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ABSTRACTS

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WATER - the key to socio-economic development and quality of life

STOCKHOLM WATER SYMPOSIUM

The 8th Stockholm Water Symposium
10 - 13 August 1998

71-SWS 98 -15174

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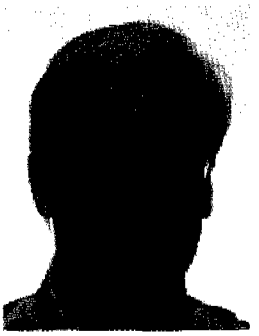

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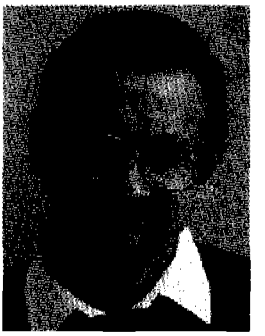

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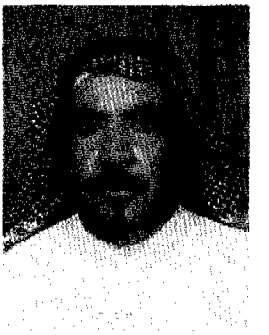

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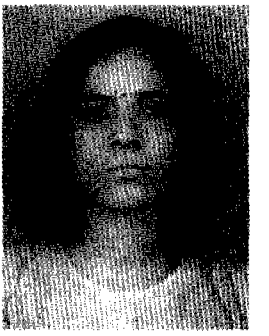

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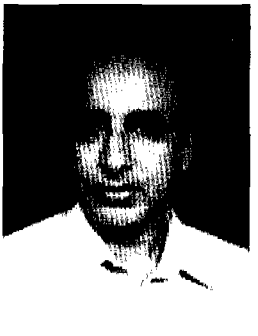

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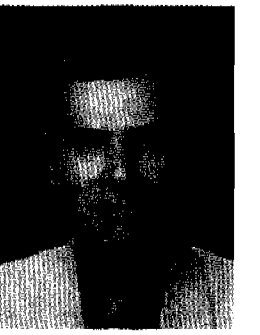

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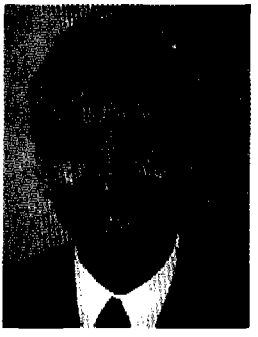

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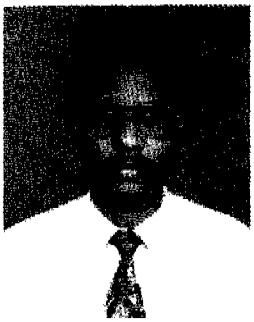

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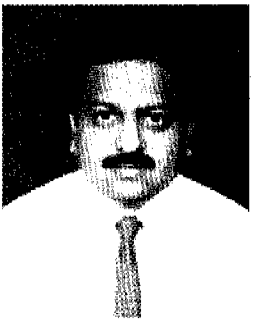

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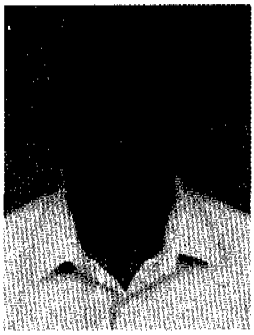

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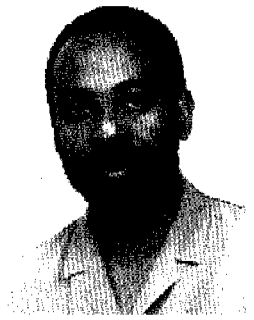

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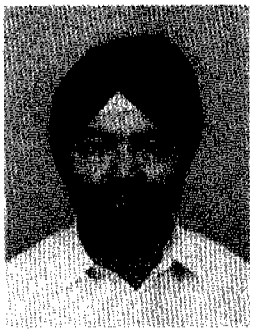

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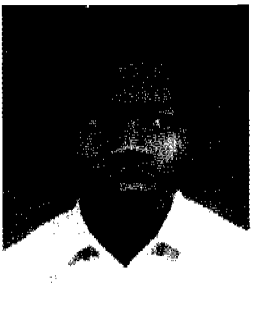

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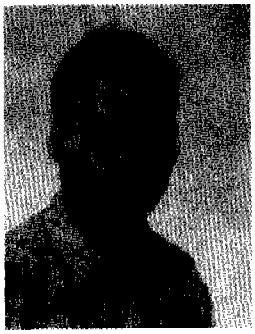

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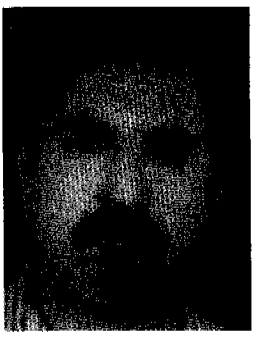

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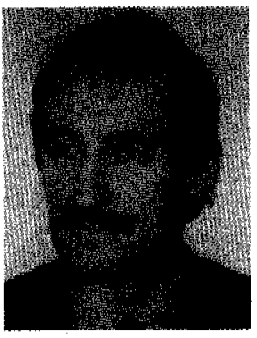

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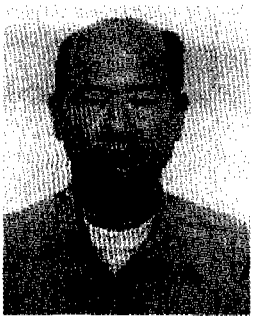

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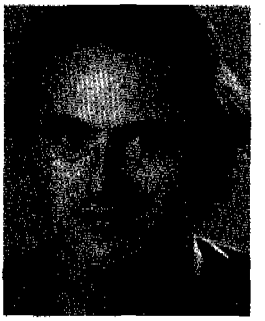

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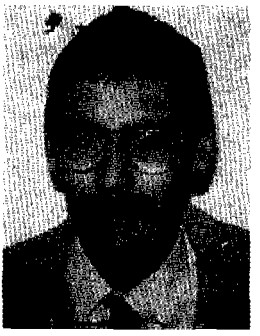

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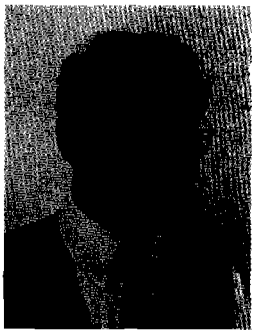

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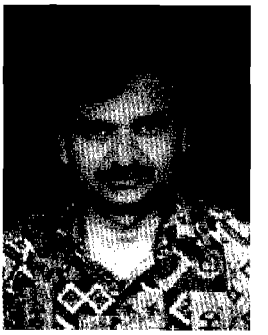

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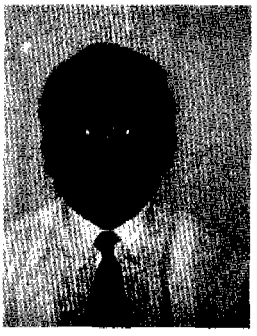

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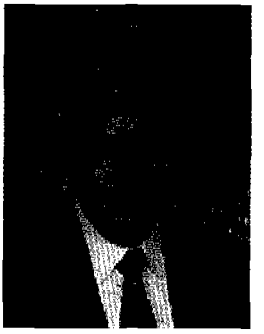

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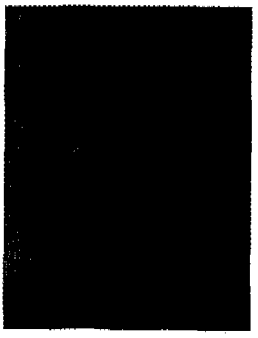

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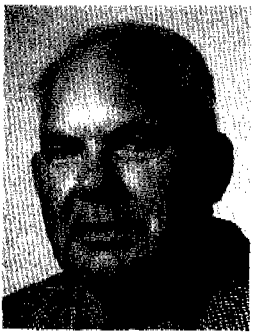

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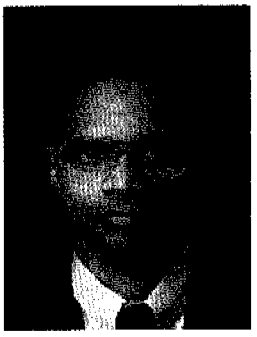

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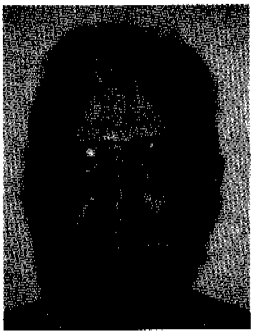

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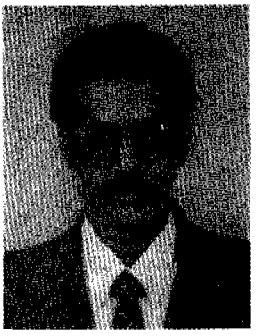

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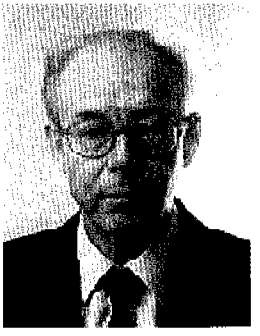

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Plenary speakers

WATER AND CIVILIZATION: REFRAMING THE DEBATE ON WATER AND CONFLICT

Jerome Delli Priscoli PhD, Senior Advisor, Institute for Water Resources, US Corps of Engineers and Editor in Chief, Water Policy.

I will address four areas in this talk:

1. Why look at water and civilization and water resources conflict?
2. Four syndromes which seem to distance us from our water history;
3. Four areas of reframing the water and conflict debates;
4. Concluding reflections on normative perspectives that water and civilization may offer.

Four syndromes which distance us from our water history

Looking at the past is essential if we are to actively create water futures. To the degree that humanity's destiny is so tied to water, we should be looking to our water past. Never the less our debates are often mired in syndromes which, unknowingly, cut us off from our past. Four of the more prominent such syndromes I call: *an everything is new syndrome: an over romanticized past syndrome; an either-or - zero-sum syndrome, and; a process incrementallism syndrome.* Engaging our water history can help us out of each.

Four Areas of Reframing the Water and Conflict Debate

1. Many state that water causes war or that water is likely cause of wars in the next century. But does it? And will it? These questions get our attention.

We all know that people have been shot and killed around water. Looking at history, some colleagues have noted, there is an inverse relationship between level of violence and level of water conflict. In other words, people will kill each other around the water hole but are increasingly reluctant to do so as the conflict grows into a national and international issue. In effect, we may be taking that personal experience of violence and incorrectly generalizing to the world. But why might this be the case?.

2. Water conflicts are pervaded by the notions that increased water sharing leads to increased vulnerability. But does it?

Water is forcing us to rethink the notions of security, dependency, and interdependency. Increased interdependence through water sharing plans and infrastructure networks is often viewed as increasing vulnerability and dependence and reducing security. However, there is an alternative way to look at interdependence. They can be seen as networks which will increase our flexibility and capacity to respond to exigencies of nature and reduce our vulnerability to events such as droughts and floods and thereby increase security. Indeed, this perspective has been central to the evolution of civilization. It may strike deeper primordial fears and instincts then we might imagine. It also plays into

fundamental beliefs found in most major religions - namely that in sharing our vulnerabilities we find strength.

The symbolic content of water as cleansing, healing, rebirth and reconciliation can provide a powerful tool for cooperation and symbolic acts of reconciliations so necessary to conflict resolution in other areas of society. In a sense, negotiations over water use, itself, could be seen as a secular and ecumenical ritual of reconciliation and creativity.

The political leads the technical in water conflicts.

Even a cursory look at Water and Civilization shows that the interaction among the political and technical is far more complex. The technical and water both lead and are lead by the political: and, visa-versa. Environmental deficiencies, not abundances explain the development of irrigation technology. And irrigation permitted the emergence of urban civilization

At one end of the spectrum, Karl Wittfogel attributed the growth of centralized bureaucracy and autocratic rule to increasing connection of water through irrigation and navigation. The combination of hydraulic agriculture, a hydraulic government and a single centered society constitutes the institutional essence of hydraulic civilization. At the other end of the spectrum, researchers talk of how community irrigation engendered a democratic spirit and a sense of community.

Building the physical water infrastructure in a collaborative and participatory way is now an important means for building the civic infrastructure and the civil society or what many call the governance environment.

Today there are numerous signs of how specific technologies are subtlety transforming conflict resolution, negotiations and decision dynamics in water conflicts.

Learning more about the wisdom and viability of traditional water management methods are important payoffs of surveying water and civilization. These range from old technologies such as found in the Negev or other areas in North Africa to various procedures for irrigation release management and hierarchy of rights revealed in court records in Medieval Spain and other areas.

The history of social organization around river basins and watersheds is humanity's richest records of our dialogue with nature. It is among the most fertile areas for learning about how the political and technical interact.

In the struggle between Human (jurisdictional boundaries) and nature (watershed and river boundaries), humans, rightly or wrongly, prevail.

The river basin has been one of the most persistent examples of how the functional and spatial necessities of water can form civilization. Historically, the River Basin concept never seems to die but rather to continually reemerge.

Evidence of functional cooperation or unification of states around a river basin can be found Hammurabi' code on the operations of irrigation trenches, the Chinese Book of the Tang on the operation of water wheels and private reservoirs and even Herodotus' stories of apportionment of waters in a river basin in Persia. The river basin has clearly played a major role in unifying communities and stimulating trade and the emergence of large political-economic organizational units

In a sense, the River Basin Commissions and Organizations can be seen as a logical progression of that deeper quest for integration. If increased integration is the next threshold of civilization, then the twentieth century's experiments with river basin organization, are central.

Concluding Reflections on Normative and Ethical Dimensions of managing water for the Future.

We need a new water ethic: an ethic to help bring a new balance around water decisions; an ethic that helps us guard against "gigantism" and "technological triumphialism" on the one hand but equallly important, against an unwarrented reverence to over romanticized past and a "technophilia."

First, the new ethic we require is not simply one of preservation. It is one that should be built teleologically; on a sense of purpose and on an active co-designing with nature. Second, a new ethic must be based on a balance between humans and technology and among structural and non-strutural approaches. Rarely have either worked alone and it is time to stop characterturing them: one versus the other. Third, a new ethic, even in our advanced technological age, should be based on finding a new balance of the sacred and utilitarian in water.

Today, our technology tells us that there is enough water - if we cooperate. One of the most important elements for cooperation is something negotiations experts call superordinate values. These are values beyond immediate utilitarian values to which competing parties can identify. Rekindling the sense of sacred in water, a superordinate value, is one way to facilitate the escalation of debate on water cooperation to higher levels and thus impact the capacity to reach cooperation and to manage conflict.

HOW DO WE FEED A GROWING WORLD POPULATION IN A SITUATION OF WATER SCARCITY?

Hubert H.G. Savenije, Professor of Water Resources Management, IHE, P.O. Box 3015, 2601 DA, Delft, The Netherlands, e-mail: hsa@ihe.nl.

Introduction

In the discussion on water scarcity, the image most commonly conveyed in the media is that of thirst. Thirst, however, is not a problem of water scarcity; it is a problem of water management. There is enough water, virtually everywhere in the world, to provide people with their basic water needs: drinking, cooking and personal hygiene. Shortage of water for primary purposes is much more a problem of lifestyles (toilet flushing) and poor management than of water availability.

This is different though with regard to food. Of the 1700 m^3/cap/yr of renewable fresh water that an individual needs annually, about 90% is needed for food production. The water scarcity problem is primarily a food problem (Brown, 1995). The main question is: how are we going to feed an ever growing population on our limited land and water resources.

A rainbow of water:

Water has many colours. Falkenmark (Falkenmark & Lindh, 1993; Falkenmark, 1995) enriched the world of water resources with the "green water" concept: the water that vegetation uses through transpiration (in the absence of irrigation). Green water (stemming directly from rainfall) is generally disregarded as a resource by engineers, who are used to deal with "blue water", the combination of surface water and "renewable" groundwater. The unrenewable or "fossil" groundwater is not part of the blue water and should be considered a mineral resource. The "white water" is the part of the rainfall that feeds back directly to the atmosphere through evaporation from interception and bare soil. It is also used for the rainfall which is directly intercepted for human use, e.g. from roof catchments. "Brown water" is waste water, the return flow of blue water used by humans. Brown water can turn into "grey water" after processing, so that it can be re-used e.g. in agriculture.

Probably the most interesting colour of the rainbow is the ultra-violet: the "virtual water", which is invisible but detectable. It is the amount of water that is used in the production of water consuming products, in its widest sense. Grains, under proper conditions use about 1 m^3 of (often green) water per kg. The trade of grain is a trade of "virtual" water (Allan, 1994).

Water scarcity and the deception of numbers

The global discussion on water scarcity is troubled by this confusing pallet of water. Statistics as in Engelman & Leroy (1993) and Gardner-Outlaw & Engelman (1997) concentrate on blue water and disregard green water. Also the key used for the allocation of renewable fresh water among riparians of a shared water resource is not clear. In addition there is no distinction between climatic conditions and no attention to

the natural temporal variability of the resource (both within the year and between years). Finally a separation should be made between primary water needs (basic water requirements) and secondary needs, which can be addressed through the trade of virtual water.

Conditions for sustainability

Sustainable use of water resources requires several conditions of sustainability. One can distinguish physical, economic, social, financial, institutional and environmental sustainability. The first aspect to address is the physical sustainability, which means closing the resource cycles. In agriculture this implies primarily closing water and nutrient cycles so as to prevent accumulation or depletion (desertification, water logging, nutrient depletion, eutrophication, degradation, sedimentation etc.). Moreover, the cycles have to be considered in their integrity (water and nutrient cycles). Economic sustainability has to do with the efficiency of the system, which implies on the one hand a reduction of scale: shortcutting cycles where possible (water conservation, water recycling, nutrient conservation, biogas conversion, duckweed plants, on-site pollution control, etc.); and on the other hand an enlargement of scale through the trade of "virtual" water.

Opportunity for food production

Engineers have for many decades concentrated their efforts on irrigated agriculture for food production. Unfortunately, they have only been partly successful in making it an economically attractive activity. Rainfed agriculture has been marginalised by water resources planners, who are mostly engineers. This does not do justice to the fact that more than 60% of all food in the world is produced under rainfed conditions (Lundqvist & Sandström, 1997), which does not even include meat production from grazing. A distinction should be made between rainfed agriculture in temperate zones, which has been highly mechanised and where production is highly efficient, in the wet tropics, where mostly small scale schemes are managed by small farmers (e.g. Bangladesh) and the semi-arid tropics. Particularly in the latter region, but also in the wet tropics, efficiencies of rainfed food production are often very low. For that reason, the potential to increase food production from rainfed agriculture is often disregarded. However, the argument should be turned around. At present almost the whole of Sub-saharan Africa relies on rainfed agriculture for its food production. Most of this is subsistence farming. If that is inefficient, then the challenge is bringing this deficient agriculture up to standards.

The poverty trap

One of the reasons why rainfed agriculture is deficient is the poverty trap. Poor people living in a marginal environment try to survive by avoiding damage resulting from hazards. As a result they do not invest in their crops or in their natural resource base. This behaviour leads to both economic inefficiency and exploitation and degradation of the resource base, both of which – in turn – sustain their poverty.

Breaking the poverty trap

The challenge is to break the poverty trap by reducing the risks of crop failure. The prime factor is securing water to bridge dry spells during the rainy season. If that can be

done, by applying relatively small amounts of blue water (supplementary irrigation), then high value crops can be grown on mainly green water. The most probable alternative for supplementary irrigation is from groundwater. The management of groundwater is much simpler than surface water and wells can be relatively small since quantities required to bridge dry spells are relatively small. Securing the water allows farmers to invest in seeds and fertilizers and in conservation of resources. The economic feasibility of supplementary irrigation has to be looked into from a broad socio-economic perspective. For this analysis one should consider the satisfaction of multiple objectives including: reducing poverty, conserving the environment, prevention of erosion and land degradation, and provision of food security. Breaking the poverty trap would also be instrumental in reaching a stable population.

Conclusion

Water is the key to restoring the balance between crop production and the carrying capacity of the natural system. Closely related to it is the nutrient balance. Investments in fertilisation, improved seeds and sustainable land use practises, however, require that the risk of crop failure due to the occurrence of dry spells is minimized and the poverty trap is broken. Supplementary irrigation from groundwater could be the key to breaking the poverty trap, by optimizing the use of green water for crop production. Relatively small quantities of blue water can safeguard crop production and by doing so have very high yields per cubic metre of blue water; much higher than can be attained from full scale (dry season) irrigation. Addressing poverty, water resources, nutrients and the environment at the same time is both the biggest challenge and the biggest opportunity to warrant food production for the coming generations.

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REFORMING THE WATER AND SANITATION SECTOR IN AFRICA OVERVIEW OF THE INSTITUTIONAL FRAMEWORK

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Approximately 380 million Africans, or more than half the continent's population, do not have access to safe water, and some 460 million lack any sanitation services. Existing deficiencies in the water and sanitation sector are often due to institutional shortcomings, although regulatory, financial and technical inadequacies also contribute to performance shortfalls.

This report reviews the various institutional options available in the water and sanitation sector in urban and periurban areas in Africa, and provides a framework for their analysis. It is based on case studies and on work done during national and regional workshops on reforms in the water and sanitation sector in Africa, organized by WUP Program. The document is structured into four sections providing a framework for analysis of the institutional options, the development of reforms, a review of the current situation in Africa, and recommendations.

1. INSTITUTIONAL OPTIONS FRAMEWORK

1.1. The public option

The public option comprises both management by local government and management by state-owned enterprises or public utilities. Water and sanitation utilities can be national, regional or local, depending on the country. Whereas water issues depend on local geographical conditions, national companies help define national investment priorities, permit economies of scale, and their structures are used to greater advantage regardless of administrative boundaries.

When private sector participation (PSP) is not feasible, institutional reform of the sector will follow the public management model, with an attempt to improve its performance by: (i) applying rules of commercial management, (ii) adopting private-sector performance ratios as benchmarks and a plan of human resource development, (iii) adopting a clear definition of the roles of the stakeholders aiming at financial autonomy and total cost recovery, and favoring a more customer-oriented approach.

The public management option is still widespread in the sanitation sector when this service is not provided jointly with potable water.

1.2. Public-private partnership "PPP"

PSP is usually considered as an option that can provide sustainable improvement in water and sanitation service delivery. West Africa is now in its second generation of reforms. The main arrangement chosen is based on the management lease contract with elements of concession and incentive to performance throughout the duration of the contract.

Major issues related to PSP include social aspects, local private sector involvement, the problems arising from central and local government arrears and the management of risks. Private financing of water and sanitation infrastructure is still very limited in Africa; it is therefore necessary to set up an enabling environment for greater PSP involvement. Community participation is a valuable complement to public-private partnership. The level of cost recovery and financial autonomy existing in the sector will determine the feasibility of PSP, the degree of involvement of the private operator, and the type of contract to be chosen. If the sector depends upon unreliable government subsidies, it will be of little interest to the private sector.

Control and regulation

Control and regulation are essential and must underlie any reform. The leading objectives of a system of regulation are: (i) to assure compliance with the standards for acceptable service; (ii) to protect the consumer from possible monopolistic behavior; (iii) to create an environment that favors commercial viability and therefore attractive to the private sector; (iv) to ensure that the management of the WS&S sector takes into consideration environmental issues.

2. REFORMS DEVELOPMENT

There is no ready-to-use institutional option; the appropriate solution is cut to measure into the continuum of available options. Regrouping the management of water and sanitation sectors presents advantages for better co-ordination and economies of scale, but also has disadvantages such as the risk of cross-subsidies, or of marginalizing the sanitation activity in favor of the more "lucrative" potable water service. It is necessary to combine approaches and diversify partnerships, seeking to involve the local private sector either alone or in partnership with international operators. Finally there is a strong correlation between financial and institutional aspects.

2.1. Implementation and management of reform

To implement and manage these reforms responsible bodies should be defined very early in the process. A plan for information, communication and awareness-building, user participation should be set up. To anchor reforms in a more global context institutional reforms should be conceived so that they are consistent with the broader contexts of environmental protection, economic reform and urban management.

2.2. Institutional development

Institutional reform alone cannot remedy the many deficiencies of the sector. They should be accompanied by a simultaneous implementation of a plan for institution-building which strengthens the capabilities of the actors involved and encourages transfer of skills and networking. Institutional reforms must include a program of training and capacity building addressing key areas. Because institutional reform is highly country specific and has not had time to generate enough data, information sharing should be favored through study visits to similar countries where reforms are already in place. Networking among water and sanitation utilities is an important component of institutional development, allowing the exchange of experience and documentation.

3. OVERVIEW OF THE AFRICAN SITUATION

The institutional reform situation was reviewed in 42 African countries: 15 English-speaking, 22 French-speaking and 5 Portuguese-speaking countries with a total population of 605 million. The review led to the following observations:

- Predomination of the national level organization: 29 countries, and specially in French speaking ones: 20. Local and regional organization predominate in English speaking countries 10/15

- In 26 countries, Water supply is managed alone, in 9 countries it is managed jointly with sanitation and in 10 countries with electricity

- Sanitation is mentioned in only 25 % of the sample which confirm the institutional backwardness of this sector compared to the water supply one.

- In 10 countries PSP is already implemented and in 24 countries reforms are under way aiming at PSP.

- Management lease is the most widespread arrangement and they are only 3 or 4 concession cases.

4. CONCLUSION AND RECOMMENDATIONS

Although the implementation of reforms is a relatively recent phenomenon, 50% of the African countries have already implemented or are in the process of implementing a reform of their water sector. Yet time frames and contract duration are such that it is still too early to discern which practices are good and sustainable.
It is nonetheless possible to make the following preliminary remarks:

⇒ Every reform is unique and must be rooted in the cultural, social, and political context of the country.
⇒ Institutional development lies at the base of all sustainable reform in the sector.
⇒ No sustainable reform is viable without political commitment and strong internal leadership.
⇒ All the actors in civil society must be mobilized through a participatory approach.
⇒ There must be a clear definition of roles and an effective allocation of risks.

⇒ PSP contracts should be specific and the contracting procedure transparent.
⇒ The regulatory framework must protect all parties.
⇒ A program of institutional development must be implemented concurrently with reform.
⇒ Sanitation is of no less importance than potable water.
⇒ Users must be given a voice, and their voice must be heard.

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Stockholm Water Symposium: August 1998
Extended Abstract of Plenary Paper

GROUNDWATER: THE THREATENED RESOURCE - ASSESSING VULNERABILITY AND PROMOTING PROTECTION

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Groundwater is a very large, often misunderstood, and almost always undervalued, resource. Of the 37 Mkm^3 of freshwater estimated to be present on this planet, about 22% occurs below the land surface in the form of groundwater. Excluding water locked in polar ice caps, this constitutes some 97% of all freshwater potentially available for human use.

As a result of its drought reliability, low development cost, widespread availability and generally excellent natural quality, groundwater has become immensely important for human water-supply in both urban and rural areas of the developed and developing nations alike. Countless large towns and many cities derive much of their domestic and industrial water-supply from aquifers, both from municipal wellfields and through very large numbers of private boreholes. More farmers all over the world are using groundwater to irrigate crops, especially during the dry season.

For the most part groundwater resources are recharged, directly or indirectly, by rain infiltrating the land surface. Many activities at the land surface can thus threaten the quality and availability of these resources. It normally (but not always) takes years for infiltrating water to find its way down from the soil and reach the watertable, and overall groundwater remains in subsurface residence for tens, hundreds or even thousands of years before it reappears at the surface.

Aquifers have a number of important characteristics, notably a capacity for groundwater storage and for groundwater flow, but not all aquifers are the same. Moreover the soil (and vadose zone) profiles actively attenuate many water pollutants. However, not all soil profiles, and the underlining hydrogeological environments are equally effective in pollutant attenuation and the level of attenuation will also vary with the type of contaminant and the nature of the polluting process in a given environment.

Evidence is accumulating that groundwater is becoming increasingly polluted. The most common contaminants are nitrate, salinity, soluble organic compounds (including some synthetic toxic species) and, in certain conditions, fecal pathogens. Serious pollution of groundwater occurs when contaminants are discharged to, deposited on, or leached from the land surface, at rates significantly exceeding the natural attenuation capacity. This is occurring widely as a result of both the indiscriminate disposal of liquid effluents and solid waste from urban development with inadequate sanitation arrangements, and of uncontrolled effluent disposal and leakage of storage chemicals

into the ground from industrial activity. Intensification of agricultural cultivation can also lead (and has led) to significant and widespread deterioration in groundwater quality under some conditions. The principal problems are the leaching of nutrients and pesticides, and increasing salinity in the more arid environments.

The recent rapid growth in groundwater exploitation in developing nations, has put groundwater resources under increasing pressure, and one result is that water is being abstracted from some aquifers at grossly unsustainable rates. This can have serious consequences in physical, economic and ecological terms, and is also associated with significant quality deterioration due to the inflow of saline water of coastal or other origin through lateral intrusion or upconing, and to the induced infiltration of poor quality groundwater frequently present in overlying shallow aquifers. These effects cause quasi-irreversible deterioration in many aquifers since once their microporous matrix is invaded with poor quality water it can take decades for this to be flushed out.

Groundwater pollution is insidious and expensive: insidious because it takes many years to show its full effect in the quality of water pumped from deep wells, expensive because by this time the cost of remediating polluted aquifers will be extremely high. Indeed restoration to drinking water standards is often practically impossible. Groundwater is one of the most valuable natural resources possessed by many nations. Without proactive protection there is serious risk of irreversible deterioration on an increasingly widespread basis.

Promoting the management and protection of groundwater resources, and the water-supplies which derive from them, represents a formidable organisational and technical challenge. It is one, however, that needs to be faced. In essence there are two fundamental requirements: to control groundwater abstraction and to constrain the contaminant load on the subsurface arising from land-use activities. The frequently very large number of individually-small abstractions from, and potential discharges, to groundwater is a major complicating factor. To be successful in groundwater protection it will normally be necessary to bring together the following key elements in a balanced way, appropriate to the local hydrogeologic and socioeconomic conditions: (a) improved definition of the resource and its pollution vulnerability, (b) strengthening of the regulatory framework, (c) mobilising stakeholder participation to generate a consensus for action and (d) appropriate use of economic instruments (such as incentives, charges, sanctions).

Where the protection of groundwater quality from anthoprogenic pollution is concerned, a vital step is to find realistic ways of meshing groundwater considerations into the land-use planning framework if one exists, or begin to promote such a framework where it does not. To do this, simplification of hydrogeological interpretations must be accepted if we are to communicate effectively with stakeholders. Useful communication tools are simple guide maps, which zone the land surface, supported by equally simple matrices which indicate what activities are acceptable where with a given design level.

A realistic balance needs to be struck between the protection of resources (aquifers as a whole) and specific water-supply sources (individual boreholes, wells or springs). For resource protection it is scientifically-valid and cost-effective to make cautious use of the natural contaminant attenuation capacity of the strata overlying the saturated aquifer, classifying the characteristics of these strata in terms of relative vulnerability of the underlying aquifer to pollution. Although "integrated vulnerability" cannot be defended in rigorous scientific terms, it is a useful concept for interdisciplinary communication if the classes are defined carefully.

As regards source protection areas, the average (saturated zone) catchment area is the primary consideration, and a small microbiological protection area should also be included. The source protection area concept is readily understood by planners and therefore of considerable value, but it has significant limitations in areas of complex hydrogeology, and where heavy and/or intermittent pumping regimes are the norm.

Land surface subdivision through a combination of aquifer vulnerability zones and special protection areas will help regulatory and planning agencies to prioritise their actions and can also facilitate the public understanding of the need for protection. There are, however, some significant obstacles to the implementation of associated groundwater protection strategies:

(a) dealing technically, financially and legally with the legacy of past pollution, in the long-standing urban and industrial areas of both the industrialised and some developing nations

(b) effecting changes in agricultural regime, as opposed to refining best management practice for existing cropping and husbandry, especially where intensive monocultures have become well established

(c) major uncertainty over the transport and persistence of some contaminants in the subsurface, which can lead to very large uncertainties in the mapping of vulnerability zones and protection areas.

The detailed implementation of groundwater protection policies will vary quite widely with hydrogeological scheme and socio-economic diversity, but raising awareness and broadening participation will always be critical elements. Care is needed when dealing with the media so as not to provoke over-reaction to groundwater pollution threats amongst consumers; this will normally divert investment into water-supply treatment and/or the purchase of bottled water, resulting in more overall expenditure but less on aquifer protection. Some concern must also be expressed about the introduction of increasingly rigorous (but not well substantiated) quality standards for drinking water, without any consideration of the incremental health benefits afforded for the likely expenditure nor of the feasibility of implementation through protection rather than treatment.

HOUSEWIVES, URBAN PROTEST, AND WATER POLICY IN MONTERREY, MEXICO

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There are multiple ways for women to contribute to the field of water resource management. From research to operations to management to Cabinet-level policy making, there is a role and a need for greater participation of women. However, women are also users of water services. In countries like Mexico, where poverty and extreme poverty are actually on the rise, this means that millions of poor women have become household managers of inadequate residential water service. Increasingly, household management of substandard public services in Third World cities has come to mean the incorporation, within the daily tasks of women in poor urban neighborhoods, of protest activity directed at remediation or obtainment of service. Protest activity can, in turn, have an impact on government water policy and investment for urban water service infrastructure.

This paper presents the results of a decade of research on the 1980s water crisis in Monterrey, Mexico, focusing on the importance of gendered urban protest to the resolution of the crisis. Years of protests by poor neighborhood women in Monterrey are shown to have contributed to fundamental and significant shifts in federal government policy regarding investment in water infrastructure for the city (Bennett 1995).

Monterrey is Mexicoís second most important industrial city and third largest in population, with close to three million inhabitants. From 1940 to 1970, the decades that constitute the iMexican Miracleî in terms of economic growth, the expansion of Monterreyís water services did not keep pace with increases in the cityís population, nor with its industrial and commercial growth. By the early 1970s, over 300,000 residents, almost 30 percent of the population, were not connected to the municipal water system. By the late 1970s and on into the 1980s, massive shortfalls in the water supply itself forced the Water Service to implement rationing across the metropolitan area as a whole, even in neighborhoods that had long-established municipal service. As water service deteriorated, city residents responded with outrage. Complaints poured in to the Water Service and to local newspapers, and protests broke out across the city.

My research on the evolution of Monterreyës water system during the twentieth century indicates that three political actors were critical to the process of planning water services for the city: the executive branches of the federal and state governments, the regional private sector elite known as the Grupo Monterrey, and women living in low income neighborhoods in Monterrey.

Various government agencies along with representatives of the Grupo Monterrey were the official power brokers for the development of hydraulic infrastructure for the city. The history of Monterreyís water problems is a history of changing relations of power between these political actors. For decades, the conflictive relationship between the Grupo Monterrey and the government constrained public-sector investment for water infrastructure. The long-term outcome of this was the citywide water crisis of the 1980s.

The rapidly deteriorating water service resulted in citywide public protests that were shaped by gender, class, and territoriality. Water service deficiencies were so severe in Monterrey by the late 1970s that low-income women used protests and other tactics of disruption as a mechanism to communicate their needs to the government. Thus it happened that poor urban women, who normally have no say in policy making or government investment decisions, had a critical impact on urban water infrastructure planning and investment once they had constituted themselves as a social actor. The protests reached their peak during the years when the government and the Grupo Monterrey were developing a more cordial and even cooperative relationship. Both the protests and changing private sector - government relations contributed to a major reversal in public-sector spending as the government for the first time in four decades made Monterreyís water sector a high priority.

Women were the primary participants in the protests over water because of the intersection of their gender and class roles. Their gender role makes women the managers of the process of social reproduction. Womenís role as the managers of social reproduction is more difficult under conditions of poverty. As cities expand without a concomitant growth in all public services, government (institutions and bureaucrats) increasingly becomes the terrain of conflict, and conflict itself increasingly is centered on issues of social reproduction rather than those of the sphere of production. As managers of the sphere of reproduction, women become the protagonists of these territorially based conflicts.

The protests had three concrete results. First, residents who carried out the most disruptive protests usually received immediate improvements in their water service, albeit often only temporarily. Second, the protests helped the Monterrey Water Service perfect its water rationing system because they provided up-to-the-minute information on actual water services in residential neighborhoods across the metropolitan area. Paradoxically, while challenging both local and state government institutions and disrupting the stability of the city, the protests in Monterrey also taught the water authority how to better manage the water system under crisis conditions. Third, the protests helped shape investment by the federal government for large water infrastructure. Protest can influence the topic of debate, it can make debate more urgent, and it can influence the willingness of decision makers to see alternatives (Pinch, 1985). The protests in Monterrey had all three effects.

Through their protest activity, low-income women in Monterrey altered relations of power because they were able to insert their own voice and new demands into a process that had until then considered the voices of only two actors, the government and the Grupo Monterrey. As result, investment for water services deviated from the normal

course of planning for such services in Third World cities. In an unprecedented move (anywhere in the Third World), the federal and state government decided to extend the municipal water system into every home in the city, bringing in-home water service to 124 neighborhoods that previously had lived only with the precarious service of water truck deliveries or unreliable standpipe service. Furthermore, the cost of extending service to these poor neighborhoods was completely recovered within three years via household payments, disproving the conventional wisdom that services cannot be extended to the urban poor because the costs of doing so are not recoverable.

This paper will review the dimensions of the water crisis in Monterrey, analyze the gendered nature of the protests over water by exploring the strategies used and their impacts, and evaluate the changes in government policy and investments in the 1980s and 1990s that are related to the protests. Political and economic contexts shape and constrain possibilities for action for all political actors. In the end, Monterreyís water services improved because relations of power changed between the Grupo Monterrey and the president of Mexico, and because through their protests poor women in Monterrey disrupted political, industrial and everyday life in Monterrey to such an extent that the government was forced to prioritize water services not only for established users but for the traditionally underserved hundreds of thousands of urban poor as well. The changes in the relationship between the federal government and the regional elite account for some but not all the improvements in Monterreyís water services. The research presented here demonstrates how the intervention of poor women using public protest strategies resulted in a landmark investment for residential water service for Monterrey that extended home water service to every impoverished household in the city a feat never before undertaken in Mexico.

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PRACTICAL WATER MANAGEMENT INITIATIVES IN SOUTH AFRICA

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South Africa is a dry, drought-prone country, where Apartheid policies sought to inflict among the most unjust distribution of an access to water of any country in the world. The country's first democratic Government inherited a situation where somewhere between 12-16 million of South Africa's 38 million population did not have access to potable water, and up to 24 million did not have safe sanitation. Even for those with access to water, there were tariff policies that effectively encouraged abuse, and resulted in a subsidization of big (usually affluent) users, rather than an investment in small (usually poor) users.

Upon becoming Minister of Water Affairs and Forestry in 1994, Professor Kader Asmal began the process of reforming water management in South Africa. A core aspect has been the re-writing of the water law, which has progressed considerably. A second major drive has been to improve the supply of water and sanitation to those denied them in the past, where again much progress has been made.

In 1995 Professor Asmal initiated a third major intervention, the *National Water Conservation Campaign*. The disregard for social justice in water management had been compounded by an engineering-orientated, supply-side mentality. The goal of the Campaign was to help to demonstrate the potential for equity, efficiency and sustainability in the supply and use of water.

The Campaign has notched up a number of successful initiatives in its three years of operation, both in terms of demand-side management and the conservation of supply. This paper gives a brief outline of five of the initiatives that point the way to possibilities for a successfully integrated water management strategy.

1. The *Working for Water* Programme

Invading alien plants (non-indigenous species that spread uncontrollably) are estimated to be using approximately 9% of South Africa's mean annual run-off. Left unchecked, the continued growth and spread of these weeds would increase this figure considerably.

All of our analyses have shown that it is invariably more cost-effective to clear first these unwanted plants, than it is to augment water supply through conventional methods such as dams or inter-basin transfers. What is more, these comparisons have been undertaken in the "accounting" way practiced by engineers in South Africa, rather than in a more holistic, resource economic assessment that looks at environmental costs, other social costs, opportunity costs, cumulative impacts, synergistic impacts, and the like. In economic terms, the work of the *Working for Water* programme is an even more attractive option.

The emphasis of this paper is to explore some of the costs and benefits for water management that are associated with the *Working for Water* programme.

However, the paper also looks at the considerable benefits of the programme in terms of job creation (unemployment being South Africa's greatest problem), community empowerment, productivity of land, incidents of fires, problems around ground-water recharge, erosion, scouring of rivers, siltation of dams, water quality, biological diversity, the ecological functioning of systems, and other benefits.

The *Working for Water* programme has won numerous awards, including the prestigious *Best Conservation Project* of 1996 in the WWF's Green Trust Awards.

2. The *National Park Resource User-pays Project*

The *User-pays Project* has been run in two of our parks - Mopani rest camp in the Kruger National Park, and Tendele rest camp in the Royal Natal National Park. The premise is that parks tend to attract those who (because of their relative affluence) are the most influential in terms of resource use - and who are tractable to conservation messages whilst in the parks.

In the project, visitors were given a reduction in the amount they paid for their accommodation, but had to pay for their own use of water and electricity. Every effort was made to make it easier for visitors to use these resource more efficiently. Water- and energy-efficient appliances were retrofitted; park interpretation efforts around resources were intensified, and a pre-payment meter with advanced communication potential was developed.

The paper outlines the results of this approach; the reaction of the visitors and staff, and the extent to which this intervention was found to change the way in which visitors used water and electricity in their homes, after experiencing the intervention at the park camp.

It won the *Best Conservation Project* of 1995 in the WWF's Green Trust Awards.

3. The *Greater Hermanus Water Conservation Programme*

The medium-sized coastal town of Hermanus, near Cape Town, faced a water shortage in 1996. In collaboration with the local authority, the author devised a 12-point conservation package aimed at reducing water consumption, whilst at the same time raising revenue from water sales - and aiming to do so with strong public support.

Central to the package was a thoroughly revised set of water tariffs, where those who drive the marginal cost of water pay the marginal price. An 11-block escalating tariff was devised, which is almost certainly the most socially just water tariff in the country. It makes basic amounts of water affordable for the poor without sacrificing a resource-economic justification for the scale of tariffs. The seasonal influx of people made an assurance of supply tariff necessary as well. The tariff structure was backed up by efforts to conserve supply (eg, catchment management, water-loss management) and to promote demand-side management (eg, informative billing, retrofitting, revised water by-laws).

The paper discusses the exceptionally successful results after the first eighteen months of the programme.

The programme is a WWF/Green Trust *Best Conservation Project* finalist for 1997.

4. The *Schools' Resource Audit Project*

Growing out of the *User-pays* project was a schools' resource audit project (called the *Schools' 20/20 Vision for Water*). This has been a collaborative effort that has seen some 4 500 schools undertaking water and energy audits. The pupils do electricity audits and both water quantity and water quality audits at their schools and environs, as well as in their homes. They are then encouraged to adopt conservation measures, and audit the efficacy of these measures.

Once again, some spectacular successes have been achieved, and there has been a great deal of progress in the effectiveness of the resource-audit and incentive kits that are provided to schools. Brief details are given in the paper.

It is a finalist for the WWF/Green Trust's *Best Water Conservation Project* of 1997.

5. The *Masakhane Pre-payment Meter Project*

Also growing out of the *User-pays* project has been a joint water/electricity/tele-communications pre-payment meter. Although the project began as part of the Hermanus water conservation package, it is now growing into a trial of considerable national importance.

The pre-payment meter has been designed as an on-line meter with very enhanced communication possibilities. The meter allows home-owners to understand better the way in which they are using resources such as water, and to budget accordingly. However, its special attraction is the link to a community-building neighbourhood watch initiative, where the on-line functions allow people to take greater control of their lives. It is called the *Masakhane* meter after the Xhosa term meaning "Let us build together", signifying its community-building aspirations.

The paper outlines the progress made in this project, thus far.

Conclusions

All five of these initiatives demonstrate the importance of the stated theme of the 1998 Stockholm Water Conference: "Water - the key to socio-economic development and quality of life". The theme sums up the particular vision that Professor Asmal has brought to the management of water in South Africa, with all the ramifications for reconstruction and development in the "rainbow nation".

Panel discussion - purpose and scope

POSSIBILITIES TO STOP THE HYDROCIDE

Where are the buttons to push?

Background

Industrial development is generally seen as a crucial key to economic development and income generation, to poverty eradication and quality of life in both post-communist and developing countries. A fundamental drawback is however the production of waste and the escalating water pollution that follows. UNIDO's projections for 2025 suggest up to more than 15 times increase of pollution load in the next 30 years for SE Asia.

Reference is often made to the inverted U-curve linking pollution to GNP in postponing waste minimization efforts to a later phase of economic development. Such an approach reveals a poor understanding of the role of fundamental climatic differences, especially the low dry season flow typical for monsoon climate and the river depletion that may be envisaged from consumptive water use in irrigated agriculture. The irreversible character of groundwater pollution as seen in a time scale of human life time is also poorly understood.

The six year series of Stockholm Water Symposia 1992 - 97 addressed a set of issues within the general niche "Minimizing harmful fluxes from land to water". The different problems have been thoroughly analyzed and a number of conclusions drawn regarding not only technology but also education, water awareness building, and integrated land and water management. Technologically it is already known how to reduce pollution loads from households and industry, and antipollution legislation exists in many countries. Key barriers are however high regarding implementation - lack of enforcement, lack of awareness of the risks involved, conflicting values, affordability and financing problems etc. Reducing pollutants from agriculture is even more difficult since the dependence on agricultural chemicals has to be seen in combination with the world's growing food needs and involves serious goal conflicts.

As concluded by Stockholm Water Symposium 1993 water quality has no constituency. Moreover, delays in curbing the pollution loads make possible a meantime further escalation of the pollution.

The many different barriers sum up into what is now spoken of as the threatening hydrocide. Increasingly, the water is becoming polluted beyond usability. The situation is characterized by a laissez-faire - a "wilful neglect" - to take action (Lundqvist, Ambio, in press), reflecting the more or less unsurmountable goal conflicts involved. There are already many examples of places where industry has met difficulty in finding usable water due to severe pollution and been forced to turn to expensive projects to meet their water needs. The current scale of the pollution problem is indicated by the fact that social unrest and riots are reported from India where people have started to turn their frustration into action: against industry for severely polluting their water bodies and against administration for not organizing defecation opportunities.

Purpose and scope

The Panel discussion will put its focus on what can actually be done to change the disastrous development as regards a deteriorating water quality all over the world in both surface waters and groundwater.

Which are the key actions?
* high level meetings,
*creation of public awareness,
*convincing of politicians,
*legislation, enforcement,
*economic incentives, etc?

Which are the key actors?
* politicians and administrators responsible for strategies, decision making and control,
* business with the technique in its hands,
* the public with their expectations and potential to provide support to politicians.

The Panel will be chaired by Mr Jim Oatridge, Chair Sustainable Water Working Group, World Business Council for Sustainable Development.

Workshop 1

Carrying capacity and crop production: water-related conflicts and opportunities

ALLOCATING WATER RESOURCES IN A DRY-CLIMATE REGION: THE CASE OF MOROCCO

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The Water scarcity and rainfall variability are currently constraining economic growth in many dry-climate developing countries. This constraining effect is often exacerbated by *ad hoc*, fragmented policies with regard to water resource planning. In order for policy makers to create and implement more holistic, integrated water resource strategies, they must have access to a reliable analytical tool for assessing the implications of drought-year scenarios for the entire economy. This paper provides a new methodology for analyzing the fundamental interrelationship between the sustainable management of a dry-climate country's water resources and the formulation of effective strategies for drought water security and henceforth socio-economic development. It also evaluates the different policy options that effect the capacity of production for irrigated agriculture, level of imports and exports, urban and industrial water supply, and environmental considerations of water use.

The analytical tool proposed in this paper captures the complex nature of water—e.g., precipitation variability and pollution—as well as the complex effect of water on the economy—e.g., intersectoral allocation and water pricing—by fusing two techniques, one drawn from engineering, the other from economics. Using a method developed by engineers, a water resource model is first created for a particular region; then, we take the innovative step of incorporating information from the model into a traditional economic input-output table. This union of water resource modeling and input-output analysis yields a Decision Support System which can be used to evaluate the trigger effect of hydrology on the macroeconomy.

Morocco has been chosen as a prototype to illustrate the proposed methodology. The water resource model developed in this study centers on the Oum Er Rbia, Bou Regrag and Sebou river basins, which provide over half of Morocco's available water and are key contributors to the GNP. The river basins studied involve multiple supplies (rivers, aquifers, dams) and demands (urban, agricultural, hydroelectrical), which are integrated to optimize long-term net benefits for all users. In order to determine the optimal allocation of water in the region, the model includes several types of constraints: technical (e.g., system continuity), physical (e.g., water and land availability), environmental (e.g., ground water extraction and pollution standards), financial (e.g., investment in infrastructure) and finally, macreoconomic (e.g., food security and international trade). Ultimately, this model produces a wide range of data that are eminently useful for water planners. Up until now, however, the data generated by such

models have not entered into the formulation of national economic strategy. Water resources have typically been viewed in isolation from the broader macroeconomic picture.

In order to overcome this isolation—and bring the management of water resources into the arena of national planning—the results of the water model developed for Morocco have been used to modify the 1995 Social Account Matrix, and create a water input-output table. The entire water cycle—from source to allocation—and the value of water to each economic sector are used to construct a new framework for observing the relationship between water and the macroeconomy. This framework highlights the sectoral impact of various water scenarios, using a set of multipliers (employment, output, income, water use). These multipliers can be manipulated to help identify sectors of strategic importance, generate an economy-wide demand curve and target investments to the most economically promising projects and areas. The agriculture sector provides up to forty percent of the employment in Morocco. Precipitation variability does not effect only the national economy—through the agriculture production—but also has various social implications, that could be overcome by investing in other sector of the economy, as the set of multipliers illustrates.

The Decision Support System elaborated in this paper is intended as a practical tool, acceptable to both water specialists and national planners, for formulating a sustainable and integrated strategy for drought-year management, and for long-term planning and management of the water sector. In particular, this framework specifies the allocation of water among conflicting sectors and projects the level of food production for various water sector scenarios. In the case of Morocco, such a strategy would include, for example, opening the agricultural market and relaxing cropping pattern regulations. These measures would shift agricultural production from crops with high water requirements and low returns (e.g., wheat, barley and rice) to vegetables and fruits, which can be grown using less water and exported to the international market. This shift would allow national planners to direct more resources to the urban sector, where new investment in industry would create three times the number of jobs that would have been created by similar investment in agriculture. Implementing water loss reduction and pollution control programs would further strengthen the economy, by making water resources more efficient and sustainable.

Although for the purposes of this study, the Decision Support System has been applied to Morocco, it can be tailored to suit the needs of other countries in which water resources are intertwined with the national economy. The Middle Eastern and North African countries in particular have been deeply affected by water scarcity, and with this in mind, the Arabic word for water has been used as an acronym for the model (MEIAH—Macro-Economic Integrated Analysis of Hydrology). This type of analytical tool can serve as a catalyst for policy debate, provide common ground for fruitful cooperation among various governmental bodies, and finally, bridge the gap between water resource planning and national socio-economic development.

MANAGEMENT OF WATER RESOURCES THROUGH THE FARMER ORGANISATIONS ESTABLISHED UNDER IRRIGATION ORDINANCE IN SRILANKA

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Introduction

Farmer Organisations (FOs) are established under Paddy Lands Act of 1958 in Sri Lanka. One major tank is controlled by one farmer organization assisted by a project manager. The project management committee represents all government departments and relevant organizations which deal with irrigation, agriculture, marketing, banking etc. under consultant capacity without any power to impose ideas. The cultivation meeting is headed by the Government Agent of the District who has a decisive power to limit the maximum cropping intensity. Water availability is the most important criteria for the decision of the date of first water issues, quantity of water issues, cropping patterns, cropping intensity and the last date of water issues. The decision taken by FO is not for the benefit of the downstream command areas. However the cropping intensity has a direct influence on the return flows to the down stream which account for one fourth of the total water used. The diversion schemes are fully dependent on the return flows from upstream. In 1996 when the Inginimitiya scheme not used water for cultivation at least for one acre due to insufficient water to feed the full extent, the return flows were eliminated leaving half-full reservoir with closed sluices on a firm decision taken at cultivation meeting. The farmers lost the previous paddy season due to drought and now had to discard MAHA season as all the farmers claim the right to use water equally but not otherwise.

Presentation of the project

The MIOYA basin of Sri Lanka has 1,533 sq.km. catchment. The stream is 50 km long and developed with six major reservoirs operated by the Irrigation Department. Agrarian Services Department also operates sixty minor tanks. Six anicut schemes across Mioya to divert water to paddy tracts are operated by Irrigation Department. It also has many smaller tanks owned by private farmers. Each farmer organization decides the cropping intensity and pattern in October for MAHA season, in March for YALA season. Farmers decide on a threshold value of quantity of water for the consideration of cropping under the tank. If water is not sufficient it postpones the meeting for another two weeks until the tank is reliably filled to satisfy the farmers. The area has 950mm of average annual rainfall but in 1996/97 it received only 450mm.The major supply usually expected in May/June was absent in 1996 and hence the tanks were either empty or half-full.

The upper catchment of Galgamuwa, Ambakola, Attaragalla, Palukadawala and Mediyawa tanks which totals to 6000 acres of command area were not cultivated and return flows were curtailed to Inginimitiya in the downstream. Inginimitiya had 20000 Acft of water but FO decided not to do cultivation as it needs 40,000 Acft for 5000 acres with 215 sq.miles of drainage area. This did not allow return flows to RBE anicut, The anicut had 200 acres of paddy under its own command with the independent catchment of 40 sq.miles below Inginimitiya but without return flow from above needed water to rescue the paddy crop during the last period of January 1997.The request for 1000Acft of water from Inginimitiya FO was not allowed as they have already lost two seasons expecting next Yala to begin with cultivation in March 1997 using already collected water. This serious issue was discussed in this paper as a management failure. The downstream Tabbowa tank, which is fed by RBE anicut canal, had survived with its own catchment of Nanneri Oya for 2200 acres of rice.

Discussion

The Farmer Organization has the interest only for its own benefit. Every land out of a total of 5000 acres was not given water to crop with only 15000 Acft reserved in the reservoir in October. But in November it had increased to 20000 Acft. Each farmer had only two acres paddy land and it is impracticable to irrigate one acre from each lot for the benefit of all the farmers. Thus few tracts can be selected in one branch canal to irrigate with available water for 1500 acres. This system of vacation shall be rotated in future for other farmers to gain equal benefit in case of low water availability as recorded in 1996.Then the return flows are ensured to the downstream farmer. Also it is a fact that unused water loses its nutrient value in two weeks. Further evaporation losses were high. Hence use of all available water is a must and cropping acreages listed accordingly.

Conclusion

The Parliament has to revise the Irrigation Ordinance to accommodate the power to cultivate lands with available water under any reservoir. The Government Agent shall be given the authority to select the farmers in rotation in case of low cropping intensity. This paper has the cropping intensity for 75% 50% 25% dependability based on hydrology of the catchment. Farmers are advised to come to an agreement in case of drought conditions to use water efficiently.

LIST OF ORDINANCES/LAWS/ACTS TO CONTROL WATER RESOURCES IN SRI LANKA

1 Agrarian services Act 1979
2 Mahaweli Authority Act 1979
3 Agricultural Corps Ordinance 1946
4 Coast conservation Act 1980
5 Soil conservation Act 1951
6 Water Resources Board Act 1964
7 National Water Supply and Drainage Board Act 1974
8 Land development Ordinance 1935
9 State Lands [Claims] Ordinance 1931
10 State Lands Ordinance 1947
11 Inland Fisheries Act 1996
12 Irrigation Ordinance 1968
13 Ceylon Electricity Board Act 1970
14 Flood protection Ordinance 1924.

RECYCLING OF WASTE WATER - AN INEVITABLE OPTION FOR CITIES: CASE OF SINGAPORE

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Introduction

Among the major water users, agriculture, industry and domestic, water use for industrial sector has been increasing at the fastest rate. This rapid rise in water consumption for industrial purposes has been more due to increasing industrial development than population increase. Thus, in Singapore, the rate of population increase declined substantially in mid-seventies in response to government's efforts. At the same time, water use increased drastically in response to increasing industrial and commercial development. Currently the global average of sectorial water use for agricultural:industrial:domestic purposes is 70%:22%:8%. With increasing urban population (in growing cities population increases at twice the rate of national average) and industrial development (often double digit growths in some cities) the water use in urban areas is increasing rapidly. With increasing population there is also need for more food. Thus greater agricultural production subsequently demands more water. This leads to greater water demand and use by urban areas and greater water demand but lesser water availability for agricultural areas. Obviously this situation is not sustainable. With greater demand and lesser amount of water available for the cities, alternate systems for augmenting the urban water supply have to be sought. Recycling of waste water seems an attractive and viable option. Understandably the cost of recycling increases with improved quality of treated water. Even recycling waste water to drinking water standards appears to costs less than the cost of desalination. Sociological considerations often prevent recycling waste water for domestic use. This paper summarizes the above issues and presents Singapore's experience of water recycling, predominantly for industrial and horticultural purposes.

Status of Water Recycling in Singapore

Singapore being an island city-state of nearly 650 sq km and a population of over 3 million, has about 220 cubic meters of renewable fresh water available annually per person. This places it far short of Falkenmark's1000 cubic meters water scarcity index (Falkenmark and Widstrand, 1992). Despite capturing over half of the rainfall within its borders, it still has to import about half of its water from neighboring countries. With its water resources under severe strain, it has to continuously seek alternate and additional sources of water. Recently there have also been plans and attempts to study the potential for desalination. In Singapore, since there is negligible agriculture, water is used nearly equally by industrial and domestic sectors. Under such circumstances, recycling of waste water may provide a viable option

for Singapore. Earlier, when water use for agricultural purposes was significantly higher, treated effluent was used for such purposes, mainly in pig farms and fish ponds (Chin 1994). Currently, water recycling is practiced after three levels of treatment. Firstly, all waste water in Singapore is subjected to conventional secondary treatment and a small proportion (around 3 percent) of the treated effluent is reused for cooling, washing and mixing of chemicals, predominantly at the sewage treatment plants, as well as for irrigation such as watering of pants and trees at treatment plants and road sides and in golf courses. About 7 percent of the treated sewage effluent is subjected to tertiary treatment processes and over 80,000 m^3 of treated water produced daily is conveyed to consumers through a 93 km long network, for industrial and other non-potable applications mostly to the industrial area around the treatment plant. First commissioned in 1966 the treatment plant is continuously being upgraded to increase its capacity and improve the effluent quality (Lee, 1995). The use of this treated effluent has also been changing from predominantly paper making to predominantly cooling with other users being textile manufacturing and washing. Earlier, the treated effluent was also used for toilet flushing by over 6000 residential units. It had to be abandoned due to complaints from consumers of smell and staining as well as higher maintenance costs due to corroding pipes. A few selected industries subject this tertiary treated sewage effluent to further treatment so as to suit their individual requirements. The total water recycling in Singapore of around 40 million m^3 annually currently amounts to about 10 percent of the total water use or sewage generated.

Potential of Water Recycling in Singapore: Economics, Technology, Health and Public Attitude

In order to assess the future potential, the paper evaluates four major factors; economics, technological considerations, health aspects and public acceptance. Economics forms the key factor in considering the recycling potential. Costs increase substantially with the degree of treatment. Presently about half of the water utilized in Singapore is for non-domestic purposes. Waste water treated to tertiary level may be produced economically and used by some industries and for non-potable domestic purpose. A major consideration for these uses is the need for a separate distribution system. Currently the price of recycled waste water (S$0.30 per m^3) in Singapore is cheaper than the regular potable water for domestic use (around S$0.60 per m^3) or industrial use (around S$1.00 per m^3). Thus there are economic incentives for those industrial users who do not require water of potable quality. With significant amount of potable water in Singapore produced through desalination, in future the gap between the cost of potable water and treated effluent would increase substantially. Thus with increasing price difference there would be greater economic incentives to use the recycled water. Since some industries have found it economical to use the treated effluent even after further treatment of their own, the potential is greater than the present use and will increase with increasing cost of potable water.

The health issues involved in using recycled water arise if the contaminants present in treated effluent come into contact with the consumers. Its probability increases when treated effluent is supplied to residential units. In order to protect the health of consumers, all applications of use of industrial water are governed by regulations which ensure that the treated effluent does not get mixed with potable water and does not become part of human consumption.

Some examples of these guidelines for preventing the treated effluent to come in contact with consumers in Singapore as summarized by Chin and Ong (1992) are:

- no supply shall be made to food and pharmaceutical establishment and canteens
- no physical connection shall be made between the industrial and potable water systems
- all pipe lines conveying industrial water shall be painted in bright yellow
- the use of industrial water for hand washing in sinks, lavatory basins and stand pipes shall not be allowed
- all installations and extension work on industrial water piping systems must be approved by the relevant competent authorities and must be carried out by plumbers licensed by the Public Utilities Board.

Once the health of consumers is safeguarded, substantial quantity of treated effluent may be available for domestic use. A survey of over 2000 households indicated that over 40 percent of potable water could be substituted by the treated effluent for usage not require drinking quality water. Flushing of toilets alone amounted to over 20 percent of total household water consumption. Considering the supply, demand and increasing costs of fresh water in Singapore, further studies are required to investigate the past problems responsible for abandoning the scheme of using treated effluent for non-potable domestic purpose. Lee (1995) cited several studies around the world showing that there were no statistically higher risks for consuming recycled water meeting the appropriate water quality standards.

In order to determine the public attitude towards using recycled waste water for various purposes, a questionnaire survey was conducted among 200 Singapore residents. Their awareness about water recycling, their level of acceptance to use recycled water for various purposes and the factors influencing their attitude were also explored. Generally the Singapore residents showed a favorable response towards consuming recycled waste water. For instance, 47 percent as against 37 percent of respondents were agreeable to drinking recycled water if it met the prescribed quality standards.. The psychological barrier seems to be the most prevalent reason for not agreeing. Over 80 percent of respondents agreed to using treated effluent for non-potable household cleaning and over 90 percent agreed to using it for toilet flushing or outdoor use. The paper provides detailed analyses of this survey.

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CARRYING CAPACITY AND CROP PRODUCTION: WATER - RELATED CONFLICTS AND OPPORTUNITIES

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Introduction:

India is considered to be a museum of societies. Among different forms of societies, the peasent society accounts of 70 per cent of population who are mainly engaged in Agriculture including livestock activities. Agricultural society in India is characterized by its hierarchical setting in which two social values namely Karma and Dharma are very important. The 1992 UN Conference on Environment and Development plans to adopt as one of its main objectives Agenda 21 - the total eradication of absolute poverty in the world by the year 2010. As the home of a billion people in the world who live below the poverty line, India has the greatest stake of any nation in the achievement of this goal. The focus continues to be survival and self-sufficiency rather than prosperity, on meeting minimum needs rather than realizing maximum potentials. Propelled by unprecedented opportunity, the country is once again poised to exceed even the most optimistic estimates of the experts. The essential requirement is a shift in perspective from need-based to opportunity-based planning.

Agriculture is vital to overcoming poverty in the country, both as a provider of food and of jobs. A 33 % increase in per capita food consumption is needed to bring the diet of the present population up to international nutritional standards for caloric intake. Among the states, Tamil Nadu is one of the water starved states in India whose per capita availability is less than the national average.

Irrigation and Agricultural Development:

Irrigation is an important input in a tropical country like India. Historically, irrigation source with a land resource was an important consequence in crop production. Land ownership in India was determined by soil and water resources of a particular region, in turn, the land ownership shaped the social and historical developments of India. Since the historical past, the importance of irrigation was evidence from the renunciation of Buddha due

to the dispute on water flowing in the river Rohini between two clans to which Buddha's mother and father were belonging. Tamil literature, Thirukkural of B.C 34 clearly brought out the importance of irrigation that is: "No life without water and no social discipline without rain".

Due to the historical and dialectical reasons, Indian society evolved into a hierarchical based on the difference in birth among the people. It is now proved by socio-economists like Gunnar Myrdal (1967) that Indian society is static, stagnated and hierarchical culminating in the social disorganization and social disintegration. Indian societies which are diverse in character are yet to satisfy the definition of a society. There is no social democracy in the back drop of political democracy in India.

There are conflicts and contradictions in the social realm creating problems in the water resources utilization. Among the different irrigation systems, tank irrigation is gaining importance as there are about 39000 tanks in the state of Tamil Nadu and most of them are degraded due to encroachment and siltation. In the case of groundwater over exploitation is observed in many locations. There are conflicts in water distribution between head and tail enders in the canal system. Further, water resources development are handicapped due to differential interest among the farmers who are living in 'caste worlds' of Indian villages. Water resources development and utilization need social integration for integrated water use.

Population and Environmental Degradation:

Population explosion is adding agony to dragedy by adding heavy pressure on water since agricultural produces need higher quantum of water compared to domestic and industrial uses. There were ancient oppression and modern destruction on the water resources in India.

The environment is becoming too polluted and degraded. Population explosion of India resulted in the reduction of forest coverage accounting lesser than the optimum of 33 per cent. Land pressure with which too much agriculture in India leads to environmental problem through soil erosion and loss of soil health. In the historical past land was the state property. Land gifts to the so called 'face born' people resulted in the removal of citizenship to tenants of the state i.e tillers of land.

Fragmentation of land holding is an important problem confronting Agricultural productivity mainly due to

inability to adopt new technology. Irrigation management programs involve storage dam to drainage point in a river command. Government programs invested heavily on irrigation projects with which targeted coverage of area and production is lacking behind. Fragmented holdings directly affect irrigation programs especially in the scarcity years. When the availability of water is only 50 per cent of the normal flow, the logical and feasible program would be to go for less duty crops or limiting the area of 50 per cent.

In the social value system, it is the duty of one or two lower castes to scavenge the environment as their social and economic duties whereas the rest entitled to pollute the environment by their social rituals, customs and celebrations. India's water resources are to be viewed from the angle of optimum population, minimum appropriate quantum of water use, social discipline and social integration. Hence, a community mode of production in the midst of scarce water and land resources is needed as in Israel. Indian scientists and planners working in water resources and utilization adopt the western parameters to solve the problems related to water resources allocation to crop production. The genuine tradition of India related to water management, the technological developments taken place all over the world and the concept of equity, efficiency and social justice are to be basic approaches for water resources management in India. The modern technological aspect should compliment the sociological demands of India.

Conclusion:

Tamil Nadu is one of the provinces of India is discussed as a case. It is facing water shortages and the supply -demand gap will be about 35 percent in the year 2015. Tanks irrigation rehabilitation and conservation of the groundwater are the major thrust areas. In this connection, Israel's 'Kibbutz like model' involving state ownership of land, water and participation of people is a good model for India and Tamil Nadu. Land army should form part of the new Agricultural model to enable youth to participate as an obligation. Thus the caste feudal order and caste outlook could be overcome. Environmental enrichment through greening programs and sanitation maintenance would be possible in a community mode of production. It needs education and enlightenment on irrigation related to Agriculture as a long range program for the acceptance of Israel's 'Kibbutz like model' for 21st Century in India and Tamil Nadu.

MANAGING CONFLICT IN THE BHAVANI RIVER BASIN

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Introduction

River basins in the arid and semi-arid regions of India are increasingly prone to competition between various users. Both surface water and ground water are plagued by pollution, overuse and other externality problems, i.e. the use by one sector/user has begun to impinge on the rights of others. The traditional systems of water rights are breaking down and need to give way to a more rational allocation of water resources.

Water is essential for all sectors of the economy-agriculture, industry, households and government. As long as there are no supply constraints, allocation can be made on the basis of need. However escalating demand in all the sectors has put pressure on the limited supply. Trading of water within a sector or between sectors is taking place at the micro-level. Unauthorised extraction of water from the river through pipe lines or lift irrigation has begun to take place in many river basins. With increasing urbanisation, large quantities of wastewater generated by industries and households are discharged into rivers or on to land. Land disposal has the potential of contaminating the groundwater.

In the past in India it was considered sufficient for cities/towns, industries or even agriculture to return wastewater to the river after use, since the major concern was water quantity and not water quality. Indian environmental legislation over the last two decades has changed the focus to some extent. However, environmental regulations are based on effluent discharge standards and not on the impact of the effluents on downstream users. Virtually no controls are placed on sewage discharge or on non-point agricultural run-off. Thus the cumulative impact of wastewater discharges at the river basin level is not known. While environmentalists are concerned about the impact of pollution on fish and other flora / fauna, the regulatory regime places secondary importance on ambient water quality.

Conflicts in the Basin

The Bhavani River basin in the State of Tamilnadu epitomises many of these conflicts of water quantity and quality:

* The construction of the Bhavanisagar dam has increased the area under cultivation more than four-fold, but has reduced the availability to existing riparians in the basin and further downstream in the Cauvery delta.

* The change in cropping pattern from dry crops (like groundnut and millet) to wet crops like paddy and sugarcane had caused conflicts within the Lower Bhavani Command, and was resolved by the Irrigation Department by using a Zonal system of water allocation.

* Unauthorised lifting of water directly from the river and from irrigation canals to irrigate non-command areas of the basin continues to cause conflicts with users in the command areas.

* The discharge of coloured effluent by a pulp and viscose rayon plant upstream of the Bhavanisagar dam, has affected the ecology of the reservoir particularly during periods of low flow. Other downstream industries including distilleries / sugar, tannery and textile industries cause significant pollution problems in the basin, affecting both surface and ground water.

* Over-exploitation of groundwater in the non-command areas has led to the lowering of the water table, thus affecting other users of ground water.

* Diversion of water for urban uses in the neighbouring basin limits the surface water availability in the Bhavani basin.

Regional Approach

It is therefore clear that a regional approach at the basin level must be adopted if the conflicts that are emerging at the local level are to be resolved. Such an approach requires the following initiatives:

(1) Accurate data must be collected on water quantity and quality and on land use in order to carry out a water accounting exercise for the basin.

(2) Planning at the basin level requires the involvement of all the stakeholders - farmers, industrialists, workers, NGOs, and government representatives. Of crucial importance in planning are the land based economic activities which affect the quantity and quality of water in the basin.

(3) Appraisal of the existing systems of water rights as well as laws governing pollution would be helpful in resolving the conflicts among users. However, mediation rather than litigation may be a preferred way of conflict resolution in the long-run. Forums or other institutional structures may have to be set up for this purpose.

REUSE OF WASTEWATER BY IRRIGATION IN A FULL-SCALE SYSTEM IN POLAND

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Land application of wastewater has a long tradition in many countries. This method has the efficient function of enabling natural recycling of organic material and utilisation of water and nutrients. However, many aspects and questions on the methods can be addressed for the practice and for the science as well. In Poland the irrigation with wastewater has two aspects. The first concerns the protection of water resources against pollution. The second one is the increase of agricultural production under water deficiency and under the limitation of mineral fertilisers. Under Polish conditions the reduction of contaminants by grassland irrigation is not only important for water protection but also from an economical point of view. There are fields, which have been irrigated with wastewater for over 100 years, and despite overloading, they meet the requirements of a second and third degree of biological treatment processes. Areas where such treatment have been carried out for many years are the Ner river valley, Osobowice near Wrocław and the Bystrzyca valley near Lublin.

Our study concerns the Ner river valley in Central Poland, which is an example of area where wastewater has been used for fertilisation and irrigation of grasslands since the 19th century. The system utilises 4 m^3/s of sewage water from the city of Łódź. Sewage from agglomeration, which has almost 1 million inhabitants, are led into the Ner river after mechanical purification. The river has a natural flow of only 0.28 m^3/s, but has for many years been loaded with an increasing amount of municipal sewage (recently 400000 m^3 per day). Grasslands covering an area of about 5000 ha along a 70 km long stretch of the river valley are irrigated by the border-strip method. Wastewater used for irrigation contained on average, about 23 mg total N, 23 mg K and 4 mg P per 1 dm^3. The coefficient of efficient water utilisation varied within 0.2 - 0,3.

A particular type of border flow irrigation was developed in the valley, which has specific soil-water conditions (deep sandy alluvial soils and a shallow groundwater table). During the irrigation process the inflow of waste water on an artificially formed border check infiltrates into the soil and fills the available porosity. Excess of water flows as surface runoff towards open drainage ditches. After some time the process of contamination elimination take place in the soil. The natural soil-plant system is a dynamic medium for absorbing, treating and utilising the waste constituents. It works as a mechanical, chemical and biological filter, which is renewed through systematic agricultural use. The irrigation and drainage system consists of 22 weirs, 19 spillways, 11 bridges, networks of irrigation and drainage channels, detailed networks of irrigation ditches and drainage outlet ditches, water flow regulating structures and communication culverts. The area between weirs constitutes a separate, individually working system of local irrigation, which covers about 200-300 ha. In this way irrigation with wastewater

from Ner river may be repeated several times along the river valley. The River Ner is the main irrigation canal and at the same time the main outlet channel for irrigation dump and drainage waters.

About 3.5% of total sewage from Poland are flowing through this system. By biomass production (60 000 tons per year) it is possible to reduce the load of total nitrogen by 1320 tons and of total phosphorus by 240 tons per year to the Baltic sea. The main purpose of this system is to produce fodder for animals and clean of wastewater. However, such a solution is connected with the threat of soil contamination and consequently with a significant threat for the human health. Such undesirable situation is caused by changes in chemical composition of wastewater from Łódź. Recently the industrial wastewater contribution in total wastewater volume was estimated as 55%. Due to considerable increase of total sewage and of toxic substance in wastewater the usefulness of wastewater as fertiliser has reduced. Bacteriostatic and chemical pollution concentration water, which used for irrigation exceeds maximum permitted standards many times. Prolonged exposure to critical pollution concentration has brought these areas to degradation, which have been made danger to health of existing there human and animal populations.

The basis for the estimation of irrigation efficiency in all three aspects, i.e. wetting, fertilisation and purification, is the water balance of the soil as well as the balance of mineral and organic soil substances. Investigations have proved that there is a direct relationship between irrigation and accumulation of organic substances in the soil. Irrigation with wastewater effects intensively the course of biological processes in soil. In consequence of the complicated biological processes an accelerated mineralization and a decession of organic matter in sandy soils, being unfavourable phenomena, are observed. On the other hand, in strongly permeable light soils a growth of organic matter in soil profile is observed. This organic matter accumulation is a factor initiating many positive changes of physical and chemical properties of the soils. The investigations carried out on light soils in the Ner river valley have proved that the accumulation of organic matter is a factor of the irrigation period length. Other changes of soil properties are rather of a secondary character and are correlated with the organic matter content in soil. A final result of many-year irrigation with waste waters of areas in the Ner river valley is the formation of a new anthrophogenic type of soil characterising by the highest potential for the plant production (Kaca, 1993).
The average yield increases under irrigation was 66%. Irrigation with sewage water in Ner river valley was effective as a fertiliser, particularly if applied all year, giving yields over 10 t hay per ha without additional mineral fertilisers (Mosiej & al., 1990). Grasslands irrigation resulted in contamination reduction, because 75 - 95% of total contaminating agents content remained in plant and soil (Somorowski & al.,1991).
As a result of such irrigation, high yields of hay ranging between 10-20 t ha^{-1} were obtained from meadows. Therefore, the agricultural utilisation of wastewater depends on a considerable degree of their chemical elements, and particularly the content of heavy metals. The metal content in the soils irrigated with wastewater depend on the organic matter amount, depth of soil layer and a distance from the point of waste inflow. The content of some heavy metals in upper soil layer exceeded sometimes 300 ppm (Zn), whereas the Cu, Pb, Cr and Cd content was only in rare cases higher than the amounts regarded as harmful for plants. Irrigation with wastewater led to an increase of

the content of heavy metals in plants. The metals content in fodder plants sometimes exceed the limit for Polish standard.

An attempt will be undertaken to assess the condition of the water in the river, which will be achieved after start of a biological step in the Łódź treatment plant. Some elements affecting the justification for the river recultivation, and the scope and efficiency of natural process of autopurification restored to the river have been considered. There are three main possibilities for improvement of water in Ner river and environmental situation in the valley:

- use the wastewater after mechanical and biological steps only for irrigation (in this case reduction of total P rich level 3.7 mg/dm^3)
- establish only constructed wetland for purification of outflow from treatment plant (wetland of surface area 340 ha will be reduce of total P to 3.6 mg/dm^3)
- use the irrigation system and construct a wetland system (reduction of total P rich level 2.3 mg/dm^3)

In light soils, radical changes occur in their physical and chemical properties of meadows; the content of soil organic matter increases considerably and quickly improves general productivity of the soil medium.
In the irrigation processes of grasslands, the purification effects of the contaminated wastewater obtained a relatively high level (0.75 - 0.95) of the load of contamination remains in the soil and with a high level of water management almost all components were consumed for the biomass production.
The purification processes in the irrigation systems of grasslands utilise natural processes and a great variety of soils organisms to recycle nutrient resources of waste water by controlled process of the irrigation are an important element of protection of water resources. The macro-irrigation system in the Ner river is an example of a complementary solution i.e. system combining agricultural production and water treatment.
We conclude that to reach the acceptable by the authorities level of concentration of total P (<1.5 mg/dm^3 after 2000) in the Ner river it is necessary to continue with agricultural production of hay to area of 5000 ha and to construct a wetland system of approximately surface area 340 ha. It is also important to continue the operation of the system to avoid any risk of heavy metals release from the soil, because only optimal level of the moisture (as a result of irrigation) will be reduce mineralization and a decession of organic matter in the soil.

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ROLE OF TREATED WASTEWATER IN MEETING FUTURE WATER DEMANDS IN SAUDI ARABIA

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Introduction

The scarcity of water in the Kingdom of Saudi Arabia is one of the most difficult problems facing social and economic development. The limited natural water resources and the high costs of non-traditional sources combined with the increase in demand for water for different uses, especially for agriculture, make this problem more complicated.

The major objective of this work was to study the contribution of treated wastewater in solving future water shortage problems in Saudi Arabia.

Available Water Resources

Water resources in the Kingdom of Saudi Arabia can be classified into conventional or natural resources (surface and groundwater) and non-conventional ones (desalinized sea water and treated wastewater) surface water in Saudi Arabia is limited although it is used in some parts of the country; mainly for irrigation. The most important natural water resource in the Kingdom is groundwater. It is utilized for all types of uses throughout the country. Desalinized sea water production has increased many folds during the last two decades. Many coastal and interior urban areas depend, to a large extent, on this source for their domestic supplies.

Treated drainage waters are important sources of water in arid and semi-arid regions of the world. These waters include drainage from urban centers (wastewater), drainage from irrigated areas and stormwaters in urban areas. Treated wastewater in urban areas constitutes the most important types of these resources as a result of increased population.

Water Demand

Demand for water in all sectors is met by either traditional or non-traditional resources but in different proportions. Domestic water supplies come from either desalinized sea water or groundwater. Agricultural and industrial water demands are met mostly by groundwater. The total demand for water in all sectors has increased many times during the last two to three decades. The main causes were the increase in agricultural production which was supported by government subsidies and the increase of population and rise in standard of living. Even the demand in the industrial sector has seen great rise due to establishment of industrial cities and programs of industrial expansions in all parts of the country.

Estimation of Future Water Supply and Demand

Population and water demand were first estimated for the period 1995-2025 with the assumption that levels of water consumption will stay at the present levels in all sectors. A second alternative would be to reduce demand in agriculture by 30% and urban demand by 25% by the end of the period. A third plan would be to reduce water consumption in agriculture by 70% and urban demand by 50% by the end of the same period. The importance of treated wastewater as supplementary source to the traditional water sources is obvious if a stringent conservation measures is adopted because it will satisfy about 45% of the agricultural sector demand by 2025. If the other types of drainage waters are also utilized, this percentage will increase.

LIFT CANALS FOR SOCIO-ECONOMIC DEVELOPMENT OF THE HIGHLANDS IN HARYANA (INDIA)

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Introduction

Large tracts of land in India have been suffering perpetually from the scourge of droughts. One such tract nearly 0.81 M.ha in area, falls in the arid zone of Haryana State (Latitude 27^0 39' to 30^0 55.5' North, Longitude 74^0 27.8' to 77^0 37.8' East), India. Hydro-Meteorological analysis shows that the normal rainfall in this region is in the range of 437 mm which occurs mostly during July to September. There is 20 % probability of rainfall departures of more than 25 % from normal. High and low temperatures are in the range of 46.4^0 C and 21.4^0 C. Thick and dark sandstorms are the regular feature in this area having high and low sand dunes.

The quality of life for about 19.6 million population of this area was inferior vis-a-vis nearly 10 million population of the other parts of the state. The area was Socio-Economically backward. There was scarcity of drinking water and rainwater collected in village ponds was the only source of water for human beings and cattle. Groundwater table was low at depth exceeding 30 m b.g.l. The area was out of command of the gravity flow because of the topographical divide where the country slope reversed from North East - South West to South West - North East. Irrigation by canals was considered impossible, and there were no other means of irrigation except very limited well irrigation due to low water table and uneconomical means for lifting of water by a pair of bullocks. The cropping pattern was entirely rainfed and the crops failed when the rains failed.

It was realised that one and the only way to Socio-Economic development of the area was to link this drought prone area to the perennial sources of water by construction of Lift Canals and exploitation of ground water by replacement of manual means of lifting water from the wells by electric/diesel pump sets and installation of shallow tubewells in large numbers.

Perennial Sources of Water

There are no perennial rivers in this area and the few rivulets which flow during periods of good rainfall are too inadequate to be considered for impounding of water. The river Yamuna which is the nearest Perennial river has no storage dam and its inflows were already committed for usage in the Gravity Canal areas. The source of water for the Lift Canals was therefore conceived in the following ways :

i) Inter-basin transfer of waters of the rivers Ravi, Beas and Sutlej of Indus basin via Bhakra Canals System of the Bhakra-Nangal Project to Western Jamuna System of the Yamuna Basin.

ii) Installation of 1500 Deep Augmentation Tubewells in the upstream Gravity Canal areas earmarked for incremental supply to Lift Canals.

Lift Canals

Four Lift Canals namely Jui, Sewani, Loharu and J.L.N. were conceived and implemented at a fast pace to provide canal irrigation to nearly 0.5 million ha. of culturable area. Total maximum lift ranges between 31.12 m for Sewani Lift Irrigation Scheme to 146.15 m for J.L.N. Lift Irrigation Scheme. The design of the canal network, for a lift irrigation scheme is in general, similar to the gravity canals excepting that well designed pump houses intercept the alignment of the canal as the country rises. A number of vertical turbine pumps having pumping capacity of 1.416 cumecs to 4.248 cumecs are provided in combination so that

pumps can be operated at optimum capacity and cost depending upon availability of water. The lift at each pump house is 5 to 8 metres and the water flows by gravity from the U/s pump house to the D/s pump house. The canal section varies from 'filling', downstream of pump house to 'cutting' upstream of the succeeding pumphouse. The pumphouses are spaced relatively further in the upstream reaches and become relatively closer in the downstream reaches as the country slope becomes steeper against which water is to be lifted. The distribution system takes off from the D/s side of each pumphouse to irrigate the U/s areas by gravity flow. These Lift Canals traverse undulating areas across high sand dunes in deep cutting and also across deep depressions. A typical part L-Section of a lift channel is shown in Fig. - I. Salient features of these canals are, reproduced in Table -I.

Fig.1: Specimen L-Section of Madhogarh Branch from Km 0.0 to 5.233

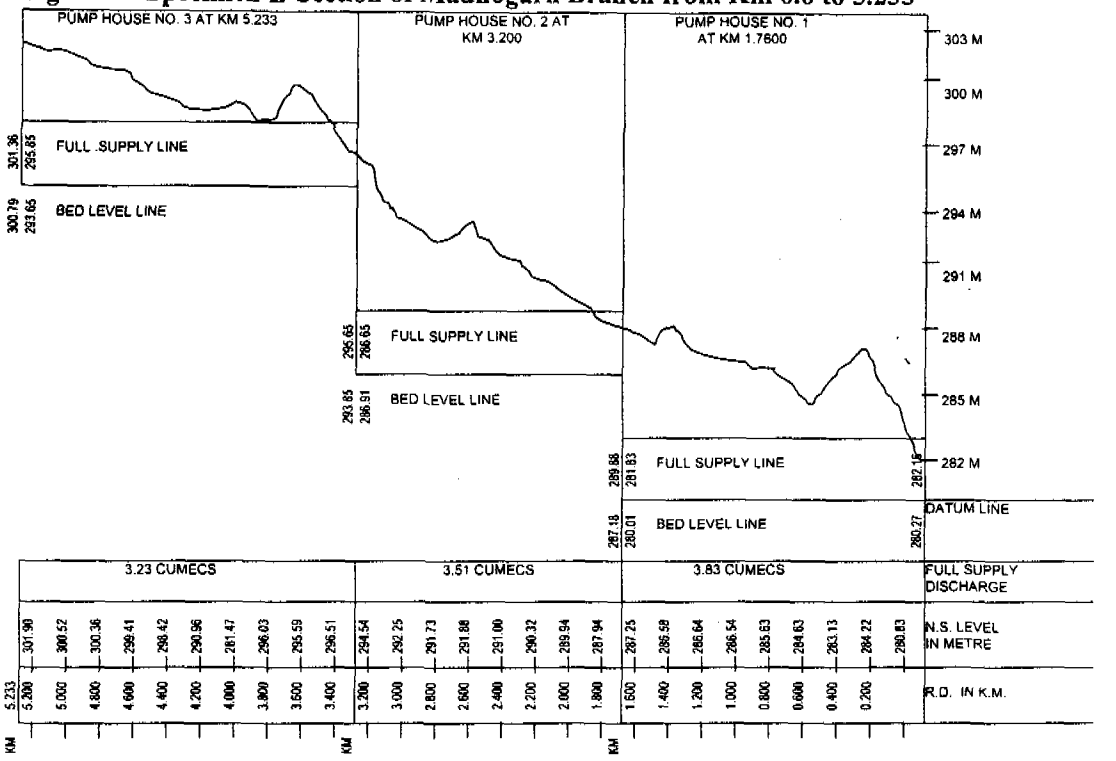

TABLE - I : Salient Features of Lift Irrigation Schemes (Haryana)

S. No.	Particulars	Sewani Lift Irrigation Scheme	Loharu Lift Irrigation Scheme	Jui Lift Irrigation Scheme	JLN Lift Irrigation Scheme
1.	C.C.A. (ha)	73,600	1,06,760	30,170	2,49,901
2.	Length of channel (km)	599.0	694.22	242.40	1340.54
3.	Intensity of Irrigation	62 %	62 %	62 %	62 %
4.	Total Lift (m)	31.12	65.65	39.25	146.15
5.	Cost (US$)	27.52	49.10	7.304	164.97
6.	Year of Commencement	1971-72	1970-71	1969-70	1974-75
7.	Year of Completion	1978-79	1986-87	1971-72	1995-96
8.	No. of Pump Houses	21	20	7	97
9.	No. of Pumps	97	57	66	645
10.	Discharge	24.16	39.05	13.24	91.79

The construction schedule for these canals envisaged winged construction i.e. completion of main canal, distributaries and minors from the head towards the down-stream year after year so that irrigation could be spread all over the command progressively as the construction and water front moved forward. The construction and commissioning schedule were so integrated that whatever part of the project was completed during a working season from October to June was opened for irrigation in July next. This strategy had the great advantage that the utilisation of irrigation potential which was created was almost concurrent.

All the canals and distribution are wholly lined. Water courses below the outlets, for the sharing of water amongst the beneficiary farmers have also been lined under the command area development programme.

Conjunctive use of Surface and Ground Water

Installation of 77,569 No. Shallow tubewells including electric/diesel pumping sets, after rural electrification in the early 70's, has contributed to the irrigated agriculture in the area. Water lifted from the shallow tubewells is transmitted through underground pipelines on account of the great beneficial value of water and the farmers have also adopted sprinkler irrigation in a bigway.

It is interesting to note that whereas the canal irrigated area is only 0.11 million ha due to limited supply of water and high lifting costs, the area irrigated by tubewells is nearly 0.218 million ha and a stage has now reached where there has been progressive decline of water table at the rate of 0.7 metre per annum. It needs to be realised that the importance of Lift Canals is due to the fact that the arrival of canal water, in a small or large measure removed the Psychological barrier from the mind set of the people that they would be left high and dry in the years of drought.

Socio-Economic Development

The 'National Agriculture Commission' inspected the first lift scheme in 1972 and observed "Lift schemes have solved a major problem of drinking water. The imaginative lift irrigation schemes have completely eliminated this area of drought conditions and will help in pushing back the desert menace. The state has found a solution to both drought and desert problem"

The greatest benefit of the development of surface and groundwater irrigation facilities is that the area has become self sufficient in Food and Fodder. Potable drinking water facilities have been extended to practically all the villages and the women folk have obtained freedom from the burden of first lifting the water from deep wells and then carrying it to their homes over long distances.

The percapita income of the people has increased and the people of this area have now almost forgotten the drought conditions and are able to march proudly alongwith the population of other areas of the state. As a result of integration of land, water and human resources, the average yield from rainfed and irrigated areas has increased from 300 kg per ha. before lift irrigation to nearly 1 tonne per ha and the production of food grains has touched 683 thousand tonnes besides 300 tonnes of oil seeds.

The key to Socio-Economic development and improved quality of life is to link the drought prone areas to perennial sources of water, by flow or by lift, depending upon the topography. The success story of the Lift Canals in Haryana is being emulated in the states of Rajasthan, Madhya Pradesh and Gujarat to implement the concept of "import water instead of food" as the abiding protection against drought.

Acknowledgements

The authors wish to place on record their sincere thanks and gratitude to Sh. P.L Diwan, Chairman and Managing Director, WAPCOS, for encouraging and guiding the authors to write this paper for the symposium.

Workshop 2

Ecological services and risk assessment:
upstream/downstream conflicts

UPSTREAM/DOWNSTREAM CONFLICTS ABOUT WATER RESOURCES AND LAND USES IN RIVER BASINS: THE NEED FOR AN INTEGRATED MANAGEMENT APPROACH

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Following up the topics indicated for Workshop 2 in the introductory framework given at the Symposium Programme, it is suggested a number of points for discussion at the Workshop:

1. River degradation and upstream/downstream conflicts in consequence of it can arise from different causes. The major of them are well-known:
(a) disturbance of hydrological regime of rivers due to:
- dam construction, especially with a large reservoir,
- overuse of water runoff,
- disruption of sediment transport or bottom sediment dredging.

(b) deterioration of water quality due to:
- eutrophication because of abundance of nutrients,
- chemical contamination (including increase of salinity),
- radioactive contamination,
- bacterial pollution,
- thermal pollution.

Upstream/downstream water sharing in a case of its scarcity belongs to the earliest subjects of conflicts between water users, particularly when water is harnessed in agriculture for irrigation. In real cases environmental impacts are commonly resulted from several interacting factors; some of them may be of secondary origin.

Change of hydrologic regime is usually followed by change of water quality. There are many cases when degradation of a river becomes stronger along a river and gives rise to a conflict situation. It takes place mostly because of overuse of water runoff for irrigation and water-supply. The typical examples are the degradation of such rivers as Colorado (which flows in the South-West of the USA and ends in Mexico), Amu Darya and Syr Darya in the Aral Sea basin, Kuban, a tributary of the Sea of Azov (Russia).

2.Another type of upstream/downstream conflicts can be caused by hydropower development with creating large reservoirs and seasonal (or multi-year) regulation of runoff. The main items that may be important for assessment of environmental impacts as possible reasons of conflicts are the following:
(1) Hydrothermal and ice regimes in deep reservoirs, including temperature stratification and its consequences (both in summer and winter periods)
(2) Change of temperature and ice regimes of rivers downstream of reservoirs, in particular, downstream of deep ones

Example: Long stretch of the Yenisei River without ice cover in winter downstream of the Krasnoyarsk Hydropower Station

(3) Water quality problems in rivers with reservoirs (including such cases due to an additional load from new users of power and water resources)

Example: Development of non-ferrous metallurgy, paper-mill and cellulose plants near HP stations on the Yenisei and Angara rivers

(4) Change of hydrological regimes of rivers and their flood plains downstream of reservoirs, including the degradation of river channels and the impact on water regime of flood plains

Examples:

- Degradation of the Ob River downstream of the Novosibirsk Reservoir near Novosibirsk
- Aridization of the flood plains of the Irtysh River downstream of the Bukhtarminsk Hydropower reservoir. [Only in Omsk region about 300,000 hectares of flood plains were damaged, including 200,000 hectares of agricultural lands. About 30% of the latter were dried up.]

(5) Abrasion of reservoir shores and impounding of ground water near shore lines

Examples: Shore processes on the Novosibirsk and Krasnoyarsk reservoirs

(6) Possible local climate change near reservoirs

(7) Possible mercury pollution of reservoir ecosystem

3.Resolving the conflict situations under consideration is possible only if solutions are well grounded in all important respects, starting from the understanding of physical aspects. In the most complicated cases, such as the degradation of rivers in the arid and semi-arid regions with agricultural activities based upon intensive use of irrigation (e.g. the cases mentioned in Paragraph 1), it is necessary to describe quantitavely hydrological and hydrochemical processes related to degrading river flow and water quality. As a matter of fact, this problem has a complex character. The totality of processes involved includes also those which are connected with a technology of irrigation, water seepage into soils, flow of surface and ground waters and the migration of salts, fertilizers and other agrochemicals (due to removing by water). Therefore the knowledge from the agrophysics, soil- and agrochemistry and other disciplines must be used here. The total consideration of the problem needs an integrated approach with applying the system analysis to describe cycling of water and other principal substances altogether in the framework of a river basin hydrological system. Modelling of the interaction between surface and ground waters is the key-point of it.

4.The integrated watershed management have to be based upon consideration of total composition of natural conditions and, in particular, upon use of ecological services of all ecosystems valuable with this regard. A river watershed usually contains various landscapes, both natural and anthropogenic, including agricultural ones. A large variety of ecosystems corresponds to them, in particular - to natural ones. Each of them plays a certain role in the hydrological cycle. However effects of some of them are especially important in relation to water and chemical cycles. As it is well-known, forests are of primary importance in regard to the water cycle and the formation of runoff in the regions with temperate climate. We speak about a water–protectional function of forests which is a kind of ecological service as well. Wetlands, both natural and man-made

(constructed), also play an similar part with this respect. Wetlands generally occur at the interface between terrestrial ecosystems, such as forests and grasslands, and aquatic ecosystems, e.g. rivers. Thus, they may be referred to as so-called boundary ecosystems. Generally the boundary ecosystems that are located between water and land, e.g. shore (or littoral) ecosystems, can be considered as particularly valuable ecosystems regarding their ecological services. As an example, reed belts along lake (or reservoir) shores must be noted.

5.Risk at water resources and land management in river basin is a special issue taking account of complex character of interrelations between upstream land and water resources uses and downstream hydrological and ecological behavior of a river. At the same time, it is important to be able to make assessments of probabilities of unfavorable consequences and damage levels for different maintenance operations or principal (structural) changes in an engineering systems.

The probabilistic risk assessment is possible for water resource systems mostly in relation to stochastic character of runoff and meteorological data. Such assessments are based on certain scenarios. Monte Carlo simulation methods can also be helpful for the probabilistic risk assessments with use of available hydrologic data. Uncertainty analysis in relation to incompleteness and imprecision of available information about natural conditions (resulted in uncertainty of model parameters) is frequently accomplished in engineering practice with use of sensitivity analysis and simple estimates.

WATER TRANSFER AS AN EFFECTIVE WAY FOR INCREASING CARRYING CAPACITY OF THE REGIONS WITH LESS WATER*

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Water Scarcity and Water Transfer Projects

Existence and development of human society need supports by a wide of variety of natural resources including land, water resources etc. and a series of production elements established for various departments of economy. However, natural resources and production elements are unevenly distributed in different regions, that leads to different carrying capacity of regions and inequitable development of regions. Data listed in Table 1 indicate that Yangtze River Basin located in South China possesses higher carrying capacity while Huaihe River Basin, Yellow River Basin and Haihe River Basin located in the northern part of China possess lower one. This is due to the water scarce in northern part of China and its lower crop yield. According to estimation per capita water in these regions is about 378 m^3 and average available water per unit area of cultivated land is 327 m^3/mu, that equivalent to 1/6 of the mean value of the whole country. The appropriate decision for resolving this problem could only be made based on regeneration through powerful efforts. That is to transfer water from regions with abundant water into the regions with less water for developing new water projects and increasing carrying capacity of latter.

Table 1. Data Regarding Carrying Capacity of Different River Basins in China

River Basins	Total Area 10^4 km^2	Population 10^8 persons	Per Capita Water m^3	Population Per km^2	Water Per Unit Farmland m^3/mu*
Yangtze River	180	4.16	2286	231	2682
Huaihe River	26.9	1.52	408	56.5	347
Yellow River	75.2	1.00	580	75.2	317
Haihe River	23.4	1.09	17.7	21.5	127

* Chinese traditional unit area of farmland, 1 ha=15 mu.

A series of new water transfer projects will be established for the sustainable and equitable economic development of the whole country, such as the South-to-north Water Transfer Projects transferring water from the Yangtze River Basin northward and the North-to-south Water Transfer Project being located in Northeastern China. Three projects are proposed for the South-to-north Water Transfer i.e. the West Route Project, the Middle Route Project and the East Route Project. These Projects would lead to change the water conditions of the regions of water scarce. For instance, the Middle Route Project will transfer water of 14.5 billion m^3 northward per annum, that could increase and improve the irrigated area of about 2.5 million ha and increase the crop yield per unit area of cultivated land on 50~100%; increase water supply of 5.8 billion m^3 annually to 17 large cities of water scarce involving Beijing and Tianjin for meeting

* The project supported by NSFC

the water demand on industrial and domestic uses. This Project has been examined at February 1998 and considered as a project with first priority to be implemented. Water will be transferred mostly by gravity along the Trunk Canal of 1235 km from the headwork to Beijing and the branch canal named Tianjin Canal of 141.6 km toward Tianjin. 14.5 billion m^3 of water will be transferred annually in the first stage and it would be expanded in the second stage. The Trunk Canal with designed discharge capacity of 630 cms at its upper part and 70 cms at its end will meet Yellow River and 603 other rivers with different drainage area, 213 among which are over 10 km^2, 77 are ranged in 10~20 km^2, 142 are over 20 km^2. 28 streams will entry into the Trunk Canal and will degrade water quality in the Canal. There will be 1627 different structures on the Canal, herewith is included the large scale tunnel crossing the Yellow River. This Project will increase significantly the carrying capacity of these regions for the human society. However, water quality problem is considered as one of the key issues for water transfer project in addition to water quantity. It could be occurred within the Headwork-reservoir and in the Trunk Canal due to 28 point pollution sources located along it.

A RBF-ANN Model for Water Quality Assessment of Water Transfer Project

In this paper a Radial Basic Function Artificial Neural Network (RBF-ANN) Model is proposed for water quality assessments of the water transfer project. The RBF-ANN model is a three layer network as shown in Fig. 1. It is capable to fix the knowledge in the network by learning and training the data sets; there is no need to ensure the knowledge of any quantitative relationship between the dependent and independent variables involved; it is able to resolve the problems of insufficient data sets and could be used for modeling complex processes including the environmental impact assessment.

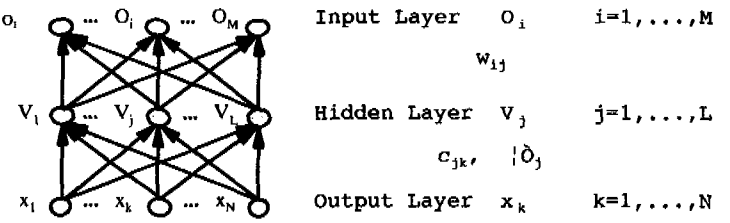

Fig. 1 Schematic diagram of the RBF-ANN model

The Radial Basic Function could be used for expressing the relationships between the input and the output in ANN. In the Model for the given input patterns x_k^u, u=1,...,P, in which P is number of input patterns, we have following results.

(1) to the hidden layer output we have unified nonlinear symmetry radial basic function (1) and nonlinear symmetry radial basic function (2) as follows:

$$V_j^u = \frac{R_j^u}{\sum_{g=1}^{L} R_g^u} \qquad (1)$$

$$R_j^u = \exp[-\frac{1}{2}\sum_{k=1}^{N}(\frac{x_k^u - c_{jk}}{\sigma_j})^2] \quad (2)$$

(2) to the output layer output we have the following equation:

$$O_i^u = \sum_{j=1}^{L} w_{ij} V_j^u \quad (3)$$

In this network the hidden layer is used for the nonlinear transformation, the output layer completes the linear combination, and the weighted values of the linear combination are as regulatable parameters.

The proposed model is applied in cooperation with the Least Squares Estimation Algorithm for training the network by the learning rules and for determining the radial basic function's centers C_j, the radial basic function's width σ_j and the weighted values of the links from hidden layer neurons to output layer neurons w_{ij}:; the standard error estimation should make the error squares being minimum while y_i^u is the expected output of x_i^u , that is:

$$E = \frac{1}{2}\sum_{u=1}^{P}\sum_{i=1}^{M}(y_i^u - O_i^u)^2 \quad (4)$$

As the parameters of the basic functions are determined, E are the functions of $w_{ij,}$ and could be solved by the least square algorithm.

Based on some changes in equations (4) we have:

$$\sum_{j=1}^{L} a_{hj} w_{ij} = y_{hi} \quad (5)$$

By equations (5) the weighted values w_{ij} could be obtained.

A Case Study Related to Application of the Model

A case study is carried out for water quality assessment of the Middle Route Project of the South-to-north Water Transfer. A 13-30-1 RBF-ANN model was trained, and it is used to assess the water quality in the Reservoir on the values of PH, $COD_{Mn,}$ $BOD_{5,}$ on the content of Nitrite nitrogen, Nitroacid nitrogen, Phenol, Cyanide, Arsenate, Hg, Cr^{+6}, Pb, Cd, total P and total Cu for 4 typical sections in the Reservoir, for 3 tributaries as pollution sources and for 3 time periods of high water, low water and medium water during the typical year 1993 respectively, with the aim to confirm the feasibility of water transfer. The results obtained are as shown in a special table in the full paper.

The case study shows that the quality of water in the Reservoir will meet the requirement of surface water of first class according to the China National Surface Water Quality Standards (GB 3838-88). It is also shown that this water transfer project could be in success for increasing the carrying capacity of the importing water regions. The case study shows that the model proposed is rather easy to be applied in practice, it has higher speed for operation in comparison with other traditional models, and it possesses adequate objectiveness and reasonability for application.

COPING WITH WATER SCARCITY IN THE SCHELDT RIVER BASIN

Strategies for sustainable fresh water resources management, cost-benefit analyses and water price mechanisms.

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Introduction: water scarcity, a global issue

The main problem of the world in the 21st century will be the availability of sufficient fresh water resources. Due to the increasing world population (approximately 10 milliard at the end of the 21st century), increasing life standards, irrigation and industrialisation, the fresh water demand on a global scale is increasing explosively. In all parts of the world, the fresh water availability per world citizen decreases rapidly. Surface and ground water pollution means an extra pressure on available fresh water quantities. Besides, atmospheric deposition, fresh water and energy resources and financial means are unequally distributed. In 2025, the half of the world citizens will live in areas of fresh water shortages. In these areas also the strongest population growth occurs. No longer, these area will be self supporting concerning food demands. As a result, more and more economic, social and political conflicts on a local, regional and international scale will exist. *In the 20th century oil resources caused many conflicts. In the 21st century, probably fresh water resources will cause more and severe conflicts. There is no substitute for water: water is the basis for the survival of human beings and the earth's ecosystems* (Saeijs and van Berkel, 1995).

Some figures:

- The present fresh water demand on a global scale is four times as high as in 1950 (Gupta, 1992).
- Between 1950 and 2000, the available amount of fresh water in Europe per habitant will decrease with 30% (Shiklomanov, 1991).
- In the year 2000, approximately 50 millions of so-called eco-refugees will drift around the world, searching for new ecosystems with sufficient fresh water (Myers, 1994).
- According to UNICEF, 11,000 children die yearly due to a lack of fresh water.
- There is only one sustainable, yearly renewable source of fresh water: atmospheric deposition. The annual deposition is about 110,000 km^3, the evaporation is about 65,000 km^3. This means a net yearly resource of 45,000 km^3.
- In the year 2000, the fresh water demand on a global scale (human use) for households, agriculture and industry will be 5,000 km^3 a year (Gupta, 1992). According to the World Bank (1993), this figure will be 18,700 km^3 a year, 42% of the 45,000 km^3, or 3,700 m3 per world citizen a year.
- UNCED-Conference, Rio de Janeiro, 1992: 1,000 m^3 fresh water per person a year is the poverty standard. In areas with high population densities and large industrial and agricultural activities, 5,000 m^3 fresh water per person a year is needed.

Diagnosis: fresh water scarcity in the Scheldt river basin.
More than 10 million people live in the Scheldt river basin. The average population density in the river Scheldt basin is 477 habitants/km2. This is almost five times the average population density in the European Union (ICPS, 1997). The average net annual renewable fresh water amount (atmospheric deposition - evaporation) in the river basin is about 5.8 km^3, or 580 m^3 per habitant (Holland, in preparation). The fresh water demand is about 35 km^3 a year, or 3,500 m^3 per habitant. Diagnosis: Related to a need of 5,000 m3 fresh water per habitant a year, the Scheldt river basin has a structural shortage. Due to pollution of surface and ground water, even less fresh water is available for human use. To fulfil the fresh water demand, water is imported from the Meuse river basin and ground water is extracted on a large scale. On the other hand river Scheldt water is exported to the Dunkirk region in France and the coastal zone in Belgium.

Strategies to cope with water scarcity
In principle, every river basin should try to become self supporting by using the yearly net atmospheric deposition on the earth's surface. If this is not sufficient other strategies should be followed. A World Water Treaty should be formulated and signed, including basic principles on sustainable management and use of fresh water resources. This Treaty could include the following elements:

- All life on earth (ecosystems and human beings) has the right to obtain sufficient fresh water amounts in order to fulfil basic needs.
- Basic needs should be fulfilled as much as possible by using the yearly net atmospheric deposition on the earth's surface in a river basin.
- Natural, mostly pure, fresh water resources (polar ice, glaciers and groundwater) should be reserved only for high-quality use and in case of emergency.
- Closed water cycles, wise use and reuse should be stimulated. One should pay for the entire costs of water use (extraction, transportation, use, purification and compensation of negative effects). The profits should be invested in the restoration of damaged ecosystems.
- Water retention in natural ground water reserves and wetlands should be stimulated. The residence time of fresh water in the cities should be enlarged.
- 'Pure' fresh water from atmospheric deposition should be separated from waste waters from house-holdings. Fresh water resources of different quality should be offered to different groups of users.
- Water reservoirs and distribution channels can be used to transport water from wet to dry areas. One should be cautious and reserved in building barrages, water reservoirs and channels, because of negative ecological, socio-economical and political effects.
- In addition to the yearly net atmospheric deposition, extra fresh water amounts could be extracted from the hydrologic cycle (polar ice, clouds, salt water), but as less as possible and only if all possibilities as mentioned above will be insufficient.

Sustainable water management in the Scheldt river basin
The water policies of the riparian states offer valuable starting points on the development of a long term philosophy on sustainable use and management of the Scheldt river basin. The International Commission on the Protection of the river Scheldt (ICPS), being installed in March 1998, should play a central and co-ordinating

role in the formulation of conditions for a sustainable development of the entire river basin. The river Scheldt water is a communal inheritance of all the riparian states!

The following recommendations are done:

1. Consequences of water scarcity should be taken into account as much serious as water quality aspects. A consistent long term philosophy is needed. Water quality can't be managed without integrating water quality. Therefore, a Scheldt river actions programme, set up by the ICPS, should include a hydrological chapter. A first step could be an extension of the considered basin area with the Dunkirk region and the Belgian coastal zone.
2. One should formulate measurable hydrological objectives in order to meet:
   - a co-ordinated management of locks and sluices on the Scheldt river basin scale;
   - the stimulation of fresh water retention in bottoms and wetlands;
   - efficient water use by house-holdings, agriculture and industries;
   - separation of sewage systems for atmospheric deposition and waste water;
   - reuse of fresh water resources and closed water cycles.
3. An uniform price for water use and pollution. Sufficient financial means are an absolute necessity to meet the water policy standards. The riparian states should define an uniform price on fresh water use and pollution, taking into account all the costs that have to be made. All extraction's of ground water and surface water should have a price, taking into account quantities, water quality, negative effects on ecosystems and users functions. The use of ground water of high quality should become much more expensive than the use of surface water with a worse quality.
4. Our generation should pay all the actual water management costs and should not take a mortgage on future generations. Also, our generation should pay a part of the costs to restore the effects of mismanagement in the past. A special Water Fund could be created to finance historical pollution and restoration of aquatic ecosystems. Besides, following the "polluter pays principle", every riparian state has its own responsibility financing water management on its own territory.
5. Sufficient waste water treatment infrastructure. The EC guideline on the treatment of urban waste water (91/271/EEC) should be implemented with the highest priority. Brussels, the 'capital city' of the European Commission, can be a leading example!
6. Cost benefit analyses of water management measures should be made in all riparian states, following comparable methods. A method should be developed, based on the intrinsic characteristics and ecological services of an entire water system, like a river basin, an estuary or a lake.

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UPSTREAM-DOWNSTREAM CONFLICTS IN THE SCHELDT RIVER BASIN AND STRATEGIES FOR CO-OPERATION

Solutions and strategies for international co-operation, water quality and pollution control, ecological services, risk assessment, business environmental policies and the use of decision support systems.

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Introduction

Over 200 major river basins are shared by two or more countries. These basins account for about 60 percent of the earth's land area and constitute a significant portion of the world's fresh water resources (World Bank, 1993). They are a great asset to nations sharing them, but at the same time a potential source of conflict. The Scheldt river basin, as an example, is shared by France (6,680 km2; 31%), Belgium (13,324 km2; 51% and the Netherlands (1859 km2; 8%). More than 10 million people live in the river basin (ICPS, 1997). The average population density in the river Scheldt basin is 477 habitants/km2. This is almost five times the average population density in the European Union (ICPS, 1997).

The river Scheldt ecosystem is of great importance for a wide variety of uses like fishing, agriculture, shipping, industry, drinking water and recreation. For centuries these activities have benefit from the river basin. The last decades, development of economical interests get more and more in conflict with the ecological services of the river system.
The Scheldt estuary is one of the few remaining European estuaries that includes the entire gradient from fresh to saltwater tidal areas. Along this gradient mud and sand flats as well as marshes occur. Fresh and brackish water tidal marshes are extremely rare habitats. The intertidal area contain highly productive life communities, which are important for sustainable human use. The Scheldt estuary is protected by national and international legislation, following Directive 79/409/EEC (EC Wild Birds Directive), Directive 92/43/EC (EC Habitats directive), and the RAMSAR convention (Meire et al., 1998).

Diagnosis: water management problems and conflicts

Water management problems

The high number of habitants, the high degree of industrialisation and the agricultural use of a big part of the area mean a considerable burden to the aquatic ecosystems in the Scheldt river basin. Water management problems are comparable in both the upstream as the downstream parts of the river basin: low groundwater and surface water levels; pollution of ground- and surface water; pollution of bottom sediments; insufficient waste water treatment infrastructure and a lack of co-ordinated management of shared tributaries (ISG, 1994; Santbergen, 1994).
Generally, from the river's source to its mouth, the emphasis of the problems shifts from the surface water to the bottom sediment. In the river's estuary, the main specific problems are: sediment contamination; reduction of fresh water inlet from the Upper-Scheldt and the Leie; the maintenance, deepening and widening of the navigation channel (maritime access to the port of Antwerp; dredging and dumping activities); habitat degradation in terms of size reduction and loss of diversity (ISG, 1994; Vroon et al., 1997).

Conflicts
The riparian states which share the Scheldt river basin have their own institutional arrangements and different ways to develop and carry out water policies. They represent a diversity of decision making cultures. Together with differences in socio-economic characteristics and a more upstream or downstream position, these factors may result in a number of (potential) conflicts. Because of diverging or conflicting objectives, decision making on transboundary Scheldt river issues often has the character of negotiations. Example: upstream parts of the river can be used as receivers of waste water while more downstream parts (in another riparian state!) are designated for the production of drinking-water. The Scheldt riparian states try to reach a degree of consensus without losing their own interests and sovereignty (Meijerink, in prep.).

The table below shows an overview of the (inter-)dependence of the various Scheldt riparian states, only concerning water quality matters.

	France	**Wallonia**	**Brussels**	**Flanders**	**Netherlands**
France	–	4-1 (Scheldt, Scarpe, Leie, Spiere)	0-0	3-0 (Leie, Scheldt, Spiere)	1-0 (Scheldt)
Wallonia	1-4 (Haine)	–	1-0 (Zenne)	7-0 (Scheldt, Spiere, Leie, Dender, Zenne, Dijle, Demer)	1-0 (Scheldt)
Brussels	0-0	0-1	–	1-1 (Zenne)	1-0 (Zenne)
Flanders	0-3	0-7	1-1 (Zenne)	–	2-0 (Scheldt, Canal Gent-Terneuzen)
Netherlands	0-1	0-1	0-1	0-2	–

An example to read the table: The *Haine* river has its source in Wallonia and debouches in the Scheldt river in France. The *Leie* river starts in France, acts as the

border between France and Wallonia and continues in Flanders, where it debouches in the Scheldt river. The *Spiere* river starts in France, crosses Walloon territory and debouches into the Scheldt river in Flanders. The *Scarpe* starts in France and debouches into the Scheldt river just before entering Wallonia. The source of the Schelt river is situated in France; the river continues in Wallonia. As a result, France has a four times upstream position 'advantage' on Wallonia. Only once, Wallonia has an upstream position 'advantage' on France. As the most downstream riparian state, the Netherlands are dependent on all the other riparian states.

Solutions and strategies for co-operation

Basic strategy principles for shared river basin management

- States sharing the catchment areas of transborder river systems have a shared responsibility for the quality, functioning and sustainable use.
- The Scheldt riparian states should not aim at the development of a supranational basin authority with legal and financial means to develop, implement and monitor river basin policies. They should aim at co-operative policy development within the existing national institutional settings.
- The added value of the International Commission on the Protection of the Scheldt river against Pollution (ICPS) compromises six aspects: integrated water management with respect to relations between upstream and downstream parts (1); efficient use of financial means (2); co-ordinated and equal application of the precautionary and polluter pays principles (3); providing support of (partly) unpopular measures and investments (4); stimulation of international co-operation and exchange of information (5); and education of the citizens (6).

International co-operation

- The ICPS is preparing an Action Programme aiming to reduce and control water pollution and to preserve and ameliorate the river's ecosystems.
- The riparian states will continue and enforce their informal co-operation on international water management problems.
- Flanders and the Netherlands co-operate in the by the European Community financed LIFE project: Marsh Amelioration along the River Scheldt (MARS).
- Flanders and the Netherlands will develop a long term philosophy on sustainable development, use and management of the river Scheldt estuary, before the end of the year 2001.

Water quality and pollution control

- There is a need for a co-ordinated, integrated water quality monitoring network for the entire river Scheldt basin, including physical, chemical and biological parameters. The ICPS has started a monitoring network in January 1998. This network will be improved and extended with more physical, chemical and biological parameters.
- The realisation of sufficient waste water treatment infrastructure in the Brussels region, the centre of the European Commission and one of the largest sources of pollution, will have an enormous spin-off on investments in the Scheldt river basin and on the improvement of the water quality of the river Scheldt.

Ecological services

- The Scheldt river's estuary plays an crucial role in water retention (contributing to flood prevention) and the life cycles of nutrients like nitrate, phosphate and carbon. It has an high biological productivity. A reduction of these ecological services will result in higher economic costs to fulfil these services. To prevent this unwise use of this natural sources, there is an urgent need to develop an method for cost-benefit analysis based on the ecosystem of a watershed like a river, lake or estuary. Such a method should take into account ecological services and intrinsic natural values of the ecosystem.
- The main challenge over the coming decades will be to maintain flood protection in the face of larger design discharges, while at the same time conserving landscape, ecological and historical features, promoting navigational use and creating new wildlife areas.

Risk assessment
- As a result of reduction in point discharges from industrial and communal sources, accidental and diffuse pollution sources become more important considering the total emissions on the water system.
- A special working-group focusing on accidental pollution has been established within the International Commission on the Protection of the river Scheldt against Pollution (ICPS). The working-group aims to reduce sources of accidental pollution. Example: The chance of accidental pollution due to industrial activities can be reduced by implementation of the best safety-technology. An co-ordinated common warning and alarm system is operational since March 1998.

Business environmental policies
- Enforcement of point discharges reduction by the major industries in the Scheldt river basin.
- The life cycle management approach, from raw material through to end product and wastes, should be central to efforts to tackle emissions.
- General implementation of best available technology. Implement method for total effluent assessment.
- Encourage industry to use clean technologies and take preventive measures.
- Pollution reduction should be achieved in close consultation between the authorities and target groups (for example: different industrial sectors). Target groups at national and regional level should themselves be responsible for producing action plans and monitoring their implementation.
- Harmonise permitting and enforcement with corporate environmental management systems and company environmental plans.

Environmental management and decision support systems
- The quality assessment of the European rivers needs a common information base. Willingness from different data generators to provide data is one of the main items to address in the near future. Systems like REMSSBOT (Regional Environmental Management Support System Based on Telematics) could be very helpful to connect and provide data and information sources of the individual riparian states (Niesing, 1996).

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THE NUTRIENT PROBLEM OF THE DANUBE RIVER AND THE BULGARIAN CONTRIBUTION TO IT

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Introduction

The importance of the nutrient load along the Danube river from its origin to the Delta area is continuously growing and is an essential factor for the eutrophication processes occurring in the Danube Delta and the North Western shelf of the Black Sea. Reliable scientific information about the nutrient load problem of the surface waters in the Danube river catchment can contribute to the development of basin-wide nutrient pollution control strategies and the implementation of harmonized environment protection activities. One of the objectives of the "Water Quality Targets and Objectives for Surface Waters in the Danube Basin" research project was to develop water quality targets and proposals for emission load reduction of nutrients, aimed at avoiding the harmful eutrophication effects in the Danube river, the Danube Delta and the North Western shelf of the Black Sea. The research and development activities of the project were carried out by a Consortium consisting of four well-known research institutes in the field of water and environment protection from the Danube riparian countries - Bulgaria, Hungary, Rumania and Slovakia, co-operating with a consulting EC partner from the Netherlands. The paper presents some results concerning the Bulgarian contribution to the nutrient problem of the Danube river.

Nutrient Load Assessment, Water Quality Targets and Scenarios for Nutrient Load Reduction

The nutrient load assessment was focused basically on two water quality parameters: the total nitrogen and the total phosphorus. The nutrient load of the Danube river originating from Bulgaria could be calculated as a total sum of the Bulgarian tributaries nutrient loads at the points of discharge of their catchments plus nutrient loads from several Bulgarian towns. Data-series of the national water quality and quantity monitoring networks were used for the nutrient discharge load assessment for the Danube tributaries. Because of lack of data from measurements on sewers in the towns, their nitrogen loads are calculated on the basis of the number of inhabitants served by sewers and specific emission coefficients of 8 g N and 1.44 g P per inhabitant per day. The loads coming from industry in these towns could be neglected. Two reference periods were taken into consideration for the nutrient load assessment study: the period of 1989-1991 and the period of 1992-1994, the first one being characterized by significantly higher load conditions, as can be seen in Table 1. The decreased nutrient load conditions during the 1992-1994 period result from the recession of economy due to change in the political-economic system.

Proposal for the targets of nutrient export to the Black Sea, as well as water quality targets for the protection of the Danube river have been developed during the project. The targets for the protection of the Black Sea are expressed in total nitrogen and total phosphorus (the proposed medium term target is total N load amount of 200 kT/year and total P load amount of 20 kT/year) at the mouth of the Danube river, while the targets

for the protection of the Danube river are expressed in nutrient concentrations (total N < 2.2 mg/l and total P < 0.2 mg/l). The last targets are set up in order to prevent eutrophication problems in slow-moving or stationary water bodies, influenced directly by the Danube. It has to be noted that the proposed targets for the Danube loads related to the protection of the Black Sea are significantly more severe than the targets for the protection of the Danube river itself.

The following scenarios for nutrient load reduction were developed during the project:

1. Autonomous scenario-optimistic version (economic recovery of the former socialist countries situated in the Danube catchment and further economic growth with the necessary control on point sources, and development of measures controlling non-point sources. This scenario has two sub-scenarios, the 1/A representing a favourable development of the reduction of the nutrient load emissions of non-point sources, and 1/B, representing a less favourable development in this field;
2. Autonomous scenario-pessimistic version (same as above, but without effective pollution control measures);
3. Scenario with a basin-wide 25 % emission reduction compared to the reference period of 1989-1991;
4. Scenario with a basin-wide 40 % emission reduction compared to the reference period of 1989-1991.

The first two scenarios were developed taking into consideration the vision about the economic status and the related to it nutrient problem in each Danubian country in the accepted two time-horizons, a medium (2005) and a long-term one (2015). The nutrient loads for the different scenarios were calculated for all Danubian countries and the results for Bulgaria are presented in Table 1.

Analysis of the scenarios has been carried out by running a DELWAQ water quality model developed by the partner from the Netherlands - Delft Hydraulics. According to the results of this analysis the realisation of the "optimistic" 1/A scenario will satisfy the targets for nutrient concentrations along the Danube river, while more severe nutrient emission reduction rates are required to satisfy the targets for the nutrients export to the Black Sea, especially export reductions of about 40 % for total nitrogen and about 50 % for total phosphorus compared to 1989-1991. Different strategies can be applied to achieve these reductions, for example, to use the same emission reduction target basin-wide or to differentiate the targets over the different Danube sub-basins, or even over the different countries. The proposal of the project for the future development is to accept a solution which imposes the strongest emission reductions for these areas where the river concentrations are the highest. On the basis of this approach nutrient emission reductions were proposed for the three Danube sub-basins, in which the suggested nutrient removal varies between 35 % and 45 % for total nitrogen, and between 40 % and 55 % for total phosphorus compared to the reference period of 1989-1991. For the Lower Danube sub-basin, which comprises the Bulgarian part of the Danube river catchment, the reduction rates are 35 % for total nitrogen and 55 % for total phosphorus (see Table 1). The implementation of these reduction rates would go far beyond the end of the considered development period (the year 2015), and the realisation depends on the available financial resources of the riparian countries.

The comparison between the Bulgarian contribution calculated during the project to the nitrogen and phosphorus loads of the Danube river and the loads at the Bucharest Declaration monitoring stations - Pristol-Novo Selo and Chiciu-Silistra - can be used as an argument for the necessity of further development of the proposed approach for the nutrient emission reductions, taking into account not only the highest river concentrations as an assignment factor of the strategy to achieve the determined target nutrients export to the Black Sea, but also the magnitude of the contribution of each country and more fair distribution of the Danube assimilative capacity. The first station can be considered as the Danube water quality background of the Bulgarian-Rumanian sub-drainage basin and the second one - as the end of this sub-basin. The results for the 1989-1994 period show that the Bulgarian nitrogen contribution varies from 1.20 % to 3.87 % and from 1.02 % to 3.44 % of the loads at the Pristol-Novo Selo section and at the Chiciu-Silistra section respectively. Bulgarian phosphorus contribution varies from 1.24 % to 5.71 % and from 1.47 % to 3.53 % of the loads at the above mentioned two stations. The conclusion which can be made on the ground of these results is that the Bulgarian nutrient contribution has unimportant influence on the Danube nutrient load.

Conclusions

The project results should be considered as the first step towards the development of the basin-wide nutrient pollution control strategy. These results should be a subject of comprehensive discussions with all riparian countries and parties from the point of view of methodology and outcomes. Continuation and further investigations on this topic is outstandingly essential for the protection of the Danube river itself and its final recipient - the Black Sea. The next phases of the development studies on sustainable water quality and nutrient load targets is recommended to improve the accuracy of nutrient load calculations as well as to be coupled with investigations on the related investment issues and cost-benefit analysis.

Table 1

Nutrient loads for two reference periods, kT/year				Nutrient loads for different scenarios, kT/year			
				Scenario 1/A			
N	N	P	P	N	N	P	P
89-91	92-94	89-91	92-94	2005	2015	2005	2015
8.7	5.9	0.76	0.69	8.2	7.7	0.66	0.64

Table 1 (continued)

Nutrient loads for different scenarios, kT/year							
Scenario 1/B				Scenario 2			
N	N	P	P	N	N	P	P
2005	2015	2005	2015	2005	2015	2005	2015
8.6	8.6	0.69	0.70	10.4	10.4	0.95	0.95

Table 1 (continued)

Nutrient loads for different scenarios, kT/year				Proposed nutrient emissions coming from Bulgaria, kT/year	
Scenario 3		Scenario 4			
N	P	N	P	N	P
-	-	-	-	-	-
6.5	0.6	5.2	0.5	5.66	0.34

RESEARCH OF CONTAMINATION OF WATER OBJECTS AT VARIOUS LEVELS OF ANTHROPOGENETIC LOAD (SURVEY HAS BEEN MADE AT THE UPSTREAM BASIN OF THE VOLGA), RUSSIA

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Introduction

The choice of an optimum water-protection strategy depends upon the general level of water basin pollution, its economic development, population density, orientation of an industrial, as well as an agricultural production, peculiarities of a hydrologic conditions, and consequently, should be supported by authentic and profoundly scientific research. From the point of view as proposed above we are going to look at the Upstream Volga Water Basin (covering the area of 41,000 sq. km) and the Ivankovo Water Reservoir up to the closing range at Dubna (net volume is 1.12 cu. km), which is the major source of water supply for Moscow. This water reservoir level is adjusted by seasons : it is consumed in winter and is filled up again in spring, while it remains full throughout summer and autumn. A hydrological aspect in the process of formation of water quality is also of great importance because the water mass of the reservoir is built up by a surface run-off within the boundaries of the watershed in spring during the snow-melting; and discharge of ground water during the winter consumption.

Methods

The crucial scientific objectives can decisiv in research of formation processes of water quality with used a systematic approach, that has to focus around two correlated blocks, which should be treated as a complex: the first one is a hydrographic network of watershed with active sources of pollution , the second one is the water area of a reservoir with the typical inner aquatic processes. For the first block of such system the methods should be developed to assess a general anthropogenetic load, to describe long-term dynamics, and also to differentiate and compare the sources of pollution; the second one demands a careful study of a qualitative condition of a water object, water distribution throughout the year, long-term changes and development of biotics. When compiling this paper we have made use of a vast experimental material and the data collected by special expeditions functioning in different years and different sectors of the watershed.

Results snd discussion

Intensive water protection activities were undertaken between 1968 and 1986, resulting in 5 to 10 fold decrease in concentration of the substances of technological genesis (zinc, copper, synthetic surface-active substances). However the quality of water did not improve in the least as regards the concentrations of suspended organic substances and biogenic elements. Our research performed at the watershed confirmed that it had been

caused by a number of functioning sources as a rule being of diffusional character. Pollution from the sources of this type may be accompanied by a surface run-off from urban areas, industrial sites, farms, peateries and also by recreation and navigation in the water area of the basin. The entire range of the enumerated sources of pollution may be classified as non-stationary ones, and dispersed all over the area (except for the drain sewerage in towns and at the industrial sites), but the main thing about them is that they are absolutely out of control and hardly can be monitored by the state services due to an extreme complexity of measurement and count.

Our observations for many years and specially arranged expeditions allowed us to differentiate four basic sources of pollution as to a number of water quality indicators. During explorations and calculations our goal was to identify an optimum water-protection strategy in the Upstream Volga basin, directed at a possible reduction of the effect produced by uncontrolled diffusion sources because they exceeded pollution caused by the point sources in terms of oil products by more than 50 times, organic matter - by 18 times, nitrogen - by 8 times and phosphorous - by 5 times.

Thus, anthropogenetic effect of the diffusion sources of pollution was the most dangerous factor for the Ivankovo Water Reservoir as per a number of indicators observed in the economic environment typical for this region of the 80-ies. Furthermore, the dynamics of the major sources of pollution have sustained drastic changes since the beginning of the 90-ies when the Russian economy was directed along the market oriented path: disposal of waste water was decreased, utilization of the fertilizers was cut down, navigation became less intensive and the fleet of boats was reduced in number. The most dramatic changes for the diffusion-class sources of pollution occurred in the agriculture as the fertilizers now are used 10 times less frequently in comparison to the 80-ies. However the area of fertilized arable land covers 12 % which is quite insignificant as compared to an entire area of the watershed. The waters flushed off the surface of the urban areas and industrial sites are contaminated nowadays by increased concentrations of the oil products and certain heavy metals, which is easily attributed to a much more intensive motor road traffic. In our estimation, the problem of diffusion pollution of the Ivankovo Water Reservoir remains a very crucial one, particularly as regards such water quality indicators as organic substances, oil products and heavy metals. Thus it is possible to present hereby two anthropogenetic levels at the watershed of the Upstream Volga in terms of certain indicators typical of various degrees of functioning of the region under consideration (Table 1).

Table 1

Evaluation of two average levels of the general anthropogenic load in the Upstream Volga at various time periods (tonnes per year)

Indicator	1984-1990 (I)	1991-1997 (II)	Ratio II / I
Oil products	6,200	5,500	0.89
Organic matter	104,030	60,000	0.58
Nitrogen	25,300	5,000	0.20
Phosphorous	1,980	800	0.40
Copper	10	7	0.70
Zinc	20	13	0.65

Continuous research of hydrochemical and hydrobiological parameters at the Ivankovo Reservoir is under way for the past 20 years now. The primary objectives of this research comprise the following : transformation and drift of the particles in the reservoir, build-up of the hydrodynamic structure, processes of spreading of the upper aquatic plants, accumulation of heavy metals in water, bottom soil and biotics, influence of the waterside sources of pollution. Water samples are collected especially frequently at the main ranges of the Reservoir facilitating keeping of records of the extreme values of concentrations. Statistical processing of the long-term observations yields accurate computations of the characteristics typical of any time periods. Average indicators of water quality and hydrochemical components for each season are given in Table 2; these averages have been obtained for two time stretches covered by research (the first one from 1984 to 1990, and the second one from 1991 to 1997).

Table 2

Water quality characteristics in the Ivankovo Water Reservoir at various seasons

Ingredients	Winter		Spring		Summer		Autumn		II / I
	I	II	I	II	I	II	I	II	
Oil products	0.54	0.31	0.77	0.72	0.44	0.26	0.38	0.25	0.72
Organic matter	16.3	13.5	18.5	15.0	17.8	13.2	14.9	11.7	0.79
Nitrogen	1.86	1.62	1.81	1.44	0.98	0.69	1.12	0.82	0.81
Phosphorous	0.12	0.13	0.19	0.13	0.12	0.12	0.13	0.12	0.86
Zinc	0.06	0.04	0.04	0.03	0.05	0.03	0.06	0.04	0.80
Copper	0.005	0.003	0.005	0.004	0.004	0.003	0.005	0.003	0.67

Conclusions

It is seen, change of anthropogenetic load levels on the big watershed does not always influence water quality change of the water body. So further it is necessary to take into consideration some other factors. Our analyses of hydrological conditions for long time shows a high correlation between biogenic components and water column.

In the paper presented hereby we have dwelt upon a systematic approach in research of the processes of formation of certain water quality at the Upstream Volga Watershed and the Ivankovo Water Reservoir. There is no doubt that this methods may be applied in research of large water basins with the purpose of studying the dynamics of development and the influence of various factors upon the aqueous medium.

INFORMATION MAINTENANCE OF WATER RESOURCES MANAGEMENT FOR PREVENTION OF ECOLOGICAL RISK IN THE NEVA BAY AND THE EASTERN GULF OF FINLAND

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The water system Ladoga Lake - River Neva - Neva Bay - eastern Gulf of Finland is the important strategic region of multifunctional purpose. The complexity of an ecological conditions in the ecosystems of these water objects is determined by peculiarities of antropogenic and natural factors.

The presence of industrial and advanced region on the whole catchment-area of this water system belongs to the first factors as the presence of such megapolicy as of St.-Petersburg with its almost 5 million inhabitants and 3000 enterprises. Besides, navigation, coastal building, underwater careers, recreation, agricultural activity, water supply, hydraulic engineering structures etc. also concern to the antropogeneous factors.

The top part of this water system is the largest in Europe the Ladoga Lake, which last decades is exposed to intensive loading. On coast of the Ladoga Lake 5 pulp and paper combines were constructed. On the major inflow of the Lake - River Volkhov, is located the large aluminium industrial complex giving the greatest loading on phosphorus to the river. In total on coast of the Ladoga 500 enterprises belonging to the various departments are located. The large pollution by nutrient elements acts from an agriculture. As a result of excess of a safe load on phosphorus the Ladoga Lake two decades back has passed from oligotrophic to mesotrophic condition and the process of its eutrophication is continueing. The most eutrophic area of the Ladoga Lake closely adjoins to a source of the River Neva, defining thus water quality of the lower parts of this water system. It is especially important because the River Neva is practically unique source of water supply for St.-Petersburg. The River Neva receives large mass of polluting substances in city boundaries. As the River Neva,connecting the Ladoga and the Neva Bay, is a short river (its long is 74 kms)with the fast current (about 1 m/s), some polluting substances get to the Neva Bay less than for one day. Therefore water quality of the Bay is determined by a condition of the Ladoga Lake and level of antropogeneous loading from St.-Petersburg. About 10 years back more than 30 organizations have carried out five years' ecological researches on all water system with the purpose of development of the recommendations on improvement of an ecological situation of water environment in this system. These researches have shown that the waste water of city makes up only 2 % from total water volume of the Neva Bay, but its contribution on separate elements makes up about 40 percents in pollution of the Bay. Despite of significant loading from the upper parts of the water system the condition of

the Neva Bay remains rather stable. It is connected with its morphological and hydrodynamical features. The Neva Bay is a shallow reservoir with a good running water. In its central transit zone the water exchange is carried out within 2-3 days.

To the other natural factors it is necessary to attribute a fitting of the eastern Gulf of Finland to slightly saline nontidal estuary with complex hydrodynamic and of morphological peculiarities.
The important meaning among the natural factors, strengthening a degree of ecological risk, belongs to periodically arising floods, bringing significant material damage. On today there are not enough calculated data about possible ecological damage because of catastrophic floods. Stopping in operation of the urban sewerage networks, flood of storage facilities with chemical and toxic substances can result in loss of resource value of the Neva Bay and the eastern Gulf of Finland. The construction of the flood protective structures of St.-Petersburg is financed by government with large lateness from the accepted resolution about the end of building in 2001. The long-term forecasts of the scientists testify about the increase of probability of catastrophic floods in period from 1997 to 2003.

At the moment the separate branches of an economy, being the consumers and users of water resources, provide the negative influence on water environment and serve as potential sources of an ecological risk.
During essential changes of economy and resources in St.-Petersburg region, being on the coast of the River Neva and the Neva Bay, connecting the largest in Europe Ladoga Lake with the Gulf of Finland, scientifical and well-founded approach is necessary to the use of water resources. Estimation of a water system condition and its functions is necessary which will allow to formulate priorities for the balanced and reasonable management and development of activity, connected to the water system.
Main components of such approach are databases, information systems about available properties of separate water environment constituents, including bottom sediments and biota, load model by polluting substances for definition a general sum of system pollution, set of forecasting models for account of water quality and ecological parameters.
The special importance, as the first steps for realization of duly and reliable information maintenance, is got by the work, carried out by data group (the chief and the author R. Michailenko, authors: S. Basova, L. Sukhacheyova, E. Smirnova and S.Victorov) at the advisory and technical help of the qualified Netherlandish experts from DELFT HYDRAULICS. For the first time in St.-Petersburg, in result of interrogation of 17 organizations, connected with researches of the water system, detailed catalogue of all natural observations (as monitoring as special) is made, and detailed review of the databases is spent. The tables in the catalogue contain the data information about the all parts of the water system Ladoga Lake - River Neva - Neva Bay - eastern Gulf of Finland, including the list of the basic characteristics of water environment.
Besides in the catalogue the analysis of metodologies and methods of these studies is submitted. The offers for development of strategy and actions plan on improvement of the water system monitoring are made.

The review of existing databases has shown, that the most complete information is assembled in the database of "Morzashchita" Administration Office. Database includes

observations since 1968 for the 118 components, including 18 hydrological parameters, 29 hydrochemical parameters, 55 hydrobiological ones and 16 sanitary-and-bacteriological and virus parameters. At present about 2 mln data and several programs of data processing and visualization form the database. In St.-Petersburg it is unique database having the state certificate of Russia.The updating of a database is carried out on a basis of observations coordinated in St.-Petersburg by "Morzashchita". These studies are carried out by a number of organizations, among which there are state institutions of federal monitoring service, state sanitary – epidemiological control, Military-and-Medical Academy.

WATER, POPULATION AND HOUSING IN DOUALA, CAMEROON: AN APPRAISAL OF WATER-RELATED PROBLEMS WITHIN SUBSAHARAN AFRICA'S MEGACITIES

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Introduction

Environmental issues remain a main concern in large cities of the developing world, where few responses have yet been brought out by public authorities despite a continuous demographic pressure (UNEP 1993, UNDP 1994). In many cases, the inefficiency of public policies have forced low income populations to elaborate alternative strategies to solve most acute problems such as water supply, waste management or housing (Sow 1986, Asnani 1994, Finquelievich and Brunstein 1994). Water as a major environmental issue rises many challenges in Sub-Saharan African large cities, including but not limited to, health and sanitation, availability of clean water for city dwellers, and, of course, the building up of houses in hazardous areas (Vennetier 1989, Stren 1991).

Without an efficient assessment and evaluation of the situation, suitable solutions would not be found for those problems, since the availability of accurate information is a pre-condition for relevant development policies (Mabogunje 1977). In African countries assessments are rather scarce and information outdated. The use of new analysis techniques like the Geographic information systems (GIS) may help decision-makers to plan more effective intervention by bringing them accurate information on sensitive areas. The purpose of this paper is to contribute to the assessment of water-related problems, through the identification and a classification of hazardous urban areas by using a GIS and remote sensing techniques. This approach includes the identification and a classification of heavily populated but easily flooded or landslide areas, and the other non suitable lands already constructed or likely to be invaded by squatters.

The case study on Douala is aimed to showing the potential of new analytical tools such as GIS and remote sensing in addressing environmental problems in fast growing urban areas of developing countries. The paper begins with a scope on the urban growth and land occupation trends in the city, and the subsequent environmental challenges, in regard with water-linked problems. Following is a description of the different materials and steps leading to a detailed cartography of hazardous areas by combining digitized maps with demographic, physical and socioeconomic data into a GIS database. After the displaying of the main results achieved, the paper ends up with a discussion on methodological and technical problems encountered during the process. As a conclusion, the author thinks there is still room for improvement, notably with inclusion of aerial photographs and satellite imagery, so as to enable the monitoring of those environmental challenges related with rapid urban growth.

The inefficiency of the public authorities policy

As the main port and economic city in Cameroon, Douala is faced with a rapid urban growth and land consumption since the last three decades, with an estimated 8% annual

rate (Mainet, 1985). More than 70% of its estimated 2 million population in 1996 (as compared to 300,000 in 1960) live in unplanned and hastily built up shanty-towns. A first global an accurate assessment of water-related problems was achieved for the 1982 Douala masterplan, using geological, topographical, climatic and demographic. Short- and long-term propositions were made to improve the situation (Minuh 1983). Unfortunately, most of the conclusions were based upon wrong demographic prospects predicting a 3 to 5% drop in the annual population growth rate between 1990 and 2001, a scenario which never occurred. Therefore, an estimated 8,000 out of the 18,000 hectares of the total built up area in Douala in 1996 are believed to be potentially non suitable for housing. These include flood or swampy zones, or land submitted to frequent landslide due to heavy rains (4000 mm annual rainfall), all resulting in the lost of many lives (Mouafo 1993). So far, the local authorities attitude towards the anarchical occupation of hazardous areas in Douala has been based upon repression, with the brutal destruction of houses. This approach failed, due to a lack of technical and also necessary legal tools to address the rapid urban sprawl. In addition to that, no preventive policy would be built up, as a result of insufficient or inaccurate information on hazardous areas. This paper will, therefore, try to confront the actual situation with the predictions of the 1982 masterplan by merging out updated data from more recent sources and new spatial analysis techniques.

Using a GIS for the assessment of water-related hazardous areas in Douala

A GIS database stores related maps features as separate map themes or layers. All these information layers can be displayed together through a process named spatial overlay. Older data would therefore be updated using more recent ones by combining vector, raster and imagery products as well as tabular files such as demographic and socioeconomic data to achieve a site analysis and environmental valuation. We assume that in Douala, water-related problems are aggravated as a result of interaction between land-based activities, occupation trends, and both ground and underground water flow patterns. A multicriteria analysis merging out from a GIS would, therefore, help in understanding the dynamics of water flow in our coverage area and the adverse effects of physical and anthropogenic actions occurring within the drainage basin.

The building up of a digital elevation model (DEM) out of the existing digitized base map of Douala is the first step of our approach. The DEM would serve as a basis for our site analysis thanks to a matching up with other existing data to determine new features such as the carrying capacity of different areas of the city, and the adverse impacts anthropogenic actions on sensitive hazardous urban areas. Next, a classification of different hazardous areas into mangrove swamps, flood zones, instable or sloppy sites would help in valuating the potential threads associated with each type of hazard so as to suggest relevant preventive or curative actions to be taken. Next, the use of various criteria like population income, slope, the maximum height reached of water during the rainy season, etc. would help merging up areas not suitable for construction and determining potentially aedificandi sites.

The aim of such an assessment is to provide decision-makers with accurate information so as to help them plan appropriate actions and interventions like banning constructions within a buffer on the shores of some rivers, imposing construction norms in some areas, or delimitating built up targeted areas to be rehabilitated or transformed into parks, and fighting the devastating water borne diseases as well. In addition, the interest of such a paper for Subsaharan African megacities lies in the use of low cost techniques to produce accurate scientific data that can easily and quickly be processed through multivariate analysis. Those could be used as decision-support tools by helping in understanding key processes and assessing environmental stresses and water-linked disturbances.

A discussion on the methodology, i.e. the prospects and limitations of such a GIS-backed environmental assessment model, will conclude this presentation. The main issues raised here include but are not limited to the matching of disparate spatial, tabular (socioeconomic) and image data to achieve site analysis, the margin of uncertainty in the model, and the ways to improve the accuracy and the resolution of input data. A combination of digitized maps, statistical data, aerial photographs and, ultimately, satellite imagery for instance should be considered here, and the global challenge of translating scientific information into managerial tools.

SELECTION OF TIME HORIZONS FOR STRATEGIC MANAGEMENT OF LAND AND WATER RESOURCES

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INTRODUCTION

This paper has been developed on the bases of research of system analyses and the performance of systems (Soroczynski, 1996, 1998). These analyses have been conducted for the purpose of justifying the development of more rational strategies for management of sustainable systems. The selection of time horizons is an important part of the above strategies.

Objectives of this paper are to link current knowledge of time horizons with population projections and the classification of systems for integrated management of land and water resources (Soroczynski, 1996) and availability of water. Time horizons for other disciplines/component systems such as environment, climatic conditions and economic analyses have also been researched. Better understanding of relationships between different component systems is necessary for comparison and selection of appropriate and justified time horizons under uncertain conditions. The adoption of more rational strategies and management practises will also contribute to the resolution of the issue.

PROBLEM

Current understanding of socio-economic systems indicates that population growth will stabilise in the future. There is a limit to growth of population within limited resources. Technological progress may, and hopefully will, provide relief in both short and long terms, but stabilisation of population would create better living conditions for existing and future generations.

Various time horizons are adopted by different scientific disciplines for management of essential resources related to their areas of responsibilities. These differences and discrepancies are of great concern in relation to current practices for management of land and water resources. The level of confidence for predictions of future events from different scientific disciplines must be understood and comparable time horizons need to be adopted. Such time horizons have been defined and justified for climatic changes (IPCC, 1996) and population growth (Lutz, 1996) only, and currently have been adopted as 100 years.

On the bases of current practices the adoption of time horizons are defined separately for each of the following component systems. These time horizons have been defined and utilized for each of the component systems except environment:

- population growth
- climatic conditions
- water resources planning and
- economic analyses.

It is affirmed that consistent time horizons for all disciplines/systems should normally be adopted unless there are other over riding concerns related to this approach. Currently strategic management of land and water resources has not been considered as one component system in relation to long-term strategic management issues. Land use planning for water resources, is related to project orientation and is not a part of long-term strategic management issues.

The GWP (1997) also postulates the need for a national approach to the development of water resources strategies. Under uncertainty of future events, these strategies should secure the best options for socio-economic developments and should also allow for optimisation of current and future costs.

Classification and performance of water sources and water systems (Soroczynski, 1996) and anticipated socio-economic development should also be considered for selection of a relevant time horizon. Given the above factors, the selection of appropriate time horizons for a country, region or catchment is a very complex issue, as different socio-economic and water systems require the adoption of different strategies. Many cities are supplied with water from dams or borefields and such systems have a considerable impact on land use planning and management of surrounding areas. The adoption of revised and extended time horizons may be critical for securing options for supply of water and maintenance of quality of life for cities and regions in the future in such areas as Asia, Australia, South Africa and other critical systems.

This paper presents: 1) currently used and proposed time horizons for management of land and water and comparison of those time horizons from other related disciplines, 2) justification of criteria for selection of time horizons for strategic management of land and water resources and 3) graphical bases for selection of time horizons accommodating relevant factors.

CONCLUSIONS

1. On the basis of the above, a revised guidelines for the selection of time horizons should be adopted to deal with uncertain conditions.

2. The adoption of a longer time horizon than 50 years, say 100 years, for critical systems which depend on integrated management of land and water resources should provide for more rational strategic planning. Further, it is postulated that the following

two stages for strategic management of land and water resources should be adopted for supply of water to major cities and towns:

- an implementation of up to 50 years
- growth model related to socio-economic development for next 50-100 years.

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Workshop 3

Business environmental policies and strategies for water pollution prevention

BUSINESS ENVIRONMENTAL POLICY. CONCEPTUAL FRAMEWORK AND STRATEGIES

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Environmental problems can be observed as degradation of land, air and water and more generally at the ecosystem level. The same problems can be traced back to human activities, for instance industry, agriculture and transportation. Today, we realise that 'end of pipe' thinking is not enough and that the commodities produced often represent an important part of the problems faced. Life-cycle analysis has become a popular tool to trace the whole set of environmental impacts of specific industrial and agricultural products 'from cradle to grave'.

Next step in this chain of reasoning is to consider the dominant life-styles in specific countries and at the level of individuals. Dominant cultural and behavioural patterns in our societies can not be excluded from consideration. Among cultural factors, I will here emphasise science and ideology, both for our attempts to understand current environmental problems and to tackle them constructively. My main interest is in the social sciences and among them I will single out two disciplines, economics and business management, for further consideration. Attempts can be made to deal with environmental problems essentially within the scope of the traditional conceptual framework of each discipline or by suggesting an alternative conceptual framework. In my judgement marginal adjustments in the traditional frameworks of economics and business studies will not be enough.

There seems also to be an increasing demand for new thinking in relation to environmental issues from the business community and from other parts of society. Environmental management systems (EMS) such as ISO 14 000 and European Union Eco Management and Audit Scheme (EMAS) exemplify initiatives within business. An increasing number of corporations claim to have an environmental policy with a focus on environmental performance in addition to more traditional ideas about monetary profits. In a report 'Signals of Change. Business Progress Towards Sustainable Development, representatives of the World Business Council for Sustainable Development (WBCSD) with its office in Geneva argues in favour of an increased focus on 'eco-efficiency' and speaks increasingly of the social responsibility of business. Behind WBCSD are some 120 transnational corporations. These companies are penetrating almost all parts of the world and many of them are growing in terms of power and sales volume. At some stage in this growth process one may understand if some actors involved start to think about the implications in terms of responsibility towards various stakeholders and society at large.

While there are exceptions, university scholars in business management and economics have not contributed much to this new development. From the point of view of mainstream neoclassical economics, 'eco-efficiency' tends to be regarded as a meaningless concept and many business economists similarly stick to a reductionist idea

of efficiency where only monetary profits and performance count. As I see it, this is an unfortunate situation. Economists and students of business alike should rather respond by suggesting new conceptual frameworks as part of a pluralistic approach. Traditional concepts and theories may be good for some purposes but not for all purposes. I believe that issues of environment and development belong to a category where the shortcomings of traditional thinking habits become accentuated.

In the paper, I will first shortly deal with some epistemological issues. Looking for a new conceptual framework and suggesting strategies for various actors or organisations is not only a matter of science in some objective sense. It is as much a matter of ideology. Mainstream neoclassical economics is science in some sense but at the same time ideology. In many ways the conceptual framework of neoclassical theory legitimises thinking patterns and behaviour of actors in business, in politics and more generally in our societies. It will be argued that the limitation of economics to one paradigm (with a particular ideological content) is questionable in relation to contemporary ideas about democracy. Only a situation of simultaneous coexistence of theoretical perspectives appears compatible with democracy.

A conceptual framework will be suggested where the political or ideological dimension is emphasised. 'Values are always with us' in social science research as argued by Gunnar Myrdal. Reference will be made to a 'Political Economic Person' (PEP) rather than the Economic Man of neoclassical theory. Instead of seeing man as a consumer maximising utility, man (or woman) is seen as an actor with many roles and embedded in networks of relationships. This Political Economic Person has an identity and an 'ideological orientation'. Ideology here refers to 'means-ends relationships' and is not limited to more or less established political ideologies (socialism, liberalism etc.). Distinctions can be made between different environmental ideologies, for instance, one characterised by 'technological optimism', another by a version of the 'precautionary principle'. As part of neoclassical theory 'rationality' is seen as a matter of optimisation in a mathematical sense (for instance maximising utility, profits or 'present value', the latter as part of Cost-Benefit Analysis, CBA). According to an alternative idea of rationality, it is suggested that decision making is a 'matching process' where the ideological orientation of specific actors is matched against the multidimensional impact profiles of specific courses of action considered.

While economics is rather monistic, the literature in business management is more pluralistic. In addition to the theory of the profit maximising firm, stakeholder theory will be discussed as well as an actor-network approach to organisations. As part of the latter view reference will be made to a 'polycentric' organisation where each individual is a Political Economic Person (i.e. an actor) and a potential centre for initiatives and action in relation to environmental issues. The organisation in turn is regarded as a collective of individual actors who differ in some respects but share some values and a kind of ideological orientation or 'business concept'. The organisation is a 'Political Economic Organisation' (PEO) which may have an environmental policy, a social policy and so on.

A holistic and multidimensional idea of economics and efficiency is furthermore suggested. Monetary calculation is still important but regarded as partial analysis. In

addition there are a number of relevant non-monetary parameters or variables that should be the subject of monitoring and accounting practices. The 'eco-efficiency' ideas advocated by WBCSD may fit into this picture but also various ideas about changes in 'manpower' and the knowledge position or know how of the corporation. Similarly, performance in social terms in relation to specific stakeholders and society at large may be a consideration.

A final part of the paper will address the issue of strategies of specific actors (individuals or organisations) in relation to other actors. Not only business corporations but also environmental organisations and universities will be discussed. Rather than the usual distinction between 'reactive' and 'proactive' strategies, a distinction will be made between 'eco' (meaning 'ecological') strategies, 'intermediate' and 'non-eco' strategies and another distinction between 'confrontational' and 'co-operative' strategies. Here we are back to an interactive, actor-relationship-network model.

As a representative of a university or 'högskola' specialising in environmental management and ecological economics, I will end my presentation by pointing to the need for education and research in the area of 'business and environment'. There is also a need of co-operation between universities on the one hand and small as well as big business corporations on the other. As part of this kind of relationships, rather than behaving opportunistically, each party should think of its specific role and responsibility in relation to the larger society.

WATER MANAGEMENT AND CLEANER PRODUCTION IN INDIA - A CASE STUDY

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Introduction

Water management strategy consists of the following waste water pollution prevention hierarchy, i.e. Water and wastewater flow reduction, Water recycling,By-product recovery and Water reuse. Once any organisation decides to go in for a pollution prevention programme , the key planning steps to be considered are,

Step 1 : Performing an assessment of plant wide water usage and waste water generation. During this phase, historical records should be reviewed to establish an information baseline. This will help in maintaining a plant water balance.

Step 2 : Identifying and evaluating potential areas for water conservation, recycling and reuse. This phase should include sanitary as well as process water use.

Step 3 : Setting goals for waste water reduction. Here one has to define waste water reduction goals and supply water reduction goals. The goal setting stage is very important

Step 4 : Implementing water management programme [F. M. Freeman, 1995]. The main theme of this paper is to highlight the waste management strategy with the help of a case study

Characterisation of waste waters

The characterising of waste water should be based on the effluent quality. The qualitative and quantitative characteristics of waste streams to be treated serve as a basis to find out whether the waste water streams are amenable to effective biological treatment, or require treatment using alternate processes [Attilio, Sharon. B, 1996].

The main parameters in waste water characterisation are:

◊ source information
◊ chemical composition
◊ physical properties
◊ biological factors
◊ flow parameters

Waste Water Treatment Processes

The main objectives of conventional treatment processes are reduction of suspended solids, pathogenic organisms, biochemical oxygen demand. The waste water treatment processes can be classified into

- Primary treatment
- Secondary Treatment
- Tertiary treatment

Primary Treatment : Processes used to screen out coarse solids , to reduce the size of solids, to separate floating oils and to equalize fluctuation in flow or concentration through short term storage [Donald, Herbert, 1979]. Sedimentation is currently the most widely used primary treatment technique. Flocculation and precipitation can help reduce the organic and inorganic load by settling the organics concerned.

Secondary Treatment : This generally involves a biological process to remove organic matter through bio - chemical oxidation. Activated sludge reactors and Trickling filters are the commonly used biological processes in India [S. P. Mahajan, 1985]. In the Activated sludge process , a portion of the activated sludge [active microbial floc] is generally recycled to the primary clarifier to improve the breakdown of wastes.

Tertiary Treatment : Many effluents require advanced treatment to remove contaminants. Common examples are

- Removal of dissolved organic by Reverse osmosis
- Removal of nitrogen compounds by ammonia stripping with air
- Removal of residual organics and color compounds by adsorption on activated carbon

Case Study On Cleaner Production

Introduction

M/s. Rawal Paper Mills (RPM) is a agro-residue based pulp & paper mill. The installed capacity is 40 Tonnes/day. The conventional soda (NaoH) cooking process is used without chemical recovery in a spherical digestor. The number of employees at the time of study was 300. The main raw material mix is given in Table 2.

Table - 2 : Raw Material Mix

Agro residue pulp	76%
Rag Pulp	5%
Waste paper pulp	19%

Table - 3 : Agro Residue Mix

Wheat Straw	65.0%
Rice Straw	21.5%
Elephant Grass	8.0%
Bagasse	5.5%

The raw material as agro pulp used in Rawal Paper Mills changes from year to year. The average raw material mix used for cooked pulp is as in Table - 3.

Need for cleaner production arose due to following reasons:

a) Escalating waste water treatment costs (Rs. 1200/Tonne).
b) Rising raw material costs (Rs. 2000/Tonne of agroresidue, Rs. 3000/tonne of chemicals).
c) Summer, water shortage forced unit to operate at reduced capacity of 15 tonnes/day. Water conversation was needed to enable full production.
d) Pressure from state pollution control boards, local bodies and NGOs
e) Increasing awareness of waste minimisation potential [Kunitoshi Sakurai, 1995].

The strategies are,

1. Reduction in consumption of raw materials and energy.
2. Reduction in wastes produced.
3. Recovery of materials from waste streams.

These strategies were grouped under 5 areas

1. ***Equipment change/modification***

Examples are, 1. Modification of existing raw material, 2. De-dusting system, 3. Installation of screw press for pulp dewatering, 4. Couch pit modification to prevent overflow during paper breakage, etc.

2. ***Input modification***

Examples are, 1. Depithing of Bagasse, 2. Removing leaves from elephant grass, 3. Substitution of some cooking chemicals, 4. Substitution of bleaching chemicals (e.g.H_2O_2) or bleaching with oxygen, 5. Replacement of existing dyes with non-toxic ones.

3. ***Process modification***

Examples are, 1. Optimisation of pulping process by external cooking with NaoH, 2. Segregation of initial concentrated black liquor, 3. Optimisation of fuel combustion in Boiler, 4. Installation of consistency indicator in the stock preparation area.

4. Waste utilisation

- Chemical recovery from black liquor (e.g.lignosulphate)
- Biogas generation from black liquor.
- Waste heat recovery in economiser and using the generated hot water in digestors.
- Waste heat recovery from dye set exhaust to generate hot water for washing purposes.

5. House keeping

Cleaner production programme was focused on

- Installation of an appropriate chute to collect screening rejects.
- Covering of all chemical closing tankers and vibratory screens with proper lids to prevent spills.
- Raw material dust control by providing an appropriate dust extraction-cum-control system.
- Insulation of condensate return lines to minimise heat loss.

Comparative Analysis With And Without CP

Production capacity

Increased by 2 tonnes/day (i.e. by 8%). It was made possible due to double felting in the paper machine and by providing uniform pressure to the edge cutting nozzle. Paper breakage was reduced by about 18 - folds a day.

Water consumption

Reduced by 28%. It was possible due to addition of a

- Screw press which after squeezing of pulp requires less water for washing and
- Substitution of fresh water by filter-rich backwater where possible.

Electricity Consumption

The specific electrical energy requirement for the paper making section alone increased by 8%, due to the fact that CP measures required additional electrical energy for transfer of waste materials (backwater, decker filtrate) for recycling, reuse, and recovery . However, the total electrical energy consumption for the combined pulp and paper sections was reduced by about 42 KwH/tonne of paper. The decrease was mainly due to the reduced electrical energy requirements for wastewater treatment. This was achieved by segregating the concentrated black liquor for solar drying.

Steam Requirement

Implementation of CP measures, such as dedusting of agro raw materials, insulation of condensate return lines, and waste heat recovery through economizers to provide hot water for maintaining the bath ratio in digestors, etc. resulted in a reduction of specific steam requirement by 8.5% .

In addition, the solar-dried black liquor cakes could effectively produce an additional 0.50 tonnes of steam/tonne of paper, equivalent to 12.5% of the existing steam requirement. Thus if these CP measure were implemented the steam requirement would effectively be reduced by about 1.0 tonne/tonne of paper, equivalent to about 21% of existing demand.

Raw Material Consumption

The reduction in fibrous raw material consumption is mainly due to the recovery of fibre from the fibre-rich waste streams. Fibre recovery amounts to about 53kg/tonne of paper. Taking an average fibrous raw material yield as 54%, the above fibre recovery is equivalent to fibrous raw material of about 98kg/tonne of paper. The fibrous raw material consumption for kraft grade was further reduced as Johnson screen rejects after refining were recycled to this stream. The rejects were of the order of 73 kg of fibre/tonne of kraft paper. This was equivalent to 138 kg of fibrous material per tonne of kraft paper. The reduction in alum consumption was mainly due to improved washing of pulp. The caustic consumption was reduced due to partial recycling of black liquor and to dedusting of raw materials.

Conclusion

Environmental impact of cleaner production

Solid waste generation is reduced by 18%. Water pollution load is reduced by 46%. 70% of this impact was due to the solar evaporation of black liquor.

Air : Particulate emissions were reduced by 8% in the flue gases from boiler due to efficient utilisation of stream & proper insulation of condensate lines. One can hence conclude that all industries will gain in several ways by going in for full fledged waste minimisation and cleaner production.

TEXTILE INDUSTRY AND GROUNDWATER POLLUTION: CURRENT ISSUES IN RURAL ENVIRONMENT AND PROTECTING THE WATER RESOURCES

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India is rapidly getting industrialised where the water pollution poses a major threat to the ecology and society. Of many pollutions from the industrial development, the effluents from dyeing and bleaching in textile industries are destructive to water, land and air. The pollution from these activities in textile industries is also highly poisonous to aquatic organisms and agriculture.

Tiruppur and Erode regions in the undivided Coimbatore District, known as Manchester of South India, of Tamilnadu in India are well-known for knitwear products such as T-shirts, banians, bed-clothes and other cotton materials in the international markets. The two towns have about 3000 textile units of which 800 are engaged in dyeing and bleaching processes and they provide employment to 8 lakh people. There is a gold rush for textile business by multinationals and industrialists as it provides more foreign exchange earnings. As a result, water is ruthlessly exploited and several hundreds of acres of both wet and dry lands are converted into textile industries.

Dyeing and bleaching of clothes in textile industries require increased use of groundwater in Tiruppur and Erode. Groundwater is pumped out with giant pumps. One dyeing/bleaching unit requires 1 lakh litres of water per day and 800 units require 80 million litres of water per day. 1 kg of clothe dyeing requires 22 litres of pure water. Besides water, many chemicals such as bronze, chromium, iron, lead, acids, caustic soda, petroleum products [coldar & pigment], synthetic dyeing, common salt and acids, which are very poisonous to the environment, are used in large scale in dyeing and bleaching activities in textile industries. About 80,000 cubic metres of effluent with chemicals such as sodium hydroxide, sodium hydrochloride, sodium sulphide, acids, a number of dyeing agents and other substances are discharged from the dyeing and bleaching units everyday without any purification treatment into the river Noyyal, tanks, other water resources and land which are the vital social support systems of the village communities Thus, an attempt is made to conduct an Environmental Impact Assessment [EIA] study in order to understand the impact of textile industries on natural resources, environment and rural communities.

AIM, OBJECTIVES AND METHODOLOGY

The main aim of this study is to assess empirically the impact of textile pollution on water resources, land, rural environment, public health and socio-economic conditions of the village communities. The important objectives of this study are:

a] To assess empirically the nature and magnitude of groundwater pollution, land pollution and pollution of water resources due to dyeing and bleaching clothes in textile industries;

b] To analyse the impact of textile pollution on the health, and socio-economic conditions of the village communities.

CASE STUDY

Environmental Impact Assessment Survey was carriedout in 4 villages to assess the water pollution, land pollution, public health and socio-economic conditions of the village communities. Orathapalayam, Kamatchipuram, Chemmangudipalayam and Thittapalayam in Tiruppur and Erode in the undivided Coimbatore District of Tamilnadu in India were selected mainly because 90 percent of the textile industries are concentrated in these two towns and the textile pollution is the highest in the surrounding villages.

DATA COLLECTION

Interview schedule containing questions related to land pollution, water pollution, pollution in water resources, public health, cropping pattern and changing socio-economic conditions of the village communities due to textile industries was prepared. The data on the above variables were collected from the villagers and the data on water and land pollutions were checked with water and soil tests in order to confirm the water and land pollutions. Water samples were collected from the wells, tanks and ponds and soil samples were collected from land in the surrounding villages.

SAMPLE

100 respondents belonging to a cross-section of the population were randomly selected from 4 villages to assess their perception about the impact of textile industries particularly dyeing and bleaching industries on water resources, land, environment and communities. The sample consisted of farmers, agricultural labourers, fishermen, community leaders, NGOs, textile industrialists, doctors in rural health centres and rural youth.

MAJOR FINDINGS

Dyeing and bleaching of clothes in textile industries require increased use of pure groundwater. 100 % of pure water is pumped out from bore-wells in the surrounding villages. Brackish water is also pumped from bore-wells within the dyeing and bleaching units. The salinity level of the brackish water is 6,000mg/l -7.000mg/l and this water cannot be used even for cleaning and washing. Groundwater is pumped out with giant pumps. There is reduction in the groundwater table due to over exploitation. The application of pumping technology of higher capacity to draw groundwater has resulted in depletion of groundwater, destruction of valuable natural resources by coloured and saline ingress and monopolisation of groundwater resources by the textile industrialists has resulted in dprivation of usable water to the rural communities.

Water after being used with chemicals, and other substances such as petroleum products [coldar and pigment], bronze, chromium, iron, lead [plumbum], acids, caustic soda [sodium hydroxide] for dyeing and bleaching clothes in textile industries is discharged everyday without purification treatment into land, catchment areas and the rivers Noyyal, Chinnakarai, Nallar and Orathapalayam dam. The water from these rivers is stored in Orathapalayam dam (which irrigates 21,500 acres of land), canals, tanks, wells and ponds which are the vital social support systems for the village communities and they depend on them for irrigating agricultural lands, drinking purposes, cattle management, fishing and many other purposes. The untreated water with chemicals and other substances discharged into water sources have polluted surface as well as the groundwater and the

land. The water test showed a TDS level of 6,000mg/l -7,000mg/l and the SAR was in excess of the
recommended limits. The soil test also showed high sodium levels beyond the toleration limit. The high content of TDS rendered the water unusable and the sodium content polluted the soil quality.

Tiruppur and Erode regions were very famous for cash crops such as groundnut, turmeric, cotton, tobacco, tomatto and chilly. These agricultural products were severely affected due to depletion/decline of groundwater, and transfer of water from village to textile industries. The decline/depletion and transfer of water have decreased agricultural production and rendered poor soil quality, changed the application of chemical nutrients and cropping pattern and reduced the value of land in the villages.

Water is highly commercialised in villages of Tiruppur and Erode. The required water is pumped out from the bore-wells in the surrounding villages located 20-30kms away and transported by lorries to the dyeing and bleaching units. One load of lorry water contains 10,000 litres - 15,000 litres and it is sold for Rs.350 to Rs.400. Nearly, 1,500 lorries have been operating everyday for transporting water to dyeing and bleaching units. Many farmers have abandoned their lands and gone for water vending.

4,37,760 tones of firewood are used as everyday energy source to heat water for dyeing and bleaching clothes. This causes serious impact on forest resources and the smoke released from heating firewood pollutes the surrounding air atmosphere.

27,980 tones of solid wastes such as plastic [2,430 tones], clothe cuttings [25,530 tones] and steel [20 tones] are generated everyday. These solid wastes are dumped on land, within residential areas and waterways. The dumping of solid wastes in the open space pollutes the land, air, water, and environment creating drainage problems, becoming a major health hazard and source of mosquito breeding.

The conversion of agricultural land into textile industries, pollution of water, land and depletion of groundwater have deprived farmers, small peasants, landless labourers and women of even their meagre wages. The women have to go long distances to collect drinking water, firewood and fodder. It also leads to land alienation, migration of rural labourers to urban areas for employment and social conflict between the farmers and industrialists.

People are compelled to drink contaminated/polluted water in the absence of potable water and they are able to bath once or twice a week. This causes skin diseases, jaundice, irritation, diarrhoea, infant mortality and death of cattles.

CLEANER PRODUCTION IN FOOD PROCESSING INDUSTRIES: CASE STUDY OF THE MAURITIAN CANE - SUGAR INDUSTRY

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Introduction

Until recently, the environmental debate in industry has largely been one of rhetoric rather than action. While it is difficult for industry to refute the general need for environmental protection, to date there has been little practical guidance as to how real progress might be made. The need now is to develop practical solutions to meet the environmental challenge. Businesses are at the core of the environmental debate and are central both to the problem and to the solution. Companies are not only assessing benefits of adopting environmental management in financial terms (savings, production efficiency, market potential) but also the risks of not adequately addressing environmental aspects (accidents, inability to obtain bank credit and other investment money, loss of markets).

The food industry is one of the world's largest industrial sectors. In some countries or regions, it is the largest single manufacturing industry sector. While food processing is not considered to be amongst the most environmentally hazardous industries, nevertheless, they can cause severe organic pollution if designed or operated with insufficient attention to the environment. Three environmental problems common to all food processing sectors are: (1) high water consumption, especially problematic in water poor or stressed countries (2) the generation of liquid effluent with high organic content and (3) the generation of large quantities of sludge and solid wastes. To solve these and other environmental problems, the food industry should adopt the cleaner production (CP) concept compared to the traditional end-of-pipe approach to pollution control.

A growing awareness throughout the Mauritian cane-sugar industry of the impacts of pollution on the environment, coupled with the introduction of sectoral effluent standards by the Mauritian environment authorities, has led to the current position whereby the sugar factories need to introduce appropriate water and wastewater management systems. The cane-sugar industry in Mauritius has got three years to comply with the legislation on effluent standards. During that three year period the industry will have to investigate cleaner production opportunities, select appropriate waste treatment technologies, gain operational experience and confidence with the technology and introduce environmental management systems.

The cane-sugar industry faces the challenge of significantly increasing its overall resource efficiency - obtaining the maximum of useful products from minimum raw materials and other impacts, including energy and water. The case study taken from the cane-sugar industry in Mauritius illustrate the extent to which environmental improvements are possible through cleaner production.

Excluding water used for irrigation purposes, the sugar cane industry in Mauritius requires an input of around 45 to 50 million cubic metres of water for processing around 5 to 6 million tonnes of cane during the crop season (June to December). This is comparable to the domestic water consumption and represents about 10% of the island's total annual water demand. The per capita freshwater availability on the island is about 1600 m^3 per year, which places Mauritius in the group of water-stressed countries. It is possible that shortage of natural freshwater can prove to be a limiting factor for future economic development. It is important therefore to minimise water use for sugar manufacture through recycling and process modification and to adopt appropriate wastewater treatment systems.

A CP assessment carried out in the sugar factories revealed that if C is the weight of cane (in tonnes) processed, the water input in the sugar factories varies between 2C to 16C tonnes. Depending on the recycling approach adopted, it can be shown that this water requirement can be reduced to about 1.5C tonnes. Consequently this could result in a significant reduction in the annual freshwater requirement for sugar manufacture in Mauritius from 50 million to 10 million cubic metres. A computer model using a factory crushing 100 tonnes cane per hour has been developed to demonstrate to the industry the various possibilities and potential for reusing water.

There are a number of relatively inexpensive measures which can be taken to reduce the wastewater pollutant concentrations at source. These are:

- good housekeeping (spillage control, maintenance, etc.)
- install oil and grease seperators
- improve sugar entrainment seperators and
- temporarily store (rather than dispose of) excess juices and liquids during periods of week-end washdown.

It is strongly recommended that some or all of these measures are carried out at all factories in addition to (and in advance of) the installation of any wastewater treatment facilities.

There are two major issues to be addressed in developing an effective CP program in the industry:

External incentives: An appropriate government policy and regulatory framework must be in place to provide effective incentives for firms to adopt cleaner production.

Response of the firms: In many cases, firms are slow or incapable in responding to the incentives and in such cases it may be appropriate to assist the firms to adjust. The approaches adopted for this purpose will vary considerably depending on the characteristics of the sector and of the firms involved. Some firms will adopt CP readily in order to gain competitive advantage. On the other hand inflexible state owned enterprises will require targeted intervention to persuade them to take advantage of the benefits of CP.

NEW APPROACH TO WASTEWATER QUALITY CONTROL IN MEXICO.

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Introduction

This paper analyses the use of economic instruments for water management through the Mexican example. The regulatory framework for wastewater quality is presented as well as its recent modifications. The discussion focuses on the policy instruments used for water pollution control, their evolution and the main difficulties encountered in their implementation. It highlights some of the main economic implications of the legal reforms. Finally, an assessment on the potential effectiveness of the new approach which combines economic instruments and regulations is made and the conclusions that may be drawn.

Mexico faces an important water pollution problem which has become a major health hazard. The pollution load is concentrated in few catchment areas. According to studies conducted by the National Water Commission (CNA), 89 per cent of the total pollution load measured in terms of biochemical oxygen demand arises in only 15 basins. The wastewater generated in the country is of the order of 230 m3/s. Despite the importance of recovering treated wastewater to satisfy the increasing water needs, the treatment capacity in Mexico is very limited. Currently, only 10 per cent of the effluents are properly treated (Semarnap, 1996).

Government strategies

As part of the solution and in addition to direct investment in water treatment, the Mexican Government avails itself of instruments for direct control such as the Mexican Official Standards (Normas Oficiales Mexicanas, NOMs) set by the Ministry of Environment, Natural Resources and Fisheries and, in particular cases, the Special Conditions of Discharge (Condiciones Particulares de Descarga), which are defined in the regulations of the National Water Law (Ley de Aguas Nacionales) as a set of physical, chemical and biological parameters and of their maximum permissible levels of wastewater discharges. The Mexican government also makes use of economic instruments to alter the polluters' behaviour by internalising their environmental costs and benefits, this is the case of the wastewater effluent charge.

The wastewater effluent charge, in use since October 1991, is an example of the use of economic instruments in water management. In its inception, this instrument was used for discharges that surpassed the levels established in the applicable norms or CPDs. It is one of the first instruments for environmental protection used in Mexico based on the Polluter Pays Principle. However, environmental authorities realised that there was room for improvements. Modifications to the Federal Law of Charges (Ley Federal de Derechos) were introduced in December 1995 in which a new procedure was set to calculate the charge: the charge is no longer based on disposal zones but on the different types of receiving water bodies, according

[1] The views presented in this paper are those of the author and do not necessarily represent those of SEMARNAP.

to the current use of the water, the treatment level required, the volume discharged and the amount of pollutants found. Three categories were created: A) water bodies with lower treatment level, B) water bodies that require secondary treatment and, C) water bodies that require a more sophisticated treatment level. This reform is fundamental because a permanent incentive was created for users to reduce the volume and degree of pollution discharged and the charge was applied per unit of pollution instead of only the exceeding levels as before. The Federal Law of Charges is revised every year. Since 1997, this law contemplates economic incentives for users of water receiving bodies that have adopted processes for better water quality than the established in the standards. There have been some changes in the classification of certain water bodies and additional pollution indicators are now considered.

New regulatory framework for wastewater discharges

As an additional option and for practical reasons, in order to control the pollution level from municipal and industrial sectors, it was considered more effective to formulate two official standards published in 1997 (one of them still for public consultation), establishing the maximum permissible levels of pollutants for wastewater discharges to national waters and goods and the maximum permissible levels of pollutants for wastewater discharges (except for households) to sewerage. This represents an enormous effort to simplify the system in place since this new approach allowed the reformulation of 43 official standards (mostly for specific industry sectors) into only these two.

The main purpose of this new approach is to provide incentives for polluters to adopt new practices, processes and technologies for the reduction of their polluting emissions. This change was driven, among other things, by the fact that the government perceived a large default among users associated with the economic crisis that struck the country. It was therefore considered that a gradual approach or multi-stage approach was the best option to implement. It has been established that the deadlines for complying to the maximum permissible levels for discharges to national waters are for the year 2000, 2005 and 2010, according to the population size in the case of municipalities and the range of biochemical oxygen demand for non-municipal discharges.

The current legal framework establishes penalties for non compliance. It is too early, however, to fully evaluate the effectiveness of these new standards. In fact, in the past months, there has been a reduction in collection mainly explained by the extension given to polluters for the construction of their abatement facilities. One important feature is that these standards allow to control all agents that discharge in a specific water body under the same parameters. This way it is possible to enjoy economies of scale while encouraging polluters to treat their discharges jointly (Giner de los Ríos, 1997). This instrument has also the advantage of being dynamic. The parameters considered are the same as in the Federal Law of Charges and the Special Conditions of Discharge, therefore, allowing for the homogenisation of policies. There is still a gap, however, in the development of a new regulatory framework for sludges originating from treatment plants and for the establishment of maximum permissible levels of pollutants for artificial aquifers' recharge and the conditions for water infiltration to soil and subsoil, in which the Mexican government is working on. A new standard authorising the use of treated wastewater for public services has recently been released for public consultation.

One the greatest problems that the system has faced in the last years is the fact that in general water polluters do not pay for their discharges. This has been the case of almost all municipalities and a large proportion of industrial dischargers. The amount collected from this heading represents a very low percentage of CNA's total collection level. The objective of environmental authorities with the introduction of these changes is to force payers on a reasonable timetable to comply with regulation charges, rather than increasing the revenue level. It is worth noting that the money collected from this heading is diverted to the Treasury and CNA receives a share of it as a budgetary provision of its services.

To conclude, the investments in water pollution control that will be required in the next years to comply with these new regulations will be huge. The CNA faces the problem of lack of infrastructure to supervise firms regularly, which implies very high costs. With the new legislation in force the charge system is now more flexible and comprehensive. However, proper institutional development is an important factor for the success of any type of instrument as well as the improvement in the monitoring and control of discharges.

Workshop 4

Meeting hydroclimatic variability in the tropics and subtropics: strategies for drought effect mitigation

A. Strategies for drought year management

B. Water harvesting

4 A Strategies for drought year management

ROLE OF TANKS IN SEMI-ARID REGION TO COMBAT DROUGHT

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This paper examines the role of tanks and the techniques of water management adopted by the farming communities to mitigate the impact of drought in the semi-arid region of Karnataka in Southern India. The present status of these tanks and efforts made to rehabilitate them is also examined in brief.

Even though tanks are popularly defined as a "small water reservoir created by throwing an embankment of earth across the flow of water". Each tank will have a defined geographical region as catchment and a command area. Since tanks are regarded as 'common property resources' every resident within the community had a right to utilize the water for purposes other than irrigation. However, it is the farmers drawing water for irrigation purposes could collectively decide on management practices to be adopted for irrigating a crop. Such collective decisions to combat a drought are based on assessment of rainfall, accumulation in the tank, performance of rainfed crops and possibilities for an irrigated crop. The methodology followed by irrigators of each tank differ from one to another.

Assessment based on rainfall: Rainfall is assessed based on a calendar having 24 divisions with specific names. In Karnataka, of this 24, only 17 are essential to raise a good crop. These 17 rains are further divided into two divisions; khariff and rabi. Rains from second week of April to last week of August is identified as Khariff and beginning of September it is Rabi.

Each of the rainy division is further sub- divided into crucial rains and non-crucial rains. Rains upto *Mrugshira* in the first week of June are very crucial for the Khariff season. Once rains fail upto this period, and if this *Mrugshira* also fail , then it is certain to be drought for that season. If rains fail upto the first week of September called *Uttare,* it is certain to be drought for the entire year, as *Uttare* is very crucial for the Rabi season. The popular proverb is *pack your baggage, if uttare fails.*

Assessment of accumulation in the tank : The quantum of rainfall expected from each division is estimated at the conclusion of each rainfall by an executive committee of the tank, however, a decision on drought for that season (*Khariff)* is taken only after the rain *Mrugshira.* The accumulation in the tank and the performance of rainfed crop is assessed collectively and the degree of incidence of drought is assessed. Based on such an assessment cropping pattern in the command area will be determined to overcome the impact of drought.

Based on these crucial rains and determination of drought, cropping pattern in the command area is determined twice in a year. At the conclusion of *Mrugshira* and at *Uttare.* If accumulation in the tank from the rains in three months duration from second week of April (*Ashwini*) to first week of june (*Mrugshira)* is low and the rainfed crops have not been sown at all, then, the first priority will be to cultivate the millet crop. If

the accumulation is above 25 per cent and if the rain fed crops have been sown and are performing well, then the preference of crop will be paddy under semi-wet condition., no irrigation is provided till the crop achieves flowering stage.

Determination of drought for the rabi season depends upon the rains upto *Uttare* in the first week of September. However, the rains from mid of august to first week of October are regarded as rains essential for the rabi season as the crop is going to be sown only in the second week of October. As the crops under rainfed conditions would have been harvested determination of crops to be grown is easier than in the previous season (*Khariff*). If the rainfed crops have failed totally and the accumulation in the tank is less than 50 per cent, the arrangements would be for a semi-wet crop of millets. Cultivation of paddy crop is allowed only if the rainfed crops have been succeeded.

Water Management: Based on the assessment of rainfall, the "*panchayat*" or the executive body takes a decision on Water Management to be adopted to overcome the impact of drought. In case of those tanks which irrigate less than 10 hectares, it is the *Panchayat* and in all other cases, it is the executive body which decides on the method of water management and the crop to be grown. In both the cases, there will be separate body for implementation. Land owners are not allowed to irrigate the fields.

Normally, the decisions of "Panchyat" are based on the quantum of water accumulated in the tank, the season and the performance of rainfed crops. Separate decisions are made for different seasons. In Karnataka, there are two seasons; khariff and rabi. Decisions are made either at the beginning of the season or as and when water gets accumulated in the tank. Decisions may also be postponed based on the performance of rains. The decisions based on the rainfall, crop and its performance in the rainfed area is given in the table. 1

The methods to be adopted for food production under drought condition can be classified into two; water based and area based. In the water based approach, the water is allocated to ensure a crop is raised even when the drought has set in. The water based approaches can be further classified as quantum based and need based.

In the quantum based approach, with the help of a clock or with the help of predetermined hole in a stone or by beating a drum for a particular time quantum of water to be distributed to every farmer is determined. The quantum of water to be distributed is based on the number of farmers in the command area and not the area. Consequently, total holding of an individual may not be irrigated. This is followed to restrict the area to be irrigated.

To bring about uniformity and to save water, crops are recommended and the method of irrigation is also prescribed. If the accumulation is above 25 per cent and if the rainfed crops have failed totally then the recommendation is for millet crop. The method of sowing will be dry sowing. No water is released for sowing or for irrigation. To save a crop one or two irrigation may be released. If it is 25 per cent irrigation and the rainfed crops have fared better then paddy crop is recommended. No water is released for irrigation, it is dry sowing of paddy. For which even the variety of paddy to be used and

the expected time at which water can be made available is also made known. If it is 50 per cent accumulation and the rainfed crops have fared badly once again millet crops are recommended. The method of sowing will be by transplanting and frequently, water will be released for irrigation.

An another methodology of quantum basis is allocation of water on the basis of weeks or days as the situation be. Here the total accumulation is allocated after multiplying the quantum either by weeks or days. If the accumulation is less then 50 per cent, then release of water is once in 15 days or two weeks. Farmers are free to raise a crop of their choice within the quantum allocated. If the accumulation is above 50 per cent, but less than 75 per cent, than the release of water is once in week. If the accumulation is less than 25 per cent, then the release water can be once in fortnight and if it is less than 10 per cent, no water is released.

In the need based approach, the method of irrigation is determined based on the quantum of water available and the growth stage of crop. This approach is normally resorted to if a crop is already cultivated. If paddy crop is cultivated in the entire command area and the water accumulated is not sufficient to raise a normal crop, then, a method called "wetting" is followed. In this method, during night, water will be let in to the fields to that level where in the top layer of the soil is made wet.

In the area based approach, normally the area to be irrigated is apportioned and all the land owners are asked to share land with one another within the area demarcated. There are two methods in this; firstly, depending upon the water accumulated, the proportion of the command area to be irrigated is determined. In the second method, depending upon the water only a particular part of the holding of an individual is allowed to be irrigated. The first method is normally refereed as 'damoosi'.

Apart from these methods depending upon the frequency of incidence of drought, practices may be developed. In those areas where rainfall is less than 500 mm in a year and incidence of drought is in once in two years, no water from the tank is allowed to be drawn. Each land owner has to make arrangements from a shallow well to irrigate. By this method, the accumulated water is conserved and only that part that has percolated is tapped for irrigation.

Present Status of Tanks in Karnataka: According to an estimate almost all the tanks that irrigate less than 10 hectares are totally silted. Those that irrigate above 10 hectares and less than 50 hectares are able to irrigate only one crop. Consequent to such siltation, the ground water levels have been drastically reduced. Having understood this ecological phenomenon, many NGOs and even the government are interested in desiltation and rehabilitation of tanks. In this process, it is the NGOs who are interested in rehabilitating the social mechanisms that can enable the community to face drought. Agencies of Government are interested only in desiltation and enhancing the physical capacity. There is no coordination between the two, consequently, the abilities of the tank to check the impact of drought is neglected.

Table.1

Decisions to Combat Drought Based on Rainfall, Crops to be grown and Water Management

Sl. No	Season	Quantum Accumulated	Performance of rainfed crops	Crop/s to be irrigated	Water Management
1.	Pre -monsoon (Late June and early July)	Less than one - fourth	Sowing has been delayed	Nursery of paddy	No water is let out, Seed bed under dry condition
2.	Monsoon (Late June and early august)	Less than one fourth	Sown but wilting due to shortage of rainfall	Sow paddy under dry conditions	No water released.
3.	Late August	Less than one fourth	Crops failed	Paddy continue, if sown already. If not, millet crop is sown	No water will be released.
4.	Late September	No water	Crops failed/ total failure	Millet crop in the command area and cultivation of the bed for a crop.	Ponds will be dug in the bed to meet irrigation requirements and water for cattle to drink
5.	Early August	Less than 50%	Performing well	Millet crop	To await good rains in the days to come. No water released.
6.	Early December	Less than 50%	Not performed well	Millet crop	Once in a week
7.	Early December	Less than 50%	Performed well	Paddy	Damoosi
8.	Early December	Less than 25 %	Not performed well:<50%	Millet	Only 50% of the command area.

DROUGHT FORECASTING AND PERIODIC EVENTS OF EL NINO PHENOMENON AND OTHER VARIATIONS

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Introduction

The global phenomenon of El Nino was discussed as the rise of water temperature of the Pacific Ocean near Ecuador from December to next December. This was discovered by fishermen and later analyzed to predict drought conditions in Asia region. It also affects America and Australia. This has increasing or decreasing property of rainfall in the tropical regions. The recurring interval of El Nino is not fixed. However it may recur in 3-10 years as noticed by periodic analysis. The teleconnections of Southern Oscillation are also studied using pressure variations between Tahiti and Darwin.

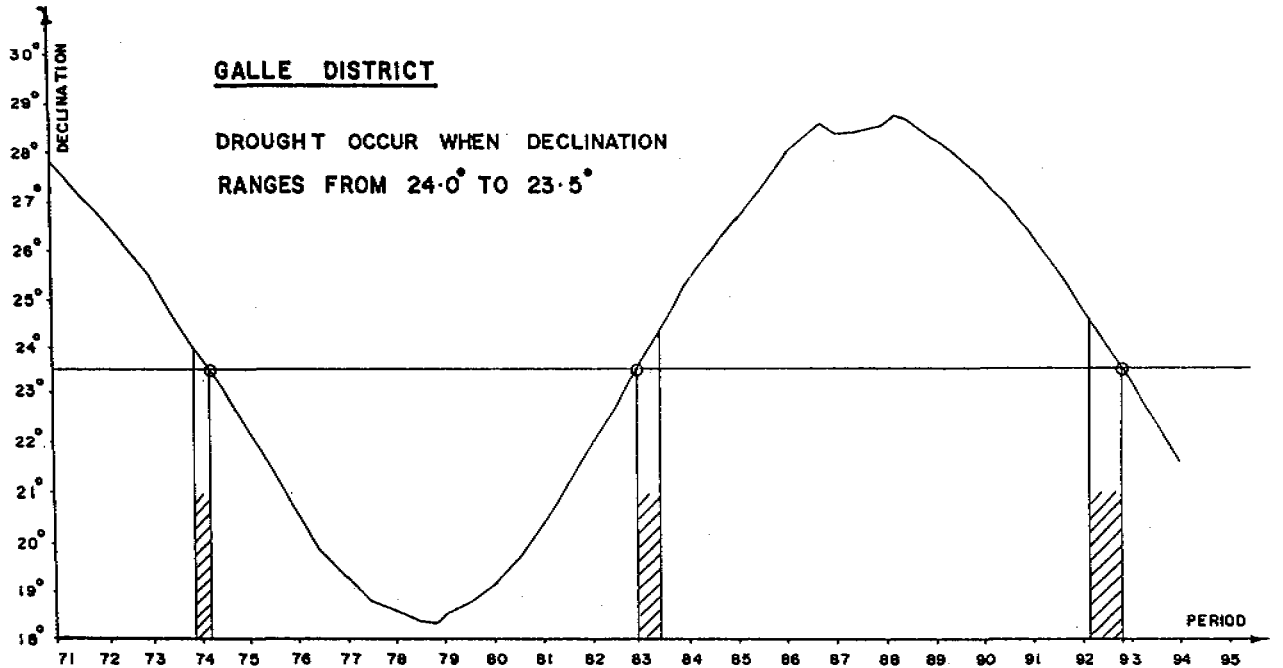
Project Details

The drought conditions in GALLE District are taken as the pilot project. The precipitation details are collected for 25 years and available climatic conditions are collected. The collection was plotted in time series. Low rainfall months are marked as 30 years average rainfall is not reached and the droughts are marked. The droughts were taken place in 1974, 1983, and 1992 with increasing order of strength. It was six months in 1992.Other periods have not shown droughts and average rainfall was not affected.

The Author investigated the global point of view and analyzed the behaviour of MOON as the creator of tides. The Moon and Earth taken together has the centre of gravity of combined system lying on the surface of the Earth. As Earth rotates daily this point of gravity rotates round the Earth. Water is attracted towards this point. When Moon is rising from bottom eastward current begin and reach maximum speed when moonrise and stops when the moon is on top. Then westward tide begin and reach maximum speed when the moonsets. THE MOON set and MOONrise give the maximum pull of tides.

Another factor, which affects the motion of tides, is the declination of Moon, which varies daily and oscillates between 18.5 and 28.5 degrees periodically. It takes 29.5 days to complete a cycle from 18.5 degrees North to 18.5 degrees South spirally in 1978.It took a route of 28.5 degrees North to 28.5 degrees South in 1988.It was repeated in 18.55 years cycle. The 1978 position was repeated in 1997.

This phenomenon is linked with the fact that Moon orbital plane is completing a cycle between +5 and -5 degrees with the orbital plane of the Earth. This is seen as the extreme edge of the moon is enveloping from 18.5 degrees to 28.5 degrees from the Equator. In other words Moon oscillates between Bombay and Lahore. Also oscillates between Kimberly and Salisbury in a period of 18.55 years. This fact has directed the



DECLINATION ENVELOPE OF MOON 1971 - 1993

TABLE-1

tidal motion. The East and West directions of the tides were slightly shifted to North and South. The tidal motion has a link between ocean currents. Also it has a link between air currents which influence the rainfall. The influence on the rainfall is analyzed in this project. The droughts have taken place when the declination envelope is between 23.5 and 24.5 degrees. This correlates that the Moon and Earth had common planes in this event and results in drought conditions.

Discussion

The extended analysis for 100 years of Sri Lanka rainfall revealed that the Moon and Earth common plane episode has resulted in droughts as noted in 1974,1983,and 1992.The El Nino condition is coinciding with this astronomical episode and repeats in a cycle of 18.55 years.

Conclusion

The results are predicting a drought in 2001 and 2010.Other periods in between may not suffer with bad droughts. This was satisfied in 1997 when all the tanks were spilling in Sri Lanka. The paper presents all the details of forecasting and this is applicable to Indonesia and commonly to all tropical countries.

CONVERTING BLUE WATER INTO PRODUCTIVE GREEN WATER: DROUGHT PROOFING OF RAINFED AGRICULTURE IN SEMI-ARID AFRICA

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Introduction

Rainfed agriculture will continue to be the dominating source of food for a foreseeable future in sub-Saharan Africa. Of the arable land, 40 % is located in semi-arid regions, which is submitted to recurrent periods of water scarcity. To keep pace with the rapid increase in food demand, a doubling of food production would be necessary over the next 25 years in the region (FAO, 1995). This addresses the urgent need of a substantial increase in crop yields, which in turn implies an improved efficiency in use of rainfall.

Two major causes to yield reducing water scarcity in rainfed agriculture in the semi-arid tropics (SAT) are; (i) the large proportion of non-productive water flows in the water balance (Figure 1), and (ii) the high risk for annual droughts and intra-seasonal dry spells. Figure 1 gives a general idea of rainfall partitioning in the SAT.

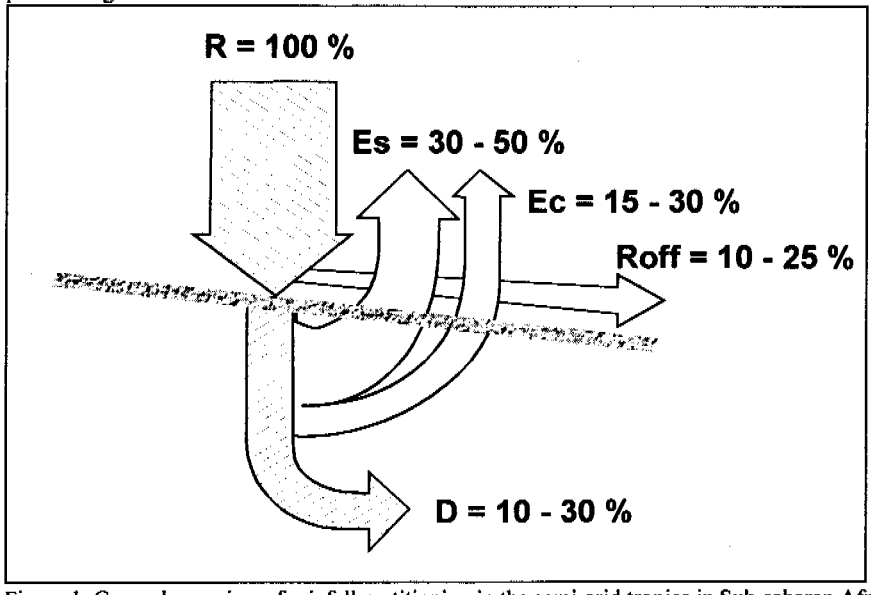


Figure 1. General overview of rainfall partitioning in the semi-arid tropics in Sub-saharan Africa.

Soil evaporation accounts for 30 – 50 % of rainfall (Cooper et al., 1987; Wallace, 1991). Surface runoff is often reported to account for 10 – 25 % of rainfall (Casenave and Valentin, 1992; Penning de Vries and Ditèye, 1991). The characteristics in the SAT of frequent, large and intensive rainfall events, result in significant deep percolation, amounting to some 10 – 30 % of rainfall (Klaij and Vachaud, 1992). The result is that productive transpiration in general is reported to account for merely 15 – 30 % of rainfall (Wallace, J., pers. comm.).

Generally, impacts of the extremely unreliable rainfall on the semi-arid savannah is analysed on an annual basis, translated into the probability of annual droughts, i.e. the risk of significant sub-average annual rainfall. This risk is high in the SAT, often with a probability of yield reductions one year out of five, and crop failure once every decade. However, yields can be significantly reduced even during years with close to average rainfall, due to short dry spells during critical growth stages of the crop.

Improving rainwater use efficiency in crop production thus includes both (i) maximising infiltration and root water uptake, and (ii) minimising the detrimental effect on crop growth caused by droughts and dry spells.

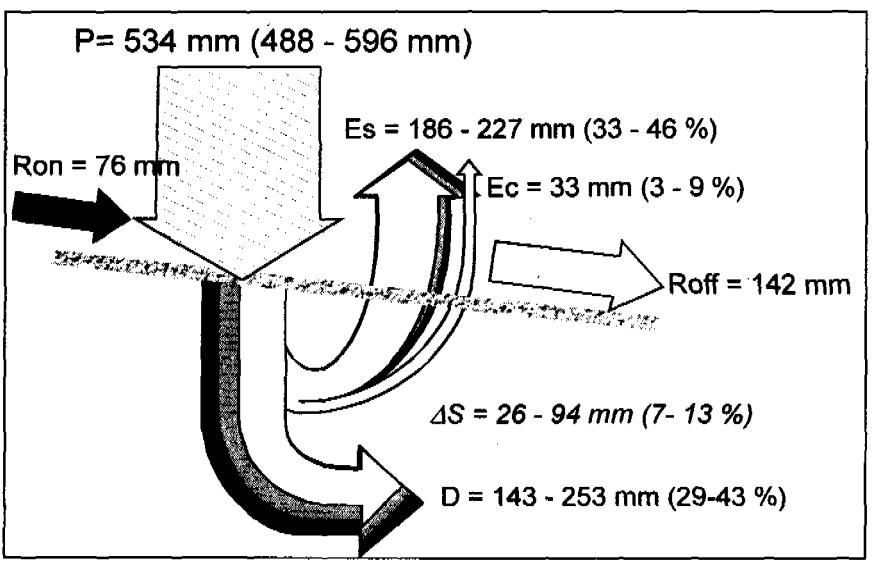
This paper presents results from an on-farm water balance research project in the Sahel (Niger) on the effects of dry-spells and surface water flows on crop growth, crop yields, and water use efficiency of pearl millet (*Pennisetum glaucum*(L.) Br.). Different options for water harvesting are discussed, based on the diagnostics of rainfall partitioning into "green" water flow as the sum of soil evaporation and plant transpiration and "blue" water flow as surface runoff and deep percolation.

Results

Annual rainfall on the 8 ha farmers field in the Samadey watershed, ranged from 488 – 596 mm 1994-1996. Eventhough this is close to the long-term average of 560 mm, the crop was hit by periods of water stress during each growth season. Despite these growth reducing dry spells, substantial volumes of water were lost from the crop field as surface runoff (R_{off}) and deep percolation (D). R_{off} was estimated to 25-30 % on soil crusted locations. D amounted to 29-43 % of rainfall. These estimates were derived from crop water balance modelling and field observations (Rockström, 1997). The estimated rainfall partitioning, averaged over the three rainy seasons, is shown in Figure 2.

Large volumes of runon (R_{on}) water were observed, originating from degraded upstream fallow areas, flowing into the crop field (estimated to an additional 80 mm of water if distributed over the entire crop field).

The cumulative "loss" of water through soil evaporation and deep percolation for the non-fertilised crop experiencing no R_{off} or R_{on}, amounted to 508 mm in 1994, 407 mm in 1995 and 403 mm in 1996. This water would be sufficient to produce 4-5 reasonable crop yields if it was allocated as plant transpiration (assuming roughly 100 mm of T for a grain yield of 700-1000 kg ha^{-1}). The conclusion, in this case of three rainy seasons with close to average cumulative rainfall, is that the major problems of the farming system are (1) a poor distribution of the rainfall resulting in short periods of crop water stress, and (2) soil



fertility constraints.

Figure 4. Estimated water flow partitioning for different soil water situations: a crop receiving a net inflow of runon water (black arrows), a crop submitted to runoff (white arrows) and a reference crop where infiltration equals rainfall (grey arrows). The figures in parentheses show the average proportion (over 3 years) of available water accounted for by each water flow.

Productive green water as transpiration amounted merely to 3-9 % of rainfall for the non-fertilised crop, which corresponded to the farmer's practice. Combined with low grain yields (300 – 700 kg/ha) and high non-productive green water losses as soil evaporation (33 – 46 % of rainfall), WUE was very low, amounting to 6000-8000 m^3 (ET) ton^{-1} grain for non-fertilised millet. This on-farm range is much higher than the water needs generally reported for cereals in the dry tropics (some 1000 – 3000 m^3 ton^{-1}), which reflects the diversion of results between water/yield experiments carried out on-station and studies on-farm, in degraded crop fields.

Such large differences in data on water needs to produce food can have a significant impact on the actual human carrying capacity of a landscape and thereby influence the outcome of future assessments on the demographic pressure on the finite water resource from a food security perspective.

Conclusions

The recurrent intra-seasonal dry spells in the semi-arid tropics, which were observed during each of the three rainy seasons studied here, together with the large observed volumes of R_{on}, indicate the possibility of developing systems of water harvesting for supplemental irrigation by capturing R_{on} water in farm ponds or earth dams.

Experiments with small amounts of supplemental irrigation (50 - 70 mm of additional water) for rainfed dryland crops, have been successful in e.g. India, resulting in yield increases for crops like sorghum, millet and maize, in the order of 20 - 100 % (Verma and Tiwari, 1995). These systems have however not been extensively adopted by farmers in semi-arid parts of India, and they are uncommon in sub-Saharan Africa. This indicates a need of further research. However, if combined with soil and water conservation measures for maximised rainfall infiltration in crop fields, it should be possible to assure a maximised green water recharge and at least a diminished risk for yield losses due to short periods of water stress. As farmers in the dry tropics tend to be risk minimisers rather than yield maximisers, with the implication that incentives for investment in e.g. fertilisers are low, such attempts of "drought mastering" can possibly enable steps towards increased and stabilised staple food production.

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STUDY ON MICRO-WATER-COLLECTING TECHNIQUE IN DRYLAND FIELD OF SPRING MAIZE

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Introduction

Dryland covers large areas in Northern China with about one third of Chinese total farming lands, among which rainfed farmland without irrigation covers 2.3×10^7 hm^2. Light and heat resources are very rich in these areas, but water resource is very limited. Water shortage and frequent droughts seriously restrain the full utilization of light and heat resources by crops, thus resulting in low and unstable yield. All these will become an obstacle to the sustainable development of agriculture in China.

Micro-water-collecting technique is a kind of agricultural measure that means to collect rainfall in a large area by setting up a water-collecting area nearby the planting area, thus enabling farmers to plant crops in the arid areas where precipitation is very limited. In recent years, some academic institutes and universities or colleges have introduced this measure into the traditional cultivation technique system, by means of building various ridges, mulching plastic films on these ridges to collect rainfall, and mulching straw in the furrows to preserve soil moisture to practise and develop dry farming. All these lead to the formation of micro-water-collecting technique in the farmland field gradually. Based on the located experimental data between 1992 and 1994 from the field water balance experiments located in Shouyang County (longitude 111°36′-112°46′E, latitude 37°32′-38°6′N, altitude 1200 m), Shanxi Province, where the Eighth Five-Year National Agricultural Key Research Project named "Comprehensive Development of Agricultural, Forestry and Animal Husbandry in Dry Farming Areas of Northern China" is carried out, this paper analyses the effect of water storage and soil moisture conservation by means of micro-water-collecting technique in the dryland field of spring maize.

Results

The results indicate:1)The rainfall infiltration depth is deeper by means of micro-water-collecting treatment than that of the control. In micro-water-collecting treatment, soil moisture of 0 to 60 cm soil layer is 0.8%-5.7% higher than that of control; 2) In micro-water-collecting treatment, the amount of soil water storage within 0-200 cm soil layers increases by 50.5 mm, 13.5-58.6 mm, and 24.5 mm during seedling stage, the critical stage of water requirement and the ripening and harvesting stage respectively compared with the control. 3)The micro-water-collecting technique has the function of regulating and adjusting the amount and distribution of field evapotranspiration, The amount of field evapotranspiration decreases by 14.7-35.2 mm during seedling stage and increases by 17.3-25.7 mm during jointing-heading stage. The strength of field evapotranspiration decreases by 0.21-0.46 mm/day during seedling stage and increases by 0.18-0.70 mm/day during jointing-heading stage; 4)The micro-water-collecting technique has the obvious effect of increasing yield, especially in the dry year. In the normal year, the

grain number per panicle increases by 36-48 grains, the thousand-grain weight increases by 29.3-39.2 g, and the yield increases by 26.3%-28.1% compared with the control. In the dry year, the grain number per panicle increases by 152 grains, the thousand-grain weight increases by 66.9 g, and the yield increases by 59.3% compared with the control; 5)The micro-water-collecting technique can raise the water use efficiency. Compared with the control, water use efficiency in micro-water-collecting plot increases by 3.11-5.01 kg mm^{-1} hm^{-2} in normal precipitation years, and increases by 7.61 kg mm^{-1} hm^{-2} in the dry year. The coefficient of water consumption, which is defined as the amount of water consumed to produce 1 kg dry maize grains, decreases by 85-210 kg in normal hydrological years compared with the control, which means that micro-water-collecting technique can save 17.7%-37.2% of water. In the dry year, the coefficient of water consumption decreases by 370 kg and 68.9% of water is saved by the micro-water-collecting technique.

Conclusion and discussion

1) In the dry farming areas of Northern China, not only the amount of rainfall is limited, but also the precipitation intensity is very low. Lots of precipitation loses through soil evaporation before it infiltrates into the soil, which makes the precious rainfall resource can not be fully used. By building ridges in the field and covering them with plastic film to collect rainfall and to preserve soil moisture, crops could be planted in the furrows where fertilizer could be put concentratively. So the micro-water-collecting technique can fulfill the purpose of precipitation collection, soil moisture conservation, effective water supply and water utilization, which prove to be an effective way for the utilization of natural precipitation in dry farming areas. The results in this paper indicate that the micro-water-collecting technique has an obvious effect on increasing infiltration depth of rainfall, preserving rainfall, adjusting and controlling crop water consumption intensity and increasing water use efficiency, etc.. The micro-water-collecting technique can save man-labor and materials compared with construction of large scale runoff farm. It can produce runoff even with a small rainfall, and it can also be used in collaboration with machinery operation in any topography (including large flat areas). So it is worthy to be adopted extensively in the large dry farming areas of Northern China.

2) When such micro-water-collecting techniques as building ridge, trip-planting, inter-cropping, plastic mulch on the ridge and straw mulch in the furrow, etc., are used unitedly, obvious effect of precipitation collection, soil moisture preservation and yield-raising could be obtained. This kind of micro-water-collecting techniques has a wide range of utilization. They can be use in the fields of wheat, millet, broom corn millet, cotton, sunflower, vegetable, tomato and orchard, etc.. For example, under the technique of plastic mulch on the ridge to collect rainfall, straw mulch in the furrow to preserve soil moisture in the early summer fallow period of wheat, soil water storage of 0-200 cm soil layers is 63.2 mm more than that of flat planting at the end of summer fallow period. The rate of rainfall preservation is 25.9% more than that of flat planting. Even in the year with a very serious dry summer when precipitation during summer fallow period is less than half of annual mean precipitation during the same period, the ratio of rainfall preservation by means of the water-collecting technique can reach 47.3%, while

it is negative under flat planting. It should be pointed out that because of the diversity of soils, climates and crops in different areas, the micro-water-collecting technique should be adopted according to the actual climatic situation, the state of water supply and demand of crops in one certain area, that is to design the appropriate proportion of ridge and furrow (such as width and height, etc.), not only to guarantee that the crop root area can obtain more water, but also to ensure an appropriate planting density. Only in this way, can the expected effect be achieved by the micro-water-collecting technique.

3) By collecting runoff of precipitation, agriculture can be developed even in areas with annual mean precipitation 50-80 mm. The experimental results obtained in three different hydrological years in the paper indicate that the effect of micro-water-collecting technique is more obvious in the dry years. It can be deduced that in the vast arid or semi-arid areas of Northern China, planting can also be effectively developed provided that the proper micro-water-collecting technique is adopted. As far as the relationship between local precipitation and crop water requirement, the appropriate ratio of water-collecting area to planting area are taken into consideration in practice, a desirable technique and engineering system, that is precipitation-collection and soil moisture preservation system, can be set up, and then planting can be developed. Such micro-water-collected technique is more effective for perennial herbage and fruit trees with deep roots and high drought resistance. It is worth mention that the field basic construction of dry farming areas can be promoted and the utilization efficiency of natural resources can be increased by means of gradually popularizing micro-water-collecting technique, which is benefit to the agricultural sustainable development in the dry farming areas of Northern China.

Key words: Soil moisture conservation in dryland, Spring maize yield, Micro-water-collecting technique, Water use efficiency

ASSESSMENT AND ALLOCATION OF SUPPLEMENTAL TANK IRRIGATION WATER FOR RICE PRODUCTION IN TAMIL NADU

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Tamil Nadu State in South India is prone to frequent droughts and the climate of the State ranges from dry sub-humid to semi-arid. The quantity and reliability of water stored for supplemental irrigation to meet the crop water demands in the water harvesting structures (minor irrigation rainfed tanks) is highly variable due to erratic rainfall and location of these tanks as series in the chain system situated in an undulated topography. The water scarcity becomes further aggravated by unplanned drawal of irrigation water and by inevitable evaporation and deep percolation losses that occur during rice growing (sole crop) season coupled with inadequate system management.

An attempt has been made to assess the daily and weekly runoff during the crop season from selected tank catchments in Palar minor basin of Ramanathapuram district of Tamil Nadu State by using these methods, viz., (i) Green - Ampt infiltration approach (ii) SCS - USDA curve number method and (iii) locally used empirical strange tables.

The Green-Ampt infiltration based runoff model for a standardized 24 hour rainfall developed by Breakensiek and Rawls (1982) was applied with a modification for estimation of continuous temporal distribution of intensity of daily rainfall using Instantaneous intensity method as suggested by Chow *et al.* (1988). The wetting front capillary pressure head, conductivity parameters, effective porosity of soil, intensity duration frequency curves for the precipitation of the study area, time of ponding and time bounds of starting and cessation of time of runoff were the important computed parameters of the Green-Ampt infiltration based runoff approach. The usual standard inputs to the Curve Number technique and the ratios between rainfall and runoff evolved by wide range of experimental studies in India were adopted by taking into account of geological and surface conditions of tank catchments in the locally adopted Strange tables for computing the runoff. The results on runoff showed that the Green-Ampt method computed higher runoff than the Curve Number technique and strange tables in dry and slightly moist conditions whereas curve number technique yielded higher runoff under wet conditions of tank catchments. The runoff results for AMC III condition of one of the selected Chinnakannankudi tank catchments for selected rainfall events is shown in Fig 1. The predicted values using Green-Ampt infiltration approach closely matched with the observed data without any significant variation for the daily, weekly and seasonal runoff during the crop season for the year 1996 for the 60 observed runoff values in the six tanks considered under the study (statistically analysed).

Table 1. Weekly Water balance for 50 per cent dependable rainfall in first six tank commands in the chain

(All units in mm)

Standard Week	Rice				AWHC = 145.0	
	PPT	ET_0	WR	WU	SMR	DEF
37	4.60	38.27	42.10	4.60	0.00	37.50
38	11.00	35.56	39.12	11.00	0.00	28.12
39	7.60	36.63	40.29	7.60	0.00	32.69
40	4.60	31.02	34.12	4.60	0.00	29.52
41	16.02	31.61	34.77	16.02	0.00	18.75
42	17.00	30.28	36.34	17.00	0.00	19.34
43	56.00	28.59	34.31	34.31	21.69	0.00
44	55.00	26.65	31.98	31.98	44.71	0.00
45	48.20	25.42	30.50	30.50	62.41	0.00
46	9.00	27.17	32.60	32.60	38.80	0.00
47	10.60	29.46	35.35	35.35	14.05	0.00
48	6.80	28.37	26.95	20.85	0.00	6.10
49	7.02	26.87	25.53	7.02	0.00	18.51
50	2.00	26.95	25.60	2.00	0.00	23.60
51	2.60	36.71	25.37	2.60	0.00	22.77
Total	**258.0**		**494.9**	**258.0**		

PPT - Precipitation
SPL - Surface runoff losses = 0 for all weeks (not shown in table)
ET_0 - Reference crop evapotranspiration
AWHC - Available water holding capacity of soil
WR - Water requirement
WU - Water usage
DEF - Deficit
SMR - Soil moisture retention storage

Table 2. Updated Weekly water availability and deficits in the tanks (1996)

Standard week	Water Availability (ha. cm)				
	Theriruveli	Purseri	Kadambodai	C.K.K. Big	Maravaikudi
37	D	D	D	D	D
38	D	D	D	D	D
39	D	D	D	D	D
40	D	D	D	D	D
41	662.2	2258.0	774.9	1015.1	360.5
42	559.8	2170.3	785.7	993.2	275.5
43	343.9	1754.3	654.9	836.9	D
44	D	1358.4	520.5	733.9	D
45	D	818.1	351.2	566.5	D
46	D	281.1	172.7	395.7	D
47	D	83.3	146.2	365.6	D
48	D	D	156.2	354.5	D
49	D	D	D	D	D
50	308.2	873.3	445.5	652.3	164.4
51	158.5	601.6	341.1	582.3	D
52	D	279.2	197.9	447.2	D

D – The weeks in which the water deficit occurs for crop growth as per water balance and also no water available in the tank with reference to runoff estimation.

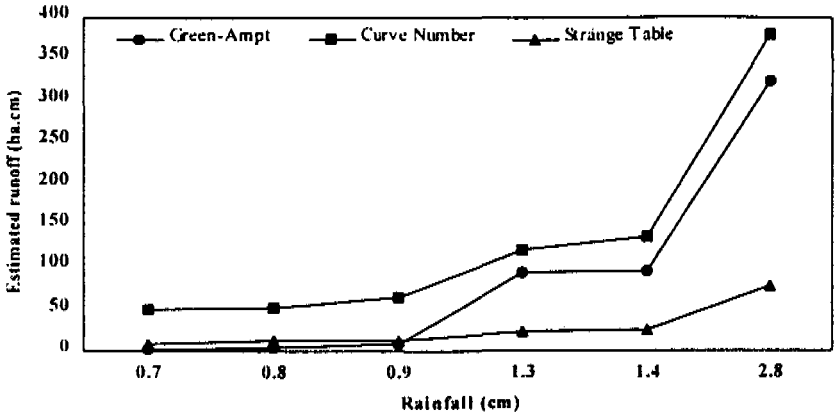

Fig. 1. Comparison of estimated runoff by different methods for Chinnakannankudi (big) in AMC III condition

The water deficits in the tank irrigable are for all standard weeks in the rice crop season have also been computed (Table 1) using the crop water balance model developed by Frere and Popov (1979) in addition to the moisture availability index (MAI) for all the standard weeks of the cropping period. The updated weekly water availability in all the tank irrigable areas for supplemental irrigation was also computed by taking into account of evaporation, seepage, percolation in tanks, irrigation water use along with weekly runoff yields. Those weeks where no water was available in tanks and also suffered from crop water deficiency were referred as 'deficit' weeks (Table 2) during which moisture stress was bound to cause yield decline in crops. There was no water availability in all the tanks during initial four weeks of crop growing season and water scarcity occurred in last four weeks in later stages of crop growth. The yield response factors were also computed for different deficit weeks as given by Stewart linear model (1969).

The yield response factors were higher for the first two weeks of the crop in all the tanks indicating that the deficit in these weeks brought a maximum decline in yield. The relatively high ratios of command area to catchment of two tanks viz., Theriruveli and Maraivaikudi have created more number of deficit weeks compared to other tanks in the same chain.

The suggestions emerged from this study are: Special agronomic water management practices like summer ploughing, seed treatment for direct sown rice seeds with a little postponement of crop season for initial two deficit weeks along with skipping of one or two irrigations during non-critical stages and supplying the same to critical period of crop growth to enhance rice production in these vulnerable tank command areas which constitute 78.5% the total irrigated area in the region.

4 B Water harvesting

THE POTENTIAL OF RAINWATER HARVESTING IN A NEW AGE

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The human civilisation in the Indian subcontinent began several centuries ago. It developed major cities and a highly productive agricultural system. Living in a monsoonal climate, in which most of the annual precipitation comes down in a hundred or so hours in a year, the people of the Indian subcontinent developed a variety of techniques to harvest rainwater to meet their irrigation and drinking water needs around the year. They not only harvested rainwater directly but also monsoonal stream flows, including flood flows, in different parts of the country. These stream flows were often connected with storage systems. The entire effort was community-based and kings provided fiscal incentives and transparency in the development and management of these systems.

Given the water crisis that is today facing the country, which has been further sharpened by the shortage of investment funds, community-based rainwater harvesting systems are once again being recognised as an important source for meeting both urban and rural water needs. Given the scale of pollution that is taking place as a result of rapid urbanisation, industrialisation and agricultural modernisation, rainwater harvesting may soon become a major source of clean drinking water.

RAINWATER HARVESTING. WATERSHED DEVELOPMENT AND PEOPLE'S MOBILIZATION

Mr Anna Hazare, Ralegan Siddhi, Maharashtra, India

The World today is facing the problems of environmental degradation, growing population and depletion of resources. There is a continuous exploitation of natural resources like petroleum, minerals and water to meet the growing needs of the increasing population. The question of saving the Mother Earth is being posed before scientists and environmentalists. Watershed development can provide solutions to some of these problems. Watershed development is not just soil and water conservation but it is a holistic approach to development.

INFLATING CITIES

The problem of unemployment is forcing rural masses to migrate to cities. This exodus is creating new social problems like rise in crime and erosion of social values. There is increasing pressure on natural resources. Development through exploitation of nature is not true development but one day it will lead to destruction. Sustainable development is possible through watershed development; that is rainwater harvesting, soil conservation afforestation and fodder (pasture) development. It will help raise the water-table ultimately leading to agricultural development generating employment in the village itself, thus checking labour migration to cities.

DANGERS OF BIG DAMS

Mega dams were and are constructed for power generation, supply of water to cities for drinking purpose and for industrial use. No attention was paid to the catchment areas of those dams. Due to unchecked tree-felling and overgrazing there was increase in soil erosion and ultimately the dams are getting silted. Desiltation is almost impossible and this will badly affect the industrial projects. Water harvesting structures are helpful not only in water conservation but also in soil conservation. Watershed management on village-as-unit-basis is the only solution for saving mega dams because every village falls in one or another catchment of a dam.

RAINDFED AGRICULTURE

In the last 50 years after independence of India, the land under irrigation has reached only 25 per cent even after huge budgetary allocations. The remaining 75 per cent agricultural lands is dependent on rains. Water harvesting will assure water supply for irrigation for a longer period resulting in assured crop. In village Ralegan Siddhi it was possible to bring additional 300 ha of land under irrigation due to rainwater harvesting. The village has become self-sufficient in food grains. There has been spectacular increase in the production of fruits and vegetables. Similarly, the milk production has increased several fold due to ban on free grazing and rise in fodder availability as a result of rainwater harvesting. The villagers have set up a grain bank so that the food grains can

be made available to the needy. This transformation of the village is the result of rainwater harvesting on micro-watershed basis.

Compared to mega-dams, the benefits of rainwater harvesting on a watershed basis can be summarised as:

1) The expenditure for mega-dam is Rs 55,000 to 60,000 ha whereas for watershed development it is Rs 4,000 to 10,000 ha.

2) Construction of mega dam is a time consuming process. Through watershed development benefits reach the beneficiaries within 2 to 3 years.

3) The number of beneficiaries of a mega dam is limited. This is widening the gap of inequality. Through watershed development distribution of benefits on equitable basis is possible.

4) The problems of soil salinity is emerging due to over irrigation. This does not happen in watershed areas.

5) Desilting of mega dams is almost impossible, but in watershed development desiltation is possible due to small sizes of the water harvesting structures.

6) There is no question of displacement of the people in the watershed development approach.

TECHNICALITIES OF RAINWATER HARVESTING

Watershed development programme is a revolutionary programme aimed at fulfilling the water need of the rural areas. Many technical aspects in this connection need to be considered:

1) **Village as a unit:** All the watersheds in a given village need to be developed simultaneously. A particular village may have several watersheds.

2) **Ridge to valley approach:** Watershed development refers to the treatment of different areas of watershed from ridge to valley covering the entire watershed so that every drop of water is either percolated or drains off in a water harvesting structure like nalabund (earthen dam) or check dam. The various treatments in ridge-to-valley approach are contour bunding, gully plugging, continuous contour trenches, forest development, fodder (pasture) development nala bunding, percolation tanks, check dams, gabion structure - all in series.

3) **Technical faults:** Watershed development involves the use of scientific techniques. If these techniques are not employed in an appropriate manner, and technical lacunae remain in the treatment of the watershed, then one might see various physical rainwater harvesting structures but with no results.

PEOPLE'S PARTICIPATION

For successful watershed development programme co-ordination of government agency, the NGO and villagers is very essential. Watershed development is not just construction of water harvesting structure but also afforestation and pasture development. Protection of plants and ban on free - grazing are not possible without peoples involvement. The five principals of Nas-bundi (family planning), Nasha-bundi (prohibition), Kulhad-bundi (ban on tree-felling), Charai-bundi (ban on tree grazing) and shram-dan (donation or voluntary labour) which are vital for success of watershed development are not possible without active participation of the local people.

WATER MANAGEMENT

It is far more important to judiciously manage the water resource made available through watershed treatment. Judicious water management techniques involve appropriate crop pattern, use of drip irrigation, community wells etc. There should be some restriction on the depth of bore wells.

GLOBAL PROBLEM OF ENVIRONMENTAL DEGRADATION

The problem of environmental pollution and ecological imbalance are not confined to the boundaries of a nation. Deforestation in one country is going to affect the neighbouring countries one of other day. Under the name of development we are exploiting the nature. The roots of these problems are in poverty as well as consumerism. Green-house gases are the cause of global warming and ozone depletion. There are efforts to remove poverty through international funds. In the same way there should be global efforts for sustainable and balanced use of natural resources. It is our duty to preserve the resources and the nature for the forthcoming generations. That is why, this workshop is an important event, as watershed development will provide an alternative to solve the above discussed global problems.

RAIN WATER CATCHMENT SYSTEM OF AIZAWL, THE STATE CAPITAL OF MIZORAM, INDIA

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The people of Mizoram state in urban and rural areas traditionally depend on rain water for drinking and domestic purpose. Aizawl the state capital of Mizoram located in the extreme eastern corner of India is at an altitude of about 1100 metres above mean sea level. The climate is moderate throughout the whole year and there is abundant rain water during the monsoon months which extends 5 to 6 months in a year. The hills of Mizoram are covered with beautiful greenery and there is no air pollution. As such rain water gives good quality of water for drinking purposes even after long storage in the dry season.

The people developed roof top rain water harvesting system which is used for drinking purposes. Rain water percolated in the soil comes out as spring sources in the lower reaches. The people make small storage facilities in the spring sources for other domestic uses. Even though there is abundant rain water during monsoon, the dry season always has acute water scarcity in all the towns and villages. The towns and villages are normally located at hill tops or on the higher ridges of the hills and the perennial water sources are far away from habited areas. People collected rain water during the monsoon period and store them for use during dry season. Even after piped water supply is made available in the capital town of Zizawl, the outskirts of the town and remote localities still depend on rain water as their main sources of water supply till today. The rooftop water harvesting system practised in Mizoram have been adopted as one of the measure for tackling the water supply systems by the government.

Rainwater Utilization Saves the Earth

Rainwater Utilization and Sustainable Development in Cities

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1. Rainwater as a Valuable Reusable Resource

The average yearly precipitation in Tokyo is about 1,400mm. This is about twice the German average. However residents in Tokyo have under-appreciated rainwater as a resource for a long time. They have overlooked rainwater flow into drains and considered that more dams are needed to be built upstream when they run short of city water supply. They have felt that rain falling in reservoir areas is a "must," whereas rain falling in their communities a "nuisance."

I have continued to advocate that cities must obtain the water they consume on their own as far as circumstances permit, and that rainwater falling in cities should not be wasted. Thus numerous "mini dams" collecting and storing rainwater should be built in cities. The stored water contributes to decreasing the city water demand, providing drinking and non-drinking water in emergencies, and helping prevent disasters including fires.

Tokyo has been inflicted with water shortage and floods alternately every few years. I therefore consider that it is necessary to appreciate the fact that more than 2 billion m3 of rain falls in Tokyo every year and, at the same time, about the same amount of water is consumed every year.

Sumida City has been actively promoting rainwater utilization policies with three aims: developing water resources in communities, restoring regional natural water cycle and securing water supply for emergencies.Sumida City strongly asked the Japan Sumo Association to introduce rainwater utilization concepts into its newly designed Sumo wrestling arena, Kokugikan in 1982. Since then the city has shown its initiatives in utilizing rainwater in the city's different facilities and constructing Rojison, a simple rainwater utilization

system, in many communities of the city hand in hand with residents.

Following the exsample of Kokugikan, nearly 500 buildings in Tokyo have introduced rainwater utilization system. The number of houses adopting fullscale rainwater utilization systems is gradually increasing, too.

2. Tokyo International Rainwater Utilization Conference

News of the efforts made by Sumida City and its residents have traveled far to The United States and the International Rainwater Catchment System Association (IRCSA) approached the City proposing to hold a conference on rainwater utilization. So the Tokyo International Rainwater Utilization Conference (TIRUC) was held in August of 1994 in Sumida City and I served as the secretary general of the organizing committee for TIRUC.

This conference was unique from three points. First, it was much larger in scale and was supported by a greater variety groups of people than any other previous conference on rainwater utilization. Over 800 people participated in the sessions and several thousand attended accompanying activities and exhibition. From overseas, we had 26 participants who have been actively promoting rainwater utilization in their countries. They were citizens, representatives of NGOs, employees of local governments, scholars and researchers from Botswana, Kenya, Tanzania, China, Indonesia, Singapore, Sri Lanka, Thailand, Denmark, France, Germany, the Netherlands and the United States.

Secondly, the conference was the first one especially focusing on the role of rainwater utilization from the urban perspective, particularly from that of a "mega-city." This is interesting for several reasons. The most notable reason is that the primary advantage of collecting and storing rainwater in urban areas is not only producing additional water supply but also controlling storm-runoff and preventing urban floods as a result.

Thirdly, the conference was organized and supported by citizens and was funded through the efforts and enthusiasm of people in Sumida City and its neighboring areas.

The following five points were confirmed in TIRUC.

(1) Population in Asia, Africa and Latin America will continue to concentrate into large cities and, as a result, those

cities will confront the problem "Urban Droughts and Urban Floods" which Tokyo faces now.

(2) The lessons of Tokyo has learned thoroughly rejecting rain and continuing to dump rainwater into sewers, and Tokyo's newly acquired wisdum on rainwater use techniques will undoubtedly contribute to resolving "Urban Drought and Urban Flood."

(3) Rainwater utilization is an internationally shared responsibility considering the "susteinable development" of cities;

(4) Rainwater utilization is directly related to acid rain and air pollution.

(5) Creating new rainwater culture in which cities can live more harmoniously with rain is required.

This conference has produced constructive results in techniques and policies regarding rainwater utilization, and has changed people' s way of thinking toward rain. Among them the largest product was networking of rainwater utilization information on global scale.

3.Subsidies for Rainwater Utilization

Sumida City also closely examined the potential of rainwater utilization as part of its policies between 1992 and 1994 based on its achievements over the previous ten years. The results showed that increasing the number of city facilities using rainwater will resolve water shortage and urban flooding, and will also help in emergencies. Thus Sumida City compiled "Guidelines for Rainwater Utilization" in March of 1996. The guidelines feature three principles.

(1) The City will install rainwater utilization systems in all its new facilities.

(2) The City will guide or dvise to residents and companies planning to construct houses or buildings in a tract of land more than 1,000m² to install rainwater utilization systems.

(3) The City will subsidize residents and companies planning to install rainwater utilization systems.

In October of 1996 the city launched the subsidies for encouraging rainwater utilization.In recent years an increasing number of local governments including Okinawa Prefecture, Takamatsu City,Toyota City, Kamakura City and Kawaguchi City have begun subsidizing or loaning funds for installing rainwater systems. This movement is spreading nationwide driving companies to develop rainwater utilization devices.

4.Local Government Council for Rainwater Utilization

The Tokyo International Rainwater Utilization Conference was held in Sumida City, Tokyo in 1994 when many cities in Japan suffered from serious water shortage in the wake of a long dry spell. This problem spurred local governments to proceed with rainwater utilization policies.

In July of 1996 municipal and prefectural governments established a council in accordance with a proposal by Sumida City, which had already been actively promoting rainwater utilization. Sumida City is now serving as the council's organizer.

The council has two aims. The first is discussing how to utilize rainwater in tackling water shortage and urban flooding problems, and for emergencies; and how to improve the regional and global environment through such different measures as the restoration of regional natural water cycle. The second aim is exchanging information on policies, and networking local governments nationwide and spreading the network worldwide. Seventy-seven municipalities and six prefectures in Japan have so far joined this council.

An annual forum (Rainwater Fair) by citizens and local governments was held in August of 1997 in Okinawa Prefecture, an island in the southernmost part of Japan that has been afflicted with chronic water shortage.

Rainwater Utilization Forum for Local Governments and Citizens will be held from August 7th to 9th, 1998 in Sumida City.

The UN Conference on Human Settlements in 1996 (Habitat Conference II) warned that "water shortage and flooding" will come to the fore as a critical issue in many cities in developing countries early in the 21st century. Thus it is extremely important for authorities on different levels to network worldwide for

exchanging information and opinions regarding their policies.

5. Activities of "People for Promoting Rainwater Utilization"

The Organizing Committee for the 1994 Tokyo International Rainwater Utilization Conference (TIRUC) was reborn in April of 1995 as "People for Promoting Rainwater Utilization," an NGO based in Sumida City. Its aim is spreading rainwater utilization among people and communities worldwide following the successes of the 1994 conference. This NGO has been engaged in many activities regarding rainwater utilization such as consultation, technology development, fact-finding inquiries, cultural research and environmental education. Some members of the group also visited China in 1995 , Germany in 1996 and Iran 1997 spreading its network overseas.

In March of 1995 after the Great Hanshin Earthquake the NGO's predecessor, the Organizing Committee for TIRUC, presented one hundred 200ℓ rainwater tanks for storing drinking water supplied by water wagons to communities in earthquake-devastated Kobe City.

Workshop 5

Significance of groundwater resources for socio-economic development

SUSTAINABLE MANAGEMENT OF GROUNDWATER RESOURCES

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Mankind presently utilizes 54% of the accessible and renewable surface- and subsurface flow. Considering its uneven distribution even today freshwater resources are already overexploited on a regional basis. Of the 4430 cubic kilometers of freshwater abstracted annually 70% are used in agriculture (i.e. food production), 25% in industry and only 5% in households. Groundwater represents about one fifth of these freshwater abstractions. Although on a global scale groundwater use looks small compared to surface water use, the order of importance is reversed if only drinking water is considered. Due to its quality, limited vulnerability, and relatively continuous availability groundwater is a resource of strategic importance.

Criteria for sustainable use of groundwater

In the context of groundwater management sustainability above all means a limitation of abstractions to a level below the long-term natural replenishment rate. But there are also other aspects to sustainability.

Falling groundwater levels are an indicator of overexploitation. They are observed world wide. The present depletion of important groundwater reservoirs is about 200 cubic kilometers per year. This is the minimum requirement of about 200 million people. Long before an aquifer is emptied by overexploitation, declining water levels can lead to lasting damage. A lowering of the water table can harm vegetation relying on groundwater. In fractured rock aquifers a large drawdown of groundwater levels can lead to irreversible closure of fractures thus diminishing the storage capacity.

In coastal areas, overexploitation of groundwater leads to seawater intrusion which is rampant along the coasts of India, Israel, Southern China, Spain and Portugal to name only a few. In the Nile delta the zone of salinized groundwater extends 130 km inland. On ocean islands there is generally the danger of upconing.

In regions with a high potential evaporation irrigation may cause groundwater level rises and salinization of soils. At a typical irrigation rate of 10000 cubic meters per hectare and year 1 to 5 tons of salts remain in the soil every year. In soils with insufficient drainage enormous quantities of salt may be deposited. Similarly, salt is deposited by capillary rise and evaporation of groundwater from a water table which is too close to the surface. The areas afflicted are of an alarming size. In Iraq they amount to more than 50% of irrigated agricultural land. Egypt with 20-40%, the US with 20-30%, and Australia with 15-20% offer a similar picture.

Sustainability not only concerns quantity but also quality because groundwater renewal is usually so slow that once polluted, an aquifer stays polluted for relatively long time.

In rural areas the pollution by nitrates and pesticides is prominent. In industrial regions pollution from petroleum hydrocarbons and chlorinated hydrocarbons is the most common problem. The experience of industrialized nations shows that depollution is very costly and still takes a long time. The remaining possibility to treat the polluted water and purify it to drinking water quality is an option which is not available to small decentralized water suppliers in the third world.

Scientific tools for sustainable groundwater management

The most important figure for sustainable groundwater management is the recharge rate of a reservoir. Especially in dry areas it is a quantity which is difficult to estimate. But even in humid areas the recharge rates to deeper aquifers are insufficiently known. As groundwater recharge from precipitation is not directly measurable, indirect methods have to be employed. Both soil water balances and head observations do not yield reliable estimates especially when recharge rates are small. From groundwater modeling on the basis of observed heads, soil moisture profiles and transmissivities only crude estimates of recharge are possible. Better estimates are possible with the help of environmental tracers. These are substances which have a well-known history in the atmosphere and are carried into the groundwater reservoir by seeping rain water. The atmospheric concentration curve will show up with a delay in groundwater wells. From this delay recharge rates can be estimated. Among those tracers are Tritium (from the nuclear tests in the 60s), Freons, and Sulfurhexafluoride. The sea salt aerosol which is deposited with the rain is also an interesting environmental tracer in arid zones as long as the deposition is the only source of salt. In that case salt concentrations in groundwater are a measure of the evaporation rate. Tritium in combination with Helium3 can be used as a clock which allows direct age dating of groundwater in the range of up to 40 years. Finally, stable isotopes such as Oxygen 18 and Deuterium are of interest. Their concentration in water depends on phase transitions and temperature. They can serve as a thermometer showing under which climatic conditions a water pumped in an arid region has been recharged.

A further difficulty is connected to the fact that important primary variables in the recharge determination such as rainfall or soil type vary strongly in space or time. The estimation of recharge will therefore always be a statistical undertaking. Under these conditions the quantification of risk and of uncertainty is of prime importance to groundwater management as robust and conservative decisions have to be made under uncertainty. In this task groundwater modeling is an important decision tool.

Implementation of management measures and utilization concepts

The central task of water resources management in general is to close the gap which opens up between freshwater demand and supply both spatially and temporally. The traditional tools of management are storage reservoirs (both dams and natural groundwater aquifers) and transfers by pipelines. In future, demand side management and innovative techniques will be as important.

A sustainable groundwater management strategy can only be as good as its potential for implementation, be it by police measures or other incentives. In many places, such as the aquifers of eastern India which are contaminated by seawater intrusion, all pumping

would have to be stopped if the salinization process is to be reversed. This is very difficult to implement. Therefore abstractions are controlled by limiting the allowable depth of a well. This depth is measured and violators are punished by destruction of the well. Similarly, by enforcing a limited depth of pump installation a red line for the minimum water level can be drawn below which no abstraction is possible. In countries with few drilling firms such as in Botswana the density of wells can be controlled by controlling the drillers. In Botswana a maximum density of one well per square kilometer is allowed. This is not so much a measure to protect the groundwater resources but to limit the density of cattle and thus overgrazing.

Much more sophisticated control mechanisms are available in the form of water pricing and taxes which can in principle reflect the scarcity and degree of overexploitation of an aquifer. Such measures have been applied successfully in the Western United States.

As severe overexploitation of groundwater usually occurs in the context of irrigation, an important measure would be to ban large scale irrigation (as opposed to watering of seedlings) from groundwater. Due to its quality, groundwater should be reserved for drinking water purposes.

The possibilities for active enhancement of groundwater resources is limited. Yet, some schemes deserve interest. In Oman for example, the peak flows of wadis are contained by dams with the intention of recharging the underlying aquifer. As fine sediment carried along by the floods will settle and clog the surface, the efficiency of recharge is, however, decreased. A well-known possibility of saving groundwater is the coupled utilization of surface- and groundwater, also called conjunctive use. In this context groundwater is used exclusively to supplement the main resource surface water in times of need, while in times of high supply of surface water the groundwater reservoir is artificially recharged.

A large potential for protecting groundwater resources lies in demand side management that is the implementation of water saving technology. It must be noted, however, that these measures usually replace the scarce resource water by another scarce resource, capital. Global estimates assume that with present technology agriculture can save 10-50%, industry 40-90% and communes and households up to 30% of current supply. And besides present technology there is future technology. In a desert reclamation project in West Australia a collection of techniques combining solar energy, water harvesting, storage and desalinization is tested for its potential of starting up a locally sustainable agricultural environment.

Non-sustainable utilization of groundwater resources may still in some cases be justified, provided it initiates sustainable development by using the income from water in an investive way. This applies to reservoirs like the Sahara aquifers where it would be a pity to forgo the utilization of otherwise useless water. By ploughing back the proceeds into technology for water saving, afforestation and other long-term benefits, a contribution to sustainability is feasible.

SEA WATER INTRUSION ALONG TAMIL NADU COAST, INDIA - AN UNDERESTIMATED RISK

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Introduction

Contamination of groundwater by sea water is a major threat faced by many coastal areas of the world (Goldberg, 1973; Das Gupta and Yapa, 1982; Radhakrishna, 1981; Yuqun Xue et al., 1993). Sea water may intrude into the inland aquifers wherever there are overdraft conditions (Todd, 1981) along the coastal aquifers. Under natural conditions, fresh groundwater is discharged into the ocean at or seaward of the coastline. With increased demands for groundwater in many coastal areas, due to the increase in population and other needs, however, the seaward flow of groundwater has been decreased or even reversed, causing sea water to intrude into the fresh water aquifers.

The Tamil Nadu Coast in India, spread between latitudes 8° 05' & 13° 35' N and longitudes 77° 30' & 80° 20' E, also experiences the problem of sea water intrusion in various proportions. The coast is nearly 1000 km in length and is known for wet crop cultivation and thereby excessive use of groundwater (Kumaraswamy, 1991). The increasing trend of salinity along the coastal areas is a major problem for drinking, domestic and agricultural purposes.

It is in this background, a study has been undertaken to investigate the problem of sea water intrusion and its environmental implications, by selecting three estuarine tracts along Tamil Nadu coast. Hydrogeochemical, geophysical, remote sensing and social surveys were carried out to find out the severity of the problem. The results of hydrogeochemical and geophysical surveys indicate that the sea water has intruded into the aquifers in various proportions. The remote sensing method identifies the areas affected by salt encrustations and social surveys bring out the impact of the sea water intrusion on the environment and also the reasons for the intrusion.

Study Area

For the present study, three estuarine tracts of Tamil Nadu were selected

a) Vaippar in Tuticorin District (78° 15' E and 9° 00' N),

b) Ponnaiyar and Gadilam in Cuddalore District (80° 05' E and 12° 30' N)

and

c) Palar in Chengalpattu District (79° 45' E and 11° 45' N)

The Tamil Nadu state in general experiences tropical climate with oppressive summer, low daily range of temperature, high humidity and moderate annual rainfall with an average of about 960 mm.

The State forms part of the Peninsular shield and about three-fourth of the total area of the State is underlain by unclassified crystalline rocks of Archaean age. The sedimentary belt forms about one - fourth of the total area, all along the coast, flanking the main crystalline mass on the west. The coastal tract is covered by younger alluvial and coastal sand formations of Quaternary age.

Materials, methods and discussion

For hydrogeochemical surveys, water samples from all the three case study areas were collected for two seasons, namely summer and winter.

These samples were analysed for their major anions and cations and other parameters like EC, TDS, pH, SAR, Hardness, etc. Ratios of some of the ions were also calculated to find out the contamination levels. Higher values of SAR, TDS, Total Hardness and Cl/CO3+HCO3 and lower values of pH, Ca+Mg/Na+K indicate the presence of saline water in the coastal area (Rodd et al., 1976; Todd, 1981; Howard and Lloyd, 1983).

From the chemical analysis, it is clearly evident that salt water has intruded into the inland aquifers at different levels. While the problem is severe in the Vaippar estuarine tract, it is lesser in the Ponnaiyar-Gadilam estuarine tract and still lesser in the Palar estuarine tract.

Geophysical surveys were carried out by using Electrical Resistivity Meters. Vertical electrical soundings as per the Schlumberger array of electrodes were conducted along profiles in all the three estuarine tracts. Apparent resistivity values at different depths were measured and iso-apparent resistivity maps were prepared. The results of these surveys also reveal that salt water is present in the inland aquifers at varying depths. The very low apparent resistivity values - below 10 ohm.m - suggest the salinity of the groundwater.

Remote sensing, one of the emerging tools in the field of earth sciences, was made use of in this study also. The salt affected areas were easily identified from the images by their peculiar tone. The results of the other two methods supplement the observations made by the remote sensing techniques.

Social surveys are one of the best ways in any study of environmental significance. This kind of surveys gives a feel of then problem and its impact on man and environment. The survey reveals that the problem has been noticed for the last two decades. The uncontrolled exploitation of groundwater with the help of electric pump sets is attributed to be the main reason for the problem of sea water intrusion. The results clearly show that large areas are left uncultivated and are now idle. Rice

cultivation has now given way to some other salt tolerant crops. The growth of prawn farms and illegal and unscientific way of mining sand from the river beds further accelerate the problem. Another notable feature is the reduced or almost nil flow of water in the rivers due to the construction of dams and also due to the low and varied rainfall in the upper basin areas.

Suggestions and Recommendations

Based on the above study and its results the following suggestions and recommendations are made.

* As a precautionary measure, upto a distance of 10 km from the coast extraction of groundwater on an intensive scale should be controlled or even banned.

* Farmers should be advised to practice salt tolerant or less water consuming crops. They should also be made aware of the consequences of the intrusion problem by the local administrators.

* Additional surface recharge facilities or percolation ponds should be constructed or improved.

* The areas occupied by salt pans and prawn farms should be strictly controlled and these should be confined to a narrow zone very near to the coast.

* Illegal mining of sand from the river bed, especially near the river mouth should be totally banned.

* In any problem of social relevance, people's participation is of paramount importance. Local people who are at the receiving end should be given adequate training / awareness for the proper and optimum utilisation of the available surface and groundwater resources.

GROUNDWATER OVEREXPLOITATION AND WATER CONSERVATION - EVALUATION OF TRADE-OFFS

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Introduction

In the wake of growing water scarcity, the necessity of identifying and evaluating alternative opportunities to realize the twin goals of food security and water conservation has often been stressed. A large number of scholars have often emphasized the need for treating water as an economic resource rather than a free gift of the nature. Very little empirical work has however been done to assign an economic value to this scarce natural resource. The inability to reflect the growing water scarcity through a proper accounting of its cost in our economic calculations has resulted in failure of efforts aimed at conserving water and in promoting its more efficient use. As a result water users continue to adopt practices which have little concern for its efficient use.

An attempt has been made in the paper to evaluate the trade-offs involved in conserving water vis-a-vis sustaining agricultural development. The paper also evaluates the role of pricing policy in achieving sustainability.

Scope

The paper draws evidence from the agriculturally most advanced region of India- the North-West Indian states of Punjab and Haryana where groundwater resources are showing clear signs of overdevelopment. The water table in large parts of the region is falling rapidly. Leading agricultural scientists and planners have expressed grave concern over the dwindling groundwater balance in the region and the threat it is posing to the sustainability of agricultural production in the "foodbasket" of India. The over development of groundwater resources in this semi-arid region has largely been the consequence of large scale shifts in cropping pattern towards water intensive crops rice and wheat and installation of a large number of tubewells. Rice cultivation offers some scope for water conservation, however, such water conserving irrigation management practices available for rice result in reduced crop yield.

Methodology

The economics of saving groundwater through adoption of end use conservation practices for rice has been worked out by contrasting the estimated reduction in present value of farm profitability as a result of reduced crop yield with the resultant saving in 'resource cost 'of groundwater - the resource cost being defined as the likely increase in farmer's cost of pumping irrigation water consequent upon a decline in water table over a specified period of time. The study uses a twenty year time frame to estimate the magnitude of groundwater

depletion, measure the resource cost and quantify the implications of water conservation on farm profitability.

The relative economics of rice-wheat farming system, under alternative water conserving irrigation management options for rice, has been compared using a modified accounting framework - the Natural Resource Accounting (NRA) framework. The Net Financial Value (NFV) for a given farming system has been estimated by deducting from the farm profits the resource cost of groundwater. To take care of possible distortions in market prices, on account of subsidies etc., the relative crop economics has also been worked out at social prices. The Net Economic Value (NEV) thus has been computed by deducting from the farm profits, calculated at social prices, the resource cost of groundwater at social prices.

Results and Conclusions

The results obtained demonstrate the implications of including and excluding the resource cost in making a financial and economic comparison of the alternative farming systems. The results signify that economic analysis that excludes the value of externalities overstate the value of resource depleting practices and understate the value of resource conserving farming practices. When the cost of depleting natural resources is taken into account, resource conserving farming practices compare more closely fiancially and economically with the conventional farming practices.

The results obtained also suggest that significant economic gains can be had from using water conserving farming practices even if such conservation results in reduced crop yield. The analysis signifies that it is socially desirable and economically feasible to accept a lower level of crop yield today in order to sustain production tomorrow. However since even the most economical level of water use on rice results in a decline in water table, albeit at a somewhat lower pace, large scale cultivation of rice-wheat farming system can not be sustained unless substantial improvement in irrigation management practices of rice can be brought about.

Apart from the need to bring about improvement in irrigation management, the study also demonstrates that agricultural pricing policy reform is a must to achieve sustainability. Prices tell farmers what to produce and how efficiently to use inputs and natural resources. The current pricing policies for inputs and crop outputs tell farmers that it is inefficient to conserve resources and efficient to deplete them. The agricultural prices should tell farmers to use their production assets efficiently and to use them today and husband them for the future as well.

The large resource costs associated with current farming practices suggest that large economic gains could be had through research into resource conservation. The groundwater declines like the ones obtaining in the study region cannot continue indefinitely. At some point of time the cost of irrigation will outweigh the benefits of rice production. However at that point of time resources may have been irretrievably depleted. Farmers in the study region should therefore be encouraged to grow crops suited to the prevailing agro-climatic and resource conditions.

LEGALISATION OF ILLEGAL TRAPPING OF GROUND WATER : A PARADOX

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Introduction

"Since the international water supply decade it has been estimated that 1200 million people are still without safe water." IHP Humid Tropics Programme ser. 3 (p.1)

Water and population has an invariable relationship. As per the World Bank report in the year 2025 the worlds population is expected to cross 800 crores. The surmountable growth of population and industrialisation affect gross capita consumption of water and resulted in its manifold increase. In the developing countries like India where already surface water is completely exploited, people started hunting for ground water which is the next most accessible resource, and the dependence on ground water as a sustained source for meeting water requirements especially domestic water increasing progressively. Besides exists an intersectoral competition of water allocation between irrigation, industry, and domestic; 50% of the irrigation and 80% of the drinking and domestic needs are met from ground water. Now the exploitation of ground water has raised to a phenomenal extent even with illegal tapping of water which is resulted in pollution and deterioration of socio-economic status of the water users.

Ground water an infinite and the largest reservoir, is assumed to have a constant discharge coefficient and contains 97% of earth's fresh water resource. It is the substantial source of drinking, agricultural and industrial water. By maintaining ecosystem, it sustains life on earth and thus becomes a vital resource in human perspective. Ground water is relatively superior for it undergoes natural filtration and has unique attributes such as built-in distribution, dependable and less vulnerable to drought, free from pathogens organism, ubiquitous and so on.

In India, 85% of rural and over 50% of urban water supplies depend upon ground water for meeting drinking and domestic water needs. Even after this 50 % people still have 'no reasonable' access to a safe water. It is declared that 40 litres and 150 litres of water for rural and urban areas required (National Water Board). When the global concern to recharge and protect ground water is on, India shows quite different picture wherein most of the states like Maharastra, Rajasthan, Gujarat and Tamil Nadu are in the process of emptying the ground water table and are at the verge of meeting its aftermath.

A Scenario of ground water in Tamil Nadu

Tamil Nadu state which is listed the second in over-use of ground water in India, in excess of recharge rate, has already harnessed the entire surface water potential. About 76% of this state is underlain by crystalline hard rock formation where the ground water potential is restricted to the weathered, fissured, jointed and fractured zones. Here, 70% of the ground water potential has also been utilised. Amidst this, Tamil Nadu stands like other over exploited states and exploit the ground water to the extent possible, and Chennai, the capital of Tamil Nadu, stands foremost not only in exploiting, but also in polluting the ground water.

In Chennai because of Mareena, the 2nd longest beach in the world, sea water intrusion has set in. Despite there is sweet water availability in certain places encouraged commercialisation of water which further influenced the indiscriminate extraction of water. This has caused sea water to intrude more. Chennai the totally urbanised area where agricultural activity is nil, water use for industries and domestic lined up in using excess and ground water has become the prime source for their use. To check this illicit consumption, government enacted Ground Water Regulation Act in 1988. Besides all the laws and legislations, the extraction could not be checked for the government is lenient about this type of water use for it considers water as source of their lives.

This go away attitude of the government encouraged people to extract water more and more and to take the law for granted to the extent of justifying this unlawful activity. Thus this has become one dimension of illegal tapping of ground water and has paved way for another illegal tapping which is said to be hazardous.

Source of life at peril

This case study by observation technique attempts to analyse the fact of how ground water is indiscriminately tapped at north Chennai, capital of Tamil Nadu state, and the impact of water on the socio-economic conditions of people of this area, where drinking water is distributed from the nearest lake. The areas close by the lake are distributed water through underground pipelines. The pipeline carries for 12 kilometres from Pulal *Eri* (lake) the drinking water to Villivakkam area. Lakhs of people live in and around this area have been supplied water from this *Eri*. The water supply seemed sufficient until the abrupt settlement took place.

In the recent past the unauthorised settlements started along the stretch the lake and brought forth the destruction of the existing structure and peril for the people. This eventuated the malfunctioning of the whole structure and disturbed the schedule of water supply to the areas. As the result of this people started picking holes here and there on the pipelines to extract the

water whenever it is needed. After taking the water they leave the holes as such which has become breeding ground for the diseases as the other waste including drainage water come in contact with the opened up pipes that carries water to the residential areas.

Thus the slapdash extraction of water has not only caused a perilous implications chance contamination and out break of diseases but also effected in unavailability of water to the adjoining areas. The obnoxious sight of this opened up ground water mixing up with underground drainage water turns our stomach but made people go accustomed to it. Thus lack of sanitation, where waste-water makes contact with water used for drinking result in diseases like kidney failure, Jaundice and other malarial and diarrhoeal diseases resulted in many deaths. This problem is more acute among poor community of this area who do not have way out. This not only affects health but also their socio-economic status, as people from these areas need to visit hospitals often because of the frequent outbreak of diseases. Also during the time of drought the people has to purchase safe drinking water and are paying more money.

If the government is not going to check this illegal attitude then the people would take the extraction as legal one and may continue till it cost so many lives. The solution for this can thus arrived that the government has to in all wise give stern warning to prevent them from involving in this illegal activity in order to protect the quality of life.

THE SOCIOECONOMICS OF GROUNDWATER RECHARGE FOR RURAL DEVELOPMENT IN SEMI-ARID REGIONS - AN ANALYSIS

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Introduction

One major factor for concern in countries of the Third World is the destabilisation and growing exodus of the majority rural population (70-90%), to overcrowded towns, as a result of the deterioration of their living conditions (through desertification and deforestation, drought, dispossession to make place for large irrigation projects or roads, salination of fields, etc.). Since costs for necessary urban infrastructure are unbearable by the resource poor governments, slums proliferate, giving rise to grave problems of habitat, shortage of water and electricity, hygiene, unemployment, criminality, etc. In the face of the important population growth in these countries, there is an urgent need to oppose this process, to enhance food production, and to secure employment for the rural people, by helping them to improve their productivity and welfare, and *stabilising them in their home area.*

In the planning of water resources management projects, engineers naturally focus their attention on physical and technical aspects. Yet, technologies used in conventional water supply systems make *engineering services costly and often unaffordable* by both governments and rural communities of developing countries. Consequently, in most semi-arid regions, catastrophic *water scarcity* as well as *health hazards* have spread, due to insalubrious water usage.

However, studies of a few remarkable *soil and water conservation (SWC)* schemes in drought-prone areas of South-Asia and West-Africa have highlighted the crucial importance of *management factors* for the success of SWC projects, in addition to geophysical characteristics inherent to the project area, as well as systematic technical measures (e.g. SWC structures, efficiency in water delivery and use, etc.). They have exemplified the relevance of *user participation* in management of projects for reducing costs, resolving conflicts, creating employment, building capacity, creating wealth and sustaining socioeconomic development in rural communities. This has contributed to stabilise the rural communities - constituting the majority of the population -, and to prevent their catastrophic emigration to overcrowded cities. Two of such projects are the *Ralegan Siddhi Initiative* in Maharashtra State in India, and the *Bango Project* in Yatenga Province in Burkina Faso (Pangare and Pangare 1992; Lamour 1996; Lamour and Ouédraogo, forthcoming). Both projects have been instigated by the village communities themselves with the purpose of *harvesting rainwater* in order to secure water availability for domestic and irrigation purposes, and improve the people's welfare.

Rainwater harvesting through groundwater recharge

In both areas, average annual rainfall amounts to around 500 mm. The bulk of rain generally falls during four months from June to October. Rainfall shows a great annual variability, and its scarcity in consecutive years has caused many severe *droughts* in both regions in the past

decades. Thanks to favourable geophysical characteristics (e.g. topography, geology and soils), systematic soil and water conservation measures have led in both cases to successful *rainwater runoff retention and aquifer recharge.* This has helped to secure one harvest in the watersheds' discharge area in years of poor rainfall, and at least two harvests during average rainfall years.

In Ralegan Siddhi, the applied technical measures comprise *contour bunding*, *afforestation*, and the construction of several *small earth dams* across the micro-watersheds' outlets in the upper reaches of the main watershed. In Bango, groundwater recharge and the fertility of the *bas-fond* or lowland was secured by the collective construction of a unique 10 m high dam; the fertile land was redistributed among the members of the farmer organisation. Even though water is stored behind the Bangò dam for a relatively long time, water distribution per gravity was found inadequate. The reasons are manifold: stongly irregular topography in the command area, inappropriate for conveyance canals; undesired reduction of the arable surface by canals; planners' fear of too high water losses in the canals; as well as users' apprehensions that easily available water from canals might lead to uneconomic use of the resource.

User participation: a key to water resources management for rural development

Because both projects were initiated by the communities themselves, external assistance did not play a predominant role. Instead, users organised at *village* level (in Ralegan Siddhi) or in a *farmer association* (in Bongo), and participated in *all* phases of the project, from its conception, data collection, construction, to the operation of water distribution, and maintenance. Following features of the projects are worth mentioning:

- *Access to information* of the rural populations, and *integration of their own priorities and resources* into the project's concept – through participation of *all* users (including the weaker community members, e.g. the women, the landless, ethnic minorities or scheduled caste members) in the project planning.
- *Resolution and prevention of conflicts*, arising from diverging interests due to nonuniform tenural structure or social differentiation (based on gender, ethnicity or caste), within the ideal frame for consensus building provided by the user organisation.
- *Setup by users of rules for more equitable water allocation and economical or optimum water use* – One main concern was thereby to reduce inequities, and improve the access of poorer farmers, landless and other underprivileged community members to harvested water. This of course, resulted in a high level of endorsement of the project by *all* the people, leading to a more active and committed participation.
- *Expert assistance had only an adviser and monitoring role* – Experts from public or governmental institutions did not impose their own concepts, but *accepted the communities' priorities*, and successfully *built on local knowledge and experience*, thereby securing *sustainability in natural resource development and use* as well as profit maximisation for the rural people. For instance, they integrated farmers' experience in *tank irrigation* in Southern India, or in the practice of *zai* cultivation as well as a traditional form of peasant organisation for mutual support, common to West-Africa, called *Naam*.
- *High flexibility of the irrigation systems* – in order to respond to variability in water availability, in land quality and land tenure in the project area.
- *Mobilization of the communities' resources* – labour, cash, material resources, traditional knowledge and innovative ideas, etc. – was instrumental in *reducing costs* and *building capacity* among the farmers.

Magnitude of locally available resources

The importance of locally available or mobilisable means, and the relevance of the strategy is often underestimated. As a matter of fact, Coward and Martin (1986), examining resource mobilization by farmers in selected locally managed irrigation systems in Nepal, the Philippines, and India (Tamil Nadu) found the level of material and financial resources contributed by farmers in these systems to be significantly higher that the fees collected from farmers on most irrigation systems managed by government irrigation agencies in the same countries. Bhatia (1991), exemplarily studying two irrigation systems in Bihar and Haryana, in Northern India, reported similar findings, as well as the bad cost-recovery of state-managed irrigation systems.

Transfer of management to users

With the increasing success of user-managed projects (e.g. watershed projects as well as canal irrigation subsystems) on the one hand, and strong pressures on most governments of developing countries, forcing them to reduce their administrative personel and to decrease state expenses on the other, many governments in South Asia are now eager to support farmer initiatives. Thus unloading onto the rural people the burden of laborious and often inefficiently (because inflexibly) carried out tasks of irrigation systems operation beyond the outlet of canal systems or of *tanks*, and of structures maintenance.

However, many cases have shown that farmers will not continue to collect data, or to participate in meetings to give voice to a decision, unless it is evident that their input is making a difference in the performance of the service they receive. They will not take over a dilapidated system or renovate a run-down system at their costs. Finally, farmers will not take responsibilty for a systems maintenance and operation if they do not have a say in its management, and if allocation rules are not functional and don't reflect their priorities, or if they are not able to redefine these rules and irrigation delivery procedures (Sengupta 1991; Uphoff et al. 1991; Yoder 1994).

Conclusion

User participation in irrigation management, by enabling the successful integration of socioeconomic factors into engineering planning, construction and operation, has proven extremely adequate for reducing government expenses, and ensuring cost-effectiveness of water management projects in the dry Tropics, while developing rural people's capacity to improve life in their communities. In the face of such new developments, there is a need for irrigation, agriculture as well as rural development administrations to accomodate user participation by making adjustments in implementation procedures for assisting financially and technically locally managed SWC and irrigation systems. In particular, aspects of transfer of ownership and responsibility of water resources systems to the farmer/user association seem crucial for motivating the local people to invest in construction and maintenance. Significant changes in the policies of multilateral and nongovernmental institutions of external assistance are also necessary, since the goal is no more to transfer technology, but to enable and *empower farmers/rural people* to develop their production-base, improve and control life in their communities (Chambers et al. 1989; Pretty 1995).

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