DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES: A SUSTAINABLE APPROACH

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Abstract: Water is a life giving and life sustaining substance. It is one of those important resources which have catered to the needs of mankind from centuries right from the time of civilization. With the passage of time the use of water has grown exponentially and the availability has declined due to some natural and manmade factors. With the greater interference and ever growing greed, human race has certainly disturbed the ecological balance especially disrupting the hydrospheric balance. Being a developing nation with ever growing population, proper management of water resources is an issue of concern. Today if we see, there is no proper distribution of water in all the geographical locations. In some places, water is in abundance and gets flooded away while in some areas, draughts narrate their dry story. Also, at some places the water is present in abundance but is of no use. Therefore, for the optimum utilization of water, proper steps have to taken. Water crisis is a global issue and with the rise in population, urbanization, industrialization this problem has become more acute. Internationally, this issue is being dealt with serious concern as many bodies have been set up and laws have been put into place for water management, so, in this paper we would suggest some similar alternatives for India, to deal/cope with this problem. We would therefore, suggest ways and methods for the proper management of the water resources available and the development of the same, so that the problem of water crisis could be met and there would be a proper flow of water in the country.

To timely tackle this growing problem, sustainable model should be adopted. The paper would highlight the current status of water resources in the country, the problems related to water or the challenges faced by the water sector in India, the action plan proposed by the government and the strategies for proper water management both in rural and urban areas. Water is a resource which should be used in a sustainable manner as it is the elixir for mankind. In order to create a sustainable environment, the management of resources is very important and water is the most vital of all resources. Thus, to maintain its vitality, measures have to be taken which involves the development and management of this substance in the best possible manner for a healthy and sustainable environment.

Keywords: ecological balance, hydrospheric, optimum utilization, sustainable environment

INTRODUCTION

"If sustainable development is to mean anything, such development must be based on an appropriate understanding of the environment—an environment where knowledge of water resources is basic to virtually all endeavors." Report on Water Resources Assessment, WMO/UNESCO, 1991

Water sustains life and is therefore a basic human need and right without which human beings will not survive. A minimum of 20 to 40 liters of water per day per person is needed for drinking and basic hygiene. However, the world's freshwater resources face increasing demands from population growth, economic activity and, in some countries, improved standards of living. Competing demands and conflicts over rights of access occur amidst the fact that many people still don't have equal access to water and sanitation. It has been described as an impending water crisis.

According to the United Nations, access to safe drinking water and basic sanitation is essential for the achievement of the Millennium Development Goals (MDGs) (UN, 2006). It is a fundamental requirement for effective primary health care and a pre-condition for success in fighting poverty, hunger, child mortality, gender inequality and environmental damage.

RESEARCH PROBLEM

Water crisis is a major problem these days and therefore, some kind of framework must be adopted which is sustainable in nature for the management and development of water resources such that there is proper availability of water in all the areas of the country.

OBJECTIVES

(a) To study the reasons for water crisis in India (b) To suggest ways and methods for the proper management and development of water resources (c) To adopt a sustainable model for water resources management (d) To study the challenges faced by water sector in the country (e) To discuss government strategies and actions for the management of water resources.

RESEARCH METHODOLOGY

This research is explorative and **descriptive** in nature as the study is mostly based on the secondary data collected from various sources like books, journals, previous studies, newspapers etc.

MAJOR ISSUES FOR WATER RESOURCES MANAGEMENT

(a) Achieving the MDGs: improving access to safe water and sanitation, and cleaning up the environment (b) Anticipating the consequences of climate change(too much water, not enough water, and bigger variability) (c) Pollution of resources (d) Inadequate distribution of the water resources (e) Using private initiatives (f) Water is not sufficiently conserved. (g) The physical infrastructure is not in place or is poorly maintained. (h) There are not sufficient funds available for water management, and for the water and sanitation sector. (i) Government agencies are not doing what they are supposed to do in the water sector, and they lack the means and expertise to do what they should do. (j) Can the role of the government not be limited to creating an enabling environment and regulating the operators in the water sector? (k) How are water rights allocated? (l) Floods and droughts (m) What is the best level to deal with these issues: the national, regional or local level, the basin or the catchment?

In a more systematic way, we can point to the following processes or forces that make water an issue to deal with: (1) Economic growth, leading to more demand for water, and more pollution of the existing resources; (2) Population growth and increased urbanisation, leading to more consumption and pollution; (3) Concerns about the health of people and the environment; (4) Forces to increase the scale of production and to go towards bigger utilities and more modern equipment; (5) Government failure to deal adequately with the issues; (6) Market failure (In a number of cases related to water, the private sector has also not stepped in to solve the issues); (7) Increasing critique on the poor management of utilities and river basin organisations; (8) The search for achieving economic, environmental and social sustainability; and (9) Climate change

MANAGEMENT OF WATER RESOURCES

Basic Principles on Integrated Water Resources Management notes that: (a) Water resources are increasingly under pressure from population growth, economic activity and intensifying competition among users; (b) Water withdrawals have increased more than twice as fast as population growth and currently, one third of the world's population live in countries that experience medium to high water stress; (c) Pollution is further enhancing water scarcity by reducing water usability downstream; (d) Shortcomings in the management of water, a focus on developing new sources rather than managing existing ones better, and top-down sector approaches to water management result in uncoordinated development and management of the resource. (e) More and more development means greater impacts on the environment. (f) Current concerns about climate variability and climate change demand improved management of water resources to cope with more intense floods and droughts.

WHAT IS INTEGRATED WATER RESOURCES MANAGEMENT?

Integrated water resources management may be defined as a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives (Cap-Net, 2006). It is cross-sectoral and thereforein stark contrast to the traditional sectoral approach that has been adopted by many countries. It has been further broadened to incorporate participatory decision making of all stakeholders. IWRM is a paradigm shift. It departs from traditional approaches in three ways: (a) The multiple goals and objectives are crosscutting so that IWRM departs from the traditional sectoral approach. (b) Spatial focus is the river basin instead of single water courses; (c) Departure from narrow professional and political boundaries and perspectives and broadened to incorporate participatory decision making of all stakeholders (Inclusion versus exclusion)

The basis of IWRM is that there are a variety of uses of water resources which are interdependent. The failure to recognise interdependency coupled with unregulated use can lead to negative consequences of water resource wastage and in the long term to the un-sustainability of water resources.

Integrated management does not segregate water users or use a sectoral approach as is adopted in many countries. Rather, water allocation and management decisions consider the impact of each use on the other. In so doing, the crosscutting goals of social, economic and environmental sustainability are considered collectively, and cross-sectoral policies are examined to shape more coherent, coordinated policies. In short, IWRM recognises that water is a scarce natural resource, subject to many interdependencies in conveyance and use. The basic IWRM concept has been extended to incorporate participatory decision making and will be discussed in more detail in section 1.4, which deals with water management principles. Different user groups (farmers, communities, environmentalists, and others) may influence strategies for water resource development and management. That brings additional benefits, as informed users apply local self-regulation in relation to issues such as water conservation and catchments protection far more effectively than central regulation and surveillance can achieve. The term management is used in its broadest sense in that it highlights the need to not only focus on the development of water resources, but also consciously manage water development that ensures sustainable use for future generations (Cap-Net, GWP, 2005).

WATER MANAGEMENT FRAMEWORK

Integrated water resources management occurs in a holistic framework, dealing with (Jaspers, F; 2001): (a) All water (spatial); (b) All interests (social); (c) All stakeholders (participatory); (d) All levels (administrative); (e) All relevant disciplines (organisational); (f) Sustainability (in all senses: environmental, political, social, cultural, economic, financial and legal).

The framework is so broad, that the aim of IWRM is to discard from sector approaches and to create environmental, institutional, social, technical, and financial sustainability through the creation of a platform for government and stakeholders for planning and implementation, and to deal with conflicts of interests.

At the core of the water management framework is the treatment of water as an economic good as well as a social good, combined with decentralized management and delivery structures, greater reliance on pricing, and fuller participation by stakeholders (World Bank, 1993). All of these principles and issues will be discussed in more detail in the following section (1.4).

WATER MANAGEMENT PRINCIPLES

A decade and a half ago (at the International Conference on Water and the Environment, convened in Dublin, Ireland, in 1992), four main principles of water emerged that have become the cornerstones of subsequent water sector reform. Principle 1: Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

Principle 1

It highlights that water is critical to sustaining life. However, freshwater is a finite resource because the hydrological cycle on average yields a fixed quantity of water per period, and the quantity of water resources cannot be adjusted significantly by human actions. Furthermore, as a resource, water is paradoxically vulnerable to development and essential to development. Effective management of water resources, which seeks to ensure that the services that are in demand can be provided and sustained over time, requires a holistic approach that links social and economic development with the protection of natural ecosystems. Effective management does not dichotomise land and water uses, but sees the integration of these uses across the whole of a catchment area or river basin.

The integrated approach to management of water resources necessitates coordination of the range of human activities that create the demands for water, determine land uses and generate waterborne waste products. The principle also recognizes the catchment area or river basin as the logical unit for water resources management.

Principle 2

Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels. Where water is concerned, everyone is a stakeholder. Accordingly, water development and management should be based on a participatory approach which draws on the principle of a democratisation of decision making, and gives recognition to the input of multiple stakeholders including users, planners and policymakers at all levels.

Real participation only takes place when stakeholders are part of the decision-making process. This can occur directly when local communities come together to make water supply, water management and water use choices. Participation also occurs if democratically elected or otherwise accountable agencies or spokespersons can represent stakeholder groups; but even in this situation, access to information, consultation processes and opportunities to participate should also be there.

Principle 3

Women play a central part in the provision, management and safeguarding of water. It is widely acknowledged that women play a key role in the collection and safeguarding of water for domestic

use, and in many countries agricultural use. However, women are less instrumental than men in key areas like management, problem analysis and the decision-making processes related to water resources. Oftentimes, the marginalised role of women in water resources management can be traced to social and cultural traditions, which also vary between societies. There is strong evidence that water managers must consider that there is an urgent need to mainstream gender in integrated water resources management to achieve the goal of sustainable water use. Cap-Net and the Gender and Water Alliance (GWA) developed a tutorial for water managers in which is explained "Why Gender Matters". Some parts of the tutorial are covered in this section, but the manual users are advised to review the tutorial for a more complete understanding of the importance of having a gender-balanced approach in IWRM.

Principle 4

Water has an economic value in all its competing uses and should be recognised as an economic good as well as a social good. Water has a value as an economic good as well as a social good. Many past failures in IWRM are attributable to ignoring the full value of water. The maximum benefits from water resources cannot be derived if misperceptions about the value of water persist.

IMPORTANCE OF ECONOMIC AND FINANCIAL INSTRUMENTS FOR IWRM

IWRM seeks to improve the efficiency, sustainability and equity of water allocations, using a multi-disciplinary approach that recognises cultural diversity and socio-economic disparities inside and among societies. As such, IWRM will benefit from a sound use of economic and financial instruments that allow decision makers and water users to achieve those goals in a context of democratic decision making. In this context, the effectiveness of economic and financial instruments is dependent of context and historic and socio-economic conditions. These must always be carefully considered when recommending specific use of economic and financial instruments for IWRM.

Before defining the meaning of economic and water finance instruments, we first need to define the subject matter of economics and finance. In very simple terms, Economics refers mainly to situations in which a decision must be taken regarding the allocation of scarce resources among alternative uses. Economic analysis pays high attention to the efficiency of the allocation and to the distribution of assets and incomes behind and around the allocation process. Economic instruments for IWRM are rationing rules or incentives that influence the allocation and distribution of water or water-related assets and incomes. Water prices, water tariffs, water rights, and water policies and regulations are among the most important economic instruments.

Economic instruments are evaluated in terms of impacts on efficiency, equity and environmental outcomes for society. Finance, on the other hand, refers to specific actions taken by organisations or firms, which can be private or public, in order to maximize short or long-run returns to their assets and investments. It is assumed that the firm's goals are clear and the role of financial tools is to assure that resources are available (in time and space) for achieving these goals. Standard financial tools are those that are under control of the firm and that affect resource flows to achieve goals, like loans, shares and cash management. Financial tools are evaluated in terms of effectiveness to achieve stated goals by the firm. We may conclude that, as water is getting increasingly scarcer (both in quantity and quality), societies (also facing population growth, and the associated needs in terms of access to water, food production and industrial development) face increasing challenges for the allocation and distribution of water and water-related assets and incomes; and this triggers increasing interest in using economic and finance instruments.

IMPLEMENTING IWRM

While there has been progress in understanding the meaning of IWRM, its importance in the context of scarcity, acknowledgement of the main (Dublin) principles, and growing recognition of the need to use the right mix of economic and financial instruments, the actual implementation of IWRM is a challenging process. There are several roadblocks to implementing IWRM, starting with entrenched sectoral interests, professional insecurities and socio-cultural myths. These challenges are nevertheless not insurmountable. The barriers to the implementation of IWRM require an incremental approach to negotiating differences, cross-sectoral integration and instituting reforms (including policy and legal reforms).Conflicts among professionals working in the various sectors and a sense of vulnerability in adopting alternative approaches to water development and management that permeates professional groupings call for skills in negotiating win-win solutions and providing platforms for very different stakeholders to develop collaboration in implementing IWRM. These processes take time and require patience.

IWRM can only be successfully implemented if, among other reforms, there is a concerted effort to integrate perspectives and divergent interests of various water users in the management framework. Formal mechanisms and means of cooperation and information exchange should be established at

different levels to achieve cross-sectoral integration. Past informal attempts have not been successful, and a formalised set of mechanisms should have the effect of ensuring commitment at the various levels.

Existing institutional and legislative frameworks have not been entirely responsive to the demands and requirements for implementing IWRM. Implementing IWRM will therefore require reform at most stages in the water planning and management cycle. Although there is an urgent need for reform, these changes can only take place incrementally – some occurring immediately and others taking several years of planning and capacity building. It will involve creating an enabling environment, developing an institutional framework and management instruments for sustainable IWRM.

WATER CYCLE MANAGEMENT

It relates to all planning, strategy development, operational and tactical decisions to optimise the water cycle to satisfy human or environmental objectives.

The term is used in different organisations to mean management of a sub-set of the whole water cycle. In Australia, it has been adopted to encompass the fresh water to sewage disposal cycle.[1][2] Elsewhere, it refers to a more holistic view of the water cycle. Figure 1 explains the mechanism of water cycle management.

Many scientific and engineering disciplines may be involved in water cycle management: (a) Meteorology deals with predicting and measuring precipitation (b) Water resource management deals with the management overview of fresh water resources available in defined areas (c) Hydrology measures water flow in river and underground and predicts flow patterns using outputs from meteorology together with mathematical modelling of river and groundwater flow (d) Water engineering encompasses water treatment, Sewerage and sewage treatment amongst other disciplines providing clean water to homes and business and taking away contaminated water to be cleaned and made available for re-use. (e) Water conservation deals principally with techniques and practices for minimising use of water whilst achieving desired objectives. (f) Environmental monitoring provides information and trends on the impact of policies adopted in water cycle management on eco-systems and sensitive biota; for example the effects of reduced river flows on salmon spawning.

WHAT IS SUSTAINABILITY?

We will now discuss economic, social and environmental sustainability and total sustainability (when all three are achieved). Other definitions of sustainability have been developed, for example by the famous Brundlandt Commission, but our definition of total sustainability consists of economic, environmental and social sustainability. By environmental criteria, Brundlandt meant those concerned with the attainment of conditions for a sustainable exploitation of natural resources and the environmental assets valued by present and future generations. In the hard version, no resources should be used up; while in the soft version, they can be used if alternatives are made available (for example wind energy replacing natural oil). They would need to be properly conserved to see to it that future generations would not suffer from resource depletion.

The relationship between environmental objectives and the functioning of water systems can be very complex. In an institutional context where environmental objectives are given no real expression (either within institutions or among decision makers), the water sector will tend to reflect this situation and is very unlikely to produce positive environmental effects. For example, if the overall effect of economic policies is to favour rapid economic growth with intensive use of water-polluting production processes, as is presently the case, for example, in China, the water sector will only amplify this, since water will be allocated to the activities favoured by these industrialisation policies.

This general consideration notwithstanding, better water management can be useful for attaining environmental objectives under various circumstances. For example, improving water management is a very good way of dealing with the growing demand for this resource. The traditional government response to growing demand has been to construct water control and distribution infrastructure. These projects have usually had a negative environmental impact; so, better management is one option for avoiding or reducing effects of this kind.

Economic viability means the benefits are more than the implied costs. Financial sustainability means an activity can be carried on without the need for additional outside financing. Environmental sustainability is defined as a lasting solution that does not affect the environment negatively. Social sustainability would be a solution that is socially acceptable in a given social and cultural context. Finally, total sustainability would then be the combination of economic, financial, social and environmental sustainability.

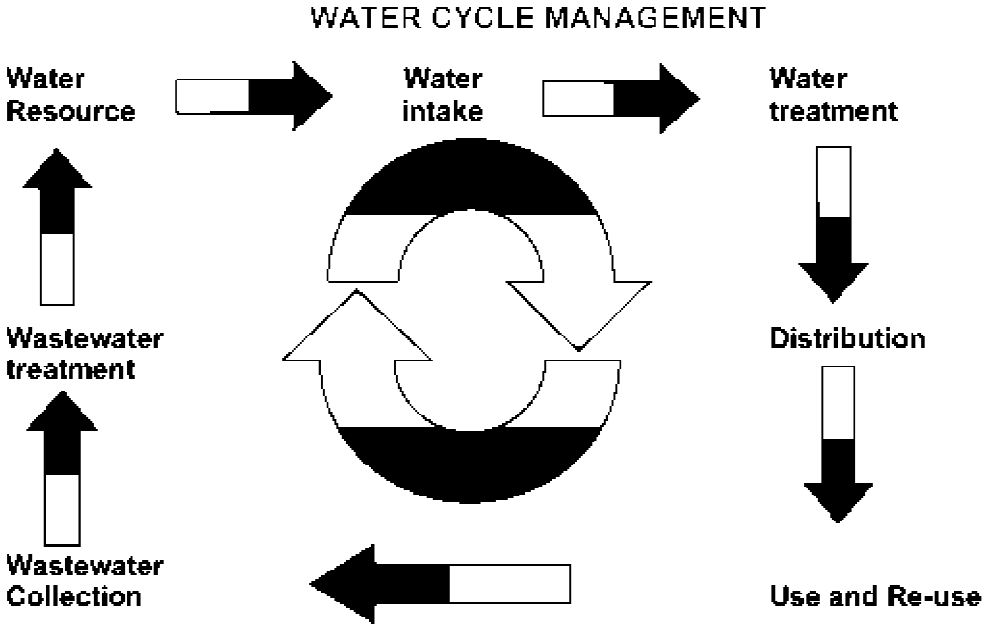

Figure 1: Showing the concept of water cycle management

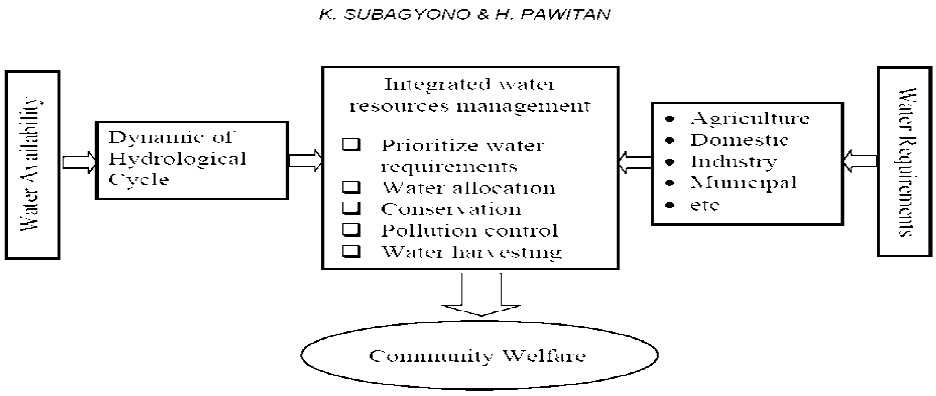

Figure 2: Diagram of integrated water resources management concept.

Rogers et al. (2002) conclude that water pricing is conceptually the simplest way to promote equity, efficiency and sustainability, but it may be one of the most difficult ones to implement politically.

ENVIRONMENTAL SUSTAINABILITY

By environmental criteria, we mean those concerned with the attainment of conditions for a sustainable exploitation of natural resources and the environmental assets valued by present and future generations to be properly conserved. The relationship between environmental objectives and the functioning of water systems can be very complex. In an institutional context where environmental objectives are given no real expression either within institutions or among decision makers, the water sector will tend to reflect this situation and is very unlikely to produce positive environmental effects. For example, if the overall effect of economic policies is to favour rapid economic growth with intensive use of contaminating processes, the water sector will only amplify this, since water will be allocated to the activities favoured by these policies.

SUSTAINABLE WATER MANAGEMENT

For an assessment of the ground water situation in a catchment, a definition of sustainable resource utilization is necessary as a starting point. In the following we will define it as a set of management practices, which avoids an irreversible or quasi-irreversible damage to the resource water and the natural resources depending on it such assoil and ecosystems. Such management allows the resource water to extend its service, including ecological service, over very long periods of time.

The abstraction from a ground water reservoir should in the long term not be larger than the long-term average recharge. The storage property of course allows temporary over pumping. As the quantities abstracted may be used consumptively (e.g. by evapotran-spiration in agriculture) and reduce the downstream flows, sustain-able management with respect to quantity requires that abstraction is limited to a fraction of recharge in order to guarantee a minimum availability of water in the downstream. These principles are violated in many aquifers all over the world.

Figure 2 shows the concept of Integrated Water Resource Management.

THE MODEL

The model given in figure 2 shows a theoretical framework for the sustainable water resource management. It is a two way process which bridges the gap between the water availability and the water requirement, thus, resulting in the community welfare. This is purely based on a sustainable approach as by integrated water resources management, proper flow of water is maintained for various purposes. The model is further explained in detail:

Water Availability

There are a number of water sources in our country, but the problem is that water from those sources is not made available to people for the use. This results in the crisis of water in spite of its great availability. Also, at some places the available water is not fir for use, thus, to overcome this problem, proper channels should be build so that water from water from all sources is accessible to the people. The second step should be to make the available water useful by its cleansing and other purification processes.

Integrated Water Resource Management

When the water is available then, a proper planning should be done about the use and allocation of that water for carrying out various activities like, how much water is to be used for generation of power, how much should be made available for drinking purpose, how much quantity is required for other activities etc. This planning would result in minimizing the wastage of water and also, would solve the problem of water crisis to some extent as the water would be supplied as per the needs of the people. For this some of the techniques can be adopted like:

Prioritize Water Requirement

It is very important to understand and study the need of water in the rural and urban areas and then prioritize them, starting from the genuine and the urgent needs. The basic or primary needs must be fulfilled first. Prioritizing must be done keeping in view the amount of water available. This would help in bringing the wastage and would result in optimization of the water resources.

Water Allocation

As stated above, based on the need the allocation must be done. For this proper planning and management is required at the first. Wise decision must be made at the time of prioritization else it affects the allocation process. Also, proper techniques must be brought in like building dams or channels, various kinds of latest irrigational practices, schemes like water loans etc for the farmers for the proper water allocation.

Conservation

Conservation is the first step towards sustainable development. If there is no maintenance or conservation of the water then certainly water crisis would haunt the mankind in the coming years. We should always practice the conservation of resources

as this result in longer availability of the resources and prevents their exhaustion. There are many techniques and practices being emphasized by the government and other local bodies for the preservation of water. Every drop is important and should be used and re-used judiciously.

Water Pollution

This major problem of the modern age is water pollution. It is a self created havoc which is causing problem for us only. This is an issue of concern and must be tackled seriously. As it is, there is water crisis and on top of that were going on polluting the remaining water, calling for our own destruction. At individual, social, national and even international level, we must stop such practices which results in water pollution. If the water is not polluted then, that water can be treated and used for secondary activities.

Water Harvesting

Water harvesting is a technique by which the water can be collected either surface or sub-surface to store up during wet period and used during dry period by applying techniques like channel reservoir, on-farm reservoir, infiltration ditches, infiltration well, check dams, water harvesting dike etc. This is a very good way for conserving water.

Water Requirements

Water resources when treated in the above mentioned manner also quenches the human requirements, thus solving the major issue of water crisis to some extent. So, we see that it is a dual process, when the water resources are treated properly and systematically then that water can directly be used for the various purposes like agriculture, domestic use, industrial purposes etc. This way, if we manage water resources well, we automatically move towards the fulfilling the water requirements.

Community Welfare

This process therefore, helps in serving the community as a whole as it cater to the water needs of the people along with maintaining proper water balance in the environment. The water-friendly practices/ water management practices results in the optimization of this precious resource and also all water needs of humans are well managed/taken care of. This is a purely sustainable approach as it also resolves the present water issues and aims at shaping a secure future. The wastage is minimized and all water resources are used in the best possible. This is how the management and development of water resources results in sustainable development of the mankind.

Water Resource Management Instruments: A Broad View

With an IWRM perspective, the objectives of managing water are to maximize economic and social welfare in an equitable manner, without damaging environmental sustainability.

The two broad approaches are: (a) Creating an enabling environment to support the various actors in the water sector in carrying out their functions (This entails economic stability, democratic policy-formation, appropriate water legislation and regulation, institutional reform, etc.) (b) Creating inducements and incentives for private parties (firms, farmers and households) to align their behaviour with general social interest (This can include coercion and exhortation by public authorities by legal, administrative and “propaganda” methods.)

These approaches normally complement and reinforce each other, though in some circumstances, they may be alternatives. The next section gives examples of policy options under these two broad categories.

Balancing supply-side approaches & demand management

As seen above, economic instruments will have important impacts on the demand for water resources and services. They work in tandem with interventions of other types, some of which act in other parts of the water cycle. Supply-side measures act on the production of water (e.g. by resource development and conservation, storage, transport and treatment), and often entail major physical infrastructural works. For water supply, it is also useful to distinguish distribution management, from the point where water enters the distribution system to the point where it reaches the final consumer. Pressure and leakage are key issues in distribution management.

There is no hard and fast definition of demand management (DM). It relates to measures directly affecting users, at the point at which water moves from the public to the private domain (e.g. onto the user’s property); and seeks to influence consumers’ use of water. Economic instruments can be used to add to the effectiveness of demand management.

PROS AND CONS OF ECONOMIC INSTRUMENTS

Using prices and markets to influence the behaviour of water users has the following advantages: (a) They are flexible, compared to administrative regulations (command and control). Pollution taxes, for instance, enable a polluting firm to continue operations, but at a cost penalty, and allow the firm to choose the methods by which it reduces pollution; (b) They penalise polluting firms or heavy water users in conditions of scarcity. Conversely, they reward or

give market advantages to individuals and firms that modify their usage. These are likely to be those that can do it more efficiently, at lowest cost to society; (c) The incentives that they provide are continual, whereas many "command and control" methods provide a once-off sanction. Economic incentives are "technology forcing", since they provide a permanent incentive to conserve water or reduce pollution; and They can be used to generate revenue.

Their main disadvantages are: (a) Prices are an uncertain method of achieving a desired amount of conservation or pollution abatement (On the other hand, tradable permits operate within a system of regulations that place a ceiling on total emissions, thus restoring certainty.). (b) Taxes and charges raise the costs of households, farms and companies, which can be inflationary, and can attract political opposition. Mitigated by lowering taxes and charges elsewhere, making the measures "fiscally neutral". It should also be recalled that regulations have a cost to water users, which are less transparent, but real, nonetheless. Where there is market failure and economic instruments must be made effective,

USE OF GROUND-WATER COMPUTER MODELS

During the past several decades, computer simulation models for analyzing flow and solute transport in ground-water and surface-water systems have played an increasing role in the evaluation of alternative approaches to ground-water development and management. The use of these models has somewhat paralleled advances in computing systems. Ground-water models are an attempt to represent the essential features of the actual ground-water system by means of a mathematical counterpart. The underlying philosophy is that an understanding of the basic laws of physics, chemistry, and biology that describe ground-water flow and transport and an accurate description of the specific system under study will enable a quantitative representation of the cause and effect relationships for that system. Quantitative under-standing of cause and effect relationships enables forecasts to be made for any defined set of conditions. However, such forecasts, which usually are outside the range of observed conditions, typically are limited by uncertainties due to sparse and inaccurate data, poor definition of stresses acting on the system, and errors in system conceptualization (Konikow and Bredehoeft, 1992). Although forecasts of future events that are based on model simulations are imprecise, they nevertheless may represent the best available decision-making information at a given time. Because of the usefulness of computer simulation for decision making, the basic construction of computer simulation models, as well as model forecasts, need to be updated periodically as the actual ground-water system continues to respond to the physical and chemical stresses imposed upon it and as new information on the ground-water system becomes available. Computer simulation models have value beyond their use as purely predictive tools. They commonly are used as learning tools to identify additional data that are required to better define and understand ground-water systems. Further-more, computer simulation models have the capability to test and quantify the consequences of various errors and uncertainties in the information necessary to determine cause and effect relation-ships and related model-based forecasts. This capability, particularly as it relates to forecasts, may be the most important aspect of computer models in that information about the uncertainty of model forecasts can be defined, which in turn enables water managers to evaluate the significance, and possibly unexpected consequences, of their decisions

INTRODUCTION: ECO-TOWNS AND THE WATER ENVIRONMENT

Eco-towns provide a tremendous opportunity to think much more creatively about water and our relationship to it. Climate change will make water much more 'visible' in the future – with a greater risk of extreme weather events such as droughts and floods. But water should not be seen only as a potential hazard – watery environments also offer fantastic opportunities for wildlife, for recreation and for providing essential environmental services. Achieving a sustainable water environment will therefore be key to the success of the eco-towns.

THE ECO-TOWNS PROSPECTUS

(a) Requires that the development as a whole should reach hzero-carbon standards, and each eco-town should be 'an exemplar in at least one area of environmental sustainability' (b) The Future Water Strategy for England sets out the Government' s plans for water in the future and the practical steps that will need to be taken to ensure that good clean water is available for people, businesses and nature. It looks ahead to 2030 and examines the water cycle as a whole, from rainfall and drainage through to discharge and treatment.

MINIMIZING AND MANAGING FLOOD RISK

Eco-town residents should rightly expect to live in a community where they can consider themselves safe and at low risk from all but the most extreme flood events, from all potential sources of flooding – and not just now, but f or generations to come. 2.1 Planning Policy Statement 25: Development and Flood Risk Planning Policy Statement (PPS) 253 sets out the general expectations on all developments in terms of planning and flood risk. The starting point is that the 'Sequential Test' should be applied rigorously to steer development away from areas of

highest flood risk and ensure that new development in flood risk areas is appropriate, safe and sustainable. PPS25 requires local planning authorities (LP As) to steer development first to areas of lowest risk (Flood Zone 1), and only if none is reasonably available then to areas of medium flood risk (Flood Zone 2). PPS25 indicates that high-risk flood areas (Flood Zone 3) may only be considered if the Sequential Test has been passed and an additional Exception Test is passed.

Assessing flood risk and improving surface water drainage Assessments of flood risk should be undertaken to provide a technical assessment of all forms of flood risk to an eco-town and its surrounding area. F or an eco-town development, a town-wide Flood Risk Assessment (FRA) is essential, together with any site-specific FRA, e.g. for smaller development cells within the eco-town:

The assessment should consider the potential risk not only of flooding from rivers or the sea but also from other forms flooding which can occur from one source, or from many in combination. These other forms can result from heavy or prolonged periods of rainfall, leading to overland surface water run-off and the exceedance and overflowing of sewer systems, groundwater, canals or reservoirs.

Where an assessment identifies some potential risks associated with surface water drainage and/or sewer flooding, the development should ensure that all flood risk is fully dealt with as part of the development master plan. Locations with known critical drainage problems will not normally be suitable. The master planning exercise should involve bringing together all the key local stakeholders to identify options for improving surface water drainage. This should follow the principles of effective planning for surface water drainage, in line with approaches taken on Surface Water Management Plans.

The eco-town-wide FRA should assess the potential for the development to exacerbate flood risk elsewhere and should influence master planning to ensure that run-off from the eco-town is no more, and preferably less, than that generated by the pre-development site.

MINIMISING FLOOD RISK AND ITS IMPACTS

Eco-towns should demonstrate innovative approaches to minimizing flood risk and should take into account the longer -term impacts of climate change over the lifetime of the development – i.e. the site should not become at higher risk later in the development' s lifetime. This should be a requirement for an eco-town (either partly or wholly) in Flood Zone 2. Options could include:

Identifying and utilising opportunities for making space for water – using strategically located green space f or flood storage in times of flood, using conveyance and Sustainable Drainage Systems (SUDS), and recreating functional flood plains. l Locating more vulnerable types of development, such as houses, care homes, hospitals and essential infrastructure, in parts of Flood Zone 1 or on the parts of Flood Zone 2 at least risk of flooding. Highly vulnerable uses should be in Flood Zone 1 .l Working with communities to improve preparedness so that if an exceptional flood does occur an eco-town suffers the least impact from the event and can recover as quickly as possible – for instance, ensuring that the design of developments appropriately incorporates flood 'resilience' measures that minimise the damage caused b y floods which enter a property (e.g. concrete ground floors, waterproof wall plaster).

PROMOTING SUSTAINABLE DRAINAGE

The SUDS approach to surface water/drainage management includes a range of techniques that, used together , can have a major role in protecting and improving water quality and in reducing the likelihood and adverse impact of flash flooding caused by run-off in heavy rain. SUDS can also increase the amenity and biodiversity value of land.

LONG-TERM MANAGEMENT AND MAINTENANCE OF SUDS

All eco-towns must clearly identify a long-term maintenance, management and governance plan relating to SUDS. This should be considered at the early stages as it may influence the design. The LP A should also obtain the agreement of the adopting agency before SUDS techniques are approved through the development process. The Interim Code of Practice for SUDS provides guidance. The Government is currently consulting on options for the allocation of responsibility for the adoption and maintenance of SUDS.

IMPROVING WATER QUALITY

Eco-towns must not create adverse pressures on the water environment (adjacent surface waters, watercourses or groundwater) that could compromise our ability to meet Water Framework Directive (WFD) objectives and other statutory objectives. Under the WFD, development must not result in any deterioration in the status of surface water bodies. A breach of WFD or other Directive objectives would put the Government at risk of infraction proceedings by the EU.

WATER QUALITY OUTCOMES

Eco-towns should aspire to improve environmental water quality (particularly in areas where there is contaminated land and/or watercourses). As

exemplars of sustainability, eco-towns should examine innovative approaches which could include: (a) Sewage treatment: Some eco-towns may require new, purpose-built sewerage systems and sewage treatment works. The design and location of these should provide benefits to local watercourses, wetlands and wider biodiversity. They should also be designed to support climate change mitigation and adaptation objectives, by, f or instance, being low carbon and sited in low flood risk locations.

The total load of sewage generated by an eco-town must not result in a deterioration of water quality elsewhere, although expansion of treatment capacity elsewhere may be a viable option. n Surface water/other discharges: Use of SUDS, such as buffer strips, would help to ensure that polluted r un-off from dif fuse sources (roads, gardens, car parks, etc.) is treated before entering watercourses.

Eco-towns must not result in a deterioration of water quality, and should contribute to achieving the environmental objectives set out in the WFD – as identified in River Basin Management Plans. To achieve good ecological status, good chemical and biological quality is a requirement, subject to exceptions relating to disproportionate cost and technical feasibility.

SOME STEPS TAKEN BY THE GOVERNMENT

The provision of clean drinking water have been given greater importance in the article 47 of the Indian constitution. It emphasizes on the duty of providing clean drinking water to the public maintain their improved health standards .The government and the ministry of water resources are thus, actively taking initiatives for the management and development of water resources in the country to solve the issues related to water crisis. Some of their significant efforts have been mentioned here: (source 2)

(a) The national water policy of 2012 was drafted keeping in mind the goal of achieving sustainable development. Many schemes and programs were started which not only aim at solving the water related problems but would also take us on the path of sustainable development. Schemes and programs like the Ganga Wing Program for flood management and river management, implementation of hydrology programs, repair renovation and restoration of water bodies, taking up various initiatives for rain water harvesting like ground water augmentation, setting up an advisory council on artificial recharge of ground water, farmers participatory action research programme, accelerated irrigation benefit program etc. (source 3) (source 4)

(b) Recently the government is working on the PPP model for water management. This is a public-private partnership working together for the water management. The public sector always might not be able to deal with the rising challenges regarding *sanitation* and *water management* and therefore cooperates with the private sector through a "partnership". Recently Kerala has adopted this model to fight against draught. Similarly, Delhi Jal Board received a clearance for this partnership model for water distribution in the dry areas. (source 5,6)

(c) Water quality monitoring is an important part of the government programme. Since 2000, water quality monitoring has been accorded a high priority and institutional mechanisms have been developed at national, state, district, block and panchayat levels.

(d) The government has also outlined requisite mechanisms to monitor the quality of drinking water and devise effective Information, Education and Communication (IEC) interventions to disseminate information and educate people on health and hygiene.

(e) From 2006-07 onwards, the states have been directed to earmark up to 20 per cent of Accelerated Rural Water Supply Programme (ARWSP) funds for tackling water quality problems.

(f) The Central government plays an important role in guiding investments in this sector, encouraging the need for training and research, and also in promoting water quality monitoring and human resources development programmes.

(g) The states plan, design and execute water supply schemes and operate through departments like Public Health Engineering Departments, Panchayati Raj Engineering Departments or Rural Development Engineering Departments and Water Boards.

(h) The Central Water Commission (CWC) in the Ministry of Water Resources (MoWR) is responsible for regulating the use of surface water for irrigation, industry and drinking water purposes. It also mediates in inter-state water allocation disputes.

(i) Central Groundwater Board (CGWB) under the MoWR has an overseeing responsibility for the monitoring of groundwater levels and rates of depletion and the production of water resource inventories and maps.

(j) National Rivers Conservation Directorate (NRCD) under the Ministry of Environment and Forests (MoEF) looks after the implementation of Action Plans to improve the quality of the rivers in India.

(k) Central Pollution Control Board (CPCB) under the Ministry of Environment and Forests (MoEF) promotes basin-wide pollution control strategies. It liaises with State Water Pollution Control Boards for laying down standards for treatment of sewage and

effluents. The Board is also responsible for action in the case of non-compliance by agencies.

(l) Rajiv Gandhi National Drinking Water Mission (RGNDWM) under the Department of Drinking Water Supply, Ministry of Rural Development (MoRD) formulates policies, sets standards, and provides funds and technical assistance to the states for rural water supply and sanitation activities.

(m) Ministry of Agriculture (MoA) is involved in planning, formulation; monitoring and reviewing of various water shed based developmental project activities.

(n) Ministry of Urban Development (MoUD) is the main ministry for policy formulation and guidance for the urban water supply and sanitation sector. The Ministry performs various functions like policy formulation, institutional and legal frameworks, setting standards and norms, monitoring, promotion of new strategies, coordination and support to state programmes through institutional expertise and finance. (source 2)

CONCLUSION

In India, investments in community water supply and sanitation projects have increased steadily from the 1st plan to the 12th plan. However, the health benefits in terms of reduction in water-borne disease have not been commensurate with the investments made.

Though health sector is bearing the burden of water and sanitation related infectious diseases, presently it does not have adequate institution or expertise for monitoring and surveillance of community water supply programmes in the country.

India has witnessed significant improvement in rural water supply with increasing coverage of areas and a large volume of financial resources made available. A series of schemes are aimed at improving the supply of drinking water for rural habitations and now for monitoring and ensuring quality. The past few years have seen greater emphasis on water quality monitoring and surveillance with specific allocation being made under Central grants. There has been great focus on setting up and upgrading laboratories at the state and district levels, and on water monitoring through field testing kits.

However, awareness, surveillance, monitoring and testing, mitigation measures, availability of alternate water sources and adoption of hygienic practises continues to remain roadblocks. There is a need to promote sanitary inspection along with the community based water quality monitoring and surveillance at the grass root level as a mechanism to identify problems and to take corrective measures.

One of the greatest challenges has been the convergence of various departments associated with water: water and sanitation programmes have operated largely in isolation from programmes in health and education. A wider approach is needed where water and sanitation issues are looked at with the aim of reducing disease, improving hygiene, improving educational levels and reducing poverty.

There can be little doubt that water is a basic necessity for the survival of humans. There is interplay of various factors that govern access and utilisation of water resources and in light of the increasing demand for water it becomes important to look for holistic and people-centred approaches for water management and development.

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