available natural resources such as water and land, while making continuous demands on technological progress to meet the needs of the growing numbers. Such expansions in economic activity bear implications for the eco-system in two ways. Firstly, resources are required to meet the increasing demands of economic activity. Secondly, increasing demands are made on nature's role as a sink for absorbing wastes arising from enhanced economic activity.

Since the eco-system is a finite system, its ability to provide life-support is limited. This limit in turn has the potential for creating stress on natural resources. For example, in the specific case of water, water stress arises due to high density of population and the concentration of economic activities in a given region. The pollution of water also reduces the availability of water conforming to the desirable standards of environmental quality and thereby further contributes to the stress.

The material balance between the flow of resources from nature to fulfil the requirements of economic activity, and the back flow of wastes from the economy to nature, also has its implications regarding such stress. The growth of economic
activity leads to both an increase in the flow of resources from nature to economy and that of wastes from economy to nature. However, the rate of regeneration of water resource in any region is bounded and given exogenously by the hydrological cycle. The water absorbing ability of any waterbody in the eco-system is also limited. As a result an indefinite growth in economic activity unless driven by material and energy conserving technical change would lead to water stress and water pollution.

These facts in turn lead to the issue of sustainability. For renewable resources such as water, the requirement for sustainable use of the water resource would set a bound or limit on the rate of harvest of the resource. This rate of harvest should not exceed the rate of regeneration. The movement along the major pathway involved in the hydrological cycle is the inter-change of water between the earth’s surface and the atmosphere through the processes of evaporation and precipitation. The energy behind this movement is derived from the sun. Solar energy therefore provides the limit to the operation of the hydrological cycle. Since the sunlight reaching the earth’s surface, per square metre is a constant, it sets an upper bound on the quantum of precipitation possible within the hydrological cycle. The availability of fresh water, a renewable resource which is dependent on precipitation, would thus be limited and would in turn set a limit to sustainable use.

The differential pressure of population and economic activity in different regions of the world with varying availability of water has led to water stress of varying
degrees. The excessive use of a water body as a sink due to the waste flowing into it exceeding its waste absorbing ability degrades water and reduces the effective supply of water of a given standard. Water pollution thus contributes to the water stress in a region.

This in turn raises the question of how developments in technology can contribute towards relaxing the bio-physical limits imposed on economic processes in order to ensure a continuous upward movement of the index of economic well-being, given a situation of increasing numbers. For example, technology for storage of water through dams and barrages can augment the supply of fresh water in order to ease water stress to a certain extent. Technological developments have to take place with a view to relaxing the constraints imposed on economic activity by the ecological system.

The related question of whether environmental constraints impose limits on the development process has attracted a lot of debate. The popular conception of the response to this question has been in the affirmative. However, it has been pointed out by some economists that technical change accompanying economic growth reduces material usage as well as waste arising per unit of GDP produced in an economy.

Increasing industrialisation, urbanisation, and its corresponding pressures for infrastructure development, implies resource and energy intensive development
pathways for a typical developing economy, which in turn implies higher levels of pollution. Initially, industrialisation in developing countries leads to a rise in the overall energy intensity of the GDP of the economy, with a rising share of the secondary sector in the GDP. Urbanisation and fossil-fuel based infrastructural development adds further to the negative impacts on the environment by increasing the pollution intensity. At a later stage of development, the share of the service sector in the GDP increases while that of the industrial sector declines relatively. This change in the sectoral composition of output leads to a lowering of the pollution intensity.

Further, it is argued that as incomes rise there are changes in the preferences of individuals which is reflected in a shift towards cleaner technology and pressures for more stringent environmental laws and regulations, due to higher awareness for environmental quality. The ability to opt and pay for less resource-intensive and environment-friendly technology also increases at higher income levels. Thus, in terms of standard demand theory, environmental quality behaves as a normal good with a positive income effect¹.

Thus, there is essentially a threshold of development after which it is observed that preferences are shifting fast enough towards less resource intensive and cleaner technologies. In this context, increasing urbanisation and population growth would imply that reaching the cleaner phase would be delayed further in time. The

¹ The environmental Kuznets curve has been used to plot how environmental stress per unit of human activity changes as activity levels change over time.
threshold level of income or the peak point of environmental stress need not be
identical across countries, since the resource endowments, preference patterns and
access to technology would differ across countries.

At the global level there are differences in the stage of development among
economies. At present, the Indian economy is in the polluting phase of development.
However, in the backdrop of this macro picture, it is important to understand that
even within a society or economy, there are divergences in preferences and income
between the richer and poorer sections. Thus, the poor end up with less quantity and
poorer quality of the resource, in particular water in the present context. They are
thereby exposed to higher risks, even within a given society/economy, which is
characterised by a certain overall average income. In any given situation, the ability
to pay for augmentation of water supplies would be dependent on two factors: the
available man-made capital stock and the stage of development of a society. Under a
situation of water scarcity, typically the poorer sections of society would suffer more
from what is termed as conditions of water-stress.

Urban areas are hotspots of population concentration and economic activity.
Typically the poor are concentrated in settlements spread over a small land area,
with stress being created in terms of both access to water and disposal of solid and
liquid wastes. Set in this context, the necessity of providing all citizens with safe
drinking water supplies has held the prime position in all discussions relating to
water supplies, and rightfully so.
The relative success in providing cities with water generates corresponding volumes of wastewater by both the industrial and domestic sectors. As cities densify the total volumes of wastewater exceed the infiltration capacity of local soils and call for the creation of greater drainage capacities and sewerage systems. The wastewater flowing out of cities in turn pollutes downstream water resources and threatens their sustainability.

The availability of usable fresh water is impaired by the extent of water pollution at any given point in time and place as has been discussed earlier. At the global level, the amount of water polluted is almost as large as the amount of water which is used by human activity. Thus, a situation of increasing water pollution implies a simultaneous reduction in the amount of usable water, which is potentially available for supporting future economic activity.

While water pollution occurs due to a varied number of causes, some of the major causes contributing towards pollution of water bodies are as follows: microorganisms found in human and animal wastes, accelerated growth of algae causing reductions in the dissolved oxygen content of the water, nitrate contamination arising from human and fertiliser wastes, disposal of organic industrial wastes, chemicals and heavy metals. Thus, it becomes obvious that water pollution problems would vary in severity across countries according to their population densities, levels of economic activity, the nature and composition of their development strategies and policies including those for industrial and agricultural development. It is equally true
that in principle most of the water pollution problems can therefore be tackled through treatment of wastes before disposal into water and land masses. Thus, the extent and efficiency of the waste treatment system becomes a critical factor in managing water stress. This in turn is dependent on the ability of a particular economy to bear the costs of treatment of wastes.

In essence, the treatment of wastes for protecting water quality would thus become dependent on the stage of economic development itself. In a situation of increased water pollution, the well-being index of a society would fall either due to lower availability of the desirable quality of water or due to use of polluted water. In a poor society, the two factors could combine and water scarcity would lead to greater use of polluted water.

### Table 1.1 Withdrawal / Availability of Water (1995)

<table>
<thead>
<tr>
<th>Income Class (per capita per annum income in US$)</th>
<th>1 (&lt;10%)</th>
<th>2 (10-20%)</th>
<th>3 (20-40%)</th>
<th>4 (&gt;40%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Income ≤ 795</td>
<td>806.18</td>
<td>1265.89</td>
<td>957.70</td>
<td>238.07</td>
<td>3267.84</td>
</tr>
<tr>
<td>Lower-middle Income 796 – 2895</td>
<td>542.40</td>
<td>285.95</td>
<td>165.33</td>
<td>137.91</td>
<td>1131.59</td>
</tr>
<tr>
<td>Upper-middle Income 2896 – 8955</td>
<td>258.95</td>
<td>13.10</td>
<td>137.30</td>
<td>63.44</td>
<td>472.79</td>
</tr>
<tr>
<td>High Income ≥ 8956</td>
<td>108.44</td>
<td>514.41</td>
<td>181.25</td>
<td>19.74</td>
<td>823.84</td>
</tr>
<tr>
<td>Total</td>
<td>1721.97</td>
<td>2079.35</td>
<td>1441.58</td>
<td>459.16</td>
<td>5696.06</td>
</tr>
</tbody>
</table>

*Source: Comprehensive Assessment of the Freshwater Resources of the World. Stockholm Environment Institute, 1997.*

According to current estimates, over one-half of the world’s population falls in the
low income category and more than one third of those in this category face medium to high water stress, with water stress being defined as the ratio of withdrawal to availability of fresh water. Table 1.1 illustrates the relationship between income levels and water stress at the global level.

To sum up, when the rule of the optimal rate of harvesting defined loosely as the amount of people a given natural resource (such as a water body) can support is not adhered to, the resource availability per capita goes down, and two kinds of problems surface. On the one hand, the problem of inadequacy of the resource itself looms large and on the other hand, problems of waste disposal and consequent pollution surface.

As income per capita increases in a developing economy, the demands made on the natural system to absorb the fall-outs of enhanced economic activity increase while the per capita raw material availability (the natural resource in question) decreases. The demands on nature increase both in terms of its ability to act as a sink and its ability to regenerate and provide a pool of natural resources.

This brings into focus the concept of scarcity of the natural resource. Economists therefore seek to put a value on the effects of changes in a natural resource, rather than on the resource itself. The relevant question to address is "what would be the impact of a change in the eco-system on human well being?" This in turn leads to the entire debate on the issues of valuation of the eco-system.
Traditional microeconomics treated environmental effects as externalities of production or consumption. Since then the realisation has dawned that beyond a certain level of economic activity, limits on the assimilative and regenerative capacity of environmental resources and sinks, results in the need for such resources to be treated as a part of the overall macro-economic management framework. A complex input-output balancing problem emerges for the economy, giving rise to the need for defining new levels of activity and a corresponding new set of prices, that take into account these resource constraints.

Today, because of increasing competition among alternative demands for a finite resource, there is a growing perception of water as an economic good and as a tradable commodity. As human demands grow, so will the price of water and possibly food prices too will show associated increases, placing a heavy burden on the poorer strata of society. Poverty alleviation has already been linked in most countries among other factors, to the success of water policies, especially in terms of access to safe drinking water.

Framework of the Study

There are several dimensions to the development process in any given context. The above discussion on the linkages between the environment and development provides the background to the present topic of research. This study focuses on the impacts of urbanisation as an inherent aspect of the development process. Rapid urbanisation creates pressures for provision of adequate infrastructural services, such
as water supply, sanitation and waste disposal.

Given this background, the present study addresses the problem of water stress in terms of both water pollution and water scarcity, in the context of urbanisation. The thesis explores the preference patterns for environmental quality, as reflected in household preferences for safe and adequate water supplies. The study analyses the impacts of a change in the water supply situation for the household sector, by exploring the links between water availability, water borne disease and the valuation of water supplies by low-income households in urban Delhi.

The study involves two alternative damage assessment exercises to assess the impacts of both the quantity and quality of water being accessed and consumed by low-income households. Thus, issues related to both scarcity and water pollution are captured. An objective assessment of the damages is made by looking at the health costs borne by households while an alternative subjective assessment is made by conducting a contingent valuation exercise for the very same households. Subsequently, the study investigates the discrepancies between value judgements and actual damage assessment as revealed by the health costs approach, i.e. between the subjective and objective valuation results. This in turn leads to policy implications for water sector planning and policy.

The layout of the thesis is as follows. Chapter 2 summarises the scenario regarding water resource potential and water balance for India, while detailing the current
scenario in Delhi. Chapter 3 focuses on the water situation in Delhi specifically in the context of urban developmental issues. Chapter 4 takes a brief look at the theory of subjective valuation and reviews the past and present literature on the subject. It also presents the theory and rationale of the model adopted for the present piece of work. Chapter 5 reviews the literature on objective damage assessment and develops the model used in the present study. Chapter 6 presents the sampling frame along with the details of the rationale behind the data collection procedure. Chapter 7 details the results obtained from the empirical exercise of objective damage assessment, namely the health costs approach. Chapter 8 presents the empirical analysis of the subjective damage assessment exercise. While Chapter 9 compares the results emerging from the two alternative valuation exercises and computes the costs of water supplied from treatment plants, Chapter 10 discusses the important policy implications and conclusion emerging from the study.