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PROBLEMS AND REMEDIES ASSOCIATED WITH WATER RESOURCE: HARVESTING AND MANAGEMENT

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ABSTRACT

Resource scarcity can exacerbate pre-existing tensions or invite new ones, and water is no exception. Within a decade, water could overshadow oil as a scarce and precious commodity at the centre of conflict and peacemaking. Hence, the then UN Sectary General Boutros Boutros Ghali (Egypt's Minister of State for foreign affairs in 1985) warned that the next war in the Middle East will be fought over water, not politics.[2] Unless the present development paradigm and its associated institutions and policies are reoriented to focus on the neglected ecological and equity dimensions of human development, the environmental crisis will eventually culminate in still more diabolic economic, social, and even, political crises. It is with this kind of diagnosis, sustainable development has been proposed as an alternative development paradigm. Adoption and implementation of the new paradigm of sustainable development , i.e., development that simultaneously ensures ecological security, economic efficiency, and social equity, demands far-reaching changes in two major directions. First, to have an altogether new concept of development rooted in the principles of co-existence and mutual dependence on the one hand, and ethical commitments in man-nature relationships on the other hand.[3] Envisioning sustainable development is a strategy to achieve immediate economic gains while maintaining indefinitely the productive potential of the renewable resource base.[4] The main focus is on the development, management and utilization of water resources in harmony with environmental conservation and the concept of sustainability.[5].

Keywords: Resource, Sustainable Development, Water, Environmental Policies, Rainwater Harvesting

Underneath the verandah in front of the room in which the Mahathma Gandhi was born in the space enclosed by the three wings of the house, is an underground reservoir, 20 feet long, 20 feet wide and 15 feet deep, with a capacity of 20 thousand gallons, for storing rain water for domestic use. The well water in Porbandar, owing to its vicinity to the sea, is brackish, hard and unfit for cooking. Rainwater was, therefore, collected and stored in the underground reservoir for use, the year round. The terrace on the top floor, carefully washed before the first monsoon showers, served as catchment for the water, running down a pipe straight into the tank. A heap of lime at the mouth of the pipe served to filter and purify the water.
In this house, five generations of Gandhi lived and prospered.

- Mahatma Gandhi Vol. [1]
(The Early Phase) by Shri Pyarelal [1]

1. INTRODUCTION

Water: An Inescapable Necessity

Resource scarcity can exacerbate pre-existing tensions or invite new ones, and water is no exception. Within a decade, water could overshadow oil as a scarce and precious commodity at the center of conflict and peacemaking. Hence, the then UN Sectary General Boutros Boutros Ghali (Egypt's Minister of State for foreign affairs in 1985) warned that the next war in the Middle East will be fought over water, not politics.[2] The already evident symptoms of an imminent environmental crisis like severe water resource depletion and ecological degradations at all levels is not just ecological phenomena alone. While the persisting demographic pressure on natural resources and the increasing reliance on resource/energy-intensive technologies have aggravated the environmental crisis, the real cause of the problem lies in the very world view and the meaning of *development* underlying a purely material growth-centered development paradigm and its attendant social, economic, and legal policies and institutions.

Strategic Imperatives

To move from the present, often destructive process of growth and development towards sustainable development path requires policy changes in all sectors, with respect to their development and their impact on the development possibilities of other sectors. Critical objectives for environment development include: changing the quality of growth; meeting essential needs for jobs, good energy and water; ensuring a sustainable level of population; conserving and enhancing the resource base; reorienting technology and managing risk and merging environment and economies in decision making.

These fundamental changes will not come easily, and will not come at all without strong leadership and the continued efforts of people.[6] The pursuit of sustainable development thus requires:

- A political system that secures effective citizen participation in decision making
- An economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis
- A social system that provides solutions for the tensions arising from disharmonious development
- A productive system that respects the obligation to preserve the ecological base for development
- A technological system that can search continuously for new solution
- An international system that fosters sustainable patterns of trade and finance
- An administrative system that is flexible and has the capacity for self-correction.

It is known that economic development always brings risk of environmental damage as it puts increased pressure on environmental resources. But policy makers guided by the concept of sustainable development will necessarily have to work to assure that growing economy remains firmly attached to their ecological roots and that these roots are protected and nurtured so that they may support growth over the long-term. Environmental protection is thus inherent in the concept of sustainable development as it focuses on the sources of environmental problems rather than the symptoms. Policy makers need to set priorities for environmental policies. In many cases, preventive action now will be cheaper than remedial measures in the future.

An agenda for change

Fresh water touches every aspect of life, from the health of aquatic ecosystems to human health, from the need to grow food for the Earth's growing population to the need to provide energy. But, only in the last few years, the complexities and connections among these issues have become more apparent. As population grows, and as the level of economic development increases, their need for water will also increase. To meet these needs, all aspects of the hydrologic cycle are modified. We move vast quantities of water from one region to another to squeeze more moisture out of them, divert entire rivers from their beds, harness the power of water falls for electricity, pump great quantities of water from ancient underground aquifers, and strip the salt from sea water. The idea of environmentally sound water management or sustainable development is to convey the concept that development is to be accomplished with minimum damage to the environment. Sustainable development can be considered a form of investment in the future. Many policies that favour investment including investment in new knowledge or improved technologies or environmental protection at the expense of current consumption do assist sustainable development.

Since water sustains all life forms, a holistic approach is needed for the development societies and economies, and the protection of natural ecosystem on which the survival of humanity ultimately depends. This includes not only the need to look at the whole water cycle, including the distribution of rainfall, the conservation of sources, the system of supply and waste-water-treatment, and the interaction with the natural environment and land use but also the inter sectoral needs. Efforts to encourage water conservation face special challenges not encountered with other natural resources. In much of the world, water is not controlled by market mechanism (price) because it is neither free for the taking, nor is water a global resource that can be traded like petroleum or given in aid like food or medicine. Understanding the limits of renewable freshwater supply requires an appreciation of how little of the planet's water actually fits into that category. In calculating how much fresh water is available for human use, **what counts is not the sum total of global fresh water supplies, but the rate at which fresh water resources are renewed or replenished by the global hydrologic cycle.**

Policymakers and planners can no longer direct engineers simply to find more water but, must shift to prudent management of the renewable water resources that exist within the borders. Long-term solution will also require them to confront the realities of population growth. Water is more a regional rather than a global resource. Escalating scarcity demands a sense of urgency that is still largely missing as well as a combination of strategies at the international, national and local levels. Because, prospects for finding major new sources of water use is relatively dim in most regions of the world. Strategies for improved efficiencies and conservation of water use are an increasingly critical component of any region's water management policies. Recycling of water, improved efficiency in water use, and reallocation of water rights offer substantial potential for stretching water supplies.

Short-term strategies are necessary where sustainability of life-support system is threatened by everyday life problems. The long-term strategy has to be developed and implemented in parallel, taking multi-sectoral approach and integrating water-related issues. Attention has to be paid to the possible impacts of climate change, in particular, the effects that it may have on rainfall, evapo - transpiration, groundwater recharge and quality, local water tables, river flow and quality, and consequently both on water demand and land-use, on terrestrial ecosystems, and on the reliable yields from water projects.

Environmental Policies

Stabilizing global climatic change and the greenhouse effect further complicates future water resources planning. Human activities over the last century have led to increase in the atmospheric concentration of trace gases that trap heat in the atmosphere. As the concentration of these gases rise, the behaviour of the earth's climate will be affected in ways that are only partly understood but which reflects as higher temperature, changes in precipitation patterns and sea level, and alterations in the frequency and intensity of major storms. Greenhouse gases come in large part from the combustion of fossil fuels, and from deforestation, which removes a sink for carbon dioxide and also releases CO_2 into the atmosphere when the forests are burnt. While many actions can be taken to reduce the emissions of these gases, growing population and growing energy use will make it exceedingly difficult to prevent some climatic changes from occurring.

[These gases, sometimes called *greenhouse gases,* include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), chlorofluorocarbons (CFCs), and ozone (O_3)]

These climatic changes will, in turn, greatly affect fresh water resources. Higher temperature will increase evaporation, change snowfall and snowmelt patterns, and lead to alterations in water availability. Changes in rainfall will affect water levels in rivers and lakes, hydroelectricity generation, and agricultural productivity. Rising oceans will contaminate coastal fresh water aquifers. Many important hydrologic processes, such as the dynamics of clouds and rain-generating storms occur on spatial scales far smaller than they can be modeled. At the same time, the hydrologic processes included in the models are far simpler than those in the real world. We, thus, know far less than we would like, about how the global water cycle is likely to change. Despite these limitations, research in the last few years has revealed some important results about how hydrology and water supplies may be affected by climatic changes.

2. PROBLEMS AND REMEDIES ASSOCIATED WITH WATER

(i) Changes in Temperature and Precipitation

Temperature and precipitation are key factors in determining the distribution of natural ecosystems like what crops we grow in what places, characteristics of human habitations and energy use, and how much water we use for different aspects of human development. One of the best current estimates is that doubling the concentration of greenhouse gases in the atmosphere, which is expected to occur within the next few decades given current trends, would cause the global average temperature of the earth to increase by about $3^{o}C$. As temperatures rise, the evaporation of water from land and water surfaces will increase, as will global average precipitation. Most recent estimates are that global precipitation will increase by 3 per cent to 15 per cent for an equivalent doubling of atmospheric carbon dioxide concentration. The greater the warming, larger the increase. Regional changes will differ substantially from global ones. Even small changes in these arid zones can lead to large changes in ecological and human systems.

The policy change, most fundamental to climate stabilization is an international commitment. There shall be one means of accomplishing this, i.e., higher prices for fossil fuels. Such a policy might take the form of escalating energy taxes based on the carbon content of fuels. Gradually rising prices would promote both energy efficiency and more rapid development of renewable energy resources like solar, wind and hydro power. Such policies are often opposed on the grounds that they would retard economic growth.

(ii) Changes in Soil Moisture

Another important water resource variable is the water held in soils, which determines what plants can be grown in different regions and how much additional water needs to be applied with irrigation to raise a crop. Soil moisture is often overlooked in climate impact studies, in part because of the difficulty of accurately modeling the stocks and flows of water in the ground. An increase in precipitation does not necessarily mean a wetter land surface or more soil moisture because increases in evaporation may exceed the increases in precipitation, leading to a net drying of the land surface. Indeed, the incidence of droughts in the United States, measured by an index that looks at soil wetness conditions, may dramatically increase as temperatures rise up despite an accompanying increase in precipitation, because of the increased evaporative losses. A similar result has been observed in detailed hydrologic modeling of river basins where, large increases in precipitation may be necessary in order to maintain present river runoff levels as temperature and evaporative losses rise.

Most climate models also suggest large-scale drying of Earth's surface over northern mid-latitude continents in summer owing to higher temperature and either insufficient precipitation increases, or actual reductions in rainfall. For example, a review of the soil-moisture results from five different climate models showed substantial agreement on decrease in soil moisture, in the central United States. Drying in these regions would affect both agricultural production and other water demands. Climate models typically exclude the direct effect of CO_2 concentrations on vegetation, and the role of other factors in altering evapotranspiration. Greenhouse warming may alter temperature, cloudiness, wind conditions, humidity, plant growth rates, rooting, leaf area, and so on. Higher CO_2 levels have been shown in laboratory and greenhouse studies, to enhance plant growth and alter the efficiency with which water is used by certain plants, but the effect on plants in the real world is still uncertain because of many complicating factors and feedbacks. The evapotranspiration in some plant communities is more responsive to changes in air temperature, the resistance of plant stomata, and net radiation, and less responsive to leaf area index, vapor pressure, and wind speed.

(iii) Changes in Runoff

Fresh water runoffs in rivers are of vital importance to human water supplies and natural ecosystems. Any change in either the timing or magnitude of runoff because of climate change will have widespread ramifications for water supply, energy generation, human health, commercial and industrial development, and environmental conditions. Less runoff in some places will increase pressures on remaining water supplies. More runoff could help water-short areas or cause severe flooding.

3. MOVING FROM CURATIVE TO PREVENTIVE MEASURES

The costs of preventing resource degradation are small compared to remediation or rehabilitation costs. A major challenge for freshwater, is to increase the level of effort for preventive measures while maintaining support for curative interventions in degraded areas. The key challenge for the future is to implement and develop broad acceptance for integrated approaches for water resources management. Management of water resources is a critically important human activity. By management of water, it meant people's control of water as it passes through its natural cycle with balanced attention to maximizing economic, social, and environmental benefits. Water planning is needed at different levels and for different purposes of water management. Planning for water resources must take into account the integration of different purpose interests if it is to be effective. The watershed approach is devised to deal with water resources, its quantification and distribution in time and space, so as to formulate strategic schemes to use water most logically matching its availability against the needs. Watershed management means to put water to maximum use and to cut loss through evaporation and runoff.

Factors affecting Evaporation

Evaporation from water bodies depends on a number of factors. The main factors affecting evaporation are surface water area, temperature, vapour pressure difference, wind velocity, atmospheric pressure and quality of water. Since evaporation is a surface phenomenon, the quantity of water lost through evaporation is directly proportional to the surface area of water exposed to the atmosphere. In view of this, for conservation of water through evaporation control, efforts need to be made to reduce the exposed surface area of water by various means.

(i) Evaporation Control Methods [7]

Evaporation being one of the major causes for loss of water from reservoirs, lakes and tanks, a number of methods has been experimented by engineers and scientists to reduce evaporation losses from water bodies. Since the basic meteorological factors affecting evaporation cannot be controlled under normal conditions, efforts have so far been restricted to managing the suppression or inhibition of evaporation from water surfaces by physical or chemical means. The following methods are generally used for evaporation control:

- Wind breakers;
- Covering the water surface; Reduction of exposed water surface;
- Underground storage;
- Integrated operation of reservoirs and
- Use of Chemical Water Evapo-Retardants (WERs).

Although, the chemical method of evaporation control has certain limitations and disadvantage of its high cost of application in normal conditions, yet this method has evoked maximum attention all over the world as a practical solution for conservation of fresh water. In view of this, chemical WERs have been described in detail. These materials can be used in powder, liquid or emulsion forms.

(ii) Chemical Water Evapo-Retardants (WERs)

Compounds in use

A non-toxic chemical, capable of forming a thin monomolecular film on the water surface is applied, which prevents energy inputs from the atmosphere from reducing evaporation. The film allows passage of enough air through it and thus aquatic life is not affected for want of oxygen. A film formed by fatty alcohols of different grades, is found most suitable for evaporation control. The compounds generally used are cetyl alcohol or hesadecanol (C_{16}-H_{33}-OH), Stearyl alcohol or Octadecanol (C_{18}-H_{37}-OH) and Biphenyl alcohol or Docosanol (C_{22}-H_{45}-OH) or a mixture of these compounds. National Chemical Laboratory (NCL), Pune have developed one more compound by synthesizing Alkoxy ethanols. All these alcohols should be 99 per cent pure for getting the desired properties of monolayer.

Long-term evaporation control measures like plantation of trees as wind breakers, reduction of exposed water surface, increase the underground storage of water, integrated operation of reservoirs etc. need to be employed. Therefore, it is better to store water underground without letting it to evaporate, pollute, log and get confined to one place. Hence, rain water which is the primary source of water, has to be managed in such a way that there should be maximum utility of it.

(iii) Rainwater Harvesting

Rainwater management has to be looked into in context of maximizing water availability in the face of increasing demand for sprinkler irrigation and domestic consumption on sustainable basis. Management of rain-runoff involves harvesting of excess rain, falling on land surface by creating a storage facility either in field or in a constructed structure. Some of the common practices are presented here.

Traditionally, rainwater harvesting has essentially meant valuing the raindrop. It has meant capturing the rain where it falls or capturing the runoff in the village or in the town.[8] Additionally, it has meant taking measures to keep that water clean, which in turn has meant not allowing the activities which dirty the water to take place in the catchments. Rainwater harvesting is an old tradition in many parts of the world, particularly in India. India receives most of its rain in just 100 hours a year and for the remaining period there is very little or nothing. Indians knew that if they did not collect the water when it rained, they would have nothing later on. So they developed a civilization built on raindrops viz.,

- In Chittor (Fort) tanks were built to capture the rain water;
- In Ladakh, where there are Glaciers fed streams, there is no water in the morning but they are full in the evening. The people learnt to capture the evening and night runoff in a tank to use it for irrigation next morning;
- In the Western and Central Himalayas, diversion channels called kuhls were built to make use of hill streams and springs;
- In Meghalaya, bamboo pipes are used for the same purpose i.e., Kuhls.
- In down south, tunnels are dug through hillocks where there is seepage of water. In desert areas, covered underground tanks called kunds are popular.

In Situ Conservation

In Situ conservation, percolating the rainwater where it falls should be the main priority. The transportation of water on trucks or carts is only temporary relief measures. Earlier the improvement in the local water resource, the better it is. In Situ conservation has many fold advantages. First and foremost, it is affordable for a common man. No external input or know how is necessary. There is no room for dependence over middlemen. As a result, there is better use of public money. Involvement of people always ensures aftercare of the project which is conspicuously absent in government projects. If we have to augment our drinking water sources and water for irrigation, we have to aim at increasing the whole water table or improve the full system. As such, it has to be taken holistically.

(iv) Water Conservation Methods along with Water Extraction Projects

Another good method would be to adopt suitable rainwater recharging techniques during the implementation of drinking water projects itself. Expenditure on conservation work may be added to the project cost. The several methods of recharging which can be tried are:

a) Percolation Pits

In Chennai, the Corporation is advertising in leading dailies asking the citizens to dig percolation pit in corner of their house sites and to direct terrace water there. In cities like Rajkot, the Lokmanch Seva Trust is successful in coaxing thousands of households to divert the rainwater from terrace to the drinking borewell through a hose-pipe connection. In Maharastra, Anna Hazare mobilized the villagers of Ralegaon Siddhi to build their own percolation tanks for rainwater harvesting. Three decades ago, a village with no water but all problems (no agriculture, no income, no schooling to all the children, almost all the villagers (men) alcoholic, no population control policy) has today become a model village. All these developments are a reality today due to addressing one problem that is water and this is supported and supplemented by motivation and determination. Steps taken by the villagers under the leadership of Anna Hazare has seen to it that not even a drop of water is runoff but percolated. The result is that water table which was below 300 feet has now raised to 30 feet. Different crops are grown along with fruits and vegetables. Community participation made a world of difference to water availability. Trees were planted, hills terraced and dams and check dams built to preserve rain water. This is what is needed in other parts of India and World over.

Water harvesting can be achieved by institutional harvesting (collection of water in original place). They are, storage of water in aquifers (artificial recharge of groundwater by percolation tanks, check dams etc.,) sub-surface dukes on river beds. Soil conservation methods also help to increase groundwater recharge. Enhancement of surface runoff collection and evaporation control by chemical films, hydrophilic constructed at strategic points, making the runoff or roof water to be collected in the percolation pit after passing through a silt trap.

b) Using Termite Hills as Percolation Pit

This method, adopted by Mr. P.M. Mohandas, a farmer in Karnataka is quite encouraging. The termite hill invariably has connections downwards and laterally, thus helping the water to spread in a very big area.

c) Raise Vegetative Barriers in the Catchments

This can be achieved only by people's participation. As stated earlier, local maintenance committees have to be set up and plants should be grown in the catchments to the possible extent. This, though a slow process, is a desirable and cheapest method of water recharging. What's required is only protection of the vegetation and no recurring expenditure is needed.

Besides, roof-top rainwater harvesting and recharging underground through existing wells or bore well or by constructing new wells shafts or spreading basins and other methods to capture runoff in the catchments, re-using treated urban and industrial effluents by using it for direct irrigation, or through recharge ponds are some other methods in the process.

d) Roof Water Harvesting (RWH)

This is an affordable method of preserving rainwater for the difficult period that is from March to May. In Kerala, there are 350 families which have successfully adopted this method. Cost of construction of 10,000 liter capacity system comes to an average of 1 Rupee per liter. Though the phrase RWH has come from west, the concept is very much Indian. It is being practiced in many homes in Rajasthan even today.

Roof water harvesting is practiced by using variety of materials as gutters (both natural and manufactured) viz.,

(i) Tin sheets - formed in to a shape of gutters and collect water;

(ii) Bamboo gutters;

(iii) Banana stem files and

(iv) Arecanut shealts.

Open air rainwater harvesting to capture the rainfall directly from the sky is practiced by using variety of materials which include,

- Royal palm leaves (placing by on a wooden stand - 200 liters per day can be collected).
- Polythene sheets (spread across in the open air devoid of trees/sheet is mounted on four wooden poles at the 4 corners and a hole is made at the center to collect water).
- Galvanized sheet (is tied from the two corners in the shape of a boat and mounted on 4 poles).
- Tree trunks (constructed boat like structures from large tree trunks).
- Natural rock cavities (constructed on large rock surfaces).
- Inverted umbrellas (in a galvanized bucket).

4. CONCLUSION

To achieve water sufficiency, water recharging and careful use need to go hand in hand. This is where setting local water users' committee periodically becomes a must. Unless people have invested in the project through cash and labour, the involvement does not come and hence at least partial cost has to be collected by them. Conservation idea has to be spread among mothers and children. If only we could check the wastage and misuse of this subsidized resource successfully, it is said to serve it to, exactly the double number at present.

CONFLICT OF INTERESTS

None.

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