Integrated Water Resources Management: Institutional and Policy Reform

Proceedings

Port of Spain, Trinidad and Tobago
June 24-27 1997

Environment Division
Sustainable Development Department
Inter-American Development Bank

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Seminar/Workshop organized by the Caribbean Council for Science and Technology (CCST), with support of the Inter-American Development Bank (IDB) the Caribbean Development Bank (CDB), the Commonwealth Science Council (CSC), the Economic Development Institute (EDI) of the World Bank,, the Inter-American Water Resources Network (IWRN) of the Organization of American States (OAS), the World Meteorological Organization (WMO) and the Government of Trinidad and Tobago.

FOREWORD

The Latin American and Caribbean region has an abundance of hydrological resources whose geographic distribution is heterogeneous. Growing water demand has increased contamination of ecosystems and water sources —including groundwater and coastal zones, as well as conflict for competitive use of the resource.

There is consensus among the international community that water is a renewable but limited resource that requires an integrated and participatory approach management. Because of the different competitive uses of this resource, water is recognized not only as a social commodity but as an economic one as well.

The Latin American and the Caribbean countries have begun a modernization process in their hydrological resource administration and they have acquired experiences by emulating water management practices in other countries in the region, and in other regions of the world.

Similar to other South and Central America proceedings this publication documents the results of the seminar/workshop that took place in June 1997 in Port of Spain, Trinidad and Tobago, organized by the Caribbean Council for Science and Technology (CCST), and cosponsored by the Inter-American Development Bank (IDB) the Caribbean Development Bank (CDB), the Commonwealth Science Council (CSC), the Economic Development Institute (EDI) of the World Bank, the Inter-American Water Resources Network (IWRN) of the Organization of American States (OAS), the World Meteorological Organization (WMO) and the Government of Trinidad and Tobago. The workshop convened government officials and experts of the Latin American and Caribbean region and international organizations to discuss the different countries experiences in water related problems while proposing guidelines to solve them.

The event brought together regional governments and donor countries to support the management of water resources in accordance with the universally adopted Dublin principles. The event also supported the formulation of common strategies and the channeling of assistance from international organizations towards subregional countries in a coherent way.

By co-sponsoring the event and the publication of the proceedings, we hope to contribute to the subregional efforts to solve the most urgent problems related to conservation, and rational use and management of valuable water resources.

Walter Arensberg
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Water Resources Management Challenges

The Caribbean faces many challenges for managing its water resources in a socially acceptable, environmentally sustainable and economically efficient manner. The region's small island characteristics, geography, history, culture, and socio-economic conditions call for solutions which include adaptation of traditional approaches to water resources management. As well, the region exhibits diverse characteristics regarding water resources availability and use. Summarized, these characteristics include that:

- The region's water resources are vulnerable to global factors such as climate change (and accompanying sea level rise, saltwater intrusion and reduced precipitation), hurricanes, and drought;
- Freshwater is scarce in many islands;
- Total water use is dominated by domestic and commercial needs (including for tourism); irrigation use accounts for about 20 per cent of total use;
- Water utilities are facing financial management problems (due to inadequate pricing and tariffs policies), poor operations and maintenance, high levels of unaccounted for water losses, as well as problems due to human resources capacity retention, limited capacity, etc;
- Institutional fragmentation and inadequate policies, funding and institutional constraints are hampering effective management of water resources due to deteriorating hydrological data collection and analysis, poor land use, causing widespread degradation of watersheds and impacting downstream water utilities and the estuarine, marine and coastal resources, water pollution from point sources and non-point sources, which is a growing problem affecting public health and freshwater and marine environments; and
- Coastal and marine resources are important to the island economies.

Progress To Date

The various special characteristics of the region have been discussed and addressed in many global and regional forums. However, in addressing the recommendations in the various sectors in the Small Island Developing States (SIDS) Programme of Action adopted in Barbados in 1994, it was recognized that a more integrated approach to water resources was necessary if these problems were to be addressed in a sustainable manner. Hence, subsequent initiatives and meetings have attempted to focus on an integrated approach. Examples of these include the Conference on Water Resources Assessment and Management in Latin America and the Caribbean (San José, 1996), which produced the San José Declaration and the Second Inter-American Dialogue on Water Management (Buenos Aires, 1996), which produced the Declaration of Buenos Aires.

Seminar Objectives

This report summarizes the discussions and presents working group reports and papers presented at the Seminar/Workshop on Integrated Water resources Management: Institutional and Policy Reform, held on 24-27 June

1997, at the Holiday Inn Hotel in Port-of-Spain, Trinidad.

Based on progress to date, the seminar/workshop sought to promote integrated approaches to water resources management in the Caribbean by:

- developing a common understanding among the cross-sectoral country team members of the water resources management challenges of the region;
- sharing relevant water resources management experiences;
- identifying and discussing priority areas requiring immediate action; and
- recommending specific steps to address them.

The seminar/workshop targeted cross-sectoral country teams and representatives from water and sewerage authorities, ministries of Agriculture, Environment, Health, Planning and Finance from 22 Caribbean countries. Following sessions dealing with issues in water resources management, experiences in water resources management in the Caribbean, experiences in natural resources management, networks for cooperation and existing programmes for regional cooperation, participants worked together in groups to formulate strategies for promoting integrated water resources management. Four key areas for action were identified: public awareness and education, institutional coordination, water resources policy and legislation and innovative financing.

The seminar/workshop fulfilled a mandate of the fourteenth plenary session of the Caribbean Council for Science and Technology (CCST), and was sponsored by the CCST, the Caribbean Development Bank (CDB), the Commonwealth Science Council (CSC), the Economic Development Institute (EDI) of the World Bank, the Inter-American Development Bank (IDB), the Inter-American Water Resources Network (IWRN) of the Organization of American States (OAS), the World Meteorological Organization (WMO) and the Government of Trinidad and Tobago.

Issues Raised and Key Points

The main recommendations of the seminar/workshop focused on the need to:

a. urgently manage water resources in an integrated manner;
b. take strategic rather than reactive action;
c. address freshwater, marine and coastal resources as a management continuum; and
d. develop strategic partnerships and networks for fostering information sharing and exchange.

According to participants, this would involve:

- Identification and establishment of appropriate coordinating units for promoting collaboration and cooperation at the regional and national levels. The primary goals for regional collaboration would be to foster cooperation for promoting the development of professional networks for addressing different components of water resources management (such as watershed management and pollution control) and information-sharing and exchange (through electronic networks etc.). The University of West Indies and other institutions of higher learning could, for example, develop appropriate curricula on a whole range of subjects related to water resources management (such as water resources economics, water legislation, water policy development, etc.) and strengthen existing programmes at the various campuses.

- Development of integrated water resources management policies and strategies for each island based on the principle that water resources management activities need to be self financed and consider demand management

as a vital cost effective policy option; and Development of appropriate public awareness and education strategies. Specific actions could include pilot projects for managing watersheds, specific strategies for sensitizing policy makers and for promoting changes in public attitudes and behavior, developing primary and secondary school curricula with a specific goal of sensitizing school children.

Policy Characteristics and Tools

Economic Importance of Sectors. The economic importance of various sectors to the national economies and the important role of water in the sector should be reflected by water resources management policies addressing water conservation.

Multidimensional Policies. Policy for integrated water resources management should deal with all aspects of management —social, economic, political, environmental, technical and cultural— which impact on effective management of the resources.

Use of Software Based Management Tools. Policy formulation processes based on the use of decision - —support and other software-based management tools should recognize the strengths and limitations of these tools. In particular, the outputs of these tools should be viewed as preliminary indicators, and traditional information gathering, consultation and analysis processes should continue to be employed.

Separation of Administrative Roles. Administrative structures should separate regulatory, enforcement, supply and monitoring and data collection roles. In addition, there is need to recognize the business focus of the privatized water utility, and to allocate responsibility for social aspects of water resources management to specialist institutions or government bodies.

Special Coordinating Mechanisms. Special coordinating mechanisms should be employed by policies and programmes aimed at integrating water resources management. Conflict management based on a shared understanding of the resource limitations and impacting issues is key to success to any integrated water resources management plan. In particular, scientists and policy makers must be brought together so that policies are formulated based on the most reliable data.

Partnership. There is need to promote partnerships between the public sector, the private sector and the wider community, through a transparent, consultative and participatory policy development and implementation process.

Demand Management

Water Conservation via Tariff Structures. Tariff structures which encourage conservation in both metered and un-metered users need to be carefully designed and implemented. Such programs include appropriate incentives for wise use and disincentives and penalties for wasteful practices and abuse.

Water Conservation via Public Awareness Programmes. Public awareness programmes which inform, educate, sensitize and encourage careful use of water, and individual and institutional responsibility towards the management of the resource need to be designed and promoted as a matter of priority.

Data collection. Adequate and reliable data collection mechanisms are needed. The value and use of such data needs to be recognized, and appropriate financing and costs sharing mechanisms to be put in place.

Policies for Retrofit. Policy to encourage retrofit should take into account that utilities often view retrofit programmes aimed at conservation as leading to reductions in income.

Reduction of Demand for Irrigation Water. Policy interventions to reduce demand for water for irrigation should include subsidized loans to purchase technology and improve irrigation network design and assistance with selection of appropriate crop varieties.

Management of Impacts

Impact on Watershed Degradation and Water Pollution. Policies and programmes for water resources management need to delineate and address the structural causes of water pollution from municipal, industrial, mining and agricultural discharge and of poor land use, degrading watersheds, influencing changes in runoff patterns, water quality, and sediment transport.
Impact on the Marine Environment. Policies and programmes for water resources management need to recognize the linkage between, and deal with impacts of actions in upper watersheds on the downstream marine environment.
Impacts of the Tourism Industry. The impact of the tourism industry on water demand and wastewater production need to be recognized by policy makers. Policies should consider the localized impacts of tourism-related water demand, the seasonality of demand, the impacts of all related development and the critical need for hotel retrofit. Policies should include application of equitable pricing and tariff structures. *Settlement Patterns*. Patterns of settlement represented a major impact on water resources in most islands, and should be addressed by policies for integrated water resources management.

Public Participation

Community Participation. The role of community participation in water resources management encompasses the identification of problems and solutions, issues and priorities. This should be embodied in any water resources management policy.

Communication

Political Awareness and Commitment. To facilitate the process of policy reform, political awareness of the relevant issues must be promoted.
Public Information and Awareness Programmes. Public information and awareness programmes need to be critical components of water resources management policies and programmes. Such campaigns need to be given priority, particularly in areas where education levels are major constraints to community action.
Stakeholder Consultations. Stakeholder consultations, should be conducted, and should include meetings with users, suppliers and licensed abstractors and regulators.
Utility Public Image. While seeking to improve service delivery efficiency, reduce wastage and become more effective, agencies with responsibility for supply of potable water must maintain a positive public image in order to gain confidence of the public and their participation to ensure success of their conservation efforts.
Networking to Maximize Access to Resources. There is need for sharing and exchanging knowledge, experience and lessons about successful water resources management practices within the region and with the international community. An effective way to accomplish this would be through improving access to regional and international electronic networks and strengthening or expanding existing networks to improve access to skills, knowledge and experiences.

Working Group Reports

During the final two days, four working groups were formed and were given the responsibility for discussing and recommending ding strategies for improving public awareness and education, institutional coordination, water resources policy and legislation and financing of water resources. The working groups recommended actions in the following areas.

Group One, **Public Awareness and Education Strategies**, focused on the inconsistency between human behavior with rational actions for proper water resources management. The group identified several reasons for this, as well as solutions for addressing the problem. These included sociological research for understanding the attitudes and behaviors of target groups, promotion of strategies for developing ownership/ stewardship toward public goods, development of advocacy programmes to target specific water resources management activities normally accorded low political priority and developing programmes which address diverse cultural practices, poverty and affluence. The group also recommended a project outline for the development of a model catchment area for demonstrating proper Integrated Water Resources Management practices.

Group Two, discussed **Institutional Coordination Strategies**, made recommendations, and identified implementing entities, time frames and mechanisms for implementation. These recommendations covered establishment of national water resources councils and a regional task force for development of policy frameworks at the national and regional levels; actions for efficient and effective coordination of support agencies; training review and strengthening; water resources information systems; and joint technical projects at the national and regional levels.

Group Three focused on **Water Resources Policy and Legislation**. It identified the requisite policies for dealing with the administration of water rights, allocation and pollution control measures, protection of water resources, the general public, watershed management and other issues related to management including investment policies. Particular attention was paid to the enactment of legislation and policies for the setting up a water resources agency, and to promote demand management.

Group Four discussed **Financing Proposals for Resources Master Plan**. It identified general sources of financing and objectives for components of the master plan. Addressing the sustainability of the plan's activities, the group looked at sources of financing for the systems and programmes required, and methods of financing provision of water for activities in various sectors. It identified two major regional programmes, and possible responsible organizations, dealing with human resources development and management information systems. To ensure the sustainability of the activities, monitoring of the strategies was recommended.

Next Steps

Participants recommended that Caribbean governments appoint cross-sectoral task forces led by dynamic persons to champion the promotion of institutional and policy reforms for the water sector, including the formulation of integrated water resources management policies and strategies in each island country. It was also recommended that the governments should utilize existing institutions (such as the Sustainable Development Councils to the extent felt appropriate) to champion the promotion of integrated water resources management and avoid developing unnecessary institutions.

There was also the need to identify an appropriate regional institution which would be charged with the responsibility to promote and coordinate institutional reforms for integrated water resources management and to provide funds and/or information about available funding for technical assistance for developing integrated water resources policies and strategies. Funding sources could include regional banks, multilateral development institutions as well as the Global Environment Facility (GEF).

A follow-up meeting was recommended for monitoring and evaluating the progress on regional and national level water resources management policy reforms.

OPENING CEREMONY

Opening Address by ***The Honourable Ganga Singh*, MP**
Minister of Public Utilities
Government of Trinidad and Tobago

Distinguished representatives of the Water and Sewerage Authority of Trinidad and Tobago, the Caribbean Council for Science and Technology of the United Nations Economic Commission for Latin America and the Caribbean, the Caribbean Development Bank, the Organization of American States, the Inter-American Development Bank and the Commonwealth Science Council, other participants ladies and gentlemen, members of the media.

Welcome to the first workshop where Caribbean territories have assembled, in a Caribbean nation, with the guidance of international organizations, to effectively manage their water resources to meet the demands of the 21st century. In welcoming you to this workshop on integrated water resources management, I also welcome you to our twin island state on behalf of the Government of the Republic of Trinidad and Tobago.

Over the years, countries throughout the world have been investing millions of dollars in sectoral projects aimed at improving our water supply and solving the countries' water problems. But the approach as been myopic. As such, many costly, and well meaning efforts have failed to provide the requirements to manage the water resources for sustainable development, and to support socio-economic development. It has become abundantly clear, therefore, that water management can no longer be treated as a sectoral issue —for it cuts across a vast number of uses.

The freshwater resources are finite and sensitive to human uses and misuses. Failure to develop an integrated water resources management strategy can lead to acute risks to humanity and the environment. It will threaten health, social and economic well being, food security, biodiversity and generally promote conflict amongst users. The protection, conservation and the long-term sustainability of the available freshwater resources are of utmost importance.

Therefore, the adoption of a proactive approach to integrated water resources management to ensure sustainable development is critical. This approach must be consistent with recommendations of the 1992 International Conference on Water and the Environment held in Dublin, Ireland and must: address quantity and quality concerns through an integrated approach; integrally link land-use management with sustainable water management; recognize water as an economic good and promote cost-effective interventions; support innovative and participating approaches; and focus on actions that improve the lives of people and the quality of their environment.

In Trinidad and Tobago, so far we are blessed with sufficient quantities of freshwater to supply all the fundamental needs of the population. However, due to the location of this resource and the seasonality factors, the distribution of water is very uneven.

As Minister of Public Utilities, it concerns me that only 28 per cent of the population is currently receiving a 24 hour supply of water. The unaccounted for water, is estimated to be about 50 per cent of net production. Of the total estimated legitimate consumption, 74.6 per cent is estimated to be residential consumption; 21.1 per cent industrial; 3.7 per cent commercial and only 0.5 per cent agricultural.

The poor quality and unreliable service and the fact that about 72 per cent of the population receives a scheduled supply, has resulted in the consumer's unwillingness to pay and this in turn generates inadequate operating funds and a further deterioration in services. Once again, we witness a vicious cycle.

Between 1976 and 1995, financing to the water sector has been in the order of over TT 3.4 billion dollars. Yet these transfers which are allegedly to help poorer sectors of the community, had exactly the opposite effect, where, in fact, poor and rural areas have suffered at the expense of the rich and urban areas.

Furthermore under the existing tariff system, which is not based on actual consumption, the majority of the population is asked to pay for water services which it does not receive. My question to this distinguished gathering is therefore a simple one: shouldn't we design a tariff system which is reflective of this reality? We in Trinidad and Tobago are now in the process of adopting pricing that induces efficient use of water as part of sound water resource management. In this regard we are examining the introduction of a Water Improvement Tariff at our major industrial estate as a way of funding upgrades to address industrial demand expansion.

The major initiatives in the water industry being embarked upon by the Government, include: The private sector participation in the management of the Water and Sewerage sector to improve efficiency and the quality of service. Under this initiative at least 75 per cent of the population is expected to receive an eighteen (18) hour supply per day; the initiation of a number of capital investment projects funded through loans from international lending agencies to provide improved water and wastewater services the establishment of a new regulatory body to protect consumers from monopoly abuse and to achieve allocative and productive efficiency; the establishment of a consultancy to design and develop a comprehensive and integrated water resources management strategy; a surface water monitoring programme for the Caroni River Basin, in Central Trinidad, to assist in water protection; the supply and installation of a telemetry hydrological data collection network to improve the reliability of water resources assessment; the development of an integrated Geographical Information System database on environmental and water resources data to promote and assess the environmental impacts on the water resource within the catchment unit; and the establishment of an Inter-Ministerial Committee of key stakeholders to steer the development of the Water Resources Management Strategy under the Ministry of Planning; and a Committee of Ministers to oversee the development of the Water Resources Management Strategy.

The Government will also give priority: 1.To the introduction of appropriate laws and by-laws for pollution prevention and enforcement measures; and 2. To the implementation of actions derived from the water resources management strategy and the strengthening of national capacities to manage water resources in a sustainable way.

I advise you that we cannot continue to set up individual defenses against the water and hope for clear results. There are many pressing water issues. However, the solution to these issues require a commitment from government, international financial institutions, not forgetting the public and private sectors, as well as the workers' representatives, to develop and implement coordinated action plans. Without cooperation, your efforts would literally be like filling water in a barrel with holes —you would have no support mechanism to hold it together. It would be of no use and water would go to waste.

Without the support of the people you are trying to protect, the maintenance of health and sustainable water management systems would only be an ecologically sound notion.

Whereas integrated water resource management is really a technical issue, I also advise that in your efforts to encourage public awareness and support to your initiative, you do so in such a way that you stir the consciousness of the factory owner who disposes of his refuse by dumping it into our water courses; that you educate the farmer about the spin off effects that chemical products can have on our groundwater; that our fishermen, divers and persons involved in the tourism industry appreciate our coastlines, and act judiciously.

In closing, I bid you a productive two-day working session. Let me remind you, Ladies and Gentlemen, that a great responsibility is placed upon you. Through your participation here, integrated water resources management in the region should intensify, so much so that we support each others efforts in committing to sustainable development. What you do, or fail to do today, would affect generations to come. I urge you therefore to share your experiences and work in unity—for in doing so you control the floodgates to Caribbean development. I thank you.

Mr. Eric Ashcroft, Chief Executive Officer of the Water and Sewerage Authority, Trinidad and Tobago welcomed participants to the meeting, noting that the large attendance confirmed a growing interest in, and awareness of, the need to conserve water. He stressed that many issues threatened water resources including climate change, pollution and over-extraction, and indicated that there was a need for a better approach to management. To this end, he suggested that there should be greater collaboration among stakeholders in the form of an integrated approach to water resources management which would facilitate developmental and environmental sustainability and an improved quality of life for future generations. Mr. Ashcroft emphasized that thoughts, ideas and strategies should be transformed into action.

Mr. Wendell Lawrence, Deputy Director, Productive Sector Division of the Caribbean Development Bank, stressed that the water supply was limited, and therefore a limiting factor in the Caribbean, and that there had been calls for help from farmers, the tourism industry, and many other sectors of the wider community. He pointed out that currently there was not enough water for domestic, agricultural, transport, tourism and hydropower purposes, and suggested that better management of water resources was necessary. He identified two priority issues to be addressed — allocation of responsibility for costs of improvement and appropriate levels of cost recovery. Mr Lawrence expressed the hope that the seminar would provide some, if not all, of the answers and indicate the right direction in which to move forward.

Mr. Donatus St Aimée, Secretary of the Caribbean Council for Science and Technology, outlined the objectives of the seminar. He stated that the water supply in the Caribbean was not as abundant as before. There was thus a need to share and develop strategies for approaching water resources management since traditional approaches no longer worked. The strategies outlined in previous water resources management seminars should be implemented and accompanied by action with the assistance of the local and international community. Suggesting that the critical issues of water resources management should be central to the planning process in both the public and private sectors, he added that there was need to encourage the population to conserve water, protect watersheds and decrease pollution. Additionally, a holistic, conservation approach to water resources management was needed.

Mr. St Aimee emphasized that these objectives would only be realized if there was action by policy makers, both in institutions and homes, and by all other stakeholders. He proposed the initiation of public awareness programmes which would encourage people to think critically about securing a reasonably clean, adequate supply of water now and in the future.

In his vote of thanks, **Mr. Francois-Marie Patorni**, Coordinator, Water Policy Reform Committee of the Economic Development Institute of the World Bank, highlighted the fact that water was a very important issue in light of increasing pollution, a fragile natural environment and limited water resources. He suggested that some keywords which should be foremost in participants' minds throughout the seminar were action, transparency, participation and partnership.

KEYNOTE ADDRESS

Water Resources Management Issues and Challenges in the Caribbean

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It is not proposed here to discuss in detail the specific water management issues faced by the countries of the Caribbean, you know far more about them that I do. It seems appropriate, however, to begin with a short discussion of the meaning, and nature of the term integrated water management. In introducing the term more than 35 years ago Edward Ackermann defined its meaning as "basically a problem in efficient organization of interdependent units within a system." Integrated water management implies, therefore taking account of all supplies and all demands or uses of water when taking decisions related to the water resource. This is, of course, not so simple. Moreover, other authors speak of integrated management as involving resource-oriented management. Some others speak of multiple-purpose management.

Yet others emphasize integration as meaning coordination among all the entities which participate in water management and, for some, integrated management includes the consideration of the environment in the decisions that are taken on the use of water. Finally, more recently, integration has been defined to include widespread participation in the decision-making process what the World Bank calls the involvement of all the stakeholders. So there are many facets to integrated water management, even more than those mentioned above. So what does this mean for the consideration and discussion of integrated water management in the Caribbean?

First, it means that the objectives established for integrated management must be consistent with the nature of both supply and demand. Caribbean countries have only small streams, are dependent on ground water, commonly face water scarcity and use desalinated sea water. These conditions are very different from those in countries with major rivers. It suggests that river basin management will have only limited relevance, but that integration between management of fresh and salt water could be important.

The demand for water, as shown by the distribution of water withdrawals, is also generally very different in most Caribbean countries, Jamaica is the exception, from that found elsewhere in the ECLAC region. In the Caribbean, it is industrial and residential withdrawals that dominate rather than agricultural demand. This, when the difference in scale is taken into account, means that, without entering and understanding the detail of the water management issues in each country, integrated management will have a particular nature in the Caribbean.

The Challenges

The major challenges in water management, which the countries of the Caribbean will face as we pass beyond the year 2000 into the twenty-first century, are not so very different from those in the rest of the world: (I) to ensure that the water resources are managed so as to maximize the contribution that this natural resource can make to increasing the productivity of the economies of the region; (ii) to manage the water resource so as to maximize its contribution to the elimination of poverty and to the raising of the quality of life; and (iii) to ensure that the water resource is managed so as to minimize the impact of water-using economic activities on the quality of the environment.

One could add more, but these three will be sufficient to keep most managers busy for a few years to come. At the same time, it must be recognized that the relative importance of the issues will vary from country to country. Moreover, the content of the issues will vary even more. For example, in Trinidad and Jamaica industrial use of water, both as input and as a deposit for residuals, will continue to be a major concern, whereas in many of the smaller countries, management issues can be expected to be dominated by concerns related to residential and recreational uses.

The water resource plays many roles in the societies of the Caribbean countries and this, because of the increased competition for the use of the water resource, will considerably complicate the achievement of efficient and effective management. In those countries of the Caribbean with the highest concentrations of population and economic activity, this multiplicity of uses becomes a major obstacle to the achievement of the contribution of the resource to increasing productivity, reducing poverty and minimizing the impact of human activities on the environment.

Recent Trends in the Water Sector

It is possible to describe current trends in water management policies as including the following major principles: (I) Decentralization; (ii) Participation; and (iii) Privatization.

The years between the United Nations Water Conference, held in Mar del Plata in 1977, and the United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, can be divided into three distinct periods. The first, from 1977 to 1982, was characterized by unprecedented economic growth in almost all of Latin America and the Caribbean. However, this period was followed, from 1982 to 1990, by the most serious economic recession since the 1930's. From 1990 onwards, most of the countries of the region began another period of growth and have recovered, to a large extent, from the recession of the 1980's. In many countries, the recovery almost coincided with the holding of the United Nations Conference on Environment and Development; in some it started somewhat earlier, and in others, economic recovery still is not fully consolidated.

Both the boom of the 1970's and the recession of the 1980's diverted interest from the situation of the public sector, and this was reflected in a lack of innovation in water resources management. Indirectly, however, both periods had repercussions on the administration of water resources. The boom of the late 1970's marked the culmination of the expansion of the public sector and of the entrepreneurial state.

One general result has been a revolutionary change in the role of central governments which, while these retain the responsibility for granting licences and monitoring the activities of third parties, they are giving up the actual operation of water-related production activities. This change has paved the way for the adoption of new standards and monitoring mechanisms for water management, as may be noted in Latin America, for example, in Colombia and Chile. In some federal countries, particularly in Argentina, the federal government has almost entirely retired from water management activities and in others, as in Mexico, considerably reduced its role.

Despite the considerable differences among the countries, the change in the role played by the State in water resources management is a widespread phenomenon, and has led to significant differences with respect to the water management policies that had been in force for over 50 years.

Emphasis is being placed on decentralization and on the participation of the private sector. This has opened the way, in some countries, for the adoption of institutional mechanisms based on the concept of integrated management of river basins through the transfer of responsibilities for the management of the resource from the ministries of the central government to local governments, to autonomous public corporations or to the private sector.

Management at the river basin level is, more and more, being viewed as the best way to absorb the environmental costs involved in the development and utilization of the water resource. However, there is still a strong emphasis on studying the physical components of water systems, or on activities and investments in the sector. More remains to be done with respect to the institutional component of water resources management, which is undoubtedly the most important aspect of this approach.

In the application of decentralization policies, it has proved very difficult to transfer real authority for decision making to local institutions. More difficult, in fact, than to transfer responsibilities to the private sector. Maybe in small countries, decentralization appears to be unnecessary, but over-centralization of authority and responsibilities can be found even in the smallest of governments.

Finally, in many countries, including some in the Caribbean, there has been a transfer of responsibilities to the private sector. This has particularly been the case with electricity generation, but it has also dominated irrigation policy with the transfer of responsibilities and authority for management to farmers. There is hardly a country in the region where this has not now occurred. In water supply and sanitation, transfers to the private sector remain less common, but examples can be found, including here in Trinidad.

The Intensification of Water Use

Throughout the twentieth century, the demands on the water resource have gradually intensified everywhere. The intensification of demands can be expected to continue as population continues to increase and economies continue to grow. This has led or is leading to a discussion of what has been termed the *Global Water Crisis*. It is not clear, however, that such a crisis exists at the global level. There is far too much variation in the distribution of precipitation and, therefore, in the natural availability of water for the situation to be uniform over the whole globe. Too much variability, in fact, for the situation to be uniform even in relatively small regions such as the Caribbean.

What is clear, however, is that as population increases and the economy grows, the demand for water will also increase. It will not only continue to grow, but the nature of the demand and the pattern of use can be expected to change as economic and social structures are modified over time. Moreover, the demand for water is a multiple and often conflicting one. The changing and multiple role of the water resource will place tremendous pressure on our ability as managers of water policy, and also as managers of the resource, itself, to cope with the continually changing issues which must confronted in these policies.

This said, the increasing demand for water must be put into context. There is no evidence, in this region, for any water shortages, but those of a local, cyclical nature. Latin America and the Caribbean account for almost one-third of global surface water and even here in the Caribbean, in most countries, water withdrawals amount to less than 5% of the available resources. The degradation of water quality extends the proportion of water under pressure, but we can still expect the areas of conflict and pressure to be limited if not always local.

Even in facing restricted or small-scale water-use conflicts, it is not likely that a centralized approach to management will achieve optimal results. Centralized institutions are inevitably both resistant to change and subject to what can perhaps best be described as revolutionary whims. What is required are more decentralized variegated institutional systems which can evolve as the pressures for change move in one direction or another.

Thoughts on the Future of Water Management

The context in which water administration policies are being discussed seems to have changed. In the last few years, there is a noticeable general trend towards an emphasis in this discussion on the decentralization of water management responsibilities, as well as on applying some of the basic precepts for water resource administration which were enunciated first 20 years ago at the United Nations Water Conference, and incorporated in the Mar del Plata Action Plan and renewed in both the Dublin Meeting and in Chapter 18 of Agenda 21, adopted at the United Nations Conference on Environment and Development, Rio de Janeiro, 1992.

Of course, it is necessary to be a little skeptical about the value of the resolution and their accompanying rhetoric which stem from international conferences. These rarely translate into operational policies. Nevertheless, from the information we have at ECLAC, there are significant signs of change in water management practice, the most important of which include: charging real prices for water services, particularly water and sewerage tariffs; a real concern for the environmental impact of water projects; serious attempts to decentralize management responsibilities and; the beginning of active water quality management. All is not resolved, and we may not live happily ever after, but there is a noticeable willingness among water management agencies, accompanying what Helm called " the shift from being a producing state to become a regulating state" to establish an overall framework of regulations for the sustainable and integrated management of the water. It is not so clear, however, what operational methods will be used fora. establishing policy; b. achieving institutional coordination; c. finding adequate planning mechanisms; or d. carrying out projects.

The incorporation into public policies of the consideration of sustainable and integrated water resource management is complicated by the growth of concern about environmental problems. In many countries, the continuing degradation of water quality is seen as the major challenge facing water management. In general, pollution control is the area where there is least management experience. In a few countries, the institutions responsible for water quality control have recently been strengthened. It is obvious to most governments that there is a need for policies and strategies for controlling pollution; for establishing information bases on pollutants and water quality; to apply useful technology for pollution control and for waste treatment; to advance in institutional development and; to establish appropriate financing mechanisms.

At the same time, concern for the impact of economic development on the natural environment together with the increasing awareness of the close interrelationship between poverty, especially rural poverty, and environmental degradation has placed environmental management in the forefront of political discussion. In the discussion, the management of water resources is sometimes interpreted as simply one more component within the institutional arrangement for the management of the environment. This has led to claims that sight has been lost of the "uniqueness" of water and of its primary role in the sustenance of environmental systems. On the other hand, in other countries, increasing concern for the environment has resulted in the strengthening of water management institutions through the first serious attempts to safeguard water quality by the control of water pollution from both domestic and industrial sources.

Towards Sustainable and Integrated Water Management

Progress towards sustainable and integrated water resource management is still hindered by many factors in most countries. One of the most important restraints is the tremendous deficiency, that still exists, in the provision of effective and efficient water supply and sanitation services. This important and growing social need, dramatically emphasized by the appearance of cholera in 1991, distracts attention from a broader discussion of changes in water

management policies. It results in the achievement of integrated water management being given a distinctly low priority both by political decision-makers and by the public.

The climax in the expansion of public economic activities typified by the undertaking of a number of grandiose water-related projects, mainly for the generation of hydroelectricity, but also for navigation and irrigation, was reached at the end of the seventies. This use of what was perceived as cheap water for development stopped during the recession of the 1980's and has not been continued in the region despite the economic recuperation in most of the countries in this decade. This parallels developments in most of the world and the multi-lateral lending institutions, once the prime movers of large projects, have become very cautious in their support for such hardware solutions.

Environmental concerns have emphasized this move away from the consideration of water as an abundant resource and led to the search for other policy options. Water scarcity is the current paradigm. Water is, however, not so much scarce in the physical sense as scarce at its current price particularly, when we treat it as a free good. Water is never free. It always has a cost to society which must, therefore, be charged to the consumer. This failure to charge a price for water which covers the real cost is what creates those circumstances, too often repeated in the world, which underlie and are the cause of the current concern with scarcity. All resources are, by their nature, scarce in relation to the demands placed upon them. If we want abundant water, then we must fix a proper price for it.

The adoption of integrated management, river basin management or any other improvements in management policy cannot solve our water problems unless we charge for the use of water, for all use of water and for all water, including the ocean such an important resource here in the Caribbean. Getting the price of water right is a necessary component of any effort to achieve and maintain the sustainable use of the water resource and for the achievement of integrated management.

WATER RESOURCES MANAGEMENT CONTEXTS

The New Paradigm in the Economics of Water Resources Management

Mr. Sergio Ardila, Economist
Region 3, Inter-American Development Bank

In his review of the economics of water resources management, Mr. Ardila indicated that there was a need to consider the analysis of incentives generated by institutional frameworks given that there were widespread failures of public provision of infrastructure services. Additionally, the implementation of new systems was necessary to allocate scarce water resources correctly. He also noted that there were several factors that impacted negatively on water resources management, including low quality of service, failure to invest to keep up with population demands, insufficient cost recovery, low efficiency (excess wastage) and lack of accountability to customers. Mr. Ardila stressed that the main source of problems in the provision of water resources management services included the confusion of regulatory and operational roles in state owned enterprises, political influence on management, lack of appropriate supervision, soft budget constraints and confusing incentives.

According to Mr. Ardila, incentives needed to be expressed by economic measures. These included, for instance, strict consequences for customers who did not pay for services, balanced books, enforcement of pollution charges, cost reduction and exploitation of profit opportunities by water utilities, and external regulation of quality, costs and environmental impacts. The Principal-Agent framework was suggested as a new paradigm applicable to water resources management. Referred to as the information approach to economics, this framework dealt with the variety of problems that arose from the absence of perfect information. A more rigorous and realistic new approach to economic analysis required the enrichment of the basic model with a full description of the objective functions of firms, consumers, regulators and information asymmetries.

International Perspective on Water Supply Management Financing and Private Sector Participation

Mr. Carlo Rietveld, Task Manager
World Bank

Mr. Rietveld was of the view that urban growth was an impending crisis for water resources management. The consequences of this growth included pollution, over-population and scarcity of water. According to Mr. Rietveld, the Water and Sanitation Decade had underestimated how much work needed to be done in water resources management, even though the old agenda appreciated that the provision of household water and sanitation was a formidable challenge. The financial issues associated with the old agenda, according to Mr. Rietveld, included high costs due to scarcity of natural water, political controversy, and the constraints of complying with Environmental Protection Agency (EPA) regulations, which posed problems even for industrialized nations. He added that compounding these problems were low user accountability, low user charges, resulting in inefficiency and wastage, and the benefits of public-spending going to the rich and not the poor.

Mr. Rietveld outlined the important lessons learned from international finance company investments. These included the need for support from government and labor, the choice of appropriate private sector companies and the need for a clear regulatory framework that included international arbitration. In closing, he stated that the new agenda for water resources management was focused on environmental sustainability.

Summary of Discussions

Stakeholder Partnerships. It was felt that water resources management should be implemented via a partnership between public and private sectors, as well as the wider community, and that partnership was a necessary element in all policy decisions.

Implications of Privatization. Participants agreed that the role of the private sector in water resources management was task-specific. While partnerships between public and private institutions were to be encouraged, there needed to be the recognition that a privatized water utility operated as a business, that is, to provide a service. Hence, while in an ideal situation there should be no antagonism between social and business goals, social issues were not the concern of the utility, which only provided the service. Social issues should be dealt with by the specialist institutions or government bodies.

Separation of Management Roles. It was stated that water resources management project structures needed to separate regulatory roles from monitoring and data collection and enforcement of legislation. In addition, water supply functions should be separated from collection of hydrological data. It was emphasized that there should be no one regulatory agency for all aspects of water resources management, even though it was difficult to avoid in very small countries where there was a shortage of qualified personnel.

ISSUES IN WATER RESOURCES MANAGEMENT

Watershed Degradation and Management Caribbean Islands

Dr. Frank Gumbs, Head Department of Food Production
University of the West Indies, St. Augustine Campus

Looking at watershed degradation and management in the Caribbean islands, Dr. Gumbs reviewed the factors affecting watershed degradation, the consequences of such degradation, soil management practices, and institutional arrangements for effective watershed management.

According to Dr. Gumbs, the two major parameters contributing to land degradation in the humid tropics were the climatic conditions, and the physiography of the Caribbean islands. These led to problems such as land slippage in steep areas during the wet season, and slumping in areas with thick soil profiles overlaid with heavily compacted or stony soils. Soil erosion, slippage and poor soil conditions were the result of poor management practices, such as overgrazing, and incorrect tilling patterns. Proper management practices, he said, were difficult to promote without encouragement to farmers. He referred to the case of St. Vincent, which had the best soil management practices in the Caribbean, due to benefits granted to farmers employing them. He noted that in the Caribbean, there was a complexity of terrain, slopes and soil types, which led to a complexity of problems. Attempts to promote proper management practices in Jamaica, Dominica and St Vincent, included mixed cropping, stone terracing and mulching, and had met with varying levels of success due to the varying levels of commitment of the farmers. Caribbean rivers were plagued by removal of stones, which led to erosion of the river banks.

Dr. Gumbs listed the natural and man-made factors affecting watershed degradation, and indicated that problems of water quality deterioration could generally be attributed to sediments from erosion, and over-utilization of chemicals for agriculture and industrial use. He provided an indication of beneficial watershed management practices, as they related to agricultural, forests and settlements. Management of agricultural land required that farming practices be based on appropriate soil management so that no real extra cost was incurred. Management of settlements, he said, primarily related to maintenance of infrastructure, such as drainage and waste disposal. He pointed out that multiple interest groups benefitted from Upper Watershed Management (UWM). As a result, he stated that farmers should not be required to bear the full costs of management, but a system of cost sharing should be instituted.

Dr. Gumbs stressed that the role of governments was to increase integration and coordination among subsectors impacting on watershed management. Administrative arrangements for effective watershed management centered on appropriate roles for local and central governments and integration and coordination among subsectors. Successful watershed management initiatives had been characterized by the government effectively fulfilling their roles, the role of communities being recognized, special incentive programmes, and public awareness. He closed with a list of requirements for integrated watershed management, which included: clear government policy on watershed protection, institutional arrangements to implement policy and plans, formulation and implementation of relevant legislation, appropriate land capability and land use schemes, appropriate watershed protection and water management in forested and upper watershed areas, land protection and flood control devices, and elimination or minimization of harmful activities in the watershed.

Impact of Agricultural Development on Water Resources in the Caribbean

Dr. Compton Paul, Director
Technical Programmes (Ag.)
Caribbean Agricultural Research and Development Institute (CARDI)

In his presentation, Dr. Paul examined agricultural development in the Caribbean, impacts on the hydrological cycle, future trends in agriculture and implications for water resources management, and recommended actions to be taken.

Based on their water resources and climate, he identified two groups of Caribbean islands: the drier Leeward islands and small islands off Venezuela, and the wetter islands where much water was available, but water quality was a problem. He noted that the history, social structures and ethnic compositions of the islands were contributing factors to management practices. In the small islands of the Caribbean, varying ecosystem and settlement types also posed particular management issues. Taking a historical perspective, he traced the developments in the agricultural sector, starting with the growth in demand for sugar, increased deforestation, slavery, indentured labour, and agriculture based on plantation models, and settlements in upper watershed areas. Subsequent to independence, high use of agro-chemicals had lead to problems of water quality and quantity. At the present time, urbanization, the growth of tourism and changing land use patterns had resulted in surface and ground water pollution and coastal water contamination.

Looking at the impacts on the hydrological cycle, he noted that agricultural development had led to problems such as inadequate water storage, scarcity in the dry season, and floods in the wet season. Problems of water supply and demand related to poor water quality and insufficient quantities, and arose from urbanization, plantation-type agriculture, which had a high water demand, and tourism. Agriculture-related factors such as road construction, agro-chemicals, agricultural and agro-processing waste also impacted negatively on water resources.

He indicated that future trends in Caribbean agriculture would be based on an increasing export orientation, which required larger producers, and more water for irrigation. Trade liberalization would result in decreasing importance of agriculture and increased consumerism and urbanization. He added that these developments would be accompanied by increasing urbanization, and domestic, municipal and industrial waste generation, deforestation, soil erosion and surface and ground water pollution.

The presentation ended with proposals for strategies needed for water resource development and use in the region. These included inter-sectoral cooperation and central coordination as key concepts related to policy reform. Proposed action included inventories of water resources, defining requirements of users and consideration of both supply-side development and demand side management, increased attention to water conservation, strengthening of institutions for water management, management of deforestation and settlement including waste management, proper land tenure systems. He urged execution of the National Environmental Action Plans (NEAPs) which had been formulated in several countries, and added that this would require inter-regional and external cooperation.

Impact of Tourism on Integrated Water Resources in the Caribbean

Ms. Glenda Medina, Executive Director
Caribbean Conservation Association

Ms. Medina noted the significance of migration and immigration patterns for water resources management. She suggested that the tourism industry, with its concentration of development in coastal areas, represented new patterns of internal migration. Examining tourism statistics in Barbados, Aruba and Jamaica, she inferred impacts on water resources. These were based on comparisons of consumption by tourists and residents, comparisons of water use by sector against their economic significance and water pricing policies. Comparing average consumption per day by residents and by tourists, it was found that in Aruba, the tourist, on average, used four times as much water; in Barbados, about five times and in Jamaica, the usage was about twice as high as the resident rate. She added that the impacts on water resources management of the tourism sector arose from the demand and supply aspects as well as waste disposal.

Institutional and policy reforms, she suggested, should focus on reducing waste, reuse, recycling, recovering and changing consumption patterns by rethinking. The Pan-American Health Organization (PAHO) had formulated a proposal for conservation in hotels in 1994. Bearing in mind the objective of that proposal, the reduction of water consumption in the Caribbean hotels through effective and efficient conservation measures, she recommended several complementary actions. Governments, she suggested, should undertake annual consumption audits, cost analysis of water services, monitoring of water quality, update of environmental legislation , employ appropriate pricing structures, and tax incentives for conservation and identify the carrying capacity of the tourism sector. Civil society was urged to establish a corporate environmental management programme, design and implement public awareness campaigns, establish environmental performance rating schemes for hotels, and implement hotel staff training. She concluded her presentation with an illustration of the effectiveness of energy and water efficiency programmes in one hotel, which had realized reductions in the energy and water costs as a percentage of total revenue, even with increasing occupancy rates.

Water Pollution: Sources and Cost Effective Treatment Options

Mr. Jason Gondron, Chief Operating Officer
Red Fox Environmental Services
& Mr. James Stone, President
Enviro-Waste Services

Stating that the presentation reflected the private sector viewpoint, Mr. Gondron gave background information on his company, which manufactured packaged sewage treatment plants for all types of applications. His company had advocated new approaches to problem solving which included improving public awareness and consumer responsibility, strengthening regulatory capacity and improving wastewater management through treatment options. In attempting solutions, he suggested that there was need for an analysis of the opportunity costs. He gave the example where Germany, while employing a municipal treatment plant, still used the satellite distribution model in remote areas.

Factors critical to determining cost effective treatment options included design, so as to minimize operation and maintenance problems and flexibility in deciding on the degree of decentralization of treatment. Treatment should also be cost effective so that maintenance and operation did not become problems with the required design.

Examples were provided of treatment systems that were used in the energy industry, the military and the navy. In closing, the speaker stressed the need to influence corporate activity through enforcement.

Summary of Discussions

Reasons for Inaction at National and Regional Levels. The lack of timely action at the regional level was noted. It was felt that this was in part due to the fact that watershed management and protection did not feature high on the agendas of regional policy makers. It was also suggested that governments did not have the human and financial resources to deal with all the problems in the region, hence these had been placed lower down on their list of priorities.

Seasonality of Tourist Arrivals and Impacts. It was agreed that the low contribution of tourism to water use may be misleading due to peaks in tourist arrivals which coincided with the dry season in most islands. Statistics represented an average over the entire year. The true impacts therefore should be ascertained, particularly in light of attempts to lengthen the tourism season in many countries. Also important were the impacts at the local level, particularly where tourism development was concentrated, and the impacts of associated activity, such as landscaping, on the water demand. It was further suggested that there was need for studies which showed the impact on the use of water resources by other sectors of the economy

Necessity of Employing Conservation Technology

The difficulty of influencing tourists through public education was noted. It was stressed that retrofit using conservation technology was the only viable solution, and could result in reduction of usage by up to 40 per cent, with consequent decreases in the volumes of sewage discharged.

Impacts of Wastewater and Pollution. The impacts of sewage dumping in coastal areas were identified as being particularly important, and as receiving inadequate attention. It was agreed that this problem required increased political will. Increased attention to water pollution was seen as necessary, since water quality had to be maintained to support a viable tourism industry. It was also proposed that action should be taken to increase the quality, reliability and availability of information to the public on the quality of drinking water being received.

Pricing of Water. It was suggested that pricing and tariff systems which were equitable, but which encouraged conservation should be applied to the tourism sector. While the appropriateness of tax incentives and preferential water rates for the tourism sector were questioned, it was felt that the economic contribution of particular sectors should be recognized when determining levels to which concessions would be granted.

Integrating all Aspects of Water Resources Management. Referring to the "island systems" approach adopted by the Natural Resources Management Unit (NRMU) of the Organization of Eastern Caribbean States (OECS), it was noted that there was need to identify the critical activities which drove the socio-economic aspects of the watershed. Water pollution, while important, should be seen in the context of a holistic system which has social, technical, legal and economic aspects.

Use of Decision Support Tools for Coastal Zone Management in Curacao and Jamaica

Dr. Frank Rijsberman, Managing Director
Resource Analysis

Dr. Frank Rijsberman gave an overview of the similarities between Integrated Coastal Zone Management (ICZM) and Integrated Water Resources Management (IWRM). The similarities, he said lay in their treatment of the biophysical environment, processes and land use, frameworks for analysis and emerging issues. The key driving factor for using integrated approaches in the Caribbean was the small sizes of the Caribbean countries. He identified a number of physical linkages between coastal and freshwater resources and the similarity in their analytical framework. He introduced the CORAL Decision Support System as a powerful tool for integrating land use, tourism and marine resources in sectoral planning. He described its major components (the user interface, economic activity model, water quality model, and ecological response model) and illustrated its usefulness using a case study. The case study focused on cost-effective coral reef protection for Curacao, and identified development issues and options related to land use, marine park management plans and tourism plans based on analyses using the water quality model, the ecological response model and cost effective analysis. He stressed the tool's effectiveness as a communication tool rather than a decision support tool, and as a means of incorporating the views and knowledge of stakeholders in planning and decision-making. He also mentioned the use of some elements of the system in Montego Bay, Jamaica to prioritize issues in integrated coastal zone management.In conclusion, he gave a brief demonstration of the use of the tool.

Summary of Discussions

Identification of Benefits of Proposed Actions. To date, cost-benefit analysis had not been incorporated in the model. The first objective was cost-effectiveness analysis. Therefore no benefits in financial terms or as positive impacts to the biota could be predicted by the model.

Data Availability and Cost. The software had been developed at a cost of $50,000.00 over a period of approximately a year. Acquiring the necessary data and information was identified as the most difficult task in using the model. An important criteria for the application of the tool was therefore the availability of the data.

The Reliability of Inputs and Outputs. Dr Rijsberman explained that although there may be some weakness in the accuracy of the data generated, the model's key strength was in identifying the impacts in order of their magnitude. He informed that there was a team working to set up more generic model testing, in Montego Bay, Jamaica.

Application of the Tool for Communication Between Interest Groups. Dr. Rijsberman indicated that the tool had not yet been used in formal integrated planning. It had been used to teach courses on Coastal Zone Management at Universities in which representatives of various governmental agencies participated, and had been presented at high schools. While some participants questioned the validity of the outputs of the tool for policy and planning, Mr.Rijsberman stressed that the major strength of the tool lay in its application for promoting a shared understanding of coastal zone management issues among interest groups with widely differing perspectives. However, he agreed that all models should have some predictive ability. He also identified the decision support system as having an advantage over other quantitative deterministic models in that it took into account qualitative considerations. In response to a question regarding the existence of similar tools, Dr. Rijsberman indicated that there

were similar tools used for IWRM. He cited the example of a tool for flood plain management which involved significant role-playing and interaction.

Water Resources Management - Demand Management Issues

Dr. Saul Arlosoroff, Senior Adviser
The Harry S. Truman Institute, Hebrew University, Israel

Dr. Arlosoroff highlighted the need to promote demand management as an integral part of water resources management. He lamented that demand management was often given low priority in management plans. He indicated that the need for demand management had arisen from the diminishing water supplies which had led to a new paradigm shift, depletion and pollution of traditional sources, remoteness of sources and growing costs of provision. Another important issue was the tremendous volumes of unaccounted for water. The problem was seen to be especially acute in developing countries where the problem was compounded by urban population growth. He explained that demand management entailed the comprehensive management at the municipal level and highlighted pricing as a key tool.

The merits of demand management were illustrated by a case study of Israel which had achieved unexpected economic success and high standards of living, contrary to what might have been predicted from its per capita water consumption and availability. The most important factor responsible for its success was the large budgetary allocations given to demand management and the top priority given to water resource issues. Dr. Arlosoroff explained that demand management was especially critical for Israel's survival not only because of its natural aridity and the variability of annual rainfall, but also the high population growth. He described the main actions taken by the Government in its new approach. These entailed licensing, new legislation, including water metering laws, and quality control. He explained that water consumption had not changed with the addition of 2 million persons to the population because of pricing, education, technology and repair and maintenance of the distribution system.

He concluded with a summary of the findings of a survey of initiatives related to a demand management approach in the Caribbean. The survey revealed that budgetary allocations, legislation and institutional arrangements were inadequate although there had been recognition of the importance of these aspects of water resources management.

Interactions of Water Production, Use and Conservation

Dr. Henry Smith, Director
Water Resources Research Institute
University of the Virgin Islands, St. Thomas, US Virgin Islands

Dr. Smith referred to a study which revealed that, in the United States Virgin Islands, water consumption was well above what was required to meet basic needs and that there was much room for more efficient use. He went on to describe water conservation initiatives and management in the United States Virgin Islands where efficient use of water resources was necessitated by the paucity of natural freshwater sources. In these islands water conservation had become a way of life, as reflected by widespread rain-water harvesting required by law, the distribution of salt-water to flush toilets, rationing, and aggressive public information campaigns. Top priority had been given to water resources conservation since the 1970's when a number of circumstances led to serious shortages in supplies. The subsequent drop in demand figures was largely due to metering, improvements in billing procedures, and in leakage detection and repair systems, performance standards for public fixture and incentives to encourage use of

more efficient fixtures, the encouragement of water conservation strategies in all development plans and changes in rate structures. Dr. Smith concluded by highlighting the importance of education and information dissemination initiatives and approaches taken in the latter. He indicated that they should be carefully designed to suit the target population and especially their understanding of water resource issues. He also pointed out that such programmes had the added benefit of fostering goodwill between stakeholders.

Summary of Discussions

Difficulty in Water Conservation Efforts. It was pointed out that physical shortages in supply did not commonly occur in most developing countries and it was therefore difficult to convince the general public that it was important to conserve water. High levels of losses were therefore common-place. Dr. Arlosoroff suggested that one approach that may be used was to make it a requirement that the main supply operations met certain levels of profitability. He also suggested that a privately run operation might have been advantageous. He stressed the usefulness of management strategies for dealing with extreme cases of waste. In expressing agreement with the latter, another participant felt that it was easier to justify conservation practices by the high cost of distribution (both operational and capital costs). The discussant added that there was a significant link between management approaches and influence over the behavior of different sectors in water conservation efforts. He concluded by pointing out that utilities often objected to retrofitting because it reduced income and that retrofitting should be applied with increased rates.

Approaches to, and Impacts of, Levying High Water Rates to Poor Farmers. The question was raised about the difficulty and effectiveness of charging high water rates to poor farmers in Israel and how it was done. Dr. Arlosoroff indicated that this group did encounter great economic difficulty and that it had been granted access to subsidized loans to purchase technology to improve irrigation networks. Farmers also received assistance through agricultural extension services to cultivate marketable crops which required less water. Negative consequences included a significant decline in the size of the farming community and transition from self-sufficiency in food production to a country with a net import bill for agricultural products.

Institutional Arrangements in Israel. Dr. Arlosoroff informed that in Israel, by law there was one body with authority over water resources. However in cases of proposals to increase water rates to farming communities (not including periodic increases which took into account the rising cost of living), discussions had to be held with the Ministry responsible for agriculture. He added that within the water resources authority there existed a department solely for demand management.

***The Bahamas Experience*.** In the Bahamas water shortage crises had resulted in the formation of a national water corporation, resulting in the rescinding of laws concerning individual rain-water catchment. The main problem experienced was the lack of resources for policing groundwater abstraction practices. There was virtually no control over the latter. Dr. Arlosoroff added that in countries with shallow water tables policing would be a problem.

***Legislation*.** Although there the need for demand management was acknowledged in most countries, it was felt that this had not been reflected by changes in legislation. Where legislation existed, enforcement was a problem. It was indicated that demand management policy for certain sectors should be sensitive to the economic importance of these sectors and possible negative impacts. The tourist industry, the mainstay of many small Caribbean countries was cited as an example.

Redesign of Water Supply Systems. The question was raised about the possibility of redesign of the civil engineering works as another strategy for demand management. Dr. Arlosoroff responded by explaining that to date

there had been no economic justification for the tremendous capital inputs that would be required. He also referred to his earlier mention of the paradigm shift where only a few engineers had begun to stop thinking about water consumption as a rigid parameter. The latter was indicative of the low priority given to demand management.

CASE STUDIES IN WATER OF RESOURCES MANAGEMENT IN THE CARIBBEAN

Water Resources Management Policy Development in Haiti

Dr. John Hervé Raymond, National Coordinator
IDB Project on Water Policy Formulation, Haiti.

Dr. Raymond gave an overview of the water resources in Haiti, noting that only 10 per cent of annual rainfall went to deep percolation and groundwater. The distribution of water for irrigation, drinking, and other sources revealed that 90 per cent was allocated for use for irrigation. He stated that some of the problems experienced in Haiti in managing its limited water resources related to lack of regulations for users, dispersed responsibility among several institutions, confusion between the roles of managers and users, inefficient and inadequate controls over water users, demographic factors, inadequate human resource development, data unavailability and over-centralization.

Identifying the institutions involved in various aspects of water resources management in Haiti, he looked at their roles, objectives, and relevant functional units. In the Ministry of Agriculture, Natural Resources and Rural Development which was responsible for policy establishment for agriculture, natural resources and rural development, the two important units were the National Service for Water Resources and the Irrigation Service.In the Ministry of Public Works,Transportation and Communications, the main units with responsibility for water resources management were the National Service for Potable Water and the Metropolitan Autonomous Center for Potable Water. Indicating their missions, populations served and daily production, he stated that the two latter units were responsible for distribution and production, divided geographically between the metropolitan area, and the rest of the island. Other relevant institutions included Electricity of Haiti, the Ministry of Environment, the Ministry of Planning and External Cooperation, the Ministry of Public Health, numerous NGOs and international funding institutions. Outlining the key provisions of legislation relevant to water resources management, he noted that each institution was covered by organic law.

Early initiatives in integrated water resources management in Haiti were marked by the establishment of a National Committee for Water in 1977, which evaluated the water sector.Various committees were subsequently formed, and a National Institute for Water established. While effective, the latter had been dismantled and its mandates taken up by the Ministry of Agriculture. Later activities included several internationally-funded projects, the most recent of which was an IDB-financed programme based at the Ministry of Environment in 1997.

Current efforts at water policy formulation attempted to separate regulatory functions from service provision functions. Key mechanisms for the policy formulation process included an inter-sectoral committee to foster communication, coordination and consultation between interest groups, information gathering and use of technical tools to identify priorities.

Summary of Discussions

Coordination between Internationally-funded Programmes. In Haiti, the plethora of regulatory and administrative structures with responsibility for various aspects of water resources management was attributed to the distribution of responsibilities for water resources management among various institutions. It was proposed that this was also responsible, in part, for the concurrent implementation of more than one internationally-funded projects with the objective of restructuring water resources management in Haiti. Attempts to coordinate activities under these programmes had proven to be very difficult. Approaches to solving similar problems in St. Lucia under an environment and watershed management programme included a national environment committee with a supporting arm comprised of relevant ministries to foster inter-ministerial communication.

Responses of User Groups to Efforts at Integration of Management. Dr. Raymond stated that positive responses to efforts at increasing the involvement of user groups in water resources management in Haiti was evidenced by initiatives at formal organization of user groups to increase management capacity.

Level of Local Involvement and Control in Internationally Funded Programmes. It was recognized that the policy formulation process could be carried out through long-term-oriented local capacity building processes. In the case of Haiti, teams of foreign consultants had been employed, which each had at least one local expert counterpart and a local coordinator.

Groundwater Development and Management in Barbados

Dr. John Mwansa, Project Manager
Water Resources Management and Water Loss Study, Barbados

Dr. Mwansa presented a hydrogeological cross-section of Barbados, and reviewed data which indicated the distribution of private and public wells in groundwater abstraction zones. He stated that in Barbados, private well operators had a poor understanding of the impacts of over exploitation of the resource. This had led to high salinity levels in freshwater supplies, as had been experienced on the West Coast. Highlighting the existence of ground water protection zones since 1963, he listed major policies and legislation regarding ground water resources management in Barbados.

Comparing the total volume of groundwater resources in an average rainfall year with the total usage, he noted that the latter exceeded sustainable and safe yield levels. Commenting on the water quality data as they related to levels of atrazine present, he indicated that while they were found to be below the concentration limit of the United States Environmental Protection Agency (EPA) and the Canadian standards, they exceeded the more stringent European standards.

Policies and legislation governing water resources management in Barbados made provisions for riparian rights licensing requirements and established a water board responsible for data collection. A ground water protection policy, not covered by any legislation, was administered by three agencies. In addition, the Barbados Water Authority had been established as a statutory authority. Dr. Mwansa outlined the zoning system employed in Barbados, which placed various restrictions on sewage systems and domestic and industrial waste disposal methods in certain areas.

The most recent comprehensive study of the groundwater resources of Barbados had been undertaken in 1997 and, he stated, was limited by the unavailability of data. The lack of significant effort at hydrological data collection had resulted in the inability to calibrate groundwater models developed. Dr. Mwansa highlighted the main findings of the study, which included that sewering of the south and west coasts would impact adversely on the salt-water-freshwater interface, that the zoning policy was not enforceable, and that the present responsibility of the Barbados Water Authority for both supply and regulation may represent a conflict of interest.

In an effort to deal with these problems, strategies currently employed included the design of new zoning restrictions, policy change, legislative change, pricing and tariff structures, pollution penalties, public awareness, coordination and consultation, capacity building and monitoring.

Dr. Mwansa concluded that the Barbados Water Authority was hampered by existing structures, and inadequate numbers of trained and qualified personnel. The Authority also concentrated on water supply, to the detriment of other aspects. The major problem with groundwater management lay in the lack of up-to-date and accurate information. In addition, insufficient research and public education was carried out. Steps had been taken to address these deficiencies. Lessons which could be learnt by other countries in the Caribbean included the need to avoid short-term projects to meet long term goals, the need to develop in-house capabilities for long-term management and planning, laws and regulations should allocate responsibility appropriately to appropriately trained staff, and public education and information dissemination should be viewed as long-term programmes.

Summary of Discussions

Limitations of Demand Management Programmes. Dr. Mwansa indicated that while the Barbados Water Authority had attempted to encourage conservation through distribution of shower heads and kitchen tap aerators to consumers who had fully paid their bills, this was not as successful as hoped because consumers did not view these as sufficient incentives for keeping up to date with their payments. He illustrated this with a comparison of the average daily consumption per person in un-metered households (148 litres), with that in metered households (243 litres). Tariff structures, he said did not encourage conservation in either metered or un-metered users. In the case of the metered users, monthly water bills represented a minimal average one per cent of monthly expenses, and in the case of un-metered users, usage was generally too far below the volume of water allowed by the lowest fixed rate to offer potential savings through conservation.

Impact of Sea Level Rise on Water Resources in Barbados. Dr. Mwansa noted that contrary to conclusions of a previous speaker, sea level rise could possibly have beneficial impacts for Barbados, due to an increased head, which would make groundwater abstraction easier, and movement of the saltwater-freshwater interface inland. This could also apply to other larger islands sharing certain characteristics of Barbados' hydrogeology which included the presence of limestone aquifers and narrow, deep fresh water lanes.

Approaches to Controlling Illegal Abstraction. In Barbados, as in Trinidad, problems of illegal abstraction were related to problems of enforcement. In addition, unclear statement of licence conditions, as well as a lack of monitoring of licenced abstractors, contributed to the problem. Approaches taken in Barbados to controlling this problem encompassed communicating resource limitations and consequences of over-exploitation to abstractors, and enlisting the support of the public in reporting instances of illegal abstraction.

Approaches to Controlling Salinity Problems. The major approach to controlling salinity problems was to shut down production, which yielded significant reductions in salinity in as little as 24 hours. Public education

programmes had resulted in a positive response by the public abstractor, but private abstractors were not as supportive. Artificial recharge was not used.

A Community Approach To Water Resources Management in The Caribbean: The Case of St. Vincent

Mr. Nigel Weekes
Forestry Division, St. Vincent and the Grenadines

Mr. Weekes outlined the water resources management plan for St Vincent and the Grenadines. Watershed management policy had been developed to meet the needs of the small rural communities, taking into consideration the constraints that the plurality of cultures placed on water resources management policies and programmes, in addition to population pressure and inappropriate national development policies. The critical constraint was the small size of the individual islands which made it difficult to distinguish watershed from non-watershed areas.

He stated that a water resources management strategy for this limited land base needed to consider the multiple user issue, the decline in agricultural productivity, increasing incidence of drought and floods, environmental decline, and a consequent decline in water quality over the nation's 13 watersheds. He described the model watershed plan collaboratively developed by the Forestry Department and Canadian expertise beginning in 1989. The first step involved a five-month socio-economic study of the Colonarie River Basin. One hundred and fifty-five interviews had been conducted with 121 householders and two State agencies operating in 10 percent of the watershed area.The demonstration project promoted agroforestry and soil conservation techniques, technology for improved land use and practical research trials. Private land owners were encouraged to subscribe to conservation practices or they would be subject to prosecution.

Problems encountered were that the demonstration project ignored the users in the lower watershed areas. Additionally it was difficult to convince the poor, landless rural people that their daily activities were problematic. The model was a technical success but lack of appropriate legislation was now the limiting factor. Lessons learn were that water resources management could not be divorced from conservation and natural resource development, and that human behavior and compliance could not be legislated. He concluded that community empowerment and participation were necessary for achieving compliance.

Summary of Discussions

Involvement of All Stakeholders. Mr. Weekes informed that all stakeholders including members of the local community had been involved in the watershed management project from the avenue to involve the community in monitoring land use and environmental problems in the watershed. The constraint regarding the low levels of literacy and widely differing perspectives would be addressed in the next financial year by a facilitator to promote dialogue with the community and with the youth development arm of the Ministry of Education. More radio and TVadvertising was proposed to help to educate and mobilize communities.

Institutional Concerns. Regarding the institutional relationships in implementation of the project and water resources management in general, Mr Weekes informed that the project had been accepted by the Ministries of Agriculture and Physical Planning, and there were several pieces of legislation dealing with watershed management. However, the Environmental Advisory Committee's sole interest was to harvest the water. It was not concerned with the problems of water resources management. Funds had not been released for the Forestry Department to manage

water quality and quantity. Another of the institutional problems was that the Water Authority also acquired land and with the expectation that the Forestry Department would rehabilitate it, although land reform was not under the jurisdiction of that department. Further the authority of the Surveyors Department in some aspects lead to poor coordination of activities.

Indicators of Project Success. Regarding approaches to project evaluation, Mr. Weekes informed that the water quantities and quality and sediment levels were measured before and after the intervention. The findings were that there was success in the upper areas where farmers planted trees, while in the middle basin, agriculture continued to have negative impacts. This was in part because regulations to support legislation had not been fully established. While he reported success in the technical aspects, other areas were estimated to be weak and the some aspects of the five year plan were two years behind schedule. According to Mr. Weekes, one drawback had been the supply of technology which could not be locally maintained. This had severely hampered the development of the project.

Importance of Clear Goal Identification, Communication and Political Will. In response to a question regarding the major reasons for the success of the project, Mr. Weekes stated that the clear identification of objectives from the start had been a critical factor. The plan had been approved in cabinet and all the stakeholders understood the concept of the pilot project and its goals. In support, he gave example of the development of Colombia's management plan for an area covering 15 municipalities which had problems such as illegal drugs and guerillas. Conflict management was needed, and was undertaken based on instilling understanding of the water supply issues. Subsequently, understanding of the goals of the project became easier. Another lesson, said Mr. Weekes, was that political will to sanction the plan needed to be present, especially at the highest levels.

Water Resources Management Strategy Preparation in Trinidad and Tobago

Mrs. Marilyn Crichlow, Acting Director
Water Resources Agency
&
Mrs. Victoria Mendez-Charles, Acting Permanent Secretary
Ministry of Planning and Development, Trinidad and Tobago

Mrs. Crichlow and Mrs. Mendez-Charles informed that the Government of Trinidad and Tobago's new paradigm for water resources management took a holistic and integrated approach in relation to economic, environmental, technical, social and political considerations. This formed the basis for the development of a comprehensive framework for the rational development and utilization of the water resources, and for a strengthened institutional framework for sustainable development. The new medium to long term water resources management strategy was one element of the World Bank- funded Water Sector Institutional Strengthening Project. It sought to mitigate several constraints including the loose coordination of the multiplicity of relevant agencies, the lack of a proper institutional and legislative framework, instability in the quantity of available raw water, increased demand for water by the tourism and petrochemical industries and declining productivity of ground and surface water sources.

According to Mrs. Crichlow and Mrs. Mendez-Charles, the strategy had been informed by other national strategic plans. Management challenges to be faced in the development of this water resources management strategy for the future included the Water Resources Agency organizational structure and staffing, the institutional and legislative framework for integrated and sustainable management, stakeholder participation, changing the national culture to support water metering and the development of an effective decision support system. Specific issues addressed were

also highlighted and included topics, such as financing, capacity building, water resources allocation and the institutional framework.

Mrs. Crichlow and Mrs. Mendez-Charles listed the important lessons learnt in the preparatory work and stressed the importance of identifying the scope of the work, and hiring the required expertise and experienced professionals for the evaluation of the technical proposal. The need for preparation for negotiation was highlighted as one important lesson for the future. The presenters then summarized the innovations in this holistic approach which included a focus on reuse, recycling and artificial recharge of water, the application of GIS, the introduction of software models, and stakeholder participation.

Summary of Discussions

Marine Ecosystem. Responding to a question regarding the treatment of the marine ecosystem by the strategy, the presenters indicated that marine water issues and integrated coastal ecosystem aspects had been taken into consideration. At present the issue was addressed only by ensuring that there were sufficient quantities of surface water for ecosystem function. They added that some by-laws to effect pollution prevention and enforcement of these laws were needed.

Cost Effectiveness of Water Resources Management Strategies. It was stated that the terms of reference for the water resources management strategy for Trinidad and Tobago stipulated that all recommendations must be cost effective. Costs and alternatives had to be assessed, bearing in mind that the driving factor for the strategy was the need to provide water for existing and expected needs.

Community Participation. In response to a question regarding the role of community participation, the presenters indicated that this was viewed as essential. They added that in order to be successful, the strategy would need to clearly indicate how often to contact communities, means of obtaining information, and how to address and incorporate issues raised by the communities.The community would participate by contributing to the strategy by identifying issues, problems and priorities, monitoring of resources and alerting to incidences affecting water quality and quantity.

Institutional Relationships. In response to a query about the relationship between the Water Resources Agency (WRA) and the Water and Sewage Authority (WASA), participants were informed that the Water Resources Agency had been established in 1966 and had been affiliated with WASA since then. In the past, some stakeholders held varying views on whether this partnership was ideal. Some felt that WRA should not have been part of WASA since the latter was an operations and user-focused utility. Some also felt that the relationship compromised the Agency's integrity. Others felt that since the primary function of the WRA was for planning, WRA should fall under the Ministry of Planning. With the inception of new management bodies, some suggested that WRA could be affiliated with there for example the Environmental Management Authority of Trinidad and Tobago.

Political Commitment and Public Awareness. Participants agreed that political commitment was essential and the public should realize the need for water resources management. It was suggested that it was worthwhile to enlist the services of education and public information experts to meet these.

Watershed Management in Northeastern Puerto Rico

Dr. Fred Scatena, Ecosystem Group Leader
International Institute of Tropical Forestry
United States Department of Agriculture

Dr. Scatena presented an overview of the problems of water resources management in Puerto Rico with specific reference to the Northeastern region and described the institutional responses to address these problems. In spite of high precipitation and abundant surface water resources in the Northeastern region the tremendous urban demand, recreational use, high levels of unaccounted for water (approximately 40 per cent), and inadequate storage facilities, led to water supply crises which necessitated strict rationing. Dr. Scatena indicated that the forest played a key role in maintaining the quality and ensuring the availability of freshwater, which he felt to be the most significant benefit provided by the forest. Other benefits were for the tourism industry, recreation and general ecological health. The water resources in this area accounted for 20 per cent of the island's total water supply. Water supply crises in 1980's stimulated the development of a new approach to water resources management which was still being developed. The strategy to address these problems entailed reduction of water losses through decentralization of the water authority, privatization of management, emergency telephone numbers, credit facilities for pipe repairs, integrated water supply and distribution systems to tackle the problems caused by localized drought, dredging of existing reservoirs, inter-agency cooperation (which led to the formulation of a Puerto Rico Water Plan and the Fast-tracking approach), plans for reforestation (Riparian buffer zones around reservoirs and island-wide projects) and conservation efforts (public awareness campaigns, low-water use toilets, rationing).

In addition, Dr. Scatena described plans for regional waste-water treatment plants and construction of settlement ponds upstream of these reservoirs. Night-time reductions of withdrawals from streams was identified as one option to help reduce the losses in aquatic larval populations of species which migrate up and downstream.

Dr. Scatena indicated that a number of these plans did not win the support of the public in different localities. The integrated water supply and distribution system and regional treatment sewerage plants were of particular concern. In addition, the fast-tracking approach was not successful. The poor public image of Puerto Rico's Water and Sewerage Authority was a key factor in the response of the general populace to public awareness campaigns. Dr. Scatena concluded by stressing the importance of the latter to the success of conservation efforts.

Summary of Discussions

Land Tenure System in Upper Watershed Areas. Dr. Scatena indicated that the forest was a protected area and therefore officially State lands. He added that land tenure might cause problems for necessary works in areas around reservoirs.

Financing of Water Supplies. Dr. Scatena indicated that cost of supply was borne by the State and that more emphasis was placed on the costs of sewerage treatment. He added that there were attempts to determine the true economic value of the resource.

Institutional Framework. Dr. Scatena described the existing institutional framework as suitable for implementing new management strategies and policies. The Department of Natural Resources and the Puerto Rico Water and Sewerage Authority were identified as the two main agencies with authority over water resources and water supply. He indicated that the problem was ensuring smooth collaboration of these agencies.

NETWORKS FOR COOPERATION

Issues in Small Island States

Mr. Charles Marville, Engineer
Operations and Maintenance, Barbados Water Authority/
Representative, Water Supply and Sanitation Collaborative Council

Mr. Marville's presentation reviewed the work of the Water Supply and Sanitation Collaborative Council (WSSCC), examined small island water issues and made recommendations for the way forward. He began with a historical account of meetings and other work, (making mention of the First Global Forum in Oslo 1991 and subsequent meetings in Rabat 1993, and Barbados 1995), which led to the identification of water resource issues of priority to small islands.The major issues identified were; watershed management, pollution, and desalination. He stressed the importance of identifying target groups to develop strategies for different sectors. The identification of finances and technical resources was also seen as necessary. He added that the formulation of effective communication strategies would generate technical aid. He concluded by announcing the Fourth Global Forum of the Council, to be held in Manila in November 1997, as the next activity on the schedule to promote water conservation.

Small Island Water Information Network (SIWIN)

Dr. Siyan Malomo, Chief Project Officer
Commonwealth Science Council

Dr. Malomo provided an insight into the work of the Commonwealth Science Council (CSC) and its relation to the Caribbean and integrated water resources management. He pointed out that the Commonwealth Science Council utilized science and technology for social, economic and environmental development. He informed that the CSC carried out its mission through collaborative efforts by providing support of research and development, human resources development, the development of science and technology policy, technology transfer, and information exchange. The establishment of a Small Island Water Information Network (SIWIN) was one outcome of a meeting of the Administrative Group of the CSC. The SIWIN, he said, was primarily a network to address water resource information in small islands, arid and semi-arid states.

The Network was established on the basis that small islands had limited water resources, and were experiencing increasing pollution and demand for water. Professionals tended to be isolated, and required information available in other parts of the world. Other partners of the network included the University of the West Indies Center for Environment and Development (UWICED), the South Pacific Applied Geoscience Commission (SOPAC) Secretariat, the University of Mauritius, the Geological Survey of Cyprus and the British Geological Survey. A SIWIN workshop had been held at the SOPAC Secretariat in Fiji from 5-7 February, 1997. At this workshop, the issues identified were similar to those in the Caribbean, and it was decided that a similar network be set up to provide water information in the Caribbean.

OAS Inter-American Dialogue on Water Management and The Inter-American Water Resources Network

Mr. David Moody, Water Resources Consultant
Unit of Sustainable Development and Environment, Organization of American States

Mr. Moody summarized the Action Plan for the Sustainable Development of the Americas Water Resources Initiatives, presented at the agency's summit in Bolivia in 1996. At this summit the OAS was charged with the coordination and follow-up of the deliberations from the meeting. He pointed out that each recommended action arising from the meeting could benefit from an information network. He described the Inter-American Water Resources Network (IWRN) as a grass-roots organization born out of the first Inter-American Dialogue on Water Management held in Miami in 1993. The participants in this Dialogue viewed the IWRN as a forum for bringing together key actors in the water sector to facilitate sustainable development and integrated water resources management world-wide. The objectives of the IWRN included building shared understanding of issues; clarifying water resources needs and priorities; increasing access to skills, knowledge and strategies; building a network of networks; and creating collaborative partnerships. In building partnerships, strategies and infrastructure employed included directories which could be used by consultants and other interested parties, a list server, a site on the World Wide Web and a number of workshops and dialogues. A product of recent IWRN workshops in Barbados and in Peru was the "Sourcebook of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean", and activity cosponsored by the United Nations Environment Programme (UNEP) In closing, Mr. Moody commented that all interested parties could get involved by subscribing to the available databases not only to obtain information, but also to post activities in which they may be involved. In so doing, continued dialogue would be promoted.

WMO: Hydrological Cycle Observing System for the Caribbean Basin

Mr. John Bassier, Chief
Hydrology Division, Hydrological and Water Resources Department
World Meteorological Organization

To underscore the growing urgency of addressing the global freshwater situation, Mr. Bassier presented a number of slides showing water issues as featured in the international press. The major question, he said, was whether there would be enough water in the twenty-first century and how the international community should respond to the problems facing the world. In the Caribbean developments in the earth's environment related to global warming indicated the critical importance of addressing water resources management issues. To assist in addressing these issues, the WMO had established a programme called the World Hydrological Cycle Observing System (WHYCOS). WHYCOS sought to address the constraints placed on the development of water projects resulting from inadequate or unreliable hydrological data. Mr. Bassier informed that it was a tool for improving the collection, dissemination and use of high quality standardized and consistent hydrological and related data at the national and international levels. In addition to the other WHYCOS initiatives, there were plans currently underway to develop a similar project for the Caribbean region (CARIB-HYCOS). In closing, Mr. Bassier noted that such a system would be beneficial to the region, if only because external support agencies insisted on design data for implementation of projects.

CATHALAC: Networking in the Humid Tropical Regions of Latin America and the Caribbean

Mrs. Maria Concepcion Donoso, Director

Centro del Agua del Trópico Húmedo para América Latina y el Caribe (CATHALAC)

Mrs. Donoso described CATHALAC as an NGO with representatives from all countries of the humid tropics of the Americas, which was established under an agreement between the Government of Panama and the United Nations Educational, Scientific and Cultural Organization (UNESCO). Its principal objective was to transfer information, knowledge and new technologies among scientists and decision makers throughout the region. This was done through the organization of workshops, seminars and conferences, and by the construction of networks within the region and cooperation with existing networks. According to Mrs. Donoso, CATHALAC also provided support for policy makers in the region. The major network comprised 15 organizations with focal points in each. She added that all the networks with which the organization was involved had the common objective of the sharing of information and the exchange of knowledge through cooperation. According to Mrs. Donoso, this was chiefly responsible for the major accomplishments of these networks in the regionalization and internationalization of research. She anticipated that increased networking would be employed to address the problems related to water resources management in the region.

INSULA: International Scientific Council for Island Development

Mr. Ronald Parris, President

Mr. Parris described INSULA as an NGO affiliated to UNESCO, established to promote sustainable development in all regions of the world by encouraging scientific and cultural cooperation among islands and by contributing to integrated planning and management of island resources. He informed that there were some 300 institutional and individual members constituting a multidisciplinary network of experts. Highlighting one activity of INSULA, he informed that on that organization's involvement with a number of information networks in European islands, involving computer technology applications, and with other information networks. INSULA's interests in the Caribbean, he stated, focused on initiating or collaborating in the development of similar information networks that would help address some of the data management issues raised at the meeting. He also emphasized the importance of bringing together social scientists, such as anthropologists and sociologists, since many of the problems of water resources management were cultural.

United Nations University/International Network on Water Environment and Health (UNU/INWEH)

Dr. Ralph J. Daley, Director

UNU/INWEH

Dr. Daley provided an overview of the INWEH, presenting it as a possible networking organization which could be accessed by interested parties in the region. He stated that INWEH was a new agency in the United Nations system, and was sponsored by the Canadian Government. Its approach was described as non-traditional, employing

no in-house staff, but soliciting the services of a team of professionals whose services were solicited for various projects. The organization's approach was an integrated one, which attempted to take a long-term perspective on the agency's activities. He expressed the hope that the agency's resources would be exploited when problem solving exercises were undertaken in the Caribbean.

MULTILATERAL SUPPORT FOR WATER RESOURCES MANAGEMENT IN THE REGION

The Inter-American Development Bank: Strategy for Integrated Water Resources Management

Mr. Luis Garcia, Principal Water Resources Specialist
Inter-American Development Bank

Mr. Garcia presented the strategy proposed for the IDB in its work in integrated water resources management in Latin America and the Caribbean (LAC). The strategy was being developed through an iterative procedure in consultation with country water resource officials, Bank staff, NGOs, and international lending and technical assistance organizations. Bank financing of water-related projects had been substantial during the past 35 years (approximately US $33 billion). Under the Eighth General Increase in the Resources of the IDB (IDB8), bank programmes in the water resource sector were required to reflect the socioeconomic and environmental needs of the borrower countries and serve the interests and needs of water users at the local and community level.

According to Mr.Garcia, the external goals of the Bank's strategy were to support a process of change regarding water resources issues — namely a shift from development to management and from a sectoral to an integrated approach. The focus of the strategy was on the flexible application of principles and instruments, taking a problem solving approach. Mr. Garcia described several instruments used by the Bank to assist borrowing member countries to achieve improvements in integrated water resources management. These instruments included country dialogue, country and regional technical cooperation, trust funds, sector and hybrid loans, project specific loans, small project loans, private sector loans, cofinancing and the Committee of Environmental and Social Impact (CESI).

World Bank: Water Resources Management Policy

Mr. Francois-Marie Patorni, Coordinator
Water Policy Reform Program
Economic Development Institute of the World Bank

Mr. Patorni informed the meeting on the work of the World Bank in water resources management. To date, the World Bank had lent $40 billion for water resources management, and projected that a further $40 billion, or 15 per cent of total bank lending, would be disbursed over the next decade. According to Mr. Patorni, in the last decade growing international consensus on sound water resources management principles had emerged. Application of these principles was required to deal with such problems as low irrigation efficiencies, the loss of 50-60 per cent of wetlands and losses in biodiversity. Traditional approaches to water management based on "getting more water to meet demands," had not proved sustainable. The World Bank had assisted with the formulation of regional water resources management strategies for the Middle East, Sub Saharan Africa and the Caribbean. In the Caribbean, World Bank support was partly provided through the Global Environment Fund (GEF), and in Trinidad, had included institutional strengthening, private sector participation in water supply, a watershed rehabilitation project, a national parks and watershed project, and a flood control and drainage project. Mr. Patorni indicated that the World Bank did not disburse funds unless the requesting country had a national water policy and strategy. The World Bank also operated at the macro level dealing with institutions based on approaches which included donor

coordination, global water partnership as represented by the World Water Supply and Sanitation Collaborative Council, and capacity building.

Caribbean Development Bank Support For Water Resources Management

Mr. Wendell Lawrence,

Deputy Director Productive Sector Division, Caribbean Development Bank

Mr. Lawrence indicated that the CDB and its member countries were limited in size and resources, and therefore the disbursements of the Bank were substantially smaller than those of the World Bank. According to Mr. Lawrence, the CDB's traditional function had been to provide financial assistance to governments and water utilities to develop water supplies, based on concern that these supplies were diminishing. The Bank's members were small island developing States, where water supply was characterized by extensive losses, as high as 50-60 per cent. The result was that production costs were not recovered. Other critical issues included polluted watersheds, problems of solid and liquid waste management and inadequate institutional arrangements. The Bank's role had been to enhance the capacity of these member States to deal with these issues themselves. Each CDB member country had its water supply under the control of different government departments, in which weak institutional arrangements, lack of regulations, and poor enforcement of policies were major constraints. Additional problems included limited finances, the inability to generate funds for new business or maintenance and repairs, flood control, storm damage, the shortage of skills, and budgetary problems. Mr. Lawrence informed that the CDB had been working to help members develop commercially viable, autonomous water supplies, but desalination projects were extremely costly.

CLOSING SESSION

Mr. Donatus St. Aimée, expressed his hope that the mix of persons represented would translate to the integration of actions in the future. He was of the view that some of the tasks set by the Honourable Minister Ganga Singh had been achieved, and clear directions for the way forward set.

Mr. Francois-Marie Patorni, clarified that the aim of the Economic Development Institute was to help disseminate seed money for water policy reform. He was of the view that the seminar had enlightened and uplifted, and provided a chance to work together. He had witnessed genuine concern and commitment for
integrated water resources management and a valuable exchange of views. In his estimation, there was a better understanding of the need for an integrated water resources management, and participants had the opportunity to define a realistic future agenda for policy reform. Where some concrete recommendations had been made, other specific actions could be extracted from the general recommendations. Mr. Patorni emphasized that whatever actions were to be taken required champions to drive change.

Mr. David Moody spoke about the growing urgency of integrated water resources management, and the plans and strategies needed to put discussions of the meeting into effect. He was of the view that progress could be achieved, even if only a few of the recommended actions were implemented, and that such progress would require good will, innovative thinking and hard work.

Mr. Luis Garcia stated that water resources management was a continuous process that had been started many years ago. In Costa Rica in 1996 a master plan for the region had been drafted. The present seminar had moved forward and looked at the details, and brought perspective and vision. This was attributed to the work of the working groups, whose mandates had been appropriately identified in his view. Solutions and ideas had been formulated for all levels. While the elements of an action plan had been achieved, someone had to move and coordinate and make things a reality, and he challenged participants to form many "working groups" to undertake this responsibility.

Mr. Wendell Lawrence was of the view that the working groups had provided a basis for future work. While acknowledging that it was sometimes difficult to follow up after meetings, he challenged each participant to do their best to accelerate and pursue the development of integrated water resources management. Mr. Lawrence urged all the participants to disseminate their own report on the conclusions of the meeting as widely as possible, and to ensure its use as the basis for discussion at the national level.

Closing Address

The Honourable Trevor Sudama
Minister of Planning and Development,
Government of Trinidad and Tobago

Mr. Chairman, Members of the Head Table, Distinguished Guests, Participants, Ladies and Gentlemen. It is indeed a great pleasure for me to address you at the closing ceremony of this Caribbean Workshop in Trinidad and Tobago, the first being held in a Caribbean island on integrated water resources management.

I wish to convey my sincere thanks to the organizers and sponsors, the Water and Sewerage Authority and the Caribbean Council for Science and Technology, for their initiative and to the co-sponsors, the World Bank, OAS, IDB, and CDB for their support to this workshop. I consider this Seminar to be of crucial importance to the continuing and overwhelming need for our Caribbean Countries to sustainably manage our water resources in support of our socio-economic development and ultimately to the improvement in the quality of life of our peoples.

On behalf of the Government of Trinidad and Tobago I also extend a special appreciation to the representatives from over twenty (20) Caribbean countries and from regional and international institutions and other resource personnel for your participation in this Seminar.

Distinguished Guests, Ladies and Gentlemen, I have noted with great interest that the aims and objectives of this Workshop were to discuss factors which affect integrated water resources management, the setting up of arrangements for promoting and maintaining an integrated and participatory approach to water resources management and ensuring that the critical issues of water are kept central to the planning process. Your deliberations in this forum could not have come at a more opportune time for Trinidad and Tobago.

My Government has already instituted a number of initiatives to improve the efficiency of the water sector in response to our socio-economic development needs. My Cabinet colleague, the Honourable Minister of Public Utilities, identified the specific measures for water sector reform in Trinidad and Tobago in his address at the opening of the Workshop.

This country has established a Consultancy to design and develop a comprehensive and integrated water resources management strategy in which all factors impacting on water resources will be considered. Your conclusions and recommendations at this workshop on policy measures, the institutional framework, legislative development, information management and community participation would be an invaluable consideration in our strategy development. I am sure that the insights derived from this Seminar would also be of benefit to other countries of the Region who may now be at different stages of their water resources strategy formulation exercise.

Ladies and Gentlemen, this Seminar has served to underscore the point that water is an economic and social resource that must be managed and conserved consistent with broader national goals and policies. In order to establish the agreed national goals and objectives, my Ministry is well embarked on the preparation of a Strategic Socio-Economic Development Planning Framework which will set the direction for the economy and society for the next seven years and provide the coordinating framework for the sectors.

This strategic planning exercise will be completed before the end of this year and will be timely to give the necessary direction to the medium-term water resources management strategy.

The interdependence of all forms of life has been recognized and water is an inextricable link in the environment.The Environmental Management Authority has recently prepared a draft National Environmental Policy through consultation with key stakeholders which will be published shortly for widespread public comment before being finalized. The Environmental Policy will provide the basis for an Environmental Management Plan and an Environmental Action Plan. The strategic environmental policy and plans will provide an encompassing framework to inform the preparation of the water resources management strategy and support on-going monitoring and enforcement sections for the conservation of resources.

Water resources management and the development and use of land are closely inter-related. The National Physical Development Plan establishes the land use planning framework and allocates land for urban settlement, rural

development, for industry, mineral extraction, agriculture, forestry, recreation, conservation and other activities. On the one hand, the location, type and intensity of land use will reflect the spatial distribution of demand for water. On the other hand the extent of the designated watershed conservation areas and the land use and other controls on the environmental performance of these activities will impact on the available quantity and quality of water resources. The water resources management strategy being prepared will be an important consideration in the Review of the present National Physical Plan. It is also imperative that the preparation of regional development plans be integrated with watershed management plans.

The Government's Public Sector Investment Programme for 1997 reflects its commitment to accelerate the provision and improvement of priority economic and social infrastructure, primarily to support private sector investment, reduce the level of unemployment and alleviate poverty.

The Government's public investment in the water and sewerage sector for 1997 of TT$158 m or nine per cent of the overall allocation demonstrates its recognition of the importance of water to the growth of our economic and social sectors, to the development of our rural areas and to our environmental amenity. The allocation of financial resources to investments in the sector is designed to achieve greater equity of access by the population, particularly persons living in the more remote areas, and by certain sectors not previously provided with an adequate supply of potable water.

Distinguished Guests, Ladies and Gentlemen, water resources management must take into account simultaneously the economic, social, political, physical, and environmental factors as part of a complex network of elements which characterize the country. The platform of the socio-economic, land use and environmental objectives and policies for such a strategy is being put in place. It is important to note that any attempt at strategy formulation can only be successful if the solutions are endogenous to the people for whom they are designed.

The keynote address at the opening of this Seminar and subsequent contributions during the past four (4) days identified some of the major regional and international issues, challenges and approaches in water resources management. The papers which were presented and discussed have focused on issues of financing and prioritization, conservation and demand management.

I have been informed that the participants have worked assiduously during the Workshop sessions yesterday and today to formulate recommendations on the major issues dominating the Seminar that may be applicable to the region. Strategies have been proposed for public awareness and education, institutional strengthening and coordination, demand management, policy, legislation and financing.

In your deliberations a number of approaches to these issues have been generated. With regard to public awareness and education, the proposals have called for the promotion of human behavior consistent with proper water resources management. The profound change in present attitudes would require building public awareness through researching the target groups, providing qualitative and quantitative information for a better understanding and appreciation of water resources, involving all interested and affected groups for greater ownership and stewardship of our water resources.

The seminar has also proposed for our consideration private sector participation in the development and management of water on the supply side and the definition of specific and separate responsibility for demand management and conservation. The provision of relevant expertise, retention of institutional capacity and effective mechanisms for cross sectoral linkages were noted as being essential to institutional strengthening and coordination. Reference has been made to the need for review and development of a clear policy and legislative framework, including feasible

enforcement provisions, the development and application of appropriate national and regional water quality standards and guidelines and tools for water resources management.

The strategies for financing have raised a range of possibilities. Differing approaches have been suggested for funding the provision of water for the various sectors —full cost recovery through user fees and direct taxation in the tourism sector, scaled user and licensing fees along with royalties in the industrial sector, scaled user fees, licence fees and subsidies for agriculture and domestic use and discharge fees for waste water. The point has also been made that funds may also be generated from mining and commercial fishing permits, recreation, data dissemination and from penalties and fines.

The wealth of recommendations will form a valuable input into our considerations for the development of water resources management strategies for countries of the region. As Chairman of the Committee of Ministers giving oversight to the development of the Water Resources Management Strategy for Trinidad and Tobago, I along with my Cabinet colleagues will ensure that due attention is given to these proposals and that appropriate direction is given to achieve the quality and timing of the required outcomes.

One of the objectives of this seminar was to provide opportunities for the exchange of experiences within the Caribbean region. This objective cannot be over-emphasized since it serves to increase the level of cooperation and effectiveness of the water management sector. I understand that the participants from the countries of the region have indicated at this Seminar that they are looking with interest to learn from Trinidad and Tobago's initiative with a private sector operator in the water sector. We would gladly share the outcome of this innovation in our water management effort. The commitment and action of Government, in partnership with the private sector and non-governmental organizations will go a long way towards achieving progress in integrated water resource management. In addition, the support of the regional and international organizations for technical assistance for training, exchange of experience, capacity strengthening and technology enhancement will provide a much needed boost to the efforts of our Governments to develop and implement our water resources strategies.

Ladies and Gentlemen, in closing, I wish to reiterate the appreciation of the Government of Trinidad and Tobago to the organizers and co-sponsors for their invaluable support to this initiative and to express the hope that participants would be able to make an enhanced contribution to integrated water resources management and to the improvement of the quality of life of the peoples of our region. I thank you.

ANNEX 1. WORKING GROUPS REPORTS

Group 1: Public Awareness and Education Strategies

The group defined the overall context of the problem in the form of a statement, the main causes of the problem and the conceptual solution for the problem, as well as one practical solution. The group recommended the development of a project plan for a model catchment area to demonstrate principles of International Water Resources Management.

Statement of the Problem. Human behavior is not consistent with proper Water Resources Management

Causes of the Problem. Lack of information. Lack of understanding. Lack of appreciation. Poor packaging of information. Lack of motivation/incentive. Lack of resources. Inefficiencies in infrastructure. Lack of enforcement of legislation. Inadequate legislation. Inadequate human and financial resources for monitoring. training, etc. Poor coordination and cooperation between agencies. Poor user perception as guardians/protectors of water resources. Lack of trained personnel to disseminate information. Low political priority. Cultural practices. Poverty/affluence.

Conceptual Solutions to Problems

Focus — Public Awareness

1. Research Target Groups: Identify needs. Evaluate past and existing programmes. Disseminate information effectively. *Increase in qualitative and quantitative information will result in better understanding and appreciation of water resources*.
2. Promote Feelings of Ownership/Stewardship: Include users as part of planning process. Foster attitudes towards protection. *Empowered persons can put pressure on politicians*.
3. Develop Advocacy Programmes: To target low political priority assigned to the problem.
4. Cultural Practices: Involve all affected groups. Develop strategies consistent with societal norms.
5. Poverty/Affluence. Involve groups representing the poor in planning from inception of programme. Educate about Negative Practices. Provide practical, reasonable and economic alternatives. Strict enforcement of legislation as a deterrent.

One Practical Solution

Project Plan. Development of a model catchment area for demonstrating proper Integrated Water Resources Management practices.

Purpose of Plan. To access the real situation in natural catchments.

Activities to achieve project completion. *Who? Mass Media* —dissemination of information.
Schools —target youths to increase public awareness.
General public —community participation to foster feelings of ownership and empowerment towards achieving sustainable water resources management. Includes NGOs, environmentalists, university students, agriculturists, industry, health departments, etc.
How? Promotion of project through competitions.

Schools: essays; drawing/art; photography; debates television quizzes; small scale models.
General public: technical proposals; photography; debates. National competition winners will go on to regional level.

Defining the Project Team. *National Level*. Project Manager. Hydrologists. Communications. Experts. Water Resource Manager. Environmentalists. Educators. Architects. Planners. Engineers. Artists. Land Resources Persons. Sociologists. Economists. Politicians.
Regional level requires coordination. General functions of project coordinator include providing complementary support to national team and bringing together other regional bodies.

Time-Frame for Project: 5 years.

Year 1: Collection of baseline data. Project proposal. EIA + Gender Impact Assessment. Site selection. Initial presentation to public. Budget formulation. Cash flow preparation. Progress review —regional and national.

Year 2: Source funding. Tendering. Contract awards for design works. Provide public information. Review progress to date.

Year 3: Start design model works. Continue public participation through consultation. Produce brochures, posters, etc. Start construction. Progress review.

Year 4: Design continues. Public information continues. Initiate site visits and tours. Increase output of brochures, posters, info sheets, handbooks. Press exposure —TV, newspapers, radio. Completion of model design. Involve community in management practices for future upkeep of project (sustainability of project).

Year 5: Finalize construction works. Implement maintenance programme for sustainability of project (include training). Further development of material. Grand opening. Progress review —lessons learnt, plans for future.

The Regional Coordinator will bring bodies together to ensure project success.

Financing the project. Estimated average cost of project for each Caribbean island = US$5m.

Total for all of the Caribbean = US$150m.

Group 2: Institutional Coordination Strategies

Group two recommends specific institutional arrangement for fostering cross sectoral coordination, as well as specific actions for achieving efficient and effective coordination.

Recommendations

1. Establish national water resources councils and a regional task force for the development of policy framework at the national and regional levels

Facilitate, coordinate and monitor the implementation of water policies and programmes.
—coordinating unit (legal authority/ normative/ regulatory and enforcement functions).
—adoption of an integrated water resources management and scientific model at the national level.
Review and evaluate existing water related institutions (which include formal consultation among stakeholders).
Reform/ improve water resources management related institutions.
—institutional strengthening and inter-agency/ inter-sectoral coordination through the use of memoranda of understanding, steering committee mechanisms.

Who: National government.
When: Short term (1- 2 years).
How: Through inter-agency and inter-sectoral units/ agencies together with the support agencies; routine monitoring and reporting of general progress through CCST.

2. Take actions to achieve efficient and effective coordination of support agencies

Establish and identify regional coordinating units for water resources management at the regional level. Prepare and disseminate inventory of on-going and planned water related projects at the national and regional level. Coordinate support agencies through instruments of cooperation (formal agreements/ joint funding agreements: MOU/ through coordinating units of water resources council, periodic evaluation meetings). Conduct periodic evaluation meetings among support agencies and regional countries.

Who: Coordinating units at national level and principal support agencies at regional level (through CCST, NRMU, UWI).
When: Short term (1- 2 years).
How: Through organization of periodic evaluation meetings by CCST.

3. Review and strengthen inter-agency training at both national and regional levels

Develop regulatory and enforcement programmes/instruments. Training in demand.
Management techniques.
Revise curricula (formal and informal). Conduct resources inventory. Human resources, financial resources.

Who: Water resources councils at national level, and UWI, associate universities, UNESCO, regional coordinating task force through CCST.
When: Immediate and short term.

How: Surveys/questionnaires; analysis and conclusions; sponsored seminars/ workshops.

4. Develop water resources information systems for sharing at regional and national levels

Develop data collection standards and databases formats. Evaluate the feasibility of developing general information system (GIS with multi-user capacity). Formulate and conduct research and development Initiate resources inventory. —human and financial/ physical, —databases/ bibliographic, data and information

Who: CMI, INSULA, CSC, at regional level; water councils, at national level.
When: Immediate to medium term (3- 5 years).
How: Technical assistance; joint technical and scientific efforts through technical cooperation activities/ projects.

5. Implement joint technical projects at the national and regional levels

Identify issues. Transfer technology. Conduct demonstration/ pilot projects for innovative technologies (e.g. Scavenger wells/ retention dams for water resources management).

Who: National water councils at the national level, and NRMU/OECS, UNESCO, supporting regional agencies at the regional level; regional coordinating task force (CCST will coordinate).
When: Immediate and on-going.
How: Through national natural resources institutes, regional university and regional research institution.

Group 3: Water Resources Policy and Legislation

Group three discussed messages for sensitizing politicians and the public about the water scarcity problems which would limit economic growth and consequently affect the quality of life.

Two major policies analyzed: 1) Establishment of a comprehensive water resources management agency. 2) Management of water resources must be guided by the concept of sustainability as laid down in the landmark report "Our Common Future."

For the Politician

1. Water is finite and must be managed sustainably. Access to potable water is a basic human right.
2. a. In (name of country) water resources will last for (x) years at a particular level of demand.
   b. The impact of development on water demand.
3. People/institutions will be identified to assess water resources.
4. Determination by legislation that the agencies responsible for supply and distribution carry out these functions by using acceptable water demand management practices.

Legislative Issues

5. Establishment of a water resources agency and identification of its main functions.
6. Allocation, priorities, norms-regulations.
7. Watersheds/zones/emergency areas.
8. Drilling codes.
9. Hydrogeological data collection and research: data collection, levels, quality, access, monitoring of abstraction.
10. Metering law: two stages —comprehensive second stage.
11. Economic unit: evaluation of economic and financial incentives, sanctions.
12. Water quality: pollution, rules, regulations.
13. Water rate-setting: automatic/special rates.
14. Board: composition, who dominates, chairperson, functions.
15. Specifications for water fittings: standards.
16. Retrofitting: incentives for, manufacture/import.
17. Monitoring unit: functions, access.
18. Special tribunal for water affairs: composition one or two judges, representative from the public.

TOPIC	POLICY	LEGISLATION
Institutional/ Administrative Issues.	Establishment of a board by law in which stakeholders are represented.	Enactment by law of a water resources agency; functions to include: CAllocation and permits for development and supply. CMonitoring. CRate-setting for resources. CHydrological data collection and research. CSupply. CPlanning.
Demand Management.	A water demand impact assessment for every project, to be considered in the overall evaluation of project proposals.	Legislation which explicitly states that all water resources belong to the States and is administered by the water resources agency Comprehensive metering laws. Drilling laws. Allocation laws. Hydrological responsibility.

INSTITUTIONAL/ADMINISTRATIVE ISSUES

1. Institutional development and interaction between institutions.
2. Cross-sectoral linkages (coordination between agencies).
3. Policy to ensure administrative reform towards efficiency.
4. Capacity retention and capacity building in organizations.
5. Policy to ensure private sector participation in water resource development and management.
6. The establishment of a unit responsible for demand management.

PROTECTION OF WATER RESOURCES

1. Water quantity and quality monitoring.
2. Development of mechanisms for enforcement (and for more effective enforcement) and supporting legislation to curtail and discourage water pollution and to promote coordinated concerted efforts by all sectors.
3. Development and application of regional standards and guidelines for monitoring water resources.
4. Policy to promote water conservation.
5. Development of regulatory frameworks.

ISSUES RELATED TO GENERAL PUBLIC

1. Public education and awareness creation to promote sustainable water resources use.
2. Policy to ensure community participation in planning and the decision-making process.

3. Policies to ensure sustainable participation in water resources management with the aim of empowerment.
4. Policy to ensure equitable and just allocation of potable water/all water resources.

ISSUES IN WATERSHED MANAGEMENT

1. Land use management in critical watersheds/all watersheds.
2. Review of policy and legislation related to watershed management.

OTHER ISSUES RELATED TO MANAGEMENT

1. Development of policy tools for watershed management.
2. Policy for investment taking into account the master plan and institutional performance.
3. Resource-oriented management policy (ensuring that activities are not project oriented).
4. The incorporation of demand management as a developmental approach.

Group 4 : Financing Proposals

Group four discussed modes and arrangements for financing water resources management activities.

ACTION PLAN	SOURCE/TYPE OF FUNDING
1.0 NATIONAL WATER POLICY To create a national water policy for the management and complete assessment of water resources as a function of natural social and economic growth trends.	National budgetary allocation. *N.B. This depends greatly on the political will to manage the water resource.*
2.0 WATER RESOURCES MASTER PLAN - (IWRM) C To define the supply and demand for water at the level of hydrographic basin, making them an integral part of the national development policies. C To create a National Waters Policy for the management and complete assessment of water resources —as a function of national, social and economic growth trends, and the countries' development strategies, and with the participation of the user sectors and the rest of society. C To establish measures to ensure that the policy is executed continuously and independently of changes in government. C To create the necessary standards to ensure that all water-related economic, social and environmental projects are based on comprehensive, up-to-date water resources assessment. C To create, for the territories with extreme water scarcity, special research studies on storage, collection and retention of precipitation and surface runoffs, as well as other means of increasing water availability (desalinization, management of demand, importation of water). C To establish intensive publicity programmes for education, communication and information aimed at raising the public awareness of the rational use of water and the need to pay its real cost, as being indispensable for the efficiency of services and the continued capacity for re-investment. C To foster the protection of the natural water resources of the basin as a means of conserving water resources.	**National** (To establish and maintain the institutional arrangements. May require technical assistance support). **External** Regional —CDB, OAS Bilateral —UK, ODA, USAID Multilateral —IDB, WB, EC, IDA, UNDP. *Note: The first priority would be to use grant aid financing, preferential credit.*

3.0 IMPLEMENTATION OF COMPONENTS OF THE MASTER PLAN	
COMPONENT	**FINANCING**
3.1 Institutional Arrangements C To establish institutional and legal mechanisms for the management of the water resources. C To establish the institutional mechanisms for effective coordination and integration among the water users.	Local/Government
3.2 Public Education C To design and carry out ongoing public education programmes nationally and regionally. C To establish interregional communication links for the exchange and dissemination of information.	Local/Government/ Regional
3.3 Legislation /Regulations C To develop water-related legislation and regulations covering surface and ground water uses. C To develop water-related legislation and regulations for the protection and conservation of water resources.	Local/National
3.4 Human Resources C To satisfy human resources needs of the water sector for the short, medium and long terms.	Local/regional/International
3.5 Information Systems C To establish a national/regional Information System. To establish appropriate programmes of rate management, compilation, storage and dissemination of water-related data and information.	Local/Regional/International

4.0 SUSTAINABILITY

Financing for the continuous operation of systems and programmes established after the limited implementation of the sector plan.

4.1 Systems and Programmes

Systems and Programmes	Source of Financing
GIS/MIS/Hydrological Data.	Regional/International. Government budget allocation. User fees licences. Royalties. Incentives.
Public Education.	
Human Resources.	
Institutional coordination and monitoring	

4.2 Sectors

Sectors	Methods (s) Goals (s)
Tourism	Full cost recovery, direct taxation, user fees
Irrigation	Scaled user fees. Subsidies (Public funds). Cost of water, licensing fees
Potable water	Scaled user fees, subsidies, licencing fees, royalties (for quantity used)
Industry	Scaled user fees, licensing fees, royalties
Electricity (hydroelectric power)	Royalty
Wastewater	
General Company	Discharge fees
Domestic	
Industrial	
Other sectors/activities	
Mining, commercial fishing, Forestry, Insurance companies, Recreation	Licences
Data dissemination, Penalties/fines	User fees

5.0 REGIONAL PROGRAMMES AND FINANCING

Programme	Sources of financing
5.1 Human Resources Development C Human resource needs assessment and development of training programmes C CMI programmes for measurement in hydrology UWI programme — water resources and hydraulic engineer/technicians C Lab technician training through CEHI/CBWMP	Regional organizations to finance, e.g. CDB, CCST, OAS/UNDP, etc. along with local and international financing
5.2 Networking/MIS C Establishment of regional network, including provision of computers	OAS, CATHALAC, CSC Commonwealth Secretariat local user subscription fees to be established
5.3 Sustainability C Ongoing monitoring of IWRM strategies —workshops and seminar	CCST/OAS/CDB/UNDP

ANNEX 2: PROGRAMME

DAY 1

8:00 - 9:00 Registration

OPENING CEREMONY

Chair: Mr. Eric Ashcroft

9:00 - 9:05	Welcome —*Mr. Eric Ashcroft*, Water and Sewerage Authority
9:05 - 9:10	Brief Remark —*Mr. Wendell Lawrence*, Caribbean Development Bank
9:10 - 9:30	Seminar Opening —His Excellency, the Honourable *Ganga Singh*, Minister of Public Utilities, Trinidad and Tobago
9:30 - 9:45	Seminar Objectives —*Mr. Donatus St Aimee*- Caribbean Council for Science and Technology
9:45 -9:50	Vote of Thanks —*Mr. Francois-Marie Patorni*, Economic Development Institute

KEYNOTE ADDRESS

9:45-10:45	Water Resources Management Issues and Challenges in the Caribbean (*Speaker: Mr. Terence Lee* —UNECLAC)
10:45-11:15	Break

WATER RESOURCES MANAGEMENT CONTEXTS

Chair: Mr. Wendell Lawrence

11:15 -12:15	New Paradigm in the Economics of Water Resources Management *(Speaker: Mr. Sergio Ardila —IDB)*
12:15 - 13:00	International Perspective on Water Supply Management , Financing and Private Sector Participation (*Speaker: Mr. Carlo Rietveld* —World Bank) Discussions
13:00 - 14:30	Lunch
14:00 - 14.30	Luncheon Address: Impacts of Climate Change on Water Resources in the Caribbean (*Speaker: Dr. Gyan Shrivastava* —University of West Indies)

ISSUES IN WATER RESOURCES MANAGEMENT

Chair: Mr. Luis Garcia

14:30 - 16:00	Watershed Degradation and Management in the Caribbean Islands (*Speaker: Dr. Frank Gumbs* —UWI) Impact of Agricultural Development on Water Resources in the Caribbean (*Speaker: Dr. Compton Paul* —CARDI) Discussions
16:00 - 16:20	Break
16:20 - 16:30	Impact of Tourism on Integrated Water Resources in the Caribbean (*Speaker: Ms. Glenda Medina* —CCA) Water Pollution: Sources and cost-effective treatment options (*Speakers: Mr. James Stone* —Enviro-Waste Services Inc. and *Dr. Jason Gondron* —Red Fox Environmental Inc.) Discussions
17:30 - 18:00	Summary and participants input
17:00 - 19:00	Cocktail Reception

DAY 2

ISSUES IN WATER RESOURCES MANAGEMENT

Chair: Mr. David Moody

8:30 - 10:00	Use of decision support tools for Coastal Zone Management in Curacao and Jamaica (*Speaker: Mr. Frank Rijsberman* —Delft) Discussions
10:00 - 10:30	Break
10:30 - 12:00	Water Resources Management: (Israel as a Case Study) (*Speaker: Mr. Saul Arlosoroff* —The Harry S Truman Hebrew University) Water production, Use and Conservation (*Speaker: Dr. Henry Smith* —UVI Water Resources Institute) Discussions
12:00 - 1:30	Lunch
13:00 - 1:30	Luncheon Presentation: Economic Considerations in Hydrological Data Collection (*Speaker: Mr. Kailas Narayan* —Caribbean Meteorological Institute)

CASE STUDIES OF WATER RESOURCES MANAGEMENT IN THE CARIBBEAN

Chair: Mr. John Bassier

1:30 - 3:00	Water Resources Management Policy Development in Haiti (*Speaker: Dr. Herve Raymond* —Ministry of Environment, Haiti) Groundwater Development and Management in Barbados (*Speaker: Dr. John Mwansa* —Barbados) Discussions
3:00 - 3:30	Break
3:30 - 5:30	A Community Approach to Water Resources Management in the Caribbean: The Case of St. Vincent (*Speaker: Mr. Nigel Weekes* —Forestry Division, St. Vincent) Water Resources Management Strategy Preparation in Trinidad and Tobago *Speaker: Ms. Marilyn Crichlow and Mrs. Victoria Mendez-Charles* —Trinidad and Tobago) Discussions
6:00 - 6:30	Group Meeting (Chairpersons + Rapporteur): Thematic Assignments, Specific Outputs, Group Work Preparation

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DAY 3

EXPERIENCES IN NATURAL RESOURCES MANAGEMENT

Chair: Mr. Francois-Marie Patorni

8:30 - 9:15 Watershed Management in Northeastern Puerto Rico *(Speaker: Dr. Fred Scaten* —US Department of Agriculture) Caribbean Small Island Water Issues *(Speaker: Mr. Charles Marville* —Barbados Water Authority) Small Island Water Information Network (SIWIN) *(Speaker: Dr. Siyan Malomo* —Commonwealth Science Council)
Discussions

NETWORKS FOR COOPERATION

9:15 - 10:30	OAS: Inter-American Dialogue on Water Management and the Inter-American Water Resources Network *(Speaker: Mr. David Moody)* WMO: Hydrological Cycle Observing System for the Caribbean Basin *(Speaker: Mr.John Bassier)* CATHALAC: Networking *(Speaker: Ms. Maria Concepcion Donoso)* INSULA: International Scientific Council for Island Development *(Speaker: Mr. Ronald Parris)* UNU/INWEH *(Speaker: Dr. R.J. Daley)* Discussion
10:30 - 11:00	Break

EXISTING PROGRAMMES FOR REGIONAL COOPERATION

11:00 - 12:30	IDB: Strategy for integrated Water Resources Management *(Speaker: Mr. Luis Garcia)* World Bank: Water Resources Management Policy *(Speaker: Mr. Francois Marie-Patorni)* CDB: Support for Water Resources Management *(Speaker: Mr. Wendell Lawrence)*

Discussions
12:30 - 1:30 Lunch

WORKSHOP: DEVELOPING SPECIFIC STRATEGIES FOR THE CARIBBEAN

1:30 -6:00 *Parallel Group Discussions*
Themes: Public Awareness and Education Strategies
Strengthening Institutional and Coordination Strategies
Legislative and Policy Development
Financing Strategies

DAY 4

8:30 - 12:00 Parallel Group Discussions (cont'd)
12:00 - 1:30 Lunch
1:00- 1:30 *Luncheon Address*: Model Watershed Management Programmes Focusing on the Use of Climate Data (Speaker: Mr. Allen Zack, —NOAA)

REGIONAL STRATEGY

Chair: Mr. Donatus St Aimée

1:30 - 3:00 *Plenary Presentation*
Thematic Group Recommendations for Regional Development
3:00 - 4:15 Regional Strategy and Programme of Action for Strengthening Water Resources Management in the Caribbean

CLOSING SESSION

Chair - Mr. Donatus St Aimée

4:15 - 4:45 Remarks: EDI: Mr. Francois-Marie Patorni
OAS: Mr. David Moody
IDB: Mr. Luis Garcia
CDB: Mr. Wendell Lawrence

Seminar Closure : His Excellency, the Honourable Trevor Sudama Minister of Planning and Development, Government of Trinidad and Tobago

ANNEX 3. PAPERS PRESENTED

CURRENT PARADIGM IN THE ECONOMICS OF WATER RESOURCES MANAGEMENT

Mr. Sergio Ardila, Economist
Environment and Natural Resources Management Division
Regional 3, Inter American Development Bank
Washington DC

Introduction

The design, analysis and implementation of projects in water resources management (WRM) has been an important area of work for Governments and the private sector for a long time. Looking at the amount of financial resources lent by the IDB to countries in Latin America and the Caribbean during the last years we can get an idea of how important this field continues to be. Loans provided by the IDB during 1996 for environmental purposes totaled US$815.3 million, and 83% of that amount (US$677.9 million) was devoted to water resources related projects. In 1995, environmental loans amounted to US$795.6 million, and water resources related projects (US$753.6 million) represented well over 90%. The total amount lent by the IDB for environmental projects during 1992, 1993, and 1994 was well above US$1.1 billion, and again WRM related projects represented a significant fraction. Figures on investments carried out by the private sector are not readily available, but it could be expected that the numbers most likely surpass those above. We should not wonder why people keep asking all sorts of questions about the economic rationale behind these investments.

These concerns have found answers in the dedicated work of academics, public officials, and staff at International Organizations who have worked on this subject for a long time. To present the current thinking on the economics of WRM 1 will briefly describe what it was approximately 25 years ago, then I will provide a summary of what we have learned from experiences during this time, and finally I will present what I think are the fundamental changes in the way we do economic analysis of policies and investments in general and water resources management in particular.

This review shows that traditional ways to do economic analysis based on the dictates of welfare economics and its concern about efficiency principles are now complemented by more careful descriptions of the way economic agents interact taking into consideration the role of institutions and information on shaping incentives and economic behavior.

Economics of Water Resources Management During the 1970's

The economics of WRM was developed initially from the basic principles of welfare economics and natural resource economics. Welfare theory provided the definition of economic efficiency as a criteria to judge resource allocations and production decisions, and the two fundamental theorems of welfare economics showed that efficient allocations can be achieved through a competitive equilibrium. On the other hand, natural resource economics showed us how the interaction of physical links, time dependencies and demand for renewable and non-renewable resources generate opportunity costs, and the dangers of ignoring them in the solution of allocation problems. These two bodies of literature were used by academics and practitioners to develop several practical applications like the well known fields of economic appraisal of projects, as a general subject, and its applications to the analysis of WRM investments. Environmental economics has been growing as an identifiable field in economics during the last 20 to 30 years, generating a wealth of policy recommendations and practical ways to look at pollution problems and natural resource management problems in general. It is customary now to think that natural resource economics deals more with stock related problems, while environmental economics has concentrated more on the policy issues

arising from externalities, and valuation of environmental amenities. These three areas, welfare economics, natural resource economics and environmental economics contain today the basic principles used in the analysis of WRM investments and policy problems.

It is interesting to observe that around the 70's it was possible to get courses of water resources economics either from economics departments as well as from water resources departments within graduate schools in civil engineering. The areas or course chapters emphasized were not the same. Courses taught in economics departments stressed the analysis of welfare issues, and sometimes the current thinking on development economics, while courses in engineering departments emphasized the dynamic linkages- either through time and/or space- and the stochastic nature of the resource.

The presentation below describes some of the main concerns tackled in the literature and practice of economic appraisal of projects, as a way to illustrate how the basic tenants of this fields were used to analyzed public investment decisions in general, and WRM investments and policy decisions in particular.

Economic Appraisal of Projects

Economic cost-benefit analysis evolved from the traditional techniques used in the financial analysis of projects by the private sector. The bulk of the methodology was developed in a series of research efforts by Little, Mirrlees, Harberger, Dasgupta, Sen, and Marglin. These methodologies differed on certain aspects such as the definition of the numerary, the emphasis on considerations about income distribution effects and some others. After a few years of discussion, it could be said that the methodology proposed by Squire and Van der Tak, based to a great extent on Little and Mirrlees, became the standard and so was labeled LMST.

The basic tenant of this literature was that in order to analyze public investment projects the analyst needs to estimate the net contribution of the project to the welfare of society comparing the most likely scenarios, with and without the project. In order to do that a fundamental point had to be remembered: market prices, if available, rarely were considered to be good indicators of the true value to society of inputs and outputs of the project.

The comparison between the with and without the project scenarios was normally made through the estimation of costs and benefits for two situations. First, a scenario that somehow resembled a possible evolution of conditions existing at the time of the analysis without the project, and second, the presumed evolution of production and costs based on projections of the impact of the project on main input and output markets. It is necessary to recognize though that practitioners with limited resources and time practiced less than academics preached.

Examples of distortions in the pricing system were abundant. Exchange rates were mostly undervalued due to the existence of very high and varying import tariffs, import controls, export subsidies and the like. Many goods were subject to marketing distortions, labor markets were subject to important price controls, and Governments participated in the production of many goods that were sold at prices that did not reflect their true production costs. Public services such as electricity, telecommunications, water, garbage collection and others were provided by public agencies charging in many cases prices well below actual marginal costs. In the case of natural resources used as inputs in projects, renewable and non-renewable, it was common to observe that Governments regulated their markets, and in most cases allocations were made by administrative procedures with very little reference to actual opportunity costs. Pollution costs were frequently recognized but seldom estimated and internalized in production costs due to lack of adequate legal frameworks and enforcement mechanisms.

To ameliorate these valuation problems, the project appraisal literature proposed the estimation of accounting prices, some synthetic prices estimated by economists that would reflect in a better way the true value to society of goods and services. Besides accounting prices for inputs and outputs, the LMST methodology proposed the estimation of national parameters, understood as the price of goods and services that will be the same for all projects carried out by a Government. A common organization of the work was to estimate the following set of parameters and accounting prices:

- National parameters: accounting discount rate, consumption interest rate, marginal productivity of capital, standard conversion factor, consumption conversion factor, investment conversion factor, accounting price for labour, accounting price for foreign exchange.

- Accounting prices for traded and non-traded goods: all goods whose incremental production or consumption with the project could be considered at the margin to be provided or destined to international markets were considered traded goods. Accounting prices for non-traded goods were computed taking into consideration the accounting prices of goods used in their production and/or the displaced consumption.

There were two basic levels for the analysis: efficiency prices and social prices. The evaluation was conducted at efficiency prices, whenever it was assumed that a unit of additional consumption was as valuable as a unit of investment, and that the marginal utility of consumption didn't change with income levels. These assumption implied that there were no difference as to who would benefit from a particular project. On the other hand, if income re-distribution effects were explicitly taken into account through consideration of changes in the marginal utility of consumption, and income saved was considered more valuable than income consumed, the evaluation was said to be conducted at social prices.

It was assumed that national agencies in charge of planning public investments were responsible for keeping updated values for all national parameters, particularly accounting prices for foreign exchange, conversion factors for consumption and investment, and the accounting discount rate. Project analysts were responsible for estimating accounting prices for main inputs, outputs and wages.

The outcome of this exercise once all computations were finished was a summary index - for instance the net present value of the project —that would indicate whether the project was economically attractive for society as a whole. Whenever the analysis was conducted at efficiency prices, it was considered that the main distortions in the economy were taken into account but no considerations were incorporated in relation to income distribution or how the income was spent. The attractiveness of the project was judged this way against all possible alternative investments, which were represented in the analysis through two main avenues: I. the accounting prices for all goods and services used or produced with the project; and ii. the accounting discount rate, which represents the best alternative use of the resources consumed with the project.

Economics of Water Resources Management

The fundamental principles followed in the economic analysis of water resources projects were not that much different from those used for other infrastructure projects, or even social projects, but certain aspects of the analysis were normally emphasized.

It's been very interesting for me to read again some sections of the classics in the analysis of WRM projects such as the books by Howe and James & Lee. As mentioned before, these texts regularly presented the main tenants of welfare economics embedded in the two fundamental theorems, and then they provided detailed descriptions of the

particular challenges presented by WRM investments and policy decisions. It was normally stressed that although computations were similar to those required for the analysis of private WRM projects, public decision making implied a broader focus involving economic efficiency issues. It was fairly common to present the discussion about different policy dimensions of the problem in the framework of multi-objective programming, a mathematical tool capable of summarizing tradeoffs among competing goals, such as income redistribution, regional development and environmental quality. Once the tradeoffs were estimated, decision makers were supposed to choose among the feasible combinations, eliciting in this way the preferences implied by an implicit social welfare function.

The presentation was normally very careful in the discussion of the close links between economics and engineering aspects of project design, particularly in cases such as flood control, drainage, water supply, hydropower, navigation, water quality control, recreation possibilities and even the impact upon fish and wildlife. The complexities generated by dynamic aspects through time and space of water resources management were discussed at length in academic as well as good conceived projects. Lots of research efforts were dedicated to better understand the economics of water supply projects based on groundwater resources and their particularities derived from the limitations imposed by maximum yields and their stochastic nature.

While it is almost customary today to read about the lack of concern for environmental and financial sustainability issues in the past, the fact is that these issues have been recognized for a long time in the literature, but the implementation of well known solutions has not been common practice. For example, Howe's book has a chapter on criteria for project design and selection and a group of case studies to illustrate the concepts. Prominent in the list of issues for special attention are: consideration of project alternatives, measurement and valuation of environmental impacts, and pricing.

To explain the role of prices Howe wrote (p. 95): The pricing scheme will substantially affect the total quantities of water used, the temporal pattern of water use, the distribution of net benefits from provision of water or other outputs, the demands for different water qualities, and the financial receipts of the water agency. The major purposes to be accomplished through pricing are:

1. to see that available water services get allocated to the highest value uses;
2. to adjust the quantity demanded by customers to the economically efficient quantity, that is, the quantity for which incremental cost just equals the customers' valuation of the last unit used;
3. to provide the proper inducement to system customers to seek the socially least cost solution to their particular problems; and
4. to recover some portion of the costs of providing the water related services.

It is generally felt, as a matter of social equity, that the persons who benefit from public programs should pay their costs.

Pricing has been an important chapter in the economics of WRM investments because their outputs are normally sold under natural monopoly conditions, or in regulated markets like in the case of private utilities in the United States. Economists have understood for a long time that it was important for the economic analysis to come up with an indication of prices to be charged for the services provided by WRM projects. Long run marginal price was normally presented as the standard to be achieved, customarily estimated as average incremental price over a long run projection for the life the project. At the same time, peak-load pricing was suggested for those services with important fluctuations in demand that implied capacity investments beyond what would be necessary for approximately constant demands.

The financial problem induced by marginal cost pricing under economies of scale, that is, total revenues not covering total costs, was treated in the literature in several ways such as:

I. by using second best pricing, following the inverse elasticity rule derived by Ramsey in the 1930's; and
ii. by lump sum transfer payments to cover part of the capital investments.

This problem was never very serious in most water supply projects that used the long run approach to pricing, given that under a long term planning scenario that optimize capacity expansions over time, the least expensive alternatives are built earlier and so marginal cost are increasing over time. Water supply projects for Caribbean countries may experience some difficulties in this regard, that is, applying long run incremental cost pricing, since recent technological improvements in desalinization processes are reducing costs.

The environmental aspects of projects were normally treated either as constraints imposed on the design of project alternatives or as implied costs estimated from the reductions in environmental quality. This is an area where the toolbox of methodologies available to practitioners has been growing rapidly during the last two decades. Contingent valuation has evolved into a widely used method, accepted for the design of public policies and even in court. At the same time, the literature has been clear about the need to incorporate the opportunity costs of natural resources, water being one of the most common examples. Nevertheless, the process of accepting that naturally occurring resources command an opportunity costs has been a long and difficult one.

Lessons from Experience

The conceptual framework for the economic analysis of investments in general, and WRM in particular, has been used for quite some time already. Valuable lessons have been derived from this experience.

Economic Appraisal of Projects

Multilateral institutions and some academics have been trying to evaluate during the 90's what has been achieved after almost a quarter century of work with cost-benefit analysis. Several evaluations have been conducted, and even several papers on the subject were presented at the 1997 meeting of the American Economic Association. An evaluation of actual practice conducted by Little and Mirrlees in 1991 arrived at the conclusion that in certain sense economic appraisal of projects had been abandoned.

1. Social pricing using distributional weights has been abandoned.
2. No distinctions were made between public and private income, or between the uses of income, whether saved or invested.
3. Sectoral conversion factors were rarely if ever calculated and used.
4. Shadow wage rates were not systematically used or estimated.
5. The values of non-traded goods were mostly converted to border values by a single conversion factor, which implies that relative prices of non-traded goods were assumed to be undistorted, except perhaps that taxes were subtracted.

While one can be surprised by these findings, it is also encouraging that practice during this time have taught us some lessons:

I. The estimation of accounting prices, costs and benefits is just the start of projects analysis.
II It was misguided to put so much emphasis on the methodologies to estimate shadow prices and conversion

factors. Computing accounting prices is one of the many tasks needed to identify the true impact of a project on society's welfare.

II A complete analysis requires an important effort to uncover the personality of a project: what would happen if the project is not carried out? Under what conditions would be likely that the project will not preform financially? How can the project be designed to make it more robust?

It is fair to recognize though that these questions were being made most of the time at multilateral institutions. All those who have been at internal committees at the IDB have heard these and many other related questions being asked to project teams. What we are making clear now is that this question was not institutionally incorporated in appraisal procedures.

As a result of these findings a new standard has evolved incorporating lessons from experience. This new approach to cost benefit analysis has certain well defined characteristics:

I. There is a great emphasis on understanding the economic forces surrounding the project, and its most likely behavior in an uncertain world.

II The use of distributional weights and different public and private sector income weights has been abandoned.

III. Shadow prices are used selectively depending on the severity of market distortions.

IV Environmental costs and benefits are included as part of the economic analysis. An informal survey conducted by the author among IDB project economists confirmed that this new standard has been closely followed for some time already by most economists at the IDB. Conversion factors are used for severely. Distorted prices, shadow wage rates are estimated whenever there are clear signs of unemployment or disguised unemployment, standard conversion factors are used for all non-traded goods, and no attempt is made to use social pricing. Distributional consequences of the project are estimated sometimes based on equal participation on net benefits, and most frequently by providing an estimation of the percentage of beneficiaries whose income fall below a poverty line defined for every country.

The 90's have also seen fundamental changes on the way to implement infrastructure projects. Private sector participation is now sought on almost all type of public services and there is a renewed concerned about institutional frameworks. In order to incorporate some of the questions raised by these changes some authors claim that fundamental changes are required on the way we do economic analysis of projects. Nevertheless, as was nicely put by Harberger on a recent paper, most questions can be fit easily within the traditional economic efficiency analysis of applied welfare economics. Four points have been brought to the discussion:

There should be a rationale for public sector involvement if the project is going to be done by the public sector.

While dictates of traditional welfare economics implied that the analysis should be invariant as to who develop projects, the theory always made clear that all differences in terms of production efficiency, tax proceeds, crowding out private investments, ability to incorporate innovations and the like are certainly efficiency concepts which ought to be part of the analysis under traditional methodologies. Thus if a project carried out by the public sector is expected to be less efficient and as a result would supply goods at higher costs than a similar one carried out by the private sector, that should be enough to disqualify the public sector project.

Projects should be compared with a clear counterfactual, which in many cases is just the creation of appropriate conditions for the private sector to do the job.

In relation to the development of counterfactual project alternatives, we need to recognize that economists have

known for a long time what is needed. The fact that we want to consider new alternatives doesn't change much in relation to the traditional prescription to use the comparison of the with and without the project scenarios as the basis for the analysis.

Fiscal impacts of projects should be identified and their costs included as part of project costs. The traditional convention on cost benefit analysis has been to assume that marginal source of funds for projects is government borrowing in the capital market. Given the fact that fiscal deficits may be generated by public investments through insufficient cost recovery or other mechanisms, it is necessary to recognize that at some point in time governments have to use fiscal revenues to pay off the debt. Given that all real world taxes are distortional, raising that extra revenue to carry the debt will carry a cost. As a result, a simple shadow price of fiscal funds applied to all fiscal in flows and outflows would be necessary to do the work of introducing this real world cost.

The issue of fungibility of funds should be addressed by international donors so they can identify what investments are in fact been financed.

Traditional cost benefit analysis has been blind to the issue of fungibility of funds because it focus on the project and not in the financing, which is taken care by the assumption of capital market financing. Given the fact that governments do not necessarily apply the same standards to all projects, and in particular that not all projects are required to get positive net benefits at the opportunity cost of capital, it could well be happening that financial resources provided for rigorously analyzed projects is actually financing marginal projects approved under weaker conditions. Several solutions have been proposed to this problem but all of them are very close to the old recommendation of cost-benefit analysis: use the same standards for all public sector investments, and if this standard is hard to achieve or not possible, at least apply them at the sectoral level by using weaker but still theoretically consistent versions of the analysis such as cost effectiveness or minimum cost solutions.

Economics of Water Resources Management

Two main aspects of the analysis of WRM projects ought to be recognized as lessons learned during the last three decades: I. the need to consider in the analysis the incentives generated by institutional frameworks

given the wide spread failures of public provision of infrastructure services; and II. the need to implement new systems to correctly allocate scarce water resources.

These two points signal that important differences existed between some fundamental assumptions in the traditional economic analysis and the real conditions under which most projects operate.

Symptoms exhibited by infrastructure services in Latin America, water services not exempted, are well known: low quality of service, failure to invest to keep up with population demands, insufficient cost recovery, low efficiency and lack of accountability to customers. While much effort has been directed to correct these problems, it seems that the underlying causes of these problems were not identified for some time. Economic efficiency concepts were used to optimize system's design and to set up cost recovery mechanisms but institutional frameworks, understood in its widest sense, were not given too much attention. As a result, in many cases incentives faced by economic agents (managers, regulator, customers) were not consistent with the behavior assumed during the analysis.

Two issues have been identified as the main source of problems in the provision of services of WRM projects: the confusion of regulatory and operational roles in state owned enterprises —the so called poacher-gamekeeper problem —and the political influence on management. These weaknesses are responsible for the lack of appropriate

oversight, soft budget constraints and confusing incentives which brought about most problems experimented by public utilities.

On the other hand, the literature on natural resource economics has provided all sort of proofs of the negative effects of failing to appropriately charge users the right opportunity costs of natural resources. Most books covering the economics of water resources today put lots of effort to explain the need to achieve a proper allocation of resources and the way in which pricing plays a role. Looking back at the statement by Howe presented above, one concludes that not much is being added. Real world experiences show that most allocations done by administrative systems fail to charge these costs. Tariffs charged for water services barely cover operation and maintenance costs, leaving no room to recover capital expenses and actual opportunity cost of the resource.

Faced with the difficulties of implementing reasonable pricing schemes through administrative mechanisms most economists now endorse the need to find ways to bring market solutions into the picture. Water markets, tradable pollution permits and some other market-like mechanisms are now proposed as the alternative to achieve correct allocations of water resources. All these schemes have the advantage of leaving consumers the difficult task of uncovering the right price for scarce resource, and assigning to governments the roles of regulator, and provider of information needed to make these markets work. The roles left to public agencies were initially seen as simple, but experiences have demonstrated that they require lots of resources, human as well as physical, in order to keep track of transactions and their implications on the way the whole system is working.

Current Thinking

Economic efficiency concepts are at the core of most welfare analysis done in economics and they have provided the basis to do economic analysis of WRM investments. The discussion above showed that cost-benefit analysis, without losing its grounding on applied welfare principles, has gone through a process of transformation from a heavy machinery methodology to become an enriched practice concerned with the particularities of the project, its alternatives, and the rationale for public sector involvement. The analysis of infrastructure projects, WRM investments included, has gone also through transformations and institutional issues are now at the centre of the discussion, but still we continue to be very much concerned with economic efficiency principles.

What has changed? I believe that the main point brought about by recent adjustments to the way we view and analyzed WRM investments is that the old known fact that institutions matter is now being fully understood and recognized. Nobody questions today that the economic efficiency analysis is heavily dependent on the institutional framework. People's behavior is affected by property rights, changes in the form of contracts elicit changes in behavior which many times have important consequences in terms of economic efficiency. Examples about the importance to consider actual incentives as part of the economic analysis abound.

Theoretically correct tariffs for water services will not generate a financially sustainable utility if consumers know that service will be provided even if they don't pay.

Public utilities that don't balance the books are unable to obtain financing to expand their services, and this circumstance hurts low income customers most of the time, even though low tariffs are supposed to be in place to benefit them.

Pollution charges will not elicit the correct amount of treatment whenever polluters know that enforcers are unable to measure effluents.

Managers of companies who don't have to balance the books or can't capture profits will not put the same amount of effort to reduce costs and exploit profit opportunities than those facing hard budget constraints.

Regulators working for the enterprise being regulated will put less effort to control quality, costs and environmental impacts.

These renewed concern with institutions is one of the results of a new paradigm in economics that has been getting its way through during the last fifteen years. This new paradigm can be referred to as the information approach to economics and it is concerned with a variety of problems that arise from the absence of perfect information, the costs of acquiring information as well as the absence or imperfections in certain key markets such as risks and capital markets, and the way rules and information affect incentives.

Most of the work done in the area of information economics involves situations of asymmetric information, that is, situations in which one or more agents know something that other economic agents don't know. The traditional example in this area is that of a worker, who is almost always in a better position to observe the true amount of effort and output produced than the employer. However, careful observation may provide the employer the ability to infer something about worker's productivity.

Most kinds of incentive/asymmetric information problems are modelled using the Principal-Agent framework. In this model the principal wants to induce another agent, called the agent, to take some action which is costly to the agent. The principal can't observe directly the actions of the agent but he can observe some kind of output which is related to the effort devoted by the agent. The problem facing the principal is then the design of a payment/incentive which induces the agent to take the best action from the point of view of the principal.

The application of this new and more realistic way to frame conventional problems has enriched several aspects of traditional economics such as: i.the theory of the firm, by introducing considerations about divergences between the interests of shareholders and managers and between managers and workers; ii. development economics, by generating a new theory about rural organizations; and iii.welfare economics, by clarifying the perfect competition model standard, the role of markets, and the cases in which a market economy handles efficiently informational problems.

The analysis of the provision of infrastructure services has been particularly enriched by these developments. The design of auctions, contracts and procurement in general, is now based on expanded versions of the Principal-Agent model. The whole field of regulatory economics, which has provided the theoretical foundations for most of the most work done on privatization of public utilities, has advanced beyond the Averch-Johnson and Ramsey-Boiteaux models thanks to the discipline of the broader principal-agent model.

The traditional approach tackled some of the same problems mentioned above but failed to exploit the fact that incentives are fundamentally shaped by institutions and the availability of information for all parties involved. The more rigorous and realistic new approach to economic analysis requires that the basic model be enriched with: I. a full description of the objective function of firms, consumers and regulators; ii. information asymmetries; and iii. institutions, rules and the way they are generated/updated.

In some sense, the old concern about the proper valuation of goods and services is now complemented with the concern to properly capture the most likely behavior of all agents involved. Economic analysis, after all, is nothing but an attempt to find optimal solutions to allocation problems based on predictions about how people will behave.

The traditional questions of what to produce, how to produce and for whom should it be produced, are now complemented by two new questions: how should these decisions be made and who should make them.

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IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES IN THE COMMONWEALTH CARIBBEAN

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Abstract

The possibility of climate change in the foreseeable future is a major environmental concern of our times, and it introduces additional dimensions of uncertainty and complexity in the domain of water resources management. This paper points out, by means of two simple but pertinent examples, that notwithstanding the long term and uncertain nature of climate change predictions, the prudent course of action is to consider the likely impacts of climate change on the planning and design of contemporary and forthcoming water resource projects; since retrofitting is likely to be more expensive.

Introduction

The impact of climate change on the water resources of the Commonwealth Caribbean islands, in particular the smaller islands, is likely to be far reaching, and would range from changes in the temporal and spatial precipitation patterns, rates of evapo-transpiration and consequently on groundwater recharge. Further, the accompanying sea level rise and the higher frequency of hurricane generated storm surges will exacerbate the sea water intrusion in critical water lenses and aquifers. Thus, these impacts have the potential to create crisis and conflict in the water resources sector, and therefore institutional intervention and advance scientific planning are required for sustainability of water supplies. The objective of this paper is to bring into sharp focus the impact of climate change on the integrated water resources management in the Commonwealth Caribbean, and the need for innovation and advance planning for dealing with the uncertainty of climate change.

Climate Change

It is well known that our planet is kept warm by the natural greenhouse effect created by carbon dioxide and water vapour in the atmosphere. However, since the industrial revolution human activities, such as combustion of fossil fuels and deforestation, have caused an increase of carbon dioxide and other greenhouse gases in the atmosphere. Thus, the possibility of climate change has deep historical roots, and it appears that human activities are causing a warming of our planet; but there may also be alternative causes, eg, an increase in the incoming solar and /or cosmic radiation.

The Fluid Dynamic General Circulation Models predict that, if no measures are taken to reduce the emission of the green house gases, an increase in global mean temperature of about 10 - 30 C and a sea level rise of 15 - 95 cm are expected before the end of the next century (Houghton, et al, 1995). Needless to say that the wide margin of predictions reflect the many uncertainties inherent in the afore-mentioned predictions. These uncertainties are caused by an insufficient understanding of the underlying physics of climate change, especially as it relates to the coupling of land, oceans and atmosphere. Further, numerical errors, arising from the use of coarse spatial and temporal grids, and the different possible scenarios of green house gas emissions in the future introduce additional degrees of uncertainties.

Impacts on Water Resources

Climate change is likely to impact on the water resources in the Caribbean in a number of ways (Shrivastava, 1994). Specifically, the annual precipitation is projected to increase by approximately 6% in the western Caribbean and decrease by approximately 4% in the eastern Caribbean. Further, changes in rainfall are expected to take place in the dry season. Consequently, the eastern Caribbean may have more severe and longer droughts, where as the western Caribbean would benefit from increase in the dry season rainfall. Regarding groundwater, an increase in the sea level due to climate change is likely to moderately increase the extent of seawater intrusion into the alluvial aquifers. However, it would severely impair the water quality in shallow water lenses and high conductivity limestone aquifers which are important, and in places critical, sources for public water supplies in the Caribbean (Shrivastava, 1997).

Regional Implications

The regional implications are examined with reference to the institutional aspects, as they relate to socio-economic considerations, public education and intervention. Further, the implications are illustrated with reference to the following two simple examples.

The first example refers to the likely increase in seawater intrusion into coastal aquifers; which may be caused primarily by the sea level rise. This would have a significant impact on the quantity and quality of water available from shallow aquifers and water lenses in islands such as the Bahamas and the Cayman Islands. In this context it should be noted that a coconut tree transpires approximately 200 litres of water per day. It may be therefore prudent to selectively clear coconut trees from fresh water lens areas to maximize the supply of water (Falkland, 1992). However, coconut trees provide the idyllic setting of small Caribbean Islands, and therefore, from the tourism perspective, selective cutting of these trees will require scientific planning, institutional intervention and public education.

The second example refers to the need for a review of engineering design standards as they relate to the construction of water supply and land drainage projects. This is because such projects may operate in a climate different from that prevailing at present. It has been shown, (Shrivastava, 1994), that it is much more economical to currently design a drainage channel taking into account the anticipated sea level rise, than to retrofit the same in the future. Further, since climate change would violate the assumption of stationarity of hydrological time series, the return periods of design storms may change, e.g., a fifty year storm may occur with a smaller return period. Therefore, there would be a need to amend the existing engineering design criteria and methodology, which would also require institutional intervention and public education.

Conclusions

The foregoing brief discussion of the impacts of climate change on water resources points out that there are basically two options available. The first is to wait and see, and retrofit when climate change becomes undeniably evident. This option is likely to lead to crisis and conflict. The second option, to carry out advance planning and preparedness in spite of the long term and uncertain nature of climate change, appears to be the preferred one as it ensures sustainability, and leads to advance planning, scientific research, institutional intervention and public education.

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WATERSHED DEGRADATION AND MANAGEMENT IN THE CARIBBEAN ISLANDS

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Objectives

- Examination of the Factors affecting Watershed Degradation
- Consequences of Watershed Degradation
- Soil Management Practices
- Institutional Arrangements for Effective Watershed Management

Definition of Watersheds

- Drainage Basin.
  - Hydrologic Unit
- Physical Features of Caribbean Watersheds
  - Upper Watersheds
  - Lower Watersheds
  - Coastal Zone and Marine Environment, Social and Economic Factors

Land Degradation in the Humid Tropics

- Humid Tropical Environment
  - Climatic Parameters
  - Significance of Forest in the Humid Tropics and the Physiography of the Caribbean Islands

Overview of Factors Affecting Runoff and Soil Erosion: Extent and Severity

- *Natural Factors*
  - Hurricanes

C *Man-made Factors*

- Inappropriate Agricultural Practices,
- Shifting Cultivation
- Slash and Burn
- Poor or no Soil
- Poor Tillage Practices
- Fires (Malicious, Accidental)
- Land Clearing for Agriculture and Squatting
- Charcoal Burning,

Settlements

- Formal
- Informal

Water Quality Deterioration

C Sediments from Erosion

C Chemicals

- Agricultural
- Industrial

Evaluation of Watershed Management Practice

C *Management of Agricultural Lands*
- Soil Conservation,
- Agronomic and Cultural Practices,
- Engineering Practices

Agronomic and Cultural Practices	Engineering
C Conservation Tillage C Intercropping and Crop Rotation C Mulching C Contour Farming and Contour Ridges and Furrows C Strip Cropping Grass and Trash Barriers C Land Use according to Soil Capability	**Drains** Stormwater Diversion Drains, Cut-off Drains, Step-down Drains Terraces, Bench Terrace, Mini-Terrace and Orchard Terrace Stone Terrace and Stone Basin

Management of Forest Lands

C Forest Wardens
C Reforestation
C Agroforestry

Management of Settlements

C Management of Infrastructure
- Roads
- Drainage
- Waste Disposal

Economics of Watershed Management

C Benefits of Upper Watershed Management (UWM)
C Sharing the Costs of UWM (Especially Soil Conservation of Agricultural Lands)

Institutional Arrangements for Effective Watershed Management

C Present Administrative Arrangements
- Role of Central Governments,
- Role of Local Governments
- Integration and Coordination among Sub-Sectors

Examples of Success
- Role of Governments
- Role of Community
- Incentives Programmes
- Public Awareness

Integrated Watershed Management

- Clear Government Policy on Watershed Protection
- Institutional Arrangements to Implement to Policy and Plans
- Formulation and Implementation of Relevant Legislation
- Appropriate Land Capability and Land use Schemes which Prevent Land Degradation, Allow Optimum use of the Land without Damage to the Environment, and Allow for Orderly and Planned Land development and land settlement schemes
- Appropriate Watershed protection and water management in forested and upland regions or the watershed.
- Land protection and flood control devices
- Elimination or minimize of harmful activities in the watershed e.g. deforestation, squatting, overgrazing, slash and burn agriculture, excessive charcoal burning, beach mining poor waste management and disposal, and excessive use of agriculture chemicals.

Note: All relevant regulatory authorities must be fully informed and must participate and collaborate as necessary.

IMPACT OF AGRICULTURAL DEVELOPMENT IN THE CARIBBEAN

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Abstract

Agricultural development in the Caribbean began with the arrival of settlers from Europe in the 16th Century. Plantations of tobacco, sugar cane, cocoa and coconuts were carved out on the forested flat coastal plans and inland valleys.

But it was sugar that changed the course of settlement as slaves were brought from Africa to work on the sugar plantations.

After the abolition of slavery around 1837, indentured labourers arrived from India and China. The freed slaves occupied small plots of land at the edges of the plantations for the growing of root crops. This was the beginning of peasant farming in the Caribbean. Some indentured labourers also obtained land for the growing of rice and plantation crops.

During this entire period there was severe deforestation as plantations spread out along the lower reaches of watersheds. There was no interest in environmental protection nor water resource management. Peasant farmers employed slash and burn land clearing, methods and shifting cultivation practices geared towards a subsistence type of agriculture. The forests were also felled for timber, fuelwood and charcoal.

As the colonial rulers expanded agriculture during the 19th and early 20th centuries, plantations were extended on coastal plains and small peasant farmers were pushed more up slope on the watersheds. Deforestation of watersheds proceeded rapidly under the increased cultivation and settlement. Meanwhile, the banana era increased the use of agricultural chemicals.

By the dawn of independence in the 1960's there was widespread poverty, unemployment, a degraded natural resource base, heavily denuded watersheds, severe soil erosion and inland and coastal water resources polluted by sediments, human generated wastes and agrochemicals. These problems were brought about because of a complete lack of interest in environmental and water resource management.

Up to the present time there is no clear governmental policy commitment to sound water resource management and Caribbean countries are now awakening to this need by the formulation of national environmental action plans. Many countries of the region have water resource management systems in place for domestic supplies but there is no integrated approach that links supply with demand across all sub-sectors. Integrated water resource management is required to place technological, socio-economical, environmental and human health considerations into a dynamic, interactive, and multi-sectoral approach, including supply-side and demand-side considerations within a sound institutional framework.

Introduction

Freshwater is critical in Caribbean countries. Economic activities linked to agriculture and other sectors are using water resources intensively and pressures on them are increasing rapidly. During the 17th and 18th centuries the focus on sugarcane production and settlement in the interiors of the islands and on the coastal strip of Guyana and the rivera in areas of Belize brought about a cycle of environmental degradation that continues today in most countries of the region (Cox and Embrie, 1990).

Large quantities of toxic agricultural, domestic and industrial contaminants are disposed of in rivers and streams that flow into the Caribbean Sea. These include highly contaminating organic effluent heavy metals and radioactive materials (IDB/UNDP, 1990). Watersheds have been deforested and their water courses have been fouled by contaminated sediments. Rapid urban population growth and industrialization are putting severe strains on the quantity of water resources for human consumption, industrial use, and agriculture. Even where rainfall is abundant, access to clean water has been restricted by inadequate storage and delivery systems (UN, 1994).

Concentration of population, infrastructure, and anthropogenic activity along narrow coastal plains and hillsides of watersheds produce both solid and liquid waste. Coastal swamps and the near shore coastal waters are often used as waste disposal sites for untreated sewerage. Most of the countries' coastal and marine ecosystems (coral reefs, seagrass beds, beaches, mangroves, wetlands) are under stress from pollution caused by particulate matter, agricultural chemicals (nitrates, phosphates and pesticides), industrial effluents, poor land management, erosion and waste from coastal settlement and urban centres. Tourist-related garbage, petroleum industry contaminants, and ship-generated wastes and oil discharges all cause severe degradation of coastal zone water resources with deleterious effects on fishing and tourism (Hunte, 1985; Maclean, 1979; IDB/UNDP, 1990; UN, 1994; Hendry and Nurse, 1991; Chakalall, 1985; Oxenford, 1991).

This paper traces the development of agriculture in the Caribbean region from the arrival of Christopher Columbus to the present. It examines the impact that this agricultural development has had on the hydrologic cycle and the need for Caribbean countries to employ the principles of integrated water resources management in order to halt the environmental degradation that has taken place and to ensure that policies are put in place so that the economic development pathway being followed by the region is sustainable. Emphasis is placed on the island countries since they are smaller, have a more restricted and degraded resource base, and face a more critical water resource problem than the mainland countries.

The paper concludes by examining possible future trends in the region's agricultural development and the resulting implications for water resource management.

Agricultural Development in the Caribbean

In 1492 Christopher Columbus arrived in the Caribbean and met native Caribbeans cutting and burning forests to plant ground provisions (root crops) which they took back to their homes along the coastlines (University Antilles and Guyana, 1988).

As settlers began arriving from Europe, they began acquiring large tracts of prime agricultural land on the flat between the mountains and the coastline. Plantations of tobacco, sugar, cocoa and coconuts yielded profits that accrued to European interests away from the Caribbean Islands. This initial economic developmental pathway based on export-oriented agriculture is the origin of poor environmental protection in the Caribbean countries (Rudder, 1991, Univ. Antilles and Guyana, 1988).

But it was sugar that completely changed the course of settlement and development in the Caribbean. Up until the 17th Century tobacco was the main crop for export; it was grown on small holdings. However, by about 1640, tobacco from the American colonies was of better quality and cheaper than that produced in the Caribbean while the price of honey in Europe was ever-increasing. Sugar cultivation, therefore, grew at a fantastic rate in all the countries but sugar was labour intensive and so slaves were brought from Africa to replace the sagging Carib Indian work force that was dying from imported diseases that accompanied the conquistadors. Over the next 300 years (1517-1837) over 10 million slaves arrived from Africa on ships that sailed the infamous trade triangle from Europe to the West Coast of Africa on to the Caribbean and back to Europe with agricultural goods, gold and silver. As slaves worked on the sugar plantations, they grew root crops and sorghum on small plots to feed themselves. At the same time, as development proceeded, trees were felled more and more for building (houses, ships, trains, water mills etc), charcoal and firewood. Land distribution became a serious issue as settlements and plantations grew in size around the 18th Century (Springer, 1987; University Antilles and Guyana, 1988).

The slave trade was gradually abolished between 1807 and 1837. The freed slaves immediately abandoned the plantations and were replaced by indentured labourers who were brought in from Europe, Africa, India and China. Former slaves began a squat on or purchase small land holdings often on marginal hilly or mountainous tracts bordering or away from the large plantations. Indentured labourers, too, were given or bought similar small plots of land for the growing of ground provisions and some plantation crops such as banana, coffee and cocoa. Rice became important in many colonies as the indentured labourers and later settlers from India arrived in the Caribbean. Agriculture on the small holdings was of the slash and burn subsistence type as the plots were hacked out of the forest edge. Independent settlements grew on sloping lands. The large plantations remained in the hands of the European settlers who held political power. Therefore, in the Caribbean peasant farming originated with the emancipation of the plantation slaves. The abolition of slavery also saw agricultural diversification away from sugar and tobacco to other crops, namely coffee, banana, citrus and spices (Univ. Antilles and Guyana, 1988).

The British Empire expanded broadly during the 19th Century and hundreds of hectares were opened up inland for cocoa, coffee, vanilla, citrus, spices, banana and exotic fruit cultivation for markets in the USA, Canada and England. In the Spanish colonies, tobacco and sugar remained very important. After 1930, the banana age grew rapidly under the United Fruit Company in Central America and Geest Industry Limited. This growth was accelerated by sound sea transport and secured markets in the USA and Europe (Univ. Antilles and Guyana, 1988).

Some islands such as the Bahamas and the smaller Leeward Islands were constantly attacked by pirates and buccaneers and so never prospered agriculturally. After the piracy period, they developed fruit, vegetables, sponge and seafood industries (Springer, 1987).

After 1950, squatters on Crown Lands began to obtain small holdings under mortgage or by amicable arrangement between the state and the planters. In the Windward Islands and Jamaica, since 1950, farmers' global strategy was to “get land to grow bananas.” Thus began the age of heavy pesticides and artificial fertilizers (Univ Antilles and Guiana, 1988).

With the advent of independence commencing in the 1960's, the regions agriculture was shaped by economists revelling in the acquisition of political authority and protected markets in Europe for traditional crops. But peasant farming continued to expand on marginal hillsides as population pressure generated land fragmentation. After independence, many large plantations were broken up and divided into small farms. Plantations remained on prime agricultural land; if they were on marginal land they failed economically and were broken up into smaller units (Wilson, 1991). During the 1970's estates greater than 40 hectares occupied over 50% of the arable land in most Caribbean countries while small holdings of less than 2 hectares occupied over 80% of farms on less than 20% of

the arable land. After 1975, there was a slump in the banana and sugar industries and the islands began to think in terms of diversifying their agriculture. However, the presence of protected markets for sugar, rice, cocoa, coffee, bananas, spices and fruit mitigated against diversification. As the global economy slumped in the early 80's international aid became the main element of the economy (Univ. Antilles and Guiana, 1989).

Now in the late 1990's international aid has dried up, protected markets are disappearing and an influx of agricultural products are forcing the Caribbean to diversify its agriculture and to try to compete in quantity and quality in the marketplace.

Demodulation of island landscapes began in the colonial period and has continued mainly in response to population increases and higher levels of consumption. Clearance for cultivation has been one of the most important activities involved in the loss of forest cover (Jackson, 1979). Looking back on agricultural development in the Caribbean it can be seen that there has been no adequate planning and preparation for true development of the Caribbean environment and its people. Beyond the provisions of some infrastructural and physical requirements for human existence, the development of the Caribbean has not included environmental protection nor sustainable use of the natural resource base. There is now widespread poverty, unemployment, a degraded natural resources base, uncertainty in trade and great susceptibility to the vagaries of international markets under liberalization. Water, air and land are diminishing in quality with irretrievable losses of tropical forests and coral reefs; there are denuded hillsides, polluted coastal seas and turbid rivers and vanishing flora and fauna. Generally, there has been a disappearance of species as their natural habitats have been destroyed to make way for “progress” (Rudder, 1991).

Lately, international agencies have been assisting Caribbean Governments in the preparation of National Environmental Action Plans (IUCN, 1993; NRCA/PIOJ, 1995; GOSL, 1994; GOSV, 1994, GOCD, 1994, COG, 1994; CARIF/ENV/005, has always lacked a regional perspective leading to little if any sustainable development. Negative outcomes of human activity in the agricultural sector are seen in most islands with severe pesticide pollution of water resources, deforestation, soil erosion and sedimentation of surface water courses and reservoirs (Rudder, 1991).

Peasant farmers continue to clear watersheds of forest cover for farming using slash and burn methods and practicing little or no soil and water conservation. Peasants are small commercial producers, part-time farmers or landless individuals. Poverty is a widespread characteristic of these last two categories of peasants. For example, the absolute poverty level of the rural population in Grenada is 25% and in Jamaica it is 51% (Chiriboya, 1991). It is this poverty that forces them to scratch out an existence on the hillsides of Caribbean islands with no interest in the long-term impacts on the natural resource base. Presently, some aid-financed projects are addressing hillside farming within a soil and water conservation perspective in many Caribbean countries but it is left to be seen if farmers will adopt better practices after the aid funds run out.

Agricultural Development Impacts on the Hydrologic Cycle in the Caribbean

The Island Countries

Physiography. The Caribbean islands are generally mountainous with the Blue Mountain peaks in Jamaica exceeding 200 m and peaks in the Dominican Republic greater than 3000 m. The Lesser Antilles (Leeward and Windward Islands) consist mainly of a chain of hilly islands with a few low-lying islands outside the main chain. The greater Antilles consist of larger islands that include Cuba and Hispaniola (Nurse, 1985; Wilson, 1989).

The island countries share many similarities in terms of their terrestrial and marine resources and levels of environmental degradation. They are made up of small fragile ecosystems with shared boundaries; this means that damage to one ecosystem has repercussions on adjoining ecosystems. Apart from significant mineral deposits in Jamaica and Trinidad, the islands have a limited natural resource base (Paul, 1996). Watersheds frequently extend from the uppermost edge of the mountains to the sea and include the coastal zone; in other cases they terminate at the rivers that disembogue directly into the sea from very steep watersheds (Gumbs, 1996).

Climate. The islands have a tropical humid climate with marked dry and wet seasons. Rainfall varies from approximately 500 mm/annum in Curacoa to over 4000 mm in the mountains of the Windwards. Rainfall is highly variable in distribution and intensity; storms and hurricanes that cause landslides and soil erosion are common. Even where rainfall is abundant, access to clean water has been restricted by inadequate storage and delivery systems. Dry season droughts and wet season floods require a better control of flows and storages (Wye College, 1996).

Supply and Demand. Except for the Leeward Islands the islands' needs for freshwater are met mainly from perennial rivers and intermittent streams but turbidity of surface water can be a problem (CARDI, 1993; Wilson, 1991). Mountain streams in Jamaica have been found to contain above 300 ppm of sediments (UNDP, FAO, 1973). Also, because of steep slopes, much of the rainfall runs off directly to the sea (30% of annual rainfall in Jamaica and Trinidad) while a large proportion (56% in Jamaica) of the annual rainfall is lost to evapotranspiration (GOJ, 1987). All of the islands except Dominica and St Vincent use groundwater as a major source of water but poor transmissibility of aquifers results in constrained water yield compounded by saline intrusion from seawater (CMI, 1980). In Trinidad, groundwater is almost fully exploited and attention is being turned to surface water storage in reservoirs. In the Windward Islands of St Lucia, Dominica and St Vincent and the Grenadines abundant surface water supplies almost all of the needs of the population. In Barbados, the major source of freshwater is a thin lens below the coral cap and this is contaminated from effluents seeping through the cap (Wilson, 1991). Because of low rainfall and a lack of forested watersheds, the populations in the Leeward Islands are forced to trap runoff in small storage dams, ponds and rooftop catchments to augment water supplies for domestic, municipal and industrial uses (Beller, 1979). Rainy season flows are stored in large tanks for year-round distribution. Some small wells supply about 25% of the Leewards' water needs (mainly municipal). The larger of these drier islands (Antigua, Virgin Islands) have desalinization plants for municipal uses but these plants are not used to full capacity because of the high cost of operation (CCA, 1991).

The long history of exploitation of the countries' water resources without due consideration to conservation and efficiency of use has led to severe restrictions on water quantity and quality thereby setting tight limits on sustainable development. This is particularly the case for low-lying coral-based islands where ground water supplies are limited and are protected only by a thin impermeable soil.

Population Pressure. As the natural and tourist populations increase rapidly in the island countries, the demand for domestic, municipal, agricultural and industrial water supplies is increasing rapidly while agriculture is demanding less water relative to the other sub-sectors. Food imports and tourism are depressing agriculture in many countries leading to a relative decrease in the proportion of water demanded by the agricultural sub sector. Since irrigation is not well-developed in the islands, water use in agriculture has been given low priority. However, in some countries like Barbados, agricultural water use is expected to increase from 20 million liters per day to 49 million liters per day by the year 2000 when demand is expected to exceed supply (IUCN, 1993). During the period 1946-1986, water consumption in Barbados grew at the rate of 5.9% per annum (Wilson, 1991). During the last few years, daily water demand in the Caribbean countries has been increasing due to increased urbanization, tourism, agricultural exports and other land developments (GOSL, 1994). Given the increasing population, the region's drive to increase food production, inadequate water supplies and the fact that per capita use is outpacing

water supplies in most of the islands, it becomes apparent that an adequate water resource is a constraint to sustainable economic growth in the Caribbean Islands (UN, 1994). The marginal cost of water is rising with the demand for water in all sectors.

Urbanization is spreading on the narrow coastal strips and forcing agriculture into more fragile and marginal areas, pushing forests to the upper catchments, and generating more domestic, municipal and industrial wastes and toxic effluents that are polluting both surface and groundwater resources. Population growth on the fragile watersheds is leading to greater land fragmentation and hillside degradation. Wetlands are also being drained for agricultural and other development. In Trinidad, for instance, part of the Nariva swamp was drained for rice cultivation with deterious environmental consequences (Read, 1987; Bacon, 1985).

Deforestation. Deforestation of island landscapes began early in the colonial period and has continued mainly in response to population increases and higher levels of consumption. In Barbados, forests were virtually removed within 20 years of the first European settlement in the 16th century and most of the rest had disappeared by 1750 (Wilson, 1991). Clearance for cultivation and building, tree felling for charcoal fuel, fuelwood and timber are the main activities involved in the loss of forest cover. In Jamaica deforestation is at the rate of 3.3% per year resulting in 400 million tonnes of soil lost due to watershed erosion on the island from 1981 to 1990; the sediment has choked coral reefs and marine fisheries (Cox and Embrie, 1990). Such watershed degradation is also common in Antiga, Cuba, the Dominican Republic, Barbados, Trinidad and Haiti. The level of deforestation varies from almost total in Barbados, Haiti and Antigua to 76% in Jamaica and 47% in Trinidad (CCA, 1989-94; Gumbs, 1992). Deforestation has resulted in drastic changes of flows and storages in catchments, severe soil erosion on steep slopes, sedimentation of water courses and reservoirs, turbidity of surface water supplies, downstream flooding, reduced base flow of rivers and streams, depleted aquifers, reduced ground water recharge, and general degradation of watersheds. Thirteen of the 33 watersheds in Jamaica are severely destroyed (Mulleady, 1994).

Watershed degradation from deforestation and the resulting soil erosion have an immediate effect on the coastal environment due to sedimentation; mangrove swamps, coral reefs, coastal hatcheries and fisheries are severely affected. Soil erosion has been calculated to be about 125 tons per has per year in Jamaica, and up to 213 ton per ha per year in Tobago on some slopes (UNDP, FAO, 1973; Ahmad and (Wilson, 1991).

Land Use. The land use pattern in the Caribbean islands is complex and is influenced by many factors such as socio-economics, topography, ecology, agronomic technology available, land tenure, culture, religion and politics. Small subsistence farmers with holdings of 0.2-2 ha. occupy the upper reaches of the watersheds on steep slopes unsuitable for agriculture while the narrow flat fertile coastal strips are occupied by plantation farmers and urban and industrial development. Small farmers have little or no environmental protection awareness and no vision for sustainable development since their emphasis is on survival and short term cash flow. In Jamaica, approximately 100,000 small farms with sizes usually under 2 ha. occupy hillsides with slopes greater than 20%. Intensive annual cash cropping on these farms has led to deforestation, soil erosion, excessive surface run-off, sedimentation of streams and reservoirs, decreased groundwater recharge of aquifers and agrochemical contamination of surface and ground water supplies. Practices such as slash and burn methods of land cleaning, shifting, cultivation, excessive tillage, overgrazing by goats and sheep and poor soil and water conservation methods have been the primary causes of watershed degradation. Settlement due to agricultural development has resulted in domestic and industrial wastes being discharged into freshwater supplies and rapid runoff of rainfall away from catchments. In St. Lucia, 97% of the island's farmers can be classed as small farmers while the other 3% of farms occupy 67% of the country's arable land (Wilson, 1991); these figures are similar for many of the Lesser Antilles and Haiti. One of the problems facing land use is that land classification systems now in use do not match the soil characteristics with the cropping patterns and, hence, soil degradation results from inappropriate land husbandry practices (UNDP, FAO, 1973).

There is a scarcity of flat land for agriculture as population and urbanization proceed at a rapid pace (Bacon 1995). This has resulted in small farmers encroaching on steep slopes and even into forest reserves. Uncontrolled and antiquated agricultural activities on steep slopes pose the greatest threat to the Islands' water resources.

Water Quality. The heavy use of pesticides together with poor domestic and industrial waste disposal have polluted not only surface and groundwater aquifers but also coastal and reef environments (Gumbs, 1992). In Dominica, the island least touched by human activities, there has been a 300% increase in the importation of agricultural pesticides since 1985 (GOD, 1994).

In Barbados, a level of 0.1-1.0 ppb of the herbicide atrazine has been found by Wood (1997) in the public water supplies while in Jamaica the toxic insecticide Dieldrin and the herbicide gramoxone have been detected in drinking water (GOJ, 1987). In Trinidad, it has been estimated that 90% of the pesticides used end up in the food chain via surface and groundwater (Trinidad Express, 17 May 1997).

The development of access roads linked to settlement, forestry and plantation have accelerated soil erosion, sedimentation and agrochemical contamination of the countries' water supplies.

In some countries mechanization and crop diversification away from sugarcane (the sugarcane trash and root system are good soil protectors) have caused an increase in soil erosion and agrochemical use.

Water quality in the Caribbean Islands is also affected by livestock wastes and by the discharge of untreated sewage from food processing plants and domestic and industrial sources. For example, 40 million litres of such sewage are pumped into Kingston's harbour each day leading to eutrophication of the waters (Wilson, 1991). On many islands, such pollution not only affects surface and groundwater but also the marine environment. For instance, the Gulf of Paria suffers from heavy flows of polluted sediments from Trinidad's watersheds. Mangrove swamps that provide coastal protection and habitat for fish and wildfowl have been degraded by sediments and effluents from run-off. Landfill space is disappearing in many islands; Barbados will have no more landfill space beyond 2000. In some countries garbage is being dumped in gullies, drains, and unused quarries (IUCN, 1993). Over pumping of groundwater also causes salt water intrusion into coastal aquifers and thereby lowers the quality of the water abstracted.

Water Management. Generally, there has been poor water management in the region's agriculture with resulting low water use efficiencies, inappropriate cropping patterns, improperly managed watersheds and the use of outmoded and inappropriate water supply technology. There is little or no supply side development and management since the marginal cost of water is rising and productivity is decreasing. Supply development especially of surface water supplies is so restrictive economically that management focuses almost entirely on the demand side by forcing users to improve water use efficiencies through conservation.

Drainage systems in the islands do not provide adequate flood control. Instead, a lack of drainage infrastructure, improper operation and maintenance and flood flow control account for flood damage (Duggal, 1990; Ramdial and Lakhan, 1980). Pollution of streams by eroded sediments causes clogged drains and water courses and produces stagnant water for the breeding of malaria vectors. The spread of water-borne diseases such as bilharzia is prevalent where water treatment is poor (GOSL, 1994).

The Mainland Countries. In Guyana, intensive agricultural activity in rice, sugarcane, coconuts and other food crops is carried out on the dyked flat coastal strip inhabited by over 80% of the country's population. The sugar, rice and coconut plantations are owned and cultivated by large private and public companies. Smaller farmers

occupy rivera in strips of land. Like the other mainland country Belize, 80% of Guyana is covered by dense forests and the annual rainfall exceeds 3000 mm. There is, therefore, an abundance of freshwater. The forests have remained virtually untouched by agricultural activity. Groundwater provides 90% of potable water supply and is extracted mainly from the coastal artesian basin. Fresh brackish water from the numerous rivers flowing from the interior mountain ranges is stored in conservancies behind the coastal belt and supplies part of the agricultural, municipal, domestic and industrial needs (Mc Pherson, 1980). Although there are abundant water resources from the many rivers, clean water provision and safe waste disposal systems are practically non-existent (GORG, 1994).

Drainage systems on the coastal strip have dumped sediments and agrochemicals into the mangrove swamps that protect the coastline and serve as habitats for fish, crustaceans and wildfowl (GORG, 1994).

Due to the agricultural development and resulting urbanization of the coastal strip, sewage is dumped untreated into the main rivers while livestock wastes, septic tanks, pit latrines and excessive use of agrochemicals cause pollution of surface and groundwater. Malfunction of the drainage and irrigation systems causes flooding of coastal areas both by sea water intrusion and from freshwater overflows. Waterborne diseases including cholera, dysentery, gastroenteritis, typhoid, schistosomiasis, malaria, hookworm and hepatitis are rampant (GORG, 1994).

In Belize, most of the population's water needs are supplied from rivers and streams. These feed from 18 main catchment areas that stretch from the Maya mountains and other uplands that rise steeply from the surrounding southern lowlands to a rolling plateau below 900 m. above sea level. Occasional ridges and summits rise several hundred meters above sea level and in places there are deep gorges carved by swift flowing rivers. Along the coasts, marine silting has created shallow lagoons, numerous reefs and associated sand and mangrove cays. The northern plains consist of rivers, swamps and lakes while in the south there are swift streams radiating from the Maya mountains (Mc Pherson, 1980).

Agriculture takes place on the lowlands and is based on rice, citrus, and sugarcane; pastures support a good livestock industry. Some small farmers occupy sloping land in the south while larger commercial farmers carry out intensive cropping in the upper reaches of the Belize River Valley. A sizeable community of small farmers try to make a living in the lower Belize River Valley. The country has an average annual rainfall of 2000 mm - 4000 mm and has both water table and artesian aquifers. Currently, irrigated water is of minor importance in total water use but there is potential for its development. Most of the population's water needs are supplied from rivers and streams. Domestic supplies are subject to conventional treatment of sedimentation, coagulation, filtration and chlorination (Gonguez, 1980).

Urbanization and population growth have increased surface and groundwater contamination. In some areas, nitrate levels are near or above recommended human tolerable levels due to effluent discharge from human and livestock activities (IICA, 1995). The citrus and sugar industries discharge wastes into surface channels and agrochemicals have been responsible for fish kill in certain streams (Gonguez, 1980).

Integrated Water Resource Management - Lessons for The Caribbean

The transformation of the region's agriculture is geared towards food security and the production of export crops to earn foreign exchange in order to repay national debts. However, there is no clear governmental policy commitment to environmental protection and sound water resource management especially against a background of a limited and fragile natural resource base. The commitment to environmental protection must be as great as that for economic development so that the cumulative impacts (for example, extensive soil erosion and surface and

groundwater contamination) will neither damage nor destroy the resource base on which sustainable development depends (GOJ, 1987).

Strict policies governing the utilization of water resources in Caribbean countries are necessary. Integrated water resources management is required to place technological, socio-economical, environmental and human health considerations into a dynamic, interactive, and multi-sectoral approach, including supply-side and demand-side considerations coupled with a sound institutional framework (UNCED, 1992; UN, 1994). However, in the Caribbean, an integrated approach is hampered by a fragmental approach to water resource management with numerous institutions, agencies and jurisdictions dealing with the various aspects of the use and management of water (Cox and Embrie, 1990). Added to this is a lack of coordination among the various agencies together with a chronic shortage of financial and human resources (CARIF/ENV/005 1994; CCA, 1989-94). Also, in most of the countries there is a considerable body of scattered laws and sections of laws related to water which date from colonial days. These laws are now irrelevant to the present -day situation. As water becomes more expensive to deliver in all sectors as it becomes scarcer and more in demand, there is a need for comprehensive water legislation, overall planning of integrated water resource management and a strong institutional framework for water policies on development and use (Davis, 1980).

The goal of sustainability will be achieved through the formulation of effective planning strategies and fully-integrated, intersectoral and regionally beneficial management approaches. This must be based on precise information, knowledge and assessment of the available water resources and their status, on a continuous basis; community and user groups must be involved in the planning and implementation processes (Chakalall, 1985). In order to optimize sustainable use of water resources, environmental concerns will need to be closely integrated with tourism and agricultural policies and activities. A key ingredient for success is an adequate database on water use by the key sectors (agriculture, domestic, municipal, tourism and industry) (Challenger et al, 1991).

Water resource planning (especially in agriculture) is almost nil in all of the Caribbean countries (Srivastava, 1984) and there is a severe lack of institutional capacity for formulating policies and standards, data collection, monitoring and analysis. There is no coordinated national strategy on water resource use and a general lack of information on water resource needs for agriculture and other sectors (IUC, 1993; CCA, 1989-94; GOAB, 1992). None of the countries has undertaken a systematic definition of its water resource requirements by sub sector, none performs the monitoring of indicators essential to making judgements concerning water resource issues (CARIF/ENV/005, 1994).

Water resource concerns have to become an integral part of the countries' public policies. The achievement of sustainable development requires greater attention not only to the establishment, monitoring and surveillance of standards and the setting up of an effective regulatory framework, but also to enhance use of incentive-based instruments such as taxes, charges, fees and subsidies and policy instruments such as water markets and/or user management (FAO, 1988).

While Caribbean countries have made substantial progress in recent years in enacting natural resource management legislation, much remains to be done to complete the legislative/regulatory and incentive or market-based framework for effective management of the region's water resources. Whenever possible, the harmonization of environmental protection and resources management legislation and regulations in the region should be pursued since there are many environmental, cultural, social and political similarities across Caribbean countries (CARIF/ENV/005, 1994; FAO, 1988).

The Caribbean region still has not developed adequate infrastructure for environmentally sound management of the growing volume of agriculture and other wastes generated by its population. Meanwhile the operation and maintenance of existing infrastructure is highly inefficient.

This problem calls for capital investments in the infrastructure required for collection, storage and delivery systems and recycling or disposal facilities for municipal and commercial solid wastes, as well as treatment and disposal facilities for industrial, domestic and agricultural wastes. Water resources should be further protected by sound water catchment management including reforestation of denuded slopes (UNCED, 1992; CARIF/ENV/005, 1994; UN, 1994). Water flows and storage in catchments must be managed in accordance with demands due to population increase and economic growth. Watershed management also has to do with human activities outside of the agricultural sector and these must be examined within the integrated approach (Jackson, 1970; Springer, 1987). Misuse of land resources and soil erosion are very common in upland watersheds. Water shortage and the quality problem has become more acute in the last decade but the region's governments have still not put in place a land reform programme for proper use and protection of hillsides. The present land capability classification criteria are not suited to cropping pattern requirements of small farmers who by necessity must occupy the fragile hillsides. The steepness of hillsides and high rainfall intensities require effective soil and water conservation measures. Land settlement programmes must go hand in hand with soil conservation and afforestation programmes and observe land capability limits (UNDP, FAO, 1973).

Land ownership discrepancies have left many large estates or flat farms idle while small farmers scratch and degrade steep mountain slopes. Cultivation on steep slopes and increasing settlement are probably the most serious watershed problems in the Caribbean. Legislation should be put in place to ensure that slopes too steep to be farmed are put in forest or agroforestry. Land must be used within its capacity (UNDP, FAO, 1973; NRCA/PIOJ, 1995; GORG, 1994; GOCD 1994; UNCED, 1992).

Possible Future Trends in Caribbean Agriculture and The Implications for Water Resource Management

- Against the background of liberalization and globalization, the loss of preferential markets and the need to compete in cost and product quality in the international marketplace (IICA, 1991), Caribbean agriculture is likely to favour larger producers who will indiscriminately produce on the limited land area with increased mechanization, irrigation, agroprocessing and agrochemicals use as is noticeably the case in Barbados, Belize, the Dominican Republic, Cuba, Trinidad and Jamaica. If policies, legislation, regulations and incentives are not put in place, heavy soil erosion and water contamination are the likely outcomes. Agricultural practices must, therefore, be environmentally friendly.

- As non-agricultural sectors become higher earners in the global liberalized marketplace, agriculture will become less of GDP in most countries (except perhaps Belize and Guyana).The importation of foodstuffs from the USA, Canada, Europe and Latin America will continue to spiral upwards. The result would be that agricultural activity would decline and that water use would increase sharply in the domestic, municipal and industrial sectors as urbanization is fuelled by consumerism.

- Urbanization will spread unto large coastal plantations and push agriculture on more fragile and marginal environments on sloping land. This would result in greater soil erosion and lower productivity in the agricultural sector. Water would be more in demand by the urban sector and water quality would suffer from urban wastes. Urbanization would also cause the younger generation to find jobs outside of agriculture thus further depressing agricultural activity.

C Small farmers will remain in marginal mountain areas and fragmentation of holdings will continue. They will continue to deforest and degrade the land as they pay little attention to soil and water conservation because of market forces, lack of transportation and marketing arrangements, high labour requirements, no apparent tangible benefits obtained from conservation practices, marketing arrangements and insecure land tenure. Because of their location, it will be difficult to enforce regulations governing water use; incentive based policies with respect to land husbandry practices might be more appropriate. They will need to practice agroforestry and afforestation if only to retain some soil on the steep slopes. It will be difficult to change watershed settlement trends by land reform programmes. The best that can be done in this situation would be to mount public awareness campaigns and education programmes for rural communities with respect to environmental protection and good crop and land husbandry practices might be more appropriate. They will need to practice agroforestry and afforestation if only to retain some soil on the steep slopes. It will be difficult to change watershed settlement trends by land reform programmes. The best that can be done in this situation would be to mount public awareness campaigns and education programmes for rural communities with respect to environmental protection and good crop and land husbandry practices.

Conclusions

It is clear that agricultural development in the Caribbean region has had and continues to have a deleterious effect on the environment at large and on water resources in particular. In order to ensure adequate supplies of freshwater together with an acceptable level of environmental protection, governments of the region will need to formulate appropriate strategies for water development and use.

Countries require a central executive body to coordinate the efforts of the various agencies responsible for water development and use across all sectors. Such a body must be responsible for sound integrated water resource management policies that provide legislation, regulations and incentives for water use.

There is a need in the region to identify the sources of surface and groundwater, their flows and storage, and their developmental capacity. Supply-side development must go hand in hand with demand side management and all users of the water cycle at all levels must participate in the formulation of water use regulations. The requirements of the end users must be defined in time and space so as to enable projections for water use.

Water conservation and efficiencies of use in the agricultural, domestic, municipal and industrial sectors must be increased. There is a need for the conjunctive use of surface and groundwater supplies. In agriculture, irrigation should be used only for high value crops so as to maximize profits. Conveyance, distribution and application efficiencies can be improved by lining canals, using drip irrigation systems and the adequate calculation of the consumptive use requirements of crops. Drought tolerant crops and cultivars should be selected. Existing delivery systems should be rehabilitated and operations and maintenance procedures properly employed. Floods must be tamed by flood control structures and runoff harnessed by water harvesting methods for use in dry periods.

Institutions for water management will need to be strengthened through inter-sectoral cooperation, training and support systems and the assistance of regional and international organizations.

Deforestation, and settlement must be managed through proper basin planning and appropriate land reform policies. Waste disposal and the monitoring of pollutants and sediments must form part of controls of water quality. Agriculture must use integrated pest management systems that employ less pesticides; where pesticides are used, they must be environmentally-friendly. Crops and cultivars must be selected for fertilizer use efficiency and nitrogen-fixing legumes must be encouraged in cropping systems so as to lessen the use of inorganic N fertilizers.

Land tenure systems must ensure the proper use of land according to land capability classes and end users of the water resources must be made aware of the consequences of improper land husbandry practices through incentives and education. Systems of land use must enhance groundwater recharge.

At the local level, policy makers and planners must work jointly so as to merge economic, political, social, cultural, environmental and technological criteria into the decision-making process. Regionally and globally, cooperation is needed on the joint development and use of water resources.

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IMPACT OF TOURISM ON INTEGRATED WATER MANAGEMENT IN THE CARIBBEAN

Ms. Glenda Medina
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Causes of The Impact

1. Demand 2.Supply 3. Disposal

Objective

To reduce water consumption in the Caribbean hotels through effective and efficient conservation measures.

Activities

- Development of national policy on water conservation, including incentive for use of water saving devices and native landscaping.
- Carrying out water audits in selected hotels and identify technically feasible options. Carry out financial and economic feasibility of proposed conservation measures.
- Prepare proposals for incentives for the funding of island wide conservation programmes in the hotel sector.
- Provide training of private sector engineering and consultants firms to enable these firms to incorporate low water usage fittings in the design of new buildings and to carry out water audits existing properties.
- Increased the awareness of the tourism business sector on the marketing and financial benefits of introducing water conservation measures in the day operations of hotel plants. Prepare a small manual on practical water conservation in the tourism sector.
- Carry out leak detection and metre replacement programme for hotels and communities.
- Proposal from the Regional Conference on Environmental Health and Sustainable Development in the Caribbean, Nassau, Bahamas, 8-11 November, 1993.

Complementary Action to PAHOS' Proposal

Government

1. Annual Audits of Water Consumption
2. Cost Analysis of Water Services
3. Appropriate Water Pricing
4. Tax incentives for Design and Implementation Water Conservation Programmes (water conservation devices, appropriate landscaping, reuse of gray waters, training of staff, rain water collection and use, water treatment plants, leak detection, use of material easily clean, improvements in architectural/ engineering design of infrastructures, optimal design of swimming pools, use of recycle water in golf courses).
5. Monitoring of Water Quality
6. Updating of Environmental Legislation
7. Identification of Carrying Capacity of Tourist Sector

Civil Society

1. Establish a Corporate Environmental Management Programme
2. Design and Implement a Public Causes of The Impact
3. Establish an Environmental Performance Rating for Hotels
4. Design and Promote Training Programmes for Hotel Personnel (All Levels)

Considerations for Institutional and Policy Reforms

C Reduce
C Reuse
C Recycle
C Recover
C Rethink

WATER POLLUTION:
SOURCES AND COST EFFECTIVE TREATMENT OPTIONS

Dr. Jason Gondron
Red Fox Environmental Services
&
Mr. James Stone
Enviro-Waste Services Inc.

Water Pollution

C Existing Standards for Effluent Discharge
  - Tertiary
  - Secondary/Agricultural

C Sources of Pollution
  - Point Sources
  - Non Point Sources

C Impact on Freshwater Ecosystems
C Impact on Marine Ecosystems

Institutional Constraints

C Lack of Consumer Awareness and Responsibility
C Inadequate Coverage Impacts Public Health
C Weak Regulatory Environments
  - Inadequate Pollution Penalties
  - Inadequate Regulations and Regulatory Mechanisms
  - Poor Waste Management

Cost Effective Treatment Options

C System Design
  - Aerobic in Comparison to Anaerobic
  - Chlorination in Comparison to UV Disinfection

C Satellite Modular Concept for Large Populations

New Approaches

C Improving Public Awareness and Consumer Responsibility
C Strengthening Regulatory Capacity
  - Pollution Control Regulations
  - Water Quality Monitoring Programs
  - Enforcement Capacity
  - Polluter Pays Penalties

C Improving Wastewater Management Through Treatment Options

Biological Sewage Treatment Process Principles

Definition

Sewage treatment systems primary requirements —The discharge from toilet facilities must be treated so that the quality of the discharge entering the receiving body of water (river, coastal-waters, lake, etc) will meet applicable quality with regard to:

1. elimination of disease causing elements;
2. amount of solids, suspended or floating, in the water being discharged; and
3. amount of material that will absorb dissolved oxygen from the receiving body of water.

The following list of definitions explain terms related to evaluating the treatment requirements and sewage treatment unit operation:

- *Bacteria* are microscopic one celled animals about the size of a red blood cell. Bacteria commonly utilize organic compounds in soil, sewage, water, animals, or plant cells as a food supply.

- *Biodegradable Organics* are those that can be broken down by microorganisms to form stable compounds such as C02 and water.

- *BOD (Biochemical Oxygen Demand)* is the amount of oxygen (expressed in mg/l) used by microorganisms to consume biodegradable organic in waste water under aerobic conditions.

Bodies of water such as rivers, lakes, and oceans contain dissolved oxygen. Depending on the temperature of the water, a certain amount of free oxygen will be transferred from the air in contact with the water into the water. This oxygen is defined as dissolved oxygen after it has been absorbed into the water.

Marine animals, fish, etc., require this dissolved oxygen for their survival. If the dissolved oxygen should be depleted by an accumulation of some pollutant, the fish and other marine animals would die.

The laboratory test that is used to evaluate the potential for waste water to absorb oxygen from the receiving body of water is the BOD test. The higher the BOD value, the greater the potential for oxygen absorption.

The oxygen demand in water is created by:

1. the dissolved oxygen used by microorganisms as they consume organic compounds in the water; and
. oxidizable nitrogen produced by nitrite, ammonia and organic nitrogen compounds, which also serve as food for microorganisms.

BOD5. Since the standard laboratory test takes five days, the term BOD5 is usually indicated.

The allowable value for BOD5 in the discharge from a sewage treatment plant will vary with the regulatory agency having jurisdiction. The maximum BOD5 requirements range from 20 to 50 mg/l. Influent BOD5 values are used for sizing of waste treatment facility air supply requirements. Therefore, instead of specifying so many pounds of raw sewage per day to be treated, the aeration system is sized to process so many pounds of BOD per day. The

difference between influent and effluent BOD5 values is used for evaluating sewage treatment unit processing efficiency.

- *Pathogenic Bacteria* are those bacteria capable of producing diseases in man, animals and plants. For example, typhoid is caused by salmonella typhosa bacteria, which is only transmitted in human faeces.

- *Faecal Coliform*. It is essential that the liquid discharged from a sewage treatment system be completely free of disease carrying microorganisms. To ensure this, the liquid is disinfected. However, it is necessary to have some sort of performance test to see that the disinfection process is effective.

Most disease carrying bacteria and viruses (called pathogenic bacteria and viruses) are very difficult to observe even in a laboratory. So a laboratory test using faecal coliform was developed where the presence one relatively easy to detect microorganism is used to indicate the possible presence of pathogenic bacteria.

The faecal coliform of bacteria, which comes from the intestinal tract of human beings, is used as an indicator of the faecal contamination and possible presence of disease carrying bacteria or intestinal parasites.

- *Blackwater* is sewage that contains only human wastes from toilets and urinals.

- *Graywater* refers to drains from laundries, sinks, showers, washing machines, etc.

- *Aerobic Bacteria*. A type of bacteria that requires oxygen for their respiration and survival.

- *Anaerobic Bacteria*. A type of bacteria that does not require oxygen for their respiration. In fact, they require an environment essentially free of oxygen to survive.

- *TSS (Total Suspended Solids*). If the liquid discharged from the sewage treatment unit contains a great deal of organic and inorganic particles in suspension it is considered a pollutant. Also a high value of TSS usually is an indication high BOD5 because of suspended organic sludge carry-over. The value of TSS is determined by laboratory testing.

  The allowed maximum TSS value for sewage treatment unit effluent is also dependent on the regulatory agency having jurisdiction. The maximum allowable values range from 10 to 50 mg/l.

- *Sludge* in a biological sewage treatment unit consists primarily of various microorganisms stuck together along with some non-biodegradable solids and organic waste material.

Enviro-Waste Sewage Treatment Unit Construction and Operation

Basically, the biological treatment process uses all the incoming sewage as food for microorganisms. The raw sewage consumed by the microorganisms is used to provide energy for cell activity and material for cell reproduction. These processes are called respiration and synthesis respectively.

Biological treatment effectiveness has been established for years. Municipal sewage treatment plants use biological processes in one form or another, because the process is proven and most economical.

The key feature of biological treatment processes is that the microorganisms, mostly bacteria, are able to easily remove organic wastes from a liquid that would otherwise be very difficult and expensive to remove by any other

means.

There are three types of bacteria used for biological sewage treatment systems and they all are naturally contained in the sewage. One type is anaerobic bacteria. This type of bacteria does not require oxygen for their metabolism. Some types will consume the organic waste material in sewage, but release methane and hydrogen sulfide gas as a by-product. Both of these gases are explosive, and the hydrogen sulfide produces the strongly offensive odour associated with this process. To be efficient, anaerobic processes require some form of heating. These reasons have precluded the use of anaerobic bacteria for package type sewage treatment units.

The second type of bacteria are aerobic. They must have oxygen for their respiration and synthesis process. They consume the organic waste material in sewage and release carbon dioxide and water vapour as by-products. This does not result in any odour or explosion hazard. No special heating requirements are needed if the sewage treatment units are located where hard freezes do not occur. The aerobic process is also faster than the anaerobic process with regard to waste reduction rates.

A third type of bacteria are facultive. This type of bacteria will function as aerobic bacteria when oxygen is present, but will also function anaerobically if there is no oxygen. Most of the bacteria population in the sewage treatment unit will be facultive bacteria. However, the bacteria population in a biological waste water treatment plant will be composed of many different types of bacteria.

If the sewage is permitted to become stale and subsequently to become septic, its odour becomes pronounced, it turns black, the solids disintegrate and decompose, the dissolved oxygen is used up, and the formation of hydrogen sulfide starts.

Both anaerobic and aerobic treatment systems are biological, that is they depend on bacteria to consume and eliminate the organic waste material in sewage. An aerobic (air required) sewage treatment process will convert to an anaerobic (no air required) process if the air supply is cut off. It will be a gradual change, and the odour will increase as the process becomes more anaerobic. However, the process will revert back to an aerobic process once the air supply is restored. It can take 12 to 36 hours for an aerobic system to become anaerobic depending on unit size and amount of sewage flowing into the system.

The Enviro-Waste sewage treatment unit utilizes a type of aerobic biological treatment process called an "extended aeration activated sludge" process (refer to Figure 2 for process flow arrangement details). Commonly called "extended aeration" process.

After the introduction of raw sewage into the sewage treatment unit, the microorganism or bacterial cell mass that is generated in the aeration chamber by cell reproduction is separated in the clarifier (second chamber) from the liquid being treated prior to discharge, collected, and recycled back to the aeration (first) chamber by the skimmer and sludge return lines where it is mixed with incoming sewage. This increases the rate of removal of the organic waste coming into the system, because that waste comes in direct contact with a hungry and relatively dense population of bacteria almost immediately. This arrangement is called an "activated sludge" process.

The extended aeration treatment concept requires that the sewage treatment unit be large enough to retain and aerate the daily average sewage flow 24 hours in the aeration chamber. This arrangement keeps the ratio of bacteria population (sludge) to the available food supply (sewage) essentially constant. The bacteria cells are continuously multiplying, and the cell population exceeds the food supply available for feeding the excess population. These cells starve to death and become food for the survivors. The result of this process is to minimize bacteria cell sludge

accumulation in the sewage treatment unit. Sewage treatment systems that do not employ the extended aeration treatment concept will require considerable drain off and disposal of sludge, because bacteria are not kept away from a food supply long enough to keep the bacteria population from increasing. As a result the bacteria population will continue to increase to a point where the bacteria sludge density becomes so great, that sludge begins to disperse and carry over with the effluent from the sewage treatment unit.

The Enviro-Waste sewage treatment system utilizes the extended aeration method of sewage treatment. Four separate operations are involved in this process (see Figure 2 for component identification by letter and schematic illustration of process). The first operation is a coarse screening process. As the influent enters the sewage treatment unit, it passes through a Bar Screen (A). The bar screen will catch any large trash such as rags, plastic bags, etc, and prevent it from entering the system. The second operation is aeration. As the sewage passes through the bar screen, it flows into the Aeration Chamber (B). The aeration chamber is the largest component of the sewage treatment system, and is usually sized to provide a 24 hour retention time for the daily average flow volume of sewage. In the aeration chamber, the incoming raw sewage is mixed with water that contains a large concentration of very active aerobic bacteria that consume the organic waste material in the sewage. Air flowing up through the liquid from the Diffusers © keeps the bacteria in suspension, and also provides the necessary amount of oxygen required by the bacteria for their respiration and digestion process. The air flow through the liquid also provides the agitation necessary to keep solids from settling on the bottom and helps break up solid waste material in the sewage.

The bacteria in the aeration chamber will stick together in little flakes of sludge called a biofloc that becomes uniformly mixed in with the water as a result of the agitation caused by air flow from the diffusers. This floc cannot be discharged from the unit, because it is also an organic pollutant. However, it is easy to process. This separation process is the third operation.

The third operation consists of clarification and settling. After the usual 24 hour average retention time in the aeration chamber, all liquid is displaced eventually by additional sewage flowing into the sewage treatment unit. The displace liquid flows around a baffle and through an opening into a separate chamber called the Clarifier (d). The clarifier is volumetrically sized to allow a minimum 4 hour retention time for the liquid flowing through this chamber. This minimum retention time is necessary to ensure solids settling separation from the liquid.

In contrast to the liquid in the aeration chamber, the liquid in the clarifier is kept as still as possible to allow the sludge to flocculate and settle to the bottom. This setting process separates the sludge from the clear liquid flowing downward and upward around the clarifier baffle. The clear liquid at the top of the clarifier, outside the clarifier baffle, is also eventually displaced from the clarifier over a Weir (E), disinfected and then discharged.

The sludge or floc that has settled to the bottom of the clarifier is continuously drawn up by the air lift Sludge Return (F) line and discharge back into the aeration chamber.

Any floating material in the liquid flowing into the clarifier is contained by the Clarifier Baffle (G), and then it will be eventually drawn in to the Skimmer Return Line (H). The floating material is then discharged back into the aeration chamber. Both the skimmer and sludge return lines operate by using air from the air supply system. The air is injected into both the skimmer and sludge return lines. As the resulting air bubbles rise, they displace the liquid in the lines. This displacement develops a suction at the inlet to each line (see Figure 3 for skimmer and sludge return line construction details).

USE OF DECISION SUPPORT TOOLS FOR COASTAL ZONE MANAGEMENT IN CURACAO AND JAMAICA

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Linkages in Integrated Management of Water Resources and the Coastal Zone

The practitioners of Integrated Water Resources Management (IWRM) are not necessarily close to the people practicing or preaching- Integrated Coastal Zone Management (ICZM). One possible reason for this is that many of the ICZM practitioners have come to this relatively young field from marine biology, oceanography or fisheries management, while the IWRM field tends to be dominated by (civil) engineers. The two fields have much in common, however, as this paper will demonstrate. For starters, the definition of the coastal zone used for small islands usually includes the island as a whole, that is, including the complete watersheds that drain into the coastal zone. Also, from an ecological perspective the zone in which fresh water and salt water mix —be it estuaries, mangroves, or lagoons— are usually very valuable. These gradient zones often have a very high biodiversity and productivity. There are also ample physical linkages between coastal and fresh water resources, for example;

- watershed management influences run-off and erosion, which affects water quality in the coastal zone (non-point source pollution);
- groundwater exploitation in alluvial coastal plains that lowers the groundwater table will often increase saline seepage and infiltration;
- waste water management —treatment plants, ocean outfalls— directly influences water quality in the coastal zone;

- coastal wetlands such as mangroves or lagoons depend on both water resources and coastal zone management; and for coastal tourism the management of the coastal zone and of the water resources are often intricately linked.

The planning methodology —or framework for analysis—for IWRM and ICZM is also often very similar. The framework that has been used in the project described in this paper for its origins in IWRM. It is a generic framework for analysis that has been developed over the last 10-15 years (Bower et al, 1994; Resource Analysis and Delft Hydraulics, 1993; Rijsberman and Koudstaal, 1989). Practical applications of this approach to IWRM and ICZM issues are given by, for instance, Baarse and Rijsberman (1986, 1987) and Ridgley and Rijsberman (1992). Following this framework, the main steps in an IWRM or ICZM analysis are as follows:

- problem identification;
- definition of objectives and criteria as yardsticks to measure fulfilment of objectives;
- definition of scenarios for uncertain, exogenous developments;
- definition of management strategies in terms of their component measures;
- analysis of the impacts of the strategies in terms of the criteria;
- evaluation and selection of the most desirable strategy.

Another link between IWRM and ICZM is that a number of the emerging issues in both fields are rather similar, for example:

- participatory approach to planning, involving NGO's and CBO's; institutional mechanisms for cross-sectoral cooperation; compliance and enforcement of integrated policies; and vulnerability to climate change.

In this paper the use of decision support tools for awareness raising, communication, training, stakeholder involvement, and consensus building for ICZM is discussed. An application of a decision support system that focuses on the interaction between land use planning, waste water resources management and coral reef management is discussed. The tool has been developed for Curacoa3 and the Maldives. A similar system is under development for Jamaica.

The CORAL Decision Support System

CORAL is developed to integrate sectoral planning of land use, tourism, and marine resources (often dealt with separately) through focus on cost-effective maintenance or rehabilitation of coastal ecosystems. The Curacao project focuses on the impact of point source pollution (waste water) as well as non-point source pollution (soil and beach erosion) on the condition of coral reefs.

CORAL consists of (see Figure 1 for an overview, and Rijsberman and Westmacott, 1996, for a more detailed description of the tool and the model components):

- ***a graphical user interface*** aimed at stakeholder use that lets users specify management strategies and evaluate their impacts (through the underlying modules) in terms of CZM indicators.
- ***an economic activity module*** that translates assumptions on economic development and environmental management into discharges of nutrients and total suspended solids at discrete discharge points in sections along the coastline.
- ***a water quality module*** that translates the pollutant loadings into average concentrations over the coral reef in six sections along the coastline (see Figure 2).
- ***an ecological response module*** that assesses the impact of pollutant concentrations in terms of coral cover and diversity.

The two main innovative elements in the approach are:

a. the interactive, computer-based approach to decision support for integrated coastal zone management; and
b. the ecological response model for coral reef health, based on fuzzy logic.

The User Interface

The DSS-side of CORAL has the following characteristics:

- It has a graphics-based user interface that makes it easy to use for people at decision maker or stakeholder level that are not experts in computers, coastal zone management or one of the related disciplines.
- It is case-study based, that is, location specific, which has the advantage of demonstrating the approach through realistic examples rather than abstract theory.
- It guides users through a generic approach to integrated coastal zone management that structures the development, analysis and evaluation of coastal zone management strategies.

- It is interactive, that is, it allows user input with respect to setting of objectives and criteria, definition of scenarios, selection of measures and strategies and evaluation of impact.
- It demonstrates intersectoral linkages and facilitates communication among stakeholder groups. The tool can be used to support consensus building among stakeholder groups, as a means toward conflict prevention, or Alternative Dispute Resolution (ADR).

The Economic Activity Model

The main purpose of the economic activity model is to determine the pollutant loadings resulting from assumptions about economic development combined with environmental strategies as well as the costs of the environmental measures taken to reduce those pollutant loadings. The economic activities distinguished in CORAL for Curacao are:

- tourism
- harbours and shipping
- manufacturing
- fisheries
- services and "other" (rest of GDP)
- the oil refinery; and
- residences.

Tourism, harbours and shipping, and fisheries are considered to be the coastal zone related activities, in the sense that they depend on the coastal zone. Manufacturing, the oil refinery and residences are separated out from the rest of the economy because of their potential impact on the coastal zone through discharges of pollutants.

Pollutant loadings are based on sectoral outputs multiplied by an emission factor per unit of output (in monetary terms) for all sectors except the oil refinery, residences and tourism. The base loadings produced by the economic activities can be reduced through end of pipe treatment. This yields the final loadings that are discharged. For residences the loadings are based on emission factors per capita, for tourism the loadings are based on the number of tourist nights. For the oil refinery the loadings are based on emission factors multiplied by output in cubic metre of oil produced.

In CORAL the user specifies waste water treatment options per section for residential and tourism sector discharges. The following options are available:

- no treatment: the base load is discharged directly ashore area (septic tanks are assumed to play a marginal role);
- on-site treatment for hotels and apartments: the treated final load is discharged into the nearshore (if there is an outfall to move the discharge off the beach it is assumed not to take the discharge beyond the reef area);
- sewerage system connected to an ocean outfall that is assumed to bring the discharge beyond the reef area;
- sewerage system connected to a sewage treatment plant and subsequent discharge on the nearshore (no outfall or a short, nearshore outfall);
- sewerage system connected to a sewage treatment plant and subsequent discharge through an ocean outfall, beyond the reef; and sewerage system for transport to a neighboring section, removing the waste water completely from this section, subsequent discharge depends on treatment level and outfall construction in the neighboring section.

For the refinery, manufacturing, harbours/shipping, and services/other sectors the user specifies base load reduction

percentages directly. It is left undefined whether these reductions are the result of improved processes (reduced discharge coefficients) or end-of-pipe treatment. Only rough estimates of costs are available for these measures. Pollutant loadings (sediment discharge) from artificial beaches can be reduced by the use of coarser — more expensive— types of calcareous sand. Sediment from artificial beaches is dealt with directly in the water quality model.

The model calculates the cost of environmental management strategies. The major component in this is waste water treatment. The costs of treatment consist of the investment costs of:

- on-site treatment systems for hotels and apartments;
- construction of sewerage systems;
- construction of treatment plants; and
- construction of outfalls.

All investment costs are assumed to occur in year one and not discounted. Annual costs of maintenance and operation are discounted (with a user-specified discount rate) to year one and added to the investment costs to obtain total costs.

The Water Quality Model

A simple water quality model has been formulated for the model to determine water quality (concentrations of nitrates and phosphates) in six sections along the coast. The model is driven by the average east-west current parallel to the coastline and takes into account the effects of tidal mixing (diffusion) perpendicular to the coastline, as well as decay of the pollutant materials within each of the six sections. This type of simple model is a relatively good approximation for a straight coastline with high lateral velocities compared to the tidal velocities. As this is the case for Curacao, this type of model was used to provide approximate indications of water quality under average conditions in the six sections. Precise water quality determination for specified times and locations are not possible with this type of model, but bearing in mind the level of accuracy of the ecological response model this is not considered to be a major drawback. For accurate estimates of water quality along beaches the model that has been used is not very appropriate and could be improved. Estimates of sediment concentrations (in terms of low, medium and high, as required by the ecological response model) have been based on the location and composition (in terms of grain-size) of artificial beaches.

The water quality model is valid for the areas of reef flat. This is the part of the reef that is taken into account in the CORAL model. If the model were to consider the reef slope then other aspects such as the influence of mixing with ocean currents would need to be considered in more depth.

The Ecological Response Model

The response model for coral reef health is an expert-system, based on fuzzy logic, that does not attempt to describe the behavior of the system deterministically (e.g. through equations that describe the behavior of the reef as a function of a set of driving variables and parameters), but simply uses a “black-box approach” to describe reef behavior. The model encapsulates and synthesizes expert knowledge into a larger number of decision rules that are subsequently used to “predict” reef behavior. The current version of the response model for Curacao links the concentrations of nutrients (nitrogen and phosphorous) and sediment over the reef to future values for coral reef health (defined by coral cover and relative species diversity) under various reef conditions (current reef health, available substrate and maximum colony size). The development of this model was originally based on the parallel

model developed for Jamaica (Ridgley & Dollar, 1997). Subsequent revisions of both models show differences in the development due to the different local situations. Another parallel study for the Maldives takes a more focused look at physical damage (Meesters and Westmacott, 1996).

Cost-effective Coral Reef Protection for Curacao

In Curacao the fairly typical situation exists that sectoral plans are developed without proper linkages or integration, particularly: the Island-Wide Development Plan (land-use plan); the Tourism Master Plan; and the Marine Park Management Plan. With CORAL the impacts of alternative development scenarios (tourism and residential development in different sections along the coastline), as well as alternative environmental management options (level and type of waste water management, particularly), on coral reef health are investigated. The emphasis is on cost-effective strategies for maintaining (or rehabilitating) coral reef health. Some attention has been paid to linked public health aspects related to water quality along beaches. Information on current reef conditions in Curacao is provided in Table 1.

The model developers have analyzed several economic development scenarios and associated possible environmental management strategies. It must be noted that these are noted the product of a decision process in which the various stakeholder groups participated, but rather a demonstration of how the DSS works. In the follow-up to the development of the DSS (currently underway) the tool has been installed in the offices of a number of stakeholders, both government departments and NGOs, and has been used for an ICZM course at the University of the Netherlands Antilles in Curacao.

Development Scenarios

The following example economic development scenarios have been pre-define in CORAL and are as follows:

a. a Reference Scenario; and
b. two growth scenarios, Growth West and Growth East.

The scenarios are described hereafter and summarized in Table 2. They are also available in the model as pre-defined scenarios for the user to examine. These development scenarios are examples to demonstrate the use of CORAL; they are not necessarily balanced development proposals for Curacao.

Table 1
Curacao Reef Conditions in 19951

Section	Cover (%)	Diversity (% Species Present/ Reference	Available Substratum (%)	Maximum Colony Size (102m2)
1. Oostpunt to Cornelisbaai	14-23	33- 61	40-50	77-316
2. Cornelisbaai - Punda	8-20	14- 26	10-50	42- 69
3. Schottegat - St. Michael	1-16	1- 55	1-40	8- 75
4. Bullenbaai	11-14	41- 61	20-30	53- 89
5. Rif St Marie - StMartha	12-16	26-100	20-40	89-143
6. Jeremi-Playa Kalki	15-23	17- 98	40	275-455

The range of values shown are the values occurring in the sub-sections within the six main sections

The impacts of the development scenarios on both the economy and on the reefs are summarized in Table 3. In essence, even though the development locations of the hotels, apartments and houses are quite drastically different, the overall impact of the three development scenarios of reef health is similar. There are differences at the level of the sections but these are not drastic. The characterization of the situation remains that the eastern and western sections are relatively pristine and that the middle sections are heavily impacted. This impact reflects the effect of the industrial zone around the Schottegat. There is a significant different in the water quality along the beaches. The western part of the island has a series of attractive beaches. The Growth-East Scenario maintains relatively good water quality conditions in the western part, at least at the first order accuracy of the simple water quality model used here. When there is some development in the western part, all these beaches become potential problem beaches if there are not sanitation measures taken. The overall loadings of pollutants are determined more by the population growth rate than by tourism development (at least at the relatively modest tourism growth rates investigated here).

Table 2:
Development Scenarios Pre-define in CORAL

Variables	**Units**	**Reference Scenario**	**Growth-West Scenario**	**Growth-East Scenario**
Economic Growth	%/year	0	3	3
Population growth		1.2	1	1
Growth in tourism demand		3	8	8
Discount rate		6	6	6
Residential development	No. of houses	Current pattern	600 from Westpunt to St. Martha Bay	600 in Spaanse Water and Jan Thiel

Variables	Units	Reference Scenario	Growth-West Scenario	Growth-East Scenario
Hotels and apartments	No. of rooms	600 in Piscadera and Cornelisbay	2000 from Westpunt to Rif St. Marie	2000 from Oostpunt to Marie Pompoen
Artificial beaches		None	Rif St. Marie Marie Pompoen	Oostpunt Cornelisbay Marie Pompoen Elyse Hotel
Harbour projects		None	Caracas Bay and Schottegat	None
Refinery output growth	% year	-1	-2	0
Manufacturing growth	% year	0	0	2

The analysis undertaken shows that optimistic growth (development) scenarios for the next 10 years would lead to a significant decline in coral cover and diversity, in line with observations over the past 20 years (Bak and Nieuwland, 1995).

Environmental Management Options

A large number of environmental management options (outlined above under the description of the economic activity model) have been tried, both individually and in combination. The DSS indicates that maintenance of current reef health would be possible, but at considerable cost. A preliminary analysis of cost-effective manners to maintain reef health at current levels would involve a combination of measures and could cost 100-200 million US$. The most-cost-effective combination of measures would appear to be a combination of reduction of a refinery pollutant discharges, combined with deep-water ocean outfalls for sewerage discharge. It must be noted that the data available to the authors on the Curacao oil refinery (both current discharges and costs of reduction) are order of magnitude only, and therefore the current results cannot be more than a first indication. Also, the model does not take into account the possible environmental impacts that deep-water ocean outfalls may have on the far-shore areas, as it only accounts for the near-shore impacts on reef and bathing water quality.

Table 3
Impacts of Development Scenarios Without Environmental Strategies

Criteria	Units	Reference Scenario	Growth-West Scenario	Growth-East Scenario
GDP/capita	NAF/year	13,000	17,300	17,300
Employment	No. Jobs	58,000	77,000	78,000
GDP share of coastal activities	%	21	22	21
GDP tourism	Million NAF	324	450	450
GDF fisheries	Million NAF	10	13	13
GDP harbour and shipping	Million NAF	115	176	154
Total N load	Kg/day	2,100	2,200	2,200
Total P load	Kg/day	790	840	870
Total SPM load	Kg/day	17,800	17,700	18,900
Average coral reef diversity	%	32	32	32
Average coral reef cover	%	9	9	9
Problem beaches (bad water quality)	No	13	14	0

An example of the results of the cost-effectiveness analysis —for individual measures— is given in Figure 3.

The first use of CORAL DSS in Curacao is to increase awareness of the linked issues among stakeholders in Curacao, rather than its formal use for planning. Following development of CORAL in 1995-1996, it has been used in 1997 in a post-graduate CZM course for (largely) government officials held in cooperation with the University of the Netherlands Antilles, and in presentation for high-school students and for environmental NGO's. In these situations the tool clearly shows its potential as a communication tool for different stakeholder groups to explore (hypothetical) options in a non-threatening, interactive manner.

Montego Bay, Jamaica. A similar tool is under development for Montego Bay, Jamaica. Several elements similar to those of the Curacao tool have, in fact, been developed by other research teams that are part of the same programme, for Montego Bay. CORAL-Curacao was used in a workshop with stakeholders, organized in cooperation with the Montego Bay Marine Park Trust in February 1997, to prioritize issues for integrated coastal zone management. This was well received and led to the current development of a user friendly DSS-tool similar to that of Curacao.

Conclusions

The use of CORAL for Curacao, but also the experience with similar tools elsewhere —for example, Rijsberman (1996), Kloditz et al (1997)— shows that this type of tool has potential for enhancing communication among stakeholder groups in potentially very conflict-rich situations. Decision support tools, such as CORAL, are not in

the first place complex modelling exercises requiring large amounts of data, but rather communication tools that can be used to facilitate discussion among stakeholder groups concerning desirable development directions and environmental strategies.

CORAL has been successfully and effectively used as an interactive awareness raising tool for complex resource management issues. CORAL allows the integration of sectoral planning along several axes, but it is not in its current form adaptable to alternative planning contexts without the help of software developers.

Tools such as CORAL can be used integrate waste water management issues with environmental management of coastal zones, which is particularly relevant for Caribbean countries with significant coast-related tourism.

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DEMAND MANAGEMENT CASE STUDY FROM ISRAEL

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This paper focuses on Israel as a case study of water resources management. However the paper concentrates on Demand Management.

Development and water experts, who have an interest in the Middle-East and in the economic development process of semi-arid countries, often, pose the question how does Israel prosper with less than 300 cubic meters of water (per capita per year) while international organizations define countries with less than 1000 cm/cap year as highly stress countries.

This paper will try to clarify some of the policies, legislative basis and selected economic issues that enabled Israel to reach a GDP of 17000 — per capita per year, supply much of its agricultural needs, (except grains) export agricultural products and maintain high standard of living all with a very limited fresh water resources.

The basis of the past strategy as well as the future one lies with a balanced combination of measures: legislative, institutional economic and technological focusing on water demand management, increased efficiency of water use in agriculture and the industry, re-use of most of its treated sewage effluents as well as the economic use of its total surface and ground water of water resources . Future water markets (internal and regional) continuous changes of water pricing policies and future large scale sea water desalination will enable the country and its immediate neighbors to continue their social and economic growth despite the water scarce conditions.

Introduction

This paper focuses on demand management (also termed water conservation, water saving strategies or the program for increased efficiency of water use). The policy of Israel to meet the growing demand for water focuses on supply and demand activities and investments, while the long range solution lies with sea-water desalination. Present-Activities are aimed at delaying the high investments and the associated costs involved with this expensive unlimited source of water.

The Three main instruments are:

1. *Re-use of Sewage Effluents*. Recent regulations have increased the level of sewage treatment in order to maximize its re-use potential and minimize the health and environmental risks as well as enhance the trading instruments for the exchange of fresh water allocations, with treated effluents mainly for Water conservation irrigation.

2. *Water Conservation/Improved Efficiency of Water Use*. Policies and achievements concentrate of mixed tools including: a.) allocations, norms and progressive block rates for each sector, and b.) research, development and implementation of agronomic techniques as well as technological means to improve water use efficiency and reduce water consumption in the domestic sector commercial, industry and the irrigation sector of agriculture and urban parks and gardens.

3. *Sectoral Water Allocations*. Recently major changes in the approach toward the system have been initiated, including elimination of urban allocations; imposing sanctions if unaccounted for water use rises above approved

levels; and the possible introduction of water market', trading with allocations on an economic basis, between members of a sector, between sectors and between Israel and its neighbors.

The Region

The Middle East and North Africa face an environmental crisis, much of it as a result of water scarcity and the existing and potential pollution of their resources. It is estimated that the investment needed to deal with and solve the problem could reach US$70 —80,000 million in the period 1995— 2005 (World Bank).

The hydro-geological conditions are in constant deterioration. As extraction from ground and surface water resources increases, so do the problems associated with low water levels and decreased quality. Inadequate human and industrial waste discharges restrictions as well as inappropriate waste water re-use programs lead to higher concentrations of chemicals and organic contaminants. The concentrations of heavy metals and toxic compounds have already reached alarming levels in various sites and the projected future cleaning costs could reach prohibitive levels less urgent and strict measure, are introduced.

The expected population growth in the region is likely to exacerbate the problems. World Bank forecasts indicate growth of 40 per cent (from 250 million in 1990) to 350 millions by the end of the century. Some regional governments will be unable to generate the financial and human resources needed to provide adequate water and sanitation facilities to meet the future demand.

Already, almost 20 per cent of the total population in the region lack an adequate potable water supply and almost 35 per cent lack appropriate sanitation. Less than 20 per cent of the urban water supplied in 1990 has been properly treated; in the industrial world this figure is above 70 per cent.

Most of the countries in the Middle East face serious water pollution problems already, while water scarcity is reaching acute levels. During the last generation the average water availability per capita has dropped from 3500 m/3 and will fall to approx 1500 m/3 per capita by the year 2020.

The countries which already exploit more than 100 per cent of their natural water replenishment levels include Hashemite Kingdom of Jordan (HKJ), Israel, the Proposed Palestinian Autonomy (PPA), Oman Qatar, Saudi Arabia, Yemen, Bahrain, Kuwait and the Emirates. It is estimated that by the year 2005, or by the latest 2010, only five of these countries will have sufficient water to satisfy growing demand.

Studies show that the incremental supplies are much costlier, may reach prohibitive levels and therefor the case study of Israel, promoting conservation of water and re-use of wastes, could become the only feasible options for the region.

Israel and Its Neighbors: Some Background

The present population of Israel is approximately 5.7 million and is increasing at an approximate rate of 2.2 - 2.5 per cent per year. Best estimates for the year 2020 indicate a potential population of 10 -13 million Israeli citizens. (The variation is mainly due to unpredictable future immigration levels).

Water Laws

Basic Premises

1. Public ownership and control by the state.
2. Right to use water to every person; through approved use and licensing.
3. Allocation (by norms).
4. Comprehensive water metering.
5. Quality control: prevention of pollution.
6. Regulated water rates (government and parliament)
7. Promotion of water conservation and efficient use of water.
8. *Institutional set-up*. Water commission with total responsibility (hydrological Constraints, allocation development of norms, licensing), Efficient use of water, legal plus economic aspects, supervision, water fund.
9. *Responsible Ministry*. Infrastructure (1996), removed from sectarian ministries.
10. *Public control via*: water board, water-court, (right to appeal to Supreme-court).

The Laws

- Water metering (1955) water drilling (1955)
- Drainage & flood control.
- Comprehensive water law (1959)
- Amendment/pollution prevention(1971)

Present average of urban water consumption (domestic, commercial and industrial) is approximately 110 m/3 per capita per year, taking into account past efforts that have resulted in approximately 30 per cent savings. Present industrial forecasts coupled with projections for urban water consumption per capita converge at an estimate of 110 - 120 m/3 per capita per year by 2020. These figures assume a much higher standard of living coupled with the very rigid and wide-scale implementation of demand management policies. When multiplied by the projected population, the level of urban water demand will amount to approximately 1000 - 1300 mcm of fresh water per year.

Inelastic agricultural demand for water to supply basic fresh food (dairy products, eggs, and vegetables for example) are estimated at 25-30 m/3 per capita; this adds an additional 220 -330 mcm/y. Urban and Inelastic consumption of fresh water resources will amount therefore to approximately 1200 -1650 mcm per year in 2020, for Israel only, which has maximum of 1700 mcm of fresh water resources per year.

Re-use of treated effluent in Israel will reach 70 - 75 per cent of the total DCI (domestic, commercial, industrial) use which amounts to almost 100 per cent of the total sewered flows (the entire population will be sewered by 2020). The estimated treated effluent flow by 2020 will be approximately 700 - 1000 mcm/y. (See Table 1).

Supply and Demand - General Background

There area number of major policy options which could significantly change supply and demand pressures in the region. Reduction of government water subsidies effects water prices, demand and public funding for water projects. Israel's large-scale demand management policy in the 1970's led to a significant increase in the product value per unit of water or land. Industrial production per unit of water has also increased substantially in Israel; during a decade of efforts in the 1970's it rose be over 80 per cent (in real terms).

Israel has already used a host of tools — including water rate adjustments, government incentives and penalties, investment credits to increase water use efficiency, enhanced research and development, the wide scale use of soil conservation and extension service, as well as local manufacture of high-quality technological systems— which have all promoted a decreased demand for water and enabled to authorities to reduce water allocations without diminishing the net income of the production sectors.

Demand Management in Agriculture and Industrial Use

This endeavor includes continued efforts, both technological as well as economic, to future reduce water use and improve the efficiency of water use in agriculture. Incremental costs of water saved in Israel range from US$0.0 5 -0.040 cm. The figures for irrigation assume increased production per unit of water in real terms; they do reflect some change in the basic production cycle, that is adapting to more economical cropping patterns and changing industrial processes. The levels of direct and indirect water production through savings and improved efficiency of water use are very important as they represent a permanent reduction in demand. Israel has already gone a long way in its efforts.

The term "effort" is much more complicated than it sounds. It means the large-scale application of appropriate irrigation technology (drip, sprinkler, automation), changes in industrial water use and water processes (like cascading water uses and cooling methods). Training, public education and effective extension has and must accompany the promotion and implementation instruments. Finally, the efficiency of pricing mechanism and the application of a market or trading system can play a dominant role in the whole operation. The significant achievements of Israel's agricultural sector are shown in Figures 3, 4 which clearly identify the results over 45 years in economic as well as physical terms. A comparison of prevailing prices for irrigation water between neighboring countries and Israel illustrates and partially explains the gap in the countries agricultural yield/cm, and the potential for reducing agricultural water demand.

Urban Water Conservation

Unaccounted for water (UFW) causes significant water and financial losses to urban utilities and municipalities. Unaccounted-for water has been substantially reduced in Israel, but remains a serious problem in other Middle Eastern countries, where for example, UFW rates in some cities are over 50 per cent and represent critical water and financial losses. Leakage, estimated to account for almost 50 pet cent of the total UFW, could reach 30 m/3 per capita/year. a utility's annual financial losses could equal approximately US$15 million per one million urban residents. There is no doubt, given experiences in Israel and other countries, that these losses can by reduced to more reasonable levels. Large sums of money can by saved and reinvested in the utility in further conservation and maintenance efforts.

Studies done in Israel and California show that the costs of water save through leakage control vary significantly, from US$ 0.15 - O.35/m/3. UFW reduction activities are usually and integral part of improving utility management; in many cases utilities cannot reach financial viability without it.

Comprehensive urban demand management addresses demand reduction at both the household and utility levels and, if applied on a large scale, it should reduce the cost of water in the Middle East as a whole. Demand management efforts in Israel, Singapore, California, and other regions have produced significant results using water conservation kits (retrofitting). The kits (including toilet flush reduction, two-volume flushing, regulated shower heads flow regulators in kitchen and bathroom sink taps, leakage control and technologies to improve garden and park

irrigation) achieved demand reductions of 10-25 per cent (sometimes 20 - 40 per cent) —retrofitting is done in households and commercial buildings.

To conclude: One cannot underestimate the importance of urban and domestic water demand management strategies. As the growth of water consumption in the region will be concentrated in cities and towns, thus a water conservation strategy will generate permanent savings at low marginal costs.

Human Waste Effluents Re-Use

Israel has completed most of its efforts at establishing and adopting water demand management for existing industries while new industries are currently installing efficient cooling systems and pre-designed 'cascading' facilities. The price mechanism as well as effluent charges are gradually being enforced and are contributing their share to industrial water management. Many of the industries are located in the urban sector and are subject to the additional utility prices.

Re-use of water effluent should be analyzed in the context of industrial and urban conservation. When effluent charges are enforced and subsidies are removed, market forces may typically produce the optimum results. It is reasonable to assume that local re-use for irrigation purposes will be the most cost-effective solution, mainly in areas where aquifer pollution is not expected. Drip irrigation of horticulture tree crops is preferred in these conditions when the fields surround most, if not all, the towns and cities. It is essential that the design and implementation of adequate sewerage systems are given top priority when the external funding instruments for the Palestinians become available. Vegetable irrigation should be avoided and therefore high-level monitoring must be established.

Effluent re-use is a valuable method of reducing demand for fresh water and therefore it is used in conjunction with water conservation. Industrial effluent charges and demand management, for example, should be integrated in a common program. When effluent charges are correctly imposed and enforced the public sector will not need, in many cases, to monitor industrial (and perhaps urban) water conservation. Minimizing effluent flows will lessen costs to industry and reduce consumers' water bills, thus internalizing the decision- making process.

Water Market — a Temporary or Permanent Solution?

Water in Israel is used within a system of allocations (annual or multi- annual) while in most countries it is user rights that determine use. In many regions, a person who owns land (or cultivates it) has the right to the water flowing beside and under the plot. In other regions various quota systems allocate the amounts of water on an annual, monthly, weekly, daily or even hourly basis. Veteran users usually have the rights to continue to use the resource.

However, the efficiency of water resource allocation and use can by substantially improved through the increased use of price mechanisms. For example, trading water on the margin or using a system in which urban/industrial demand is met by supply from farmers could reduce inefficiency. Irrigation water in Israel was, and is today, partially subsidized when supplied by the National Water Company. This administrative allocation system creates a 'rent seeking' operation for the development of new resources and higher demand could lead to over-pumping from underground sources. *See Annex I for Water Trading and Water Pricing issues in Israel. a Water Market Where Urban increased Demand will be sold (indirectly) by farmers could substantially improve sector management and efficiency of use.

A Brief Outline Of Proposed Changes

First, water would be charged at its shadow price (or opportunity costs), would be established if rates match marginal costs and if financial Suppliers would operate as controlled public utilities, new mechanism will therefor projects markets will support the investment. Price mechanisms will therefor promote the total efficiency of the sector and possibly eliminate the rent-seeking' impact and potential political conflicts. Second, the new system would enable transfer of water between various users —mainly from agricultural consumers to cities, to the Palestinians and to Jordan— with minimum conflict with farmers, who "sell" part of their allocation (or are compensated for the loss of income).

The water market may facilitate short and medium-term solutions for Israel. It could also serve to improve the nation's water relations with the Palestinian Autonomy and Jordan. The proposal is based on classical economic principles that would help Israel, the P.A. and Jordan to meet growing demand for water in the urban sector and, at the same time, will encourage farmers to increase their water efficiency. The parties will voluntarily trade water, under the supervision of an agency like the Water Commission. * See Annex I which deals with Water Trading and Pricing Issues in Israel.

Conclusion

Out of approximately 600 mcm/y being supplied to the urban and industrial sector in Israel, it is possible and feasible to reduce the water demand by 15-20 per cent. It is assumed that if the proper program is implemented 80 -120 mcm of water per year can be presently saved. It can delay a future sea water desalination plant (at an estimated investment cost of approximately US$ 400 million) and will save present running costs (energy, chemicals etc.) of approximately US$ 0.15 - 0.20/m/3, plus the savings of annual costs of desalination program.

As most of the incremental demand growth will be concentrated in the urban/industrial sector, a comprehensive demand management policy should become a major component of the regional water policy. In the year 2020, when the population west of the River Jordan will rise to over 12 million, the potential savings would amount to approximately 200 mcm/y and if multiplied by present sea-water desalination costs it may reach a saving of US$200 million per year. This huge sum of money could be used for indefinite coverage of water conservation and effluent re-use projects throughout the region.

Increasing efficiency of water use in agriculture could by itself generate substantial increases in production per unit of water (or effluent) and/or absolute savings. It is estimated that the cost per cubic meter of water saved (or its comparable value in production) will be, based on Israeli experience, approximately 10 -15 US cents which is much lower than the forecasted marginal cost of additional resources of water in Israel.

In order to sustain the country's economic demand for water (fresh plus effluent) policy must be based on major investments, aggressive public education, government incentives and penalties, implementation of a 'water market' as well as appropriate changes in water rates. It calls for an elaborate social and political campaign. Cost per cubic meter, to treat and transfer and the investments to facilitate exchange of fresh water sources for secondary or tertiary treated effluent, could rise to close to sea water desalination costs. In any event Israel may be forced to desalinate sea-water before the year 2020 unless large-scale regional transfers are achieved. Desalination of brackish water has already been integrated into the system. In the Central Negev desalination of existing brackish aquifer may be a major source of water, possibly as soon as 2000 -2010. All these programs cannot be implemented unless large-scale investment are made, including the use of international funding and private-sector involvement.

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INTERACTIONS OF WATER PRODUCTION, USE AND CONSERVATION

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Introduction

Satisfying basic human water requirements necessitates utilization of water from several sources in water short areas. When water supplies exceed basic needs, then additional needs are met. Eventually, factors may intervene necessitating a revaluation of needs for water and adjustments in usage to meet those needs. An awareness of how these additional needs evolve and how changes may be made to accommodate them is useful when water shortages are likely to develop. In this paper, these subjects as well as mechanisms for implementation of residential water conservation programs are reviewed.

Assessing Basic Human Water Requirements

Water is essential for survival of life. What does a human being need water for and just how much? Is each person entitled to water? If so, what is the minimum amount of water necessary for survival or should a person have a right to more than that? These questions were addressed by Peter H Gleick in his article "Basic Water Requirements for Human Activities: Meeting Basic Needs" in the June 1996 issue of Water International. Gleick recommends in his article that 50 litres (13.2 gallons) of clean water per day be considered a fundamental human right. The table below presents an itemized breakdown for his claim.

Table 1
Recommended Basic Water Requirements for human needs

Purpose	**Recommended Minimum (litres per person per day)**
Drinking Water	5
Sanitation Services	20 to over 75*
Bathing	15
Cooking and Kitchen	10
Total Recommended Basic Water Requirement	50

* An average of 401/p/d is considered adequate for direct sanitation hookups in industrialized countries

With changing standards of living, there has historically been a corresponding per capita increase in water demand. This is normally attributed to an increase in the need for drinking water, removing or diluting wastes, producing manufactured goods, growing food, and producing and using energy. The water required for each of these vary with climatic conditions, lifestyles, culture, tradition, diet technology and wealth. Access to water sources is a very important variable in determining the amount of water use. This is illustrated particularly well in the Tables 2 and 3 as developed by Gleick.

Table 2
Domestic Water Use by Distance to Source

Source of water	Water Use (litres/capita/day)
Public Standpipe further than 1 kilometre	less than 10
Public Standpipe closer than 1 kilometre	20
House Connection simple plumbing, flush toilet	60 to 100
House Connection urban with gardens	150 to 400

Table 3
Rural Household Water Use by Climate and Source

Climatic Zone	Public Stand Post (litres/capita/day)	House Connection (litres/capita/day)*
Humid	10 to 20	20 to 40
Average	20 to 30	40 to 60
Dry	30 to 40	60 to 80

*Without flush toilets or gardens.

Evolution of Water Demands to Exceed Available Supplies

As populations change and demands increase there is a corresponding need to increase water supplies. This is particularly a challenge in areas where climatological and geographic constraints are tight. The Caribbean is such an area. A brief illustration of the United States Virgin Islands experience can serve as an example of how apparent needs (demand) evolve with availability of water.

The US Virgin Islands are located at the northern end of the Leeward Islands in the Caribbean about 50 miles south east of Puerto Rico and 625 miles to the northwest of Trinidad. They consist of three major islands, St. Thomas, St. John and St. Croix, and are principally of volcanic origin with steep slopes and shallow soils. None of the islands are greater than 85 square miles in area. Annual rainfall averages about 45 inches and nearly half of the rain falls between August and November. The average annual temperature is 80o F.

The economy has in the last 75 years changed from agriculture and fishing to one based on tourism. The current population is approximately 115,000. In the past 25 years there has been a high influx of persons from other Caribbean islands, the mainland United States and elsewhere throughout the world. The annual per capita income average is close to that of the United States and is now among the highest in the Caribbean region. Consistent with the discussion above, water demands have increased consistently with the increasing standard of living leading to utilization of water from several sources to meet the needs of the population.

Due to the relatively small size of the islands, steep slopes and high evapotranspiration rates, surface water supplies are limited. Streamflow is for the most part ephemeral occurring during the high intensity rainfall during the rainy season. Purpose built ponds have been used in the past for cattle watering. No surface water is used for human consumption.

Shallow dug wells in alluvial aquifers provided some water in the past for agricultural use, cattle watering, and even human consumption. Low ground water recharge rates due to short high intensity rainfalls, steep slopes and shallow soils coupled with increasing demands and increasing sources of contamination and high water quality standards make these wells of low significance.

Drilled wells make possible the extraction of larger volumes of water. In St. Croix where there is a limestone aquifer, ground water satisfies a small portion of the water demand. There is always the need for careful management of this source to prevent over pumping and the very harmful effects of saline water intrusion. Furthermore, the increasing population's need to discharge wastewater has resulted in contamination of the ground water supply because of leachate from the widely used septic tanks. At the same time there has been additional pollution of aquifers, such as the Tutu aquifer in St. Thomas, with petroleum products and other hazardous wastes.

A natural alternative to utilization of water available from the surface and through ground water extraction is harvesting the water as it becomes available from the sky. Contamination and distribution problems are avoided. Rain water harvesting forms a major source of water for the people of the US Virgin Islands where all buildings (churches and warehouses excepted) are required to provide for the catchment and storage of rainfall that falls on rooftops. Volumes of storage that must be provided are regulated by law though there are no provisions for monitoring the quality of water in these cisterns.

Cisterns are the preferred source of drinking water for most Virgin Islanders. They provide a cherished level of cherished independence from a centralized distribution system and are a fairly reliable water source in areas where no other sources, even the public distribution system, are likely to be.

The high cost of providing these cisterns (approximately $1.25/gallon) add to the high cost of home construction in the US Virgin Islands. Increasing per capita water consumption along with the proliferation of multistory dwellings are other challenges to using cisterns for water supply.

Rain water harvesting is also practice elsewhere in the Caribbean. Among the places where cisterns are used are Bermuda, the British Virgin Islands, Antigua and the Cayman Islands. Barbados and Montserrat have recently shown an interest in expanding their usage of rain water harvesting systems.

It is necessary to note that the original source of water for the public water distribution system in St Thomas was water harvested from purpose built catchments on the hillsides surrounding Charlotte Amalie, the principal town. These catchments were constructed principally from concrete, and sometimes from elevated coated sheet metal. They deposited harvested water in concrete storage tanks. The tanks provided water to a distribution system that supplied potable water to the residents and also served for firefighting purposes.

The introduction of a public distribution system was a principal contributant to increasing water demand in the town of Charlotte Amalie as it has been throughout the Caribbean. This is consistent with the information provided in Table 2 on effects of access on water demand. The availability of the distribution network also made possible the use of water supply sources not available before. A ready source of high quality seawater and the availability of capital (a large proportion from United States grants and loans) made the US Virgin Islands a prime candidate for the use of desalination technology. All forms of desalination technology have been tried in the US Virgin Islands —distillation, freezing, electrodialysis and reverse osmosis.

The high quality of the desalinated water and the high cost of its production led to a desire to avoid using this water for applications where lower quality water could be used. As a consequence, a secondary distribution network was installed in Charlotte Amalie through which raw sea water was distributed for fire fighting, street and gutter cleaning and for toilet flushing purposes. The introduction of the dual water distribution system has resulted in decreasing the quality of the ground water supply in Charlotte Amalie and the discontinuance of use of virtually all wells in the city.

A further consequence of the introduction of the distribution system and desalination technology was the creation of an expectation that water would always be available in demand satisfying quantities and quality independent of the occurrence of the rainfall. Thus, in the early experimental days of desalination when the early plants were fraught with problems, barging water from Puerto Rico (as a supplement) was introduced. Additionally, now even cisterns users outside the distribution system trucked water to their homes to supply cisterns that could not meet demands due to poor design and/or construction inadequacies, prolonged dry periods or even excessive demands placed on these formerly carefully managed systems.

This glorious age in water availability was not to last. In the early 1970's the desalination plants were proving to be unreliable, attitudes in Puerto Rico concerning exportation of their water by barge and even the anticipated submarine water pipeline to the USVI. The distribution system was approaching the end of its useful life in the highly corrosive salt water laden soils of downtown Charlotte Amalie and was losing over 60% of the very expensive desalinated water. Furthermore, the customary funds to correct all of these problems were not forthcoming as it had been in the past from the Government of the United States. On top of that, costs of fossil fuels had risen dramatically increasing the costs of desalination and barging. At one point, the most fortunate residents could expect only two hours of water on a daily basis through the distribution system because of strict water rationing. The quality of distributed water was questionable because of inflow to the leaky lines of sewage contaminated salt water from the sanitary sewers that had been laid in close proximity to potable water lines. Bottled water was served to tourists and visitors. Cistern users, including hotels and apartment houses, who had gotten accustomed to this ready availability of water also were severely affected for the rationing program also applied to the public stand pipes from which water trucks were filled.

Meeting Demands With Less Water

Conservation of water then became not a choice but a necessity. More efficient plumbing fixtures were installed with the aid of rebates. Public education programs were implemented to assist in changing water use attitudes and practices and incentives were provided to decrease dependence on the public water supply system for water. A high level of water consciousness developed in the community as residents and visitors alike were counseled through a promotion blitz to use every drop of water wisely. Increased attention was paid to monitoring water consumption with existing water meters and then charging customers for water used. Per capita water consumption dropped dramatically.

Even now where the water distribution systems have been rehabilitated and expanded and the islands are served by state of the art desalination plants that have for the last 18 years been producing water at or better than design standards, water conservation remains a way of life. The lessons learned about the tendency for demand to increase as water availability increases and the need to practice water conservation are applicable to all Caribbean Islands.

Institutional Approaches for Implementing Water Conservation

There are several ways in which institutions can promote water conservation. This takes place principally through the authority of these agencies to issue approvals which generally take place in the process of building construction. These institutions might include governmental agencies, utility companies and plumbing and building codes. Since these institutions' effect is mainly during the construction phase of buildings, they only affect new homes or homes undergoing major renovations. There are measures though that may be implemented that are not affected by these authorities and to rely on these institutions solely when expedited results are desired would be not productive.

Local government can effect water conservation during times of extreme shortages. Ordinances can be passed that restrict certain practices during time of shortages. These might include things such as limiting car washing, lawn watering, replenishment of swimming pools and other less critical uses of water.

A more permanent method for implementing water conservation may take place through planning commissions. For instance, the Coastal Zone Commission in the US Virgin Islands looks with greater favour on applications for developments in the coastal zone if the applicant includes water saving measures as part of her project. Among these are the use of water saving fixtures, provisions for recycling or multiple use of water, and landscaping strategies providing for most effective usage of available water.

The influence of the government might also be exerted through the use of incentives. Investors might be provided tax or other breaks to include water conservation in development projects. The use of grant/loan funds in the USVI are often conditioned on the use of water conserving strategies in the funded activities. Rebates can be made available to encourage the installation of water saving devices in homes.

Government agencies are major purchasers in the Caribbean. Procurement policies and practices of public agencies might also affect the use of conservation in a community. Not only could this be used to influence suppliers to maintain inventories of water saving devices and facilitate their availability to the public, but also use of these fixtures in public facilities can serve as demonstration projects and reduce public apprehensions that might occur due to unfamiliarity.

Perhaps the best way institutions can influence water conservation is through public education. Government agencies, schools, churches, public and private utility companies, and non-governmental organizations can include

water conservation information in their newsletters, sponsor media spots on the subject, provide tips in their mailings and in other ways keep the issue before not only the general public but also in the minds of their own employees.

Water Pricing For Facilitating Water Conservation

One institution that has the potential for immediate water conservation results is the utility bill. Water is perceived as being cheap. Where there is a charge for water, the water bill is usually the lowest utility bill in a household. In general, the price charged for a commodity affects the level of usage of the commodity. For this reason, water pricing is sometimes suggested as a way to encourage water conservation. Some pricing mechanisms have been successful in doing so and others have not.

One of the difficulties with attempting to use price as a means of controlling volumes of water consumed has to do with an ongoing controversy over whether residential water demand is price elastic or not. When a commodity has readily available substitutes or the commodity is available in large quantities relative to demand, then price can be used to control the demand. If when the price of the item is raised the consumer can readily purchase the same item somewhere else at the lower price or may instead purchase a substitute item, then the item is said to have an elastic demand curve. On the other hand, if an item has no substitutes or is available only in small quantities, then the consumer generally has to pay the price charged for the item. That item then has an inelastic demand curve. The price elasticity of residential water demand though is controversial though for water has no substitutes and is available in relatively large quantities. The only consensus is that there are several factors that must be considered other than simply increasing price that will result in a significant reduction in residential water demand.

Water pricing strategies though are used with varying degrees of success to reduce reckless usage of water. Some utility companies and small water company operators such as landlords in apartment buildings find it adequate to recover their cost of providing water by charging the same amount to each customer. This amount is found by dividing the cost of their supplying water by the number of customers served and is known as a set price. Each customer then receives the same bill and the distributor's bookkeeping problems are minimized. This approach does not encourage water conservation for an individual customer's bill is not a direct reflection of her water usage. The customer actually is motivated to use more water due to the belief she has already paid for the water.

Installation of water meters permit other pricing schemes. With the use of meters, customers have the economic incentive of reducing their bill by using less water and also the customer attaches a cost to each unit of water consumed. A scheme similar to the one previously described can be applied where an average cost is charged to each consumer by dividing the total cost of the water consumed by the group by the quantity of water consumed. This is referred to as a flat rate. The water provider under this scheme also recovers his cost but again there is little incentive for the consumer to reduce her individual consumption. This scheme assumes that the cost of providing water increases in proportion to the quantity of water supplied. This is usually not true and the customer tends to be overcharged.

The most widely used rate structure is the decreasing block rate. With this approach, there is a minimum charge for a fixed quantity of water. Costs for additional quantity blocks of water over that first block decreases as the quantity of water consumed increases. This system then has the cost of the water increasing at a declining rate reflecting economies of scale for the utility to provide the water. This approach promotes little water conservation for the incentive to conserve decreases as the amount of water consumed increases.

The opposing approach is referred to as the increasing block rate. Here a fixed amount is charged for an initial quantity of water. An increasing amount is charged for each block above the first block. The cost of water increases

at an increasing rate. Pricing water in this manner is justified if the supplier's unit cost of providing the water increases with increasing production. This is referred to as diseconomies of scale and usually does not occur in supplying water. This rate structure is favorable to promoting water conservation.

Whatever the pricing scheme, in the Caribbean the price the consumer pays for water often is less than the true cost of obtaining and distributing the water. While some may argue that charging the true cost would affect the level of water consumed, questions like those raised by Gleick concerning basic rights to water are raised. Furthermore, increases in price alone cannot bring about water conservation for poor people very often cannot cut their water consumption and many of the more affluent people will not.

Closing Thoughts

1. When water is available it will be used. The quantity of water generally used far exceeds basic needs so there is generally room for conservation.
2. Short of having the experience where water conservation is absolutely necessary, public education is the most effective way of promoting water conservation.
3. Water metering is vital for not only application of water pricing strategies but also serves to alert consumers to their level of usage.
4. Wise usage of water has far reaching consequences in a community including wastewater reduction and reduced energy consumption.
5. Though an effective water conservation program could reduce a utility company's income and suggests the possibility of a need for a rate increase, the consumer's water bill still should be lower than without water conservation.

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ECONOMICS CONSIDERATIONS IN HYDROLOGICAL DATA COLLECTION

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Introduction

Water is a prime necessity for life; it sustains all plant and animal life; it strongly influences our decisions on where we live, what we eat and the state of our health. In our daily lives we take water very much for granted; we believe that water will always be there. But the harsh reality is that water is very much a finite resource, which has to be shared among an ever increasing world population.

World Water Balance

The world water balance is as follows:

Total water on surface of the earth: 1.36* 109 km3

Amount of sea water: 1.323 * 109 km3

Water in the form of ice and snow: 2.9* 106 km3

Ground Water: 8.0* 106 km3

Rivers and lakes: 0.2* 106 km3

This balance shows that, of the fresh water available for human use, approximately ninety-eight percent is ground water. About half of this amount is below a depth of 800 meters and therefore considered inaccessible.

Thus the amount of fresh water which seems to be available for human use is the order of four million cubic kilometers. However, this is not strictly true.

The world's freshwater is renewed in the hydrological cycle of evaporation and precipitation. Average annual global rainfall over land is about 110,000 km3, 70,000 km3 are lost through evaporation before reaching the sea. This leaves 40,000 km3 of run-off that is potentially available for use. However, the actual quantity of fresh water that is available for human use is much smaller, due to the following factors:

1. Precipitation that falls on uninhabited areas, such as Antarctica, is of no relevance to human use.
2. Much of the precipitation falls heavily over short periods and runs off into the sea too quickly to be exploited.
3. Annual variations in rainfall mean that the volume of precipitation that can be guaranteed every year, without fail, is considerably smaller than the annual average.

These factors reduce the freshwater available for human use from a theoretical total of 40,000 km3 to an actual total of about 9000 km3. However, even this amount is enough to take care of present and future consumption needs. Current annual global freshwater consumption is about 4000 km3 - less than half of what is available. This is the equivalent of 800 m3 per year per person for a world population of five billion people.

Thus, theoretically, there is enough fresh water available to satisfy the world demands for the present and well into the future. The reality, however, is that in many areas of the world there are shortages and access to water which is below the standard required for human use. The reason for this is the uneven distribution of fresh water around the globe as well as the annual variation of rainfall over the globe, e.g. yearly per capita run-off ranges from about 120,000 m3 in Canada to about 70 m3 in Malta. South America provides about ten times more per capita run-off than either Asia or Europe, and predictions suggest that by the year 2000, there will be even greater imbalances between continents. While per capita availability in Europe and North America will not change greatly, less water will be available to each Asian, Latin American and African as their population continue to grow. Water availability is a critical factor in socio-economic development, limiting progress in many areas such as Sahelian Africa and other arid and semi-arid zones.

As a result of shortages water of inferior quality is often used to meet demands. Conversely, the need for clean water makes heavy demands on total resources. For example, it is estimated that some 450 km3 of waste water currently enters the world's rivers. It requires 6000 km3 of water to transport this waste away and dilute it. Cleansing the world's waste thus requires a volume of water equivalent to two thirds of what is available.

It should be obvious, therefore, that in order to utilize the fresh water resources of the world, it is essential that first hand knowledge of what is available locally and regionally, rather than globally, is required. It is necessary that exploration and studies be done on the local and regional scales, of the quantity and quality of the fresh water that is potentially available for use -hence the requirement for monitoring.

The Data Collection Problem

User requirements for data are enormous and it is impractical to establish a network to cater for every conceivable user and purpose. It is thus desirable to have an optimum network to cater for user requirements in a general way. The design of such a network requires a certain criterion on which the spatial network configuration should be based. More often than not, such a network has grown arbitrarily over the years, and stations were added when there was a need for the data. In small developing countries hydrological networks are frequently absent and hydrological measurements are made when they are needed. Of course, in such situations, there is no long term, or even short term data to work with, but only “spot measurements”. Analyses of such data can be very mis-leading and can result in gross under-or over-design of hydraulic structures. Financial constraints play the leading role in developing countries for the lack of any suitable hydrological network. However, in spite of economic constraints, it is highly desirable to have a minimum level of hydrological data collection capability in a nation-wide hydrometric network. Hydrometric data are time-bound, that is, they are dependent on records which can be collected only as the phenomena unfold with the passage of time. It is estimated that a minimum of twenty-five to fifty years of hydrometric data are desirable to give an adequate picture of conditions for the design of water resource projects. This certainly, is an ideal situation, which is rarely realized before development takes place, but it does indicate the necessity of setting up at least a minimum network in under-developed areas well in advance of the actual need for the data. One major problem is to determine ahead of time, say ten to fifteen years in advance, the locations from which data will be required. However, if a development plan has been established and the need for the data has been recognized, then this will help greatly towards the goal of determining the locations for hydrometric stations.

Another major problem, of course, is the problem of having to convince administrative authorities of the need to allocate sufficient resources for the establishment of the stations, their subsequent operation and maintenance and the processing and analysis of the data. The very minimum length of data required for any useful analysis to be done is ten years. This means that before any development takes place in a location, one or more hydrometric stations should be installed, at least ten years in advance. Thus resources will have to be allocated for the establishment of

such stations and its maintenance and operation at an absolute minimum of ten years before any use can be made of the data. Under such circumstances it is not easy to convince the relevant authorities in developing countries to allocate scarce resources for such tasks. When the necessary expertise are lacking in such countries, then it becomes almost impossible to obtain the necessary resources to operate and maintain a hydrometric network. Such conditions, even though they may seem extreme, do exist.

Data Types

Hydrometric Data

Data on river levels and flows and their variations in time. The rivers in the Caribbean islands, where they exist, carry sufficient water to meet most foreseen needs. However, for big projects such as hydropower development, one has to be careful, since it is very easy to over-design for the rivers, which are very small for such projects. It is very necessary, therefore, to monitor the rivers on a continuous basis, before such projects are designed. Unfortunately, there are very little existing data, either on the variability of flows with time and space, or on the water quality, particularly the amount of sediment transported by the rivers, so that the efficient engineering design of facilities associated with the rivers or their use, that is, weirs, intakes, bridges, pipelines etc, is severely constrained.

Water Use

Data on the various uses of water; it is essential that a knowledge of what is being used is available.

Ground Water

Data on ground water and their variations in time. Many of the smaller Caribbean Islands do not have any source of surface water and have to rely on ground water sources to supply their demands. Also, in some of the larger islands, ground water is used to supplement the surface water supply. Since these are small oceanic islands, one has to be very careful in the extraction of ground water, because sea water intrusion is always a threat. Hence the necessity for ground water monitoring cannot be over-emphasized to ensure:

1. Safe extraction
2. Prevention of salt water intrusion
3. Prevent deterioration of the water quality.

Data Needs

Operational Support

Water resources data are required in numerous operational situations such as flood control projects, hydropower operation and agriculture. Availability or lack of data can very well determine the success of failure of such projects.

Planning Purpose

Water data are required for a variety of planning purposes, such as domestic supply, industrial and agricultural use.

Cost of Data Collection

Network Installation

The need for water data in the development process in the region is not without recognition by senior administrators of the region. Previous efforts to collect data attest to this fact. However, the major problem facing the collection of hydrological data in the region is the lack of knowledge among administrators of the difficulties involved in the collection process. In the Caribbean islands problems of accessibility, steep rocky rivers with high flood and sediment transport capacities compound the problems even further. Of course, these problems only increase the cost of collecting the data.

However, in spite of the high cost of collecting the data, numerous studies by WMO that have been done usually indicate an economic benefit of ten to twenty times greater than the cost.

These high cost effectiveness can be obtained provided that:

a. The programmes should be designed on a multi-purpose national basis to satisfy all possible users.
b. The programmes should be set at a realistic level so that funding does not place a strain on available finances.
c . The level of staffing and funding of the operation must be sufficient to ensure that the data collected is reliable and continuous and appropriate to the economic investment made. (The worst case is one in which data is collected intermittently; such data may be worst than no data).
d. To cut costs, existing facilities should be utilized wherever possible.

Operations and Maintenance

Once the network of stations has been established it has to be maintained. To say the least, this is a difficult task under the best of circumstances; and the best of circumstances do not exist in the real world.

Because of its inherent variability, the collection of hydrological data must be undertaken on a long term basis, e.g. the minimum length of record to quantitatively define the chances of experiencing a medium drought or flood, is of the order of twenty-five years. To determine extreme conditions even longer lengths are required. It is therefore extremely important to understand at the outset, that hydrological data collection must be undertaken as a long term project.

This means that resources have to be allocated on a recurrent basis over a long period, continuously, to operate and maintain the network. Unless such a commitment of resources can be made at the outset of the programme, a lot of effort put into the programme may be wasted. Very often data collection programmes are commenced without the commitment of the necessary resources for the long term period, with the result that the benefits of the initial effort is never realized.

Telemetry

Proper environmental and natural resources management is a key issue of the development policies of countries all over the world. A report addressed to those in government concerned with planning and management of water use, commissioned by the United Nations Environment Programme and co-sponsored by the Economic Commission for Latin America states:

The study stems from a growing conviction among governments and development specialists that greater attention should be paid to environmental quality in the pursuit of economic and social development objectives; that this requires, among other things, innovative approaches to natural resources management.

In order to manage natural resources innovatively and water happens to be our most precious natural resource, it is necessary to use monitoring techniques which are according with and complement the modern approaches to resource management. Among them, remote sensing and data transmission systems together with computerized data management, are tools which most adequately serve this purpose and allow the resource specialist to have a timely and ample spectrum of data coverage of the areas of interest.

Telemetry Network Planning

Planning of a telemetric system is a delicate aspect of the whole process of adopting an automatic data collection network. It does not only involve those aspects related to the location of new stations, the number of parameters and measuring points required to obtain the desired results, the type of stations and transmission method to be used; but it must involve also, a comprehensive revision of the institutional organization and how the new technology can be merged into the mainstream of activities in a smooth and proper manner. This evaluation should consider the following points:

1. Human resources available for the project
2. Data processing and communication facilities
3. Workshop facilities
4. Operation Schedules
5. Analysis of end users' requirements
6. Spare parts

The CMI/COHI is presently involved with the OAS in a project: "Caribbean: Planning for Adaptation to Global Climate Change (CPACC)." Telemetering equipment will be established throughout the Caribbean area mainly to monitor sea level rise. A central data base will be set up at the CMI/COHI and all data will be transmitted against satellite to this central data base. This data base will not be restricted to the CPACC project but can be used by other data collection agencies to have their stored in a central location. Hydrological services around the region can make use of this facility.

Problems in Data Collection, Analysis and Dissemination

Funding Cuts

As pointed out before, once a network of stations has been set up, it should be maintained and kept in operation for a minimum of twenty-five years, so that the full benefits of the use of the data may be realized. However, twenty-five years is a long time and economic, political and social conditions can change drastically during this time. Such changes usually can propel changes in the priorities set for the country, which means that there can be funding cuts for ongoing projects. Unfortunately, programmes for data collection usually suffer heavily whenever there are cuts in funding. The results of such cuts are usually the reduction of the network of stations and lack of maintenance of stations that are kept in operation. Reduction of the network leads to a loss of data, hence no analysis available for projects requiring such data. The result is either under —or over— design of projects which eventually leads to economic losses.

Staff Turnover

The problem of staff turnover varies significantly among the countries of the Caribbean. The main problem areas are:

1. Staff leaving shortly after training resulting in the loss of the benefits that should have been obtained from such training.
2. Staff being trained in hydrology but not utilized in the field of hydrology on their return to their services.
3. Frustration among some trained staff because of lack of promotional opportunities.
4. Low salaries paid to trained hydrological personnel in some services, in comparison to other personnel of similar status in other sections of the public service.

Training

Hydrological data collection, analysis and maintenance require a high level of training in a number of disciplines and such training is relatively costly. While there is no shortage of training facilities available for training of hydrological personnel, too often personnel are unable to take training because of lack of funding. The Caribbean Operational Hydrology Institute (COHI) was established in 1982 to cater for the training needs of the English Speaking Caribbean Territories. The courses conducted by COHI are at two levels - the Lower and Higher technicians' levels. Many graduate level courses are available outside of the region for first degree graduates. However, again, funding is a problem, even for candidates from the Caribbean Region who are nominated to attend the courses run at COHI.

Proposed Solutions

Increasing Political Awareness and Commitment

Politicians are the ones who make the decisions whether funding is available or not for hydrological data collection, analysis and dissemination. The problem is that the politicians also have to make decisions to commit resources to other agencies as well. Many times the commitment of resources for hydrological purposes are made available after other agencies have been allocated their requirements. It is not surprising, therefore, that in the Caribbean Islands, where resources are always in short supply, the hydrological activities suffer.

Because of the lack of resources a proper network of stations is not maintained on a continuous basis; data is collected in a hap-hazard manner whenever personnel are free from other duties, and other necessary resources such as transportation and finances are available. This leads to a situation where you may have some data, but such data lack continuity, reliability and accuracy. Analysis of such data is meaningless and can be very misleading, if used. In such cases “nothing” may be better than “something.” So what is the solution?

In 1980, the UNDP/WMO consultant, Mr. K Potter, made visits to each island of the Caribbean, which are members of the Caribbean Meteorological Organization. The purpose of the visits was to: make a survey of the hydrometeorological and hydrological networks, identify gaps in the networks, make recommendations for filling the gaps and specify equipment requirements. One of the important findings of Mr. Potter's mission was that: no hydrological capability existed in the smaller Caribbean Islands.

Among his recommendations were:

1. The establishment of a hydrological unit with some analytical capability and with general national responsibility for collection, processing and dissemination of hydrological data for water resources management, agricultural and other purposes.
2. A staff complement comprising two senior technicians and five junior technicians would be required.
3. Training at the Lower and Higher Technicians' level at the Caribbean Operational Hydrology Institute would be of considerable assistance in fulfilling the requirements for trained personnel.

Since Mr. Potter's mission there have been attempts at establishing a network of stations at a number of locations in several Caribbean Islands. These efforts have met with varying degrees of success. However, not many of the stations, if any, survive through the rainy season, especially recording equipment. Many times you are left in a situation where the equipment is washed away with the very flow that you want to measure. Thus the measurement of hydrological parameters is not simple and straight forward.

It is therefore of vital importance that politicians, administrators and decision makers be made aware of:

1. The role of hydrological data and analyses in water resources planning and project design and execution;
2. The financial technological and social benefits to be derived from use of such data;
3. The difficulties and problems of measuring hydrological parameters; and
4. The resources required for such measurements over the long term period.

Internalizing Data Collection Costs

Many agencies requiring hydrological data for their operations may be willing to pay towards the cost of obtaining the data, since use of the data will enable them to economize on their operations and the benefits are much greater than the cost of the data.

However, before a decision can be made to impose a cost on users for the data, the data must be available when requested and also must be reliable and continuous. It is therefore essential that the data collection programme be well established and maintained before a decision to ask users to pay for the data is made. However, once the data collection programme is well established user fees can compensate to some degree the cost of collection of the data.

Institutional Co-ordination

Because of the high cost for the collection of hydrological data it is of utmost importance that there be maximum co-ordination among institutions involved with such data collection programmes. It is highly desirable that there should be a single agency in each country which has national responsibility for the collection of hydrological data and for co-ordination of all user agencies. Such co-ordination can greatly reduce duplication and thus the overall cost of collection of the data.

Dissemination

It is important again that a single agency in each country be responsible for the dissemination of the data. The CMI/COHI has the facility (data base) for storing data from all member countries of the CMO. Countries are urged to make use of this facility to store duplicates of their data.

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WATER RESOURCES MANAGEMENT POLICY DEVELOPMENT IN HAITI

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Summary

Water resources sector in Haiti is characterized, on one hand, by relatively important water resources, although not uniformly distributed, where only ten percent of the resources is used by two major subsectors: agriculture and drinking water. On the other hand, the sector is characterized by insufficient regulations, frequent confusion between roles of managers and users, inefficient and inadequate control over the water user community, non-existence of an institution responsible for water protection and allocation, excessive centralization, and a plethora of institutions involved in the sector without coordination.

During the last twenty years some initiatives have been taken in order to develop a water resources management policy in Haiti. More recently, on October 1996, on request by the Ministry of Planning and External Cooperation (MPCE), the United Nations Development Program (UNDP) approved a project to evaluate and reorganize the water resources sector, define a national policy and strategy and make concrete proposals for its reorganization. Also, on February 1997 on request by the Ministry of Environment (MDE), an agreement was signed with the IDB for a water policy formulation program. Later on, both UNDP and IDB, agreed to coordinate their efforts for supporting the government of Haiti to reorganize the water resources sector.

In order to organize the water resources sector, six major actions are proposed:

- Creation of an intersectoral committee where all water issues will be discussed;
- Identification and assessment of the institutional, technical, financial, and human resources constraints that makes difficult integrated water resources management in the country;
- Presentation of some scenarios for organizational restructuring of the water resources sector in the country;
- Discussion of the proposals with the Government and in workshops with all concerned sectors;
- Preparation of an integrated water resources management action plan; and
- An inventory of water resources, and preparation of a GIS based water balance.

The success of these coordinated programs will hopefully mark a major shift in water resources management policy in Haiti: from an isolated sub-sectoral approach, where the needs and uses are dealt separately, to an integrated approach.

Introduction

During the last 20 years, different attempts in water resources management have been initiated in Haiti in order to respond to the multiple problems generated by the sector. Indeed, from the National Committee for Water (CONAE) in 1977, to the project-law for the creation of a Water Council (GCE) in 1995, the major concern was to reorganize the water resources sector.

Recently, on October 1996, on request by the Ministry of Planning and External Cooperation (MPCE), the United Nations Development Program (UNDP) approved a project to evaluate and reorganize the water resources sector,

define a national policy and strategy, and make concrete proposals for its reorganization. More recently, on February 1997, on request by the Ministry of Environment (MDE), an agreement was signed with the Interamerican Development Bank (IDB) for a water policy formulation program.

This paper is an attempt to give an overview of the existing water resources management policy in Haiti. Furthermore, the major trends for the last twenty years in terms of developing water resources management are discussed. One of the latest trend proposed by the IDB financed program was that management should be integrated and not perform by sectors. Strategies used in this program to meet the objective of water policy formulation are presented.

Water Resources Management Policy, Why?

A Picture of the Water Resources Sector

1. *Water resources availability*

- Water resources are relatively important in Haiti. The mean annual rainfall is 1,400 mm, but varies from one region to another, going from 400 mm to 3,600 mm. Based on the mean annual rainfall, an estimate of 40 x 109 m3 of rainfall is received annually. However, only ten percent (4 x 109 m3) goes into deep percolation and groundwater. The other 90%goes as runoff or is evaporated.
- Coastal aquifers constitute around 17.3% of the country area of 27,750 km3. Potentially, the groundwater resources are estimated to be 56.2 x 109 m3 (DIEPA, 1990)where 48x 109 m3 of water is stored in continuous aquifers, and 8.2 x 109 m3 in karstic area.
- Lakes and ponds are spread on 23,000 ha (230 km2). They constitute a reserve of 1.1 x 109 m3 of water, but the majority is salted.
- In 1995, water resources used in Haiti represented about 10% of available resources (Table 1). For the same period, the needs represented about 17% of the available resources (Table 2).

Table 1
Water Use -vs- Available Water Resource in Haiti

Regions	Drinking Water (x10/m3/yr)	Irrigation (x 10/m3/yr)	Other (Electricity (x 10/m3/yr)	Total Use (x 10/m Regions 3/yr)	Resources (x 10/m3/yr)
North	5.0	8.4	0.4	13.8	1,000
North West	11.0	161.0	-	172.0	1,200
Centre North	8.0	410.0	-	418.0	3,800
Centre South	80.0	333.5	4.0	417.5	1,100
South East	1.5	69.0	70.5	800	
South West	5.5	187.0	0.25	192.75	4,700
TOTAL	111.0	1,168.0	4.65	1,266.9	12,600

Table 2
Needs -vs- Water Resources Available in Haiti (1995)

Regions Other	Drinking Water (x 10/m3/yr)	Irrigation (x 10/m3/yr)	(Electricity (x 10/m3/yr)	Total Needs (x 10/m3/yr)	Resources (x 10/m3/yr)
North	17.2	34.4	0.4	52.0	1,000
North West	27.0	383.0	-	410.0	1,200
Centre North	20.0	680.0	5.0	705.0	3,800
Centre South	126.0	385.0	5.0	516.0	1,100
South East	6.8	150.0	-	156.8	800
South West	14.0	375.0	0.6	389.6	4,700
TOTAL	211.0	2,007.4	11.0	2,229.4	12,600

- Agriculture and then drinking water are the most important users. There are 130 irrigation systems in the country for 70,000 ha. Twelve percent (12%) of the irrigated lands use groundwater;
- In 1995, there was only a 39% coverage for potable water in Haiti (Table 3); and
- Only 20% of the potential hydropower is used for electricity. The hydroelectric plants use around 4 x 109 m3 of the available water resources.

Table 3
Potable Water Coverage in Haiti (%)

Year 1990	1980	1990	1995
Port-au-Prince	48.0	53.2	35.0
Secondary Cities	47.0	58.6	45.0
Rural Areas	8.0	33.5	39.0
Country	18.0	39.5	39.0

2. Problems Identification

The major problems identified in the water resources sector are as follows:

- insufficient or no regulations at all. Menard, 1979, and Dante-A-Caponera, 1989, summarized the problems

in the legislation as follows: legislation is old, dispersed and in contradiction, incomplete, difficult to apply taking into account the imperfection in defining the authorities in charge for water policies and procedures;

- C dispersed attribution in a plethora of institutions, services;
- C frequent confusion between role of managers and users;
- C inefficient and inadequate control over the water user community;
- C non-existence of any institution responsible for water protection and allocation;
- C institutional separation of water-user sectors from the water resources and the division which tends to exist between the user sector. The organization and most pressing interests of the potable water entities are separate from these of the hydro-electric sector, or the irrigation authorities;
- C excessive centralization; water services are generally centralized in government organizations and agencies;
- C growing demands;
- C major population migration to urban areas. In 1995, 32.6% of the population was living in urban areas compared to 24% in 1980. In the same year, 25% of the total population of Haiti (Table 4) was living in the metropolitan area (Port-au-Prince, Petion-Ville, Delmas, and Carrefour). It is estimated, by the year 2005, 39% of the total population will be living in this area.

Table 4
Population of the Metropolitan Area Compared to the Total Population of Haiti

Year	1950	1990	1995	2000	2005
Metropolitan Area	250,000	1,317,866	1,814,083	2,497,142	3,347,393
Total Population	3,200,000	6,486,047	7,180,294	7,958,964	8,821,709
Ratio (%)	7	20	25	31	39

- C diminution of 50% in the minimum discharges (Table 5). The decline in water availability from springs and other underground sources has been widely observed. The incidence of flooding and the damage caused by even normal precipitation reflects the extent to which many watersheds are in a state of collapse;
- C status quo taking into account the interests and deep changes necessary in the sector;
- C lack of adequately trained human resources and absence necessary in the sector;
- C lack of adequate and reliable hydro-meteorological and water quality data.

Table 5
Comparison of Discharges for Some Rivers During Drought Periods

Regions	Rivers	Q(m3/s) 1950	Q(m3/s) 1990
North	Grande River, Du Nord, Limbe	3.44	0.75
Nort West	Trois Rivieres	2.22	4.80
Centre North	Fer A Cheval	3.08	1.12
	La Theme	5.2	3.10
	Saut d'Eau Guayamouc	0.80	0.73
	Samana	67.5	19.75
		2.25	0.73
Centre South	Momance	3.97	1.47
	Riviere Grise	3.90	1.90
South East	Gosseline Pichon	1.00	0.30
		0.80	0.27
South West	Grande River Nippes Voldrogue	3.2	1.72
	Grande Anse	0.40	0.20
		22.20	12.40

The Institutions Involved

- Ministry of Agriculture, Natural Resources and Rural Development (MARNDR), officially created by the constitution of 1843, is among the oldest Ministry in Haiti. It has the mission of establishing a national policy in the area of agriculture, natural resources and rural development. It has a Division of Natural Resources and seven important services involved in water resources. The National Service for Water Resources and the irrigation service are among them.
- National Service for Water Resources (SNRE), created in December 1980, under the name Water Resources Bureau (BRE), and then SNRE in 1984, has the role of inventory, conservation, exploitation, development and protection of the water resources. It has different sections: meteorology, climatology, hydrology and sedimentology.
- Irrigation Service (SIG), which is responsible for designing, planning, supervising and maintaining all irrigation systems in the country.
- Ministry of Public Works, Transportation and Communications (MTPTC), which mission stated in its latest organic law (October 18, 1983) is in charge of the study, planning, execution, maintenance, control, supervision, and evaluation of all physical infrastructures related to urban and rural equipments, to ports and airports, communication systems, and to potable water systems. It has two autonomous institutions involved in the distribution of potable water.

- Metropolitan Autonomous Central for Potable Water (CAMEP), created in 1964, which mission is to supply potable water to the metropolitan area with an estimated population of 1,814,083 habitants. The daily production is estimated to be 100,000 m3 (compared to an estimated need of 220,000 m3).

- National Service for Potable Water (SNEP), created in May 13,1964, which attribution is to supply potable water to all the country except the metropolitan area. An estimated 5,366,211 habitants are deserved in 1995. The daily production is estimated for the same period to be 32,587 m3 (deficit for the needs is 50,000 m3) and an electricity company.
- Electricity of Haiti (EDH), created by decree on June 16, 1977, is responsible for electricity generation, distribution and commercialization.
- Ministry of Environment (MDE), created in November 1994, is a normative and regulatory agency, which can serve to protect the water resources. It does not have yet an organic law.
- Ministry of Planning and External Cooperation (MPCE), created on February 1989 (earlier called in 1963 National Council for Development and Planning CONADEP), which mission is to integrate all programs and projects in a policy of global planning and to coordinate the external cooperation.
- Ministry of Public Health (MSPP), created in September 1945, with its latest organic law in November 28, 1983, has a program of construction of water potable systems since 1973.
- Community Standpipes for Hygiene and Potable Water (POCHEP), created in March 1981, which attribution is to supply water to rural localities of 500 to 2,000 habitants.
- Direction of Public Hygiene (DHP), created on February 24,1919, which mission is to control drinking water quality and general public hygiene.
- Non-Government Organizations (NGO), participating in construction and maintenance of irrigation and potable water systems. Those NGOs (around thirty) are involved in the sectors without control. The HAVA (Haitian Association for Voluntary Agencies) was created in 1981 in order to coordinate the NGOs. For more than six years, the water unit did not work. In principle those NGOs are supervised and coordinated by a Unit of NGOs coordination (UCAONG) in the Ministry of Plan (MPCE).
- Funding institutions and international organizations involved in programs realization and projects: IDB (Interamerican Development Bank), IDA/BM (World Bank), CFD (French Fund for Development), FENU (United Nations Funds for Equipments), KFW/GTZ (Kreditanstalt fur Wiederaufbau/ Gesellshaft fur Technishe Zuzammen Arbeit), UNDP (United Nations Development Program), USAID (United States Agency for International Development), UNICEF (United Nations funds for children), ACDI (Canadian Agency for International Development), OPS/OMS (Panamerican Organization for Health/World Organization for Health), UNOPS (United Nations Office for Project Services), OIM (International Organization for Migration). Table 6 gives a summary of the investments in the sector during the 1981-1990 period.

The Existing Legislation

- The constitution of March 1987, stating in Article 36-5 that the property right is not applicable for springs, rivers, lakes. They are part of the state public domain.

- The different organic laws for the public institutions involved in the sector:

  - April 7, 1958 and September 30, 1987: Ministry of Agriculture, Natural Resources and Rural Development (MARNDR);
  - May 13, 1964, December 1966, April 1973 and September 1979: Metropolitan Autonomous Central for Potable Water (CAMEP);
  - August 26, 1971, November 20, 1975 and November 28, 1983: Ministry of Public Health (MSPP);
  - June 16, 1977: Decree for the Creation of the Electric Company (EDH)
  - August 31, 1977: National Service for Potable Water (SNEP);
  - August 18, 1978 and October 19, 1983: Ministry of Public Works, Transportation and Communications (MTPTC); and

S October 30, 1978: Decree for the Creation of the Secretary of Plan (MPCE).

Table 6
Summary of Investment in the Water Resources Sector for the 1981-1990 Period

Financing Institutions	**Amount (US$)**	**Percentage (%)**
FENU 3.2	2,286,000	3.2
KFW	7,945,647	10.9
USAID/CARE	7,697,000	10.6
UNDP	3,560,256	4.9
IDA/BM	11,545,809	15.9
Belgium Gvt	564,500	0.8
ACDI	1,900,000	2.6
IDB	5,410,405	7.5
Rotary Club Int	541,420	0.7
UNICE	1,477,000	2.0
PAM	3,604	0.0
GTZ	2,005,059	2.8
OPS/OMS	1,620,000	2.2
FAC	447,000	0.6
CFD	7,250,400	10.0
UE	1,375,000	1.9
AIEA	98,000	0.1
OPEP	-	
Japanese Gvt.	675,253	0.9
State of Haiti	11,108,578	15.3
NGOs	5,102,300	7.1
TOTAL	72,613,231	100.0

- The Rural Code of May 1962. In Section II (Article 64), it defines arid region less than 750 mm of average rainfall during a year),semi-arid region (between 750 mm and 1350 mm of average yearly rainfall), and humid region (more than 1350 mm). Also in Chapter 1 (Article 131) it states that springs, rivers, lakes are public domain, and cannot be appropriate for private use. In Chapter II (Article 150), to drill a well you need to make a declaration to the Ministry of Agriculture and gives all information required.
- The law of June 12, 1974, regulating the use of groundwater. The regulating authority is the Ministry of Agriculture (MARNDR). From March 1979 to December 1960, well drilling is the Cul-de-Sac Plain is forbidden by the Ministry.
- The decree of April 1989, giving to the Metropolitan Autonomous Central for Potable Water (CAMEP) the control for any water resource for drinking purposes. Therefore, CAMEP can use the groundwater and gives authorization for potable water well drilling. However it is under the competency of the Ministry of Agriculture the use for agriculture. The decree of August 1989: the Ministry of Agriculture (MARNDR) is not anymore a member of the Administration Council of CAMEP, because of diverging interests.
- Project law of June 1995 for the Water Council.

Water Resources Management Policy Development

The Early Initiatives

Some early initiatives started twenty years ago in order to coordinate the Water Resources Sector.

- March 1977: The National Committee for Water (CONAE) prepared a national report to be presented to the International Conference on water at Mar del Plata. In May 1978, the National Committee make a general evaluation of the water sector;
- January 1979: the Enlarged Committee for Water (CEE), composed with the representative of the main water users, replaced the CONAE. The main objective was the creation of a National Institute for Water (INADE);
- December 1980: the idea for a National Institute of Water was abandoned for the creation of the Water Resources Bureau (BRE) in the Ministry of Agriculture (MARNDR). Later on, in 1984, this Bureau became the National Service for Water Resources (SNRE). During the same period, 1980, as a continuation for the activities of the International Decade of Potable Water and Sanitation (DIEPA), a National Committee for Potable Water and Sanitation (CONADEPA) was created. CONADEPA disappeared after December 1990;
- September 1985: a project-law was completed by the CONADEPA for the creation of a National Council for water and sanitation (CONADEA), which attribution was to coordinate the national policy on water and sanitation. Its creation was dictated by the necessity of having a databank in water resources, and managing the water resources; and
- September 1992 a Coordination Committee for Potable Water activities (CEEP)was created by the UNDP, UNICEF, and OPS/OMS. It stayed until 1994.

The Later Initiatives

June 1995: an interministerial technical commission, under the initiative of the Ministry of Public Works (MTPTC), worked on a project-law for the creation of a Water Council (GCE), which main attributions are to take control of the water sector planning, to coordinate and elaborate with the involved sectors a national policy on water resources, and any law, regulation related to the policy, and to serve as referee in water conflicts;

- May 1996: diagnostic of the potable water sector and sanitation (Agenda 21).
- July 1996: creation of the Reform Unit for the potable water sector (URSEP) in the Ministry of Public Works (MTPTC);

- October 1996: starting of a UNDP financed program in the Ministry of Planning (MPCE) on reorganizing the water resources sector;
- February 1997: starting of a IDB financed program in the Ministry of Environment (MDE) on water policy formulation.

Water Policy Formulation Program

Objectives

- Formulating a water policy which reflects the concern of the cross-sections of stakeholders. Some basic water resources policy principles will be proposed. These principles will refer to, at least, the following aspects: integrated water resources management, both surface and groundwater, using the watershed as the management unit; a system for efficient allocation of water between competitive users and use, enabling community participation and guaranteeing the conservation of the environment, including biodiversity, fresh and saline water ecosystems and the watersheds; separation of the regulatory from the service provision functions, regulatory role of the state; enabling the participation of the private sector; capacity building at all levels; and an institutional and legal (water code) framework suitable to local conditions, that enables and guarantees all of the above;

- Organizing and improving access to existing technical information pertinent for the scope and nature of the existing water resources predicament in Haiti. Sound water policy formulation must be grounded in a clear picture of the current and projected situation, and an appreciation of the interaction between the water-user sectors, and the state of the resource;

- Devising an operational structure for integrated water resources management, and an initial investment plan within the Ministry of Environment as the lead institution in implementing the policy. The plan will elaborate on the nature of the needs, proposed activities, calendar, budgets and terms of reference where applicable.

Strategy

- ***Building consensus***
  - creation of an intersectoral committee to coordinate with water user subsectors, and where all water issues will be discussed;
  - coordination with the UNDP financing program in the Ministry of Planification (MPCE) and cooperation among international agencies; and
  - consultation with stakeholders, managers, state agencies and all concerned sectors and subsectors, and presentation/discussion in workshop of scenarios for organizational restructuring of the water resources sector in the country.

- ***Gathering information***:
  - identification and assessment of the institutional, technical, financial, and human resources constraints that make difficult the integrated water resources management; and
  - data acquisition and exchange networks for reliable information in the sector;

- Using technical tools (GIS, modelling and DSS) to establish management priorities.

Concluding Remarks

The goal of this paper was to share a particular experience in water resources management policy development in Haiti. Twenty (20) years have been dedicated to the matter without tangible outcome. Water resources management in Haiti requires deep changes in the organizational structure, laws, habit and status quo. It is our hope that this new IDB financed program in the Ministry of Environment will finally bring around the table all the stakeholders, will increase awareness among politicians and legislators of existing and potential problems stemming from inadequate water resources management, and will make the shift from the isolated sub-sectoral approach to an integrated approach for water resources management.

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GROUNDWATER DEVELOPMENT AND MANAGEMENT IN BARBADOS

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Introduction

Barbados is an island which is presently entirely dependent on groundwater abstracted from a coral-rock formation varying in thickness from 100 to 350 ft, which is underlain by an impervious formation made up of clays, sand, shale and marl. For this paper springwater is considered part of the groundwater resources.

Historically, prior to the enactment of the Underground Water Control Act, CAP 283 in 1953, there was no requirement for a licence to abstract water from a well or to sink a well, therefore, groundwater development and management was carried out by individual landowners digging wells to supply their own needs as required. In 1857, however, the government provided for the formation of a private water supply company under the Water Works Act, 1857 to supply water to Bridgetown and followed this up with the Water Supply Act, 1886, which allowed for the formation of a second private company to supply water to the rural areas up to the 750 ft contour. Initial water supplies by both companies were obtained from spring sources.

In 1895, however, the Government of Barbados bought the two companies and established the Water Works Department, a government agency and forerunner to the present Barbados Water Authority (BWA), which has almost full control over the development, control, protection and management of the total water resources in Barbados.

A well survey carried out in 1945 by Alfred Senn, showed that there were almost 800 water wells in existence of which 535 were in use. These wells, which are generally hand dug either through the use of chisels (older wells from the days of slavery) or dynamite, vary in depth from as low as 5 ft along the low-lying West Coast to 300 ft in the central areas of the island. Some of the public wells also have horizontal adit 7 ft high x 4 ft wide x 4 ft in water and 100 ft long.

The 1953 Underground Water Control Act, provided for the creation of a Water Board to control and manage the development and protection of groundwater resources and to issue licences for the sinking of new wells or the deepening of existing wells and the abstraction of groundwater from wells. However, records of licensed abstractors are only available from the mid-seventies. Even though the Act provides for licences to be for a fixed period of time, almost all the licences granted so far are in perpetuity.

Overview of Water Resources Development

In 1996, total abstractions were estimated at 43-47 mgd, out of which 35 mgd was abstracted from 21 public supply wells and two spring sources operated by the Barbados Water Authority and 8-12 mgd from about 120 privately owned and operated wells. Based on these estimates, it has been concluded that abstractions from all but three of the nineteen (19) groundwater units either equal or exceed the safe yield estimates for average rainfall year conditions. These estimates of abstractions, except for the public supply wells which are all metered, are based on installed pump capacity, since almost all of the privately operated wells are not metered.

In order to get a better handle and control of the private well abstractions, the Board of Directors of the Barbados Water Authority recently (April 1997) approved a one-year moratorium on the granting of new groundwater licenses and imposed a deadline of June 30, 1997 for all private abstractors to install meters on their wells and keep records of abstractions according to a standard format provided by the Barbados Water Authority. The Barbados Water Authority has also advertised for the post of a Well Inspector, whose duties will include the monitoring and inspection of wells to ensure compliance to licence conditions, which are also under review. It is planned that at the end of the one-year moratorium, an up-to-date record of all abstracts and abstractions will be obtained and maintained.

Despite this requirement for licensing of all abstractions and the provision that wells in existence before 1953 could not be denied a licence, an unknown number of private wells are still operating without licences. With the filling of the post of Well Inspector, it is envisaged that all private water wells in use and including abandoned wells will be identified and monitored.

Water Resources of Barbados

Groundwater in Barbados occurs in two modes as depicted in Figure 1. About 83% of the wells identified in the 1945 survey were located in the "sheetwater" zone. "Sheetwater" zone is Barbadian terminology for the area where the freshwater lenses floats on top of seawater and the "streamwater" zone is the remainder of the aquifer further inland. Presently, 62% of all wells in use are located in the "sheetwater" zone and 60% of all privately owned wells in use are in the "sheetwater" zone. This breakdown in distribution of the groundwater wells is important, in light of the fact that most private well operators have little or no understanding of the need to monitor and control their abstractions, so as not to cause salt-water intrusion.

Estimates of available water resources have been based on data collected during short-term studies conducted through the use of foreign consultants Senn (1945) Stanley Associates (1978), Klohn-Crippen Consultants (1997). Table 1 gives a breakdown of the water resources estimates, based on the 1978 Study. These estimates have been revised downwards by the 1997 Study, due to differences in average rainfall figures and evapotranspiration estimates used.

Table 1
Breakdown of Available Water Resources

Source	Under Average Rainfall Conditions	In the 1 in 15 Design Drought Year
Groundwater	45.27 MGD	30.18 MGD
Surface Water*	7.19	2.89
Springs	1.80	1.30
Runoff**	0.53	0.00
Total	54.79	34.37

**The surface water figure is the estimated amount of water that can be impounded behind dams in the eastern part of the island called Scotland District.*

***The runoff is the amount of water that can be prevented from running off into the sea by the use of dams in gullies (dry stream courses) thereby inducing the water to recharge the aquifer.*

Table 2 gives a summary of trend/seasonal analyses of some water quality parameters. Despite the noted upward trends in the water quality parameters monitored for and analyzed, the general water quality is still quite good and meets most of the international drinking water quality standards and guidelines. The salinity levels which showed an upward trend influenced by overpuming during the two consecutive 1 in 15 drought years in 1993 and 1994, have moved downwards based on the 1995 and 1996 monitoring figures.

Water Use

Presently, most of the domestic, industrial and commercial water requirements are supplied from the Barbados Water Authority's operated public water supply system which covers almost the entire island (98%). However, some of the cooling water requirements by some industries are met from private well abstraction (e.g. sugar factories, electricity generating plant), but the actual abstractions are not known due to lack of metering of most private wells.

Table 3 gives a breakdown of water-use based on consumption records for metered customers (30%) and estimated consumption figures for fixed-rate customers.

Table 3
Breakdown of Water Usage

Use Category	Consumption (mgd)
Domestic (metered and unmetered)+	31.16
Industrial and Commercial	3.71
Hotels and Ships	1.02
Agricultural*	9.76
Golf-course Irrigation	0.54
Total Consumption	46.16

+Domestic water use includes water used by government and statutory corporations.
*Approximately 30% (2.95 mgd) of the agricultural irrigation water usage is from the public supply system.

Policies, Legislation and Institutional Framework

Policies and Legislation for Groundwater Development and Management

A substantial body of applicable laws and policies exists to address groundwater development and management in Barbados. However, the Government of Barbados has not formally adopted a policy pertaining to public and private groundwater rights and recourse has had to be sought from the English Common Law when these issues have arisen.

The following Acts and Policies are applicable:

. *Three-Houses Spring Act, 1713.* This Act relates to the Spring and Rivulet called the Three-Houses Spring, in the Parish of St. Philip. It provides for adjacent inhabitants through whose lands the said rivulet runs to make a dam and detain the water for his or their own use: provided no such dam, drain or channel causes the rivulet

to dry up below and water is allowed to flow downstream to keep the pond at the end of the rivulet full at all times for the parishioners of St. Philip to water their stock thereat.

This Act is outdated and does not provide any role for the Barbados Water Authority (BWA) to play and recent conflicts between the land owners on the damming of the rivulet and the difficulties encountered in addressing these issues have highlighted the need to review or repeal the Act.

B. *Porey's Spring Act, 1864.* This is an Act to make better provision for the collection and delivery of the water of Porey's Spring, in the parish of St.Thomas. It gives powers of authority to the Vestry of the parish of St Thomas to construct and maintain works for the collection and delivery of water from Porey's Spring, and to charge a fee for the delivery of this water to persons other than the inhabitants of this parish.

An offer recently made to the BWA to purchase the land on which the spring is located is now under review.

C. *Underground Water Control Act, CAP 283,1953.* This is an Act to make provision for the control and use of the underground sources of water supply in the Island and other matters connected therewith. The Act provided for the establishment of a Water Board with powers to control and regulate the development and use of the groundwater resources,through licensing and provision of necessary regulations. This includes control of abandonment of wells which, however, has not been fully exercised.

D. *Groundwater Protection Zoning Policy, 1963*. This is a far-sighted policy adopted by Cabinet as Government Policy in 1963 and revised by the Cabinet in 1973, to provide for the protection of the groundwater by sub-dividing the Island into five zones prohibiting harmful land uses, with the highest degree of protection in the Zone 1 areas which are closest to the public supply wells. See Table 4 for a summary of the conditions applicable to each Zone. The prohibition of the new development in Zone 1, has been incorporated in the Development Order under the Town and Country Planning Act.

E. *Barbados Water Authority Act CAP 274A, 1980*. This is an Act to provide for the establishment of the Barbados Water Authority, a statutory corporation falling under the Ministry of Public Works, Transport and Housing.

Apart from the two spring sources that fall under the Three-Houses and the Porey's Spring Acts, the remainder of the water resources are controlled under this Act. The Act gives power to the Barbados Water Authority to provide water and sewerage services and jurisdiction to make regulations, educate, advise and operate systems to manage, allocate, and monitor the water resources of Barbados with a view to ensuring their best development, utilization, conservation and protection in the public interest. The Act also requires the Authority to obtain and analyze information and maintain records of the total water resources of Barbados as well as conduct research programmes and prepare statistics for its purposes.

The Barbados Water Authority, administered through a Board of Directors, has assumed the authority of the Water Board to licence wells under the Underground Water Control Act and provision has been made to extend the provisions of the Act relating to the control of underground water to apply *mutatis mutandis* to the control of surface waters.

Institutional Arrangement for Groundwater Development, Assessment, Monitoring and Control

The Barbados Water Authority is at the moment charged with the responsibility to carry out all the above activities for the whole island except for the two spring sources controlled by the Three-Houses and Porey's Spring Acts. Three other main agencies have roles that can impact on groundwater use, monitoring and control:

1. *The Ministry of Agriculture and Rural Development.* The Ministry has a Land and Water Use Unit which is responsible for developing and delivering water for irrigation and through the Barbados Agricultural Development and Marketing Corporation (BADMC) operates a number of wells for this purpose.

   This unit previously also carried out the hydrological investigations for siting new wells and during and after the 1978 Water Resources Study, was responsible for salinity profiling and monitoring.

2. *The Ministry of Health and the Environment*. The Environmental Engineering Division of the Ministry is responsible for monitoring and control of conditions likely to affect the quality of land, air, water and general health and environmental well-being of the inhabitants of Barbados.

   They are also required to review all development applications to ensure compliance with the groundwater protection zoning policy and currently carries out a monthly monitoring programme for BWA and some private wells for chemical and bacteriological contaminants.

3. *The Town and Country Planning Office*

   Here, the enforcement of the zoning policy is carried out through the use of the Development Order which states that exemptions from development control do not apply to Zone 1.

Institutional Constraints and Challenges

In spite of the challenges arising out of overlapping and duplication of some responsibilities between various agencies, and the lack of institutionalized coordination to minimize these conflicts, the major constraints seem to be the lack of adequately trained manpower to carry out these functions, inadequate financial compensation to attract and retain qualified staff and lack of structured training programmes.

The present arrangement whereby the Barbados Water Authority has responsibility for both regulating and licensing of groundwater abstractions and supplying water is also seen as a potential area of conflict.

Water Resources Management and Water Loss Studies

Objectives

The primary objective of these studies was to develop a comprehensive water resources management programme in Barbados in which all elements of an integrated approach are considered. Important elements of the Study included: an analysis of the existing situation modelling of groundwater protection policies, water rights issues and legislation, water demand analysis, water conservation planning, an evaluation of groundwater recharge and water source augmentation alternatives and the development of a twenty-year Water Resources Development and Management Plan.

Status and Findings

Those studies were conducted by Klohn-Crippen Consultants Ltd. in association with Stanley Associates Engineering Ltd. and Consulting Engineers Partnership from June 1995 to February 1997, and were funded by a loan to the government of Barbados from the Inter-American Development Bank (IDB). The final report is due July 1997. Some of the findings related to groundwater development and management are:

- Present groundwater abstraction levels either equal or exceed the safe yields for an average rainfall year.
- The number of rainfall recording stations has declined considerably from a high of around 200 to about 40 stations and there is little or no hydrological data being collected by the BWA for water resources assessment and management. Based on available rainfall records and analysis of these records, average annual rainfall is “56 and not 60" estimated by previous study of 1978.
- Use of Turc's Equation underestimated the evapotranspiration losses in the 1978 study.
- Developable groundwater resources are smaller than previously estimated.
- Sewering of the South and West Coasts would impact on the salt-water-freshwater interface and may cause inland movement of the sea along the coastline of about two (2) meters.
- Out of the sixty-seven (67) boreholes constructed in 1978 for salinity interface profiling, less than ten (10) were still usable, making it difficult to estimate and model interface movement and quantities of brackish water available as well as to calibrate the computer models.
- Some land use activities in Zone 1 areas, pose a threat to the groundwater (i.e. illegal dumping of garbage, oil extraction, industrial waste disposal) and better control and monitoring needs to be exercised to avert potential problems.
- The existing groundwater protection zoning policy may not be enforceable as it is not supported by law.
- The present combination of responsibilities of the BWA as a supplier and regulator may be conflicting.

Strategies

New Zoning Arrangements

The existing five-zone water protection policy seems to have worked well, but places heavy restrictions on land availability for new development (Zone 1 areas take up about 8% of the land). Competing land use demands and available information on die-off rates for bacteria and viruses makes the 300-day travel time requirement for Zone 1 too conservative.

It is recommended that addition monitoring be carried out in combination with computer modelling for a five-year period before implementing these recommendations.

Policy Changes

In order to implement the new zones recommendation, a policy change is required.

Legislation Changes

The BWA does not at the moment have the authority to levy a fee for groundwater abstraction and licences. It is recommended that the following powers be provided:

- C by regulation impose a fee, calculated as a rate per unit volume of water abstracted, to defray the costs of monitoring and regulating the source;
- C impose a fee to defray the costs of processing of an application for a licence either on a first application or on an application for renewal; and
- C impose a fee, calculated as a rate per unit volume of water abstracted, as a general revenue and to encourage water conservation.

The regulatory and water resource assessment monitoring, control and management functions of the Barbados Water Authority be placed under new and independent Board.

Changing Pricing and Tariff Structure and Pollution Penalties

A new block tariff structure has been proposed and submitted to the Minister and is intended to recover most of the costs as well as facilitate loan repayments. It has also been recommended that the current maximum penalties of BDS$500.00 or 6 months imprisonment provided for under the Underground Water Control Act be changed to fines of BDS$100,000.00 on indictment and BDS$50,000.00 on summary conviction, confiscation of economic gains or 6 months imprisonment.

Strengthening Co-ordination

Presently, hydrological data collection is carried out by a number of government and private agencies. It is recommended that a single entity called the Water Resources Board be established to carry out these and other activities including the licensing and other regulatory functions presently under the Barbados Water Authority.

Improving Public Awareness and Consultation

Use should be made of all media to provide information on available water resources, limitations and mode of occurrence. This should include adaptation in school curriculum and not be limited to drought situations.

Improving Local Capacity

An institutional strengthening study, the Water Resources Management and Water Loss Studies have all made recommendations on improving the existing organizational structure and staffing levels and the adoption of a training policy and structured training programme.

Developing a Systematic Groundwater Monitoring Programme

A comprehensive groundwater monitoring programme has been proposed to monitor groundwater quality as well as collect data for groundwater resources assessment, groundwater model calibration, control and prevention of over pumping, on an on-going basis.

Conclusions

1. Even though an adequate body of laws and regulations exist to provide for proper groundwater development, assessment, monitoring, control and protection, the BWA has not fully exercised all its responsibilities, instead concentrating on water supply, operational and maintenance requirements of the public water supply system.

2. The Barbados Water Authority is currently hampered by the existing organizational structure and staffing levels and inadequate numbers of trained and qualified personnel knowledgeable of best practices and requirements for groundwater development and management.
3. Apart from the lack of up-to-date and accurate information on groundwater abstractions and the upward trending of some of the water quality parameters noted, no other areas of major concern to groundwater development and management were observed.
4. Very little research and public education is being carried out by the Barbados Water Authority. However, a slight improvement in public education was noted with the establishment of a public relations unit.
5. In most instances steps are being taken to address these deficiencies as evidenced by the Organizational Strengthening Study, Water Resources Management and Water Loss Studies, as well as the one-year moratorium on granting of new groundwater abstraction licenses. However, it takes a long time to get these systems in place.

Lessons for Other Caribbean Islands

1. Dependence on the use of short-term (one-year to two-year) projects by Consultants to produce data and information for long-term planning of water resources development projects is throwing good money to waste.
2. There is a strong need to develop in-house capabilities to conduct long-term and on-going data collection and analysis for proper planning, and development and management.
3. Provision of laws, regulations and allocation of responsibilities for proper groundwater development and management should go hand in hand with allocation of trained and qualified manpower to carry out the required functions and enforcement of the laws.
4. Use of computer models requires a lot of data for model calibration and verification.
5. Public Education and Information Dissemination should not be limited to drought or emergency situations.

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A COMMUNITY APPROACH TO WATER RESOURCES MANAGEMENT IN THE CARIBBEAN: THE CASE OF ST. VINCENT AND THE GRENADINES

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Introduction

Watershed Management is critical to small island states like ours in the Caribbean whose society is organized in small communities many rural in which a plurality of cultures converge and place numerous pressures on our natural environment.

A study of human settlements shows that societies were established and developed around water sources whether they were rivers, streams, lakes, springs, or even wells and of course the sea. Water is maybe the most essential natural resource for sustaining man's earthly existence.

As communities develop their water management system must also develop to meet the use of the community. It is important that in the formulation and implementation of our policy, programme, regulatory framework or management system for natural resources the community, its views, needs, demands must be taken fully into account for success.

In this paper I will attempt to show how water resource management system can be effective and successful when they are based on the needs and views of the community and coping with the types of demands the community makes.

The Role and Importance of Watershed and Watershed Management in SIDS

St. Vincent and the Grenadines like all the Small Island Developing States in the region have limited natural resources. Fortunately the country possesses a relatively productive exploitable forest, and rich coastal and marine environment. The small size of St. Vincent and the Grenadines and indeed all of the OECS states makes it difficult to distinguish watershed from non-watershed areas. Most planners in these islands consider the entire island as a watershed zone area.

When one looks at the coastal and marine eco-systems of the islands of St. Vincent and the Grenadines one realizes its considerable value to the national economy and to the quality of life of its peoples. It is important that the forested area of these islands are protected to ensure a reliable quantity and quality of water and to preserve the bio-diversity. Since, the advent of the Europeans in the 1660's the watershed has been the primary focus for development. Today most of these costal areas are the areas of greatest economic and human activity in agriculture, fishing, industrial development, tourism, human settlement -housings, social and physical infrastructure, etc.

The multiplicity and intensity of land uses in the “Watershed areas” of St. Vincent and the Grenadines is generated by development pressure from an increasing population and the particular style of development adopted by the population. The rapid increase in development pressure is placing greater stress on the interacting terrestrial and marine ecosystems. The multiple uses of the coastal resources is resulting in serious land use competition and land use conflicts which threatens the potentials for sustainable development. In order to ensure that the fragile and limited natural resources of these islands are conserved, managed and developed in a sustainable manner, there is need to formulate and establish appropriate and implementable natural resource management systems and practices.

Without proper watershed management St. Vincent and the Grenadines could suffer severely from a wide range of environmental and socio-economic problems such as:

- Reduction of agricultural productivity and loss of jobs.
- Increased severity of droughts and floods.
- Increased pollution and a general deterioration of the environment.
- The reduction in the quantity and quality of water available.
- The loss of flora and fauna.

General Background of St. Vincent and The Grenadines

St. Vincent and the Grenadines is an archipelagic state with approximately 30 islands, islets, and cays. St. Vincent is the largest island covering an area of approximately 133 sq. miles.

St. Vincent is always referred to as the "Mainland" with most of the population and major settlements including its capital Kingstown. There are several islands that comprise the state of St. Vincent and the Grenadines, which include the main inhabited islands of Bequia, Mustique, Canounan, Mayreau, Union Island, Palm Island and Petit St. Vincent.

Table

ISLAND	AREA SQ. ML	POP 1997
St. Vincent	133.0	111,105
Bequia	7.0	5064
Union Island	4.0	2008
Canouan	3.0	769
Mustique	2.0	189
Mayreau	1.0	672
	150.0	119,907

The physical features of St. Vincent is mountainous, with a narrow coastal shell of the island rising rapidly to a suggested, interior mountainous spine (WMP 199). Most of the land area of St. Vincent consist of highly dissected, deep, steep —ridged, narrow valleys with gentle sloping lands near the coast.

St. Vincent is blessed with a relatively high rainfall, ranging from about 1700 mm in the Central mountain range. Rising along the mountain ridge one seasonal tributary streams that converge into several short, steep rivers that flow into the Caribbean sea on the Leeward, coast and into the Atlantic sea on the Windward Coast. All rivers are confined to very steep, very narrow, incised valleys in the mountains flowing through narrow alluvial flood plains near the coast, often forming small alluvial dealt.

The soils in St. Vincent are very fertile and are volcanic in origin, with agriculture as the major economic activity. Most of the agricultural activity is concentrated on lands under 2000 ft. —including hill sides where there is intensive farming. Banana is the predominant cash crop and accounts for appropriately 40% of St. Vincent agricultural exports. Most of the land above 2000 ft. is forested and is managed for the protection of water catchments and the preservation of the islands bio-diversity.

Presently, there is limited tourism activity on St. Vincent despite the great potential for nature tourism. Most of the tourism activity is located in the South near the few White Sand beaches.

The Grenadines on the other hand are very small with a series of dry hills and white sandy beaches, clear blue waters, and in extensive sheltered coral reef systems. There is limited agricultural activity on these islands since they receive little annual rainfall (40-50 inc). Thus, agriculture is non-existent or subsistence in nature. Tourism is the major economic activity in the Grenadines as these island have great tourism potential.

Watershed Management in St. Vincent

Small island states such as St. Vincent and the Grenadines have to consider global opinion and need to adjust its forest management practices accordingly. Besides external factors, there are many tangible and intangible benefits associated with the socio-economic, environmental and ecological aspects of forestry that make watershed management an important national concern.

Approximately 38% of the land base in St. Vincent is covered with forest. The primary forest, palm forest and dwarf forest combined covers approximately 12.7% (4300 ha.) of the land base. Most of the natural forest are in very rugged areas but despite the relative inaccessibility, they are under serious pressure from other land use activities. Further removal of the remaining forest cover would impact on the environmental and ecological equilibrium causing serious socio-economic consequences.

Watershed management is a multi-purpose one and must address all its different aspects, such as water, land, plants, animals, and climate and operates as a system. All components within a watershed are connected to each other so that changes in anyone can have an effect on the others either in a negative or positive way. Of all the components water is the main factor that integrates the function of the watershed.

Forest management in St. Vincent covers thirteen (13) watersheds. The majority of these watersheds are divided into sub-watershed areas called “catchment areas: (CCA 1991).” These catchments are located on the steeper slopes where the water is collected in small holding systems called reservoirs. The water is then channelled by pipeline to treatment plants by CWSA and then distributed for domestic use or to power stations for the turning of turbines to generate electricity by VINLEC. All water used in St. Vincent is supplied by gravity (surface water).

Problem and Issues Related to Watershed Management

In St. Vincent deforestation of the upper watershed, is a very serious problem. As a result there has been a general reduction of water flows with seasonal variation of floods and low flows. Some erstwhile perennial streams have now become seasonal. Erosion of slopes and the resultant sedimentation of streams are also increasing.

Farming of these up land areas, especially banana cultivation, poses several other problems including the indiscriminate use of pesticides, herbicides and other chemicals which threaten both amphibious life in the streams and down stream uses of water. In addition, poisonous substances are often used to kill fresh water fish.

Compounding the problem is the fact that many of the reservoirs supplying water for domestic use are uncovered and are susceptible to contamination.

Management of the watersheds in St. Vincent and the Grenadines is of great importance because the country survival depends on it. The general population therefore, must realize the importance, and must commit themselves to the practice of watershed management. Whatever happens in the watersheds will ultimately effect all the inhabitants of the country.

Management Approach

The Forestry Division has the responsibility to "Police" the forest and its environment. CWSA and VINLEC are two government institutions that operate in the watersheds. VINLEC depends on the watershed for its supply of water used at its hydroelectric generation station at Richmond, Cumberland and South Rivers. While CWSA on the other hand depends on the watersheds for its supply of water for domestic and industrial use.

In accordance with the Central Water and Sewerage Authority Act 1991 water development and management are the responsibility of the Central Water Authority. It gives the institution the powers to investigate, conserve, control and distribute the use of water resources.

Legislation

There is no single piece of legislative instrument in St. Vincent and the Grenadines which specifically addresses the issue of watershed management. However, legislation relevant to the watershed management and other natural resources is found in several instruments, for example:

- Town and country planning, etc (Act 45 of 1992)
- National, Regional and Local area plans
- Water Control
- Tree Preservation
- Zoning
- Environmental Impact Assessment
- Environmental Protection
- Fisheries Act (1986) and Fisheries Regulations (1987)
- Beach Protection Act (1982)
- Forest Resources Conservation Act (1992)
- Central Water and Sewerage Authority Act (1978)
- International Conventions
- Environmental Issues and Policy
- The Government of St. Vincent and the Grenadines has listed six issues in its National Environmental Action Plan (Draft).
- Soil and liquid waste management
- Land use planning
- Coastal and marine resources
- Water pollution
- Noise pollution
- National parks and protected areas

Although government sees the importance of reversing the trend of environmental degradation throughout the island state, the disposal of solid waste has been given priority over the other environmental issues.

Government policy on the environment is addressed in two categories

a. Projects and programmes must be developed to improve health, and the general quality of life of the nation.
b. The Utilization of the natural resources of the country must not be at the expense of the welfare of future generations.

It is important to note however that water resources development and management forms with a means and an end in the wider regulatory framework for natural resources management as outlined in the National Resources Conservation Act.

The passage of the Natural Resources Conservation Act in 1992 highlights the following:

a. The conservation, management and development of forest;
b. The preparation of inventories and demarcation of forest boundaries;
c. The preparation and implementation of the national forest resource conservation plan, individual forest management plans and conservation plans;
d. The control and supervision of cutting, harvesting, milling and sale of timber and other forest produce, including charcoal, where the activity is conducted by Government agencies;
e. The regulation of the activities of persons and corporations who cut, harvest, transport, mill and sell timber and other forest produce on crown lands;
f. The issuing of licences and permits for the harvesting of timber and other forest produce;
g. The inspection and collection of information and statistics concerning the use of timber and other forest produce;
h. The protection and preservation of water resources in forest reserves, cooperative forests, conservation areas and along streams and rivers in co-operation with the Central Water and Sewage Authority and St. Vincent Electricity Services;
I. The regulation of fires on Crown Land;
j. The promotion of the practice of forest and agro-forestry in agricultural pastoral and other areas in conjunction with the relevant divisions of the Ministry of Agriculture and encouragement of proper forestry practices and management on private land through advice and assistance;
k. The promotion of proper soil and conservation practices;
l. The promotion and supervision of forest research;
m. The survey, establishment, management, development and administration of forest reserves;
n. The protection of the natural landscape to maintain the visual quality of the environment on Crown land;
o. Maintenance of biological diversity;
p. The training of the staff;
q. The promotion and implementation of educational programmes to improve understanding and the contribution of forest to national well-being and national development;
r. The prosecution of offenders against this act and regulation made under this act, including compounding of offences;
s. The promotion, establishment, management, development and administration of recreation facilities in co-operation with the Ministry of Tourism; and
t. The discharge of any other function and duties that may be assigned under this Act or any other Act.

Case Study

Colonarie

In 1989 the Government of St. Vincent and the Grenadines and CIDA funded the Forestry Development Project. The plan is intended to serve as a model for the preparation of other watershed management plans in St. Vincent and the Grenadines, which like the Colonarie Drainage, experience increased land use pressures (Development Project 1994).

In order to address all the socio-economic problems adequately. The terms of reference called for the preparation of a management plan for a high priority watershed to act as a standard and model for future detailed planning for the country's forest resources.

The Colonarie River basin was selected to serve as the study area for the detail Management Plan mainly because the watershed exemplifies the technical particularly the social problems and challenges facing resource management in St. Vincent and the Grenadines.

Several studies were carried under the watershed management plan which includes.

- Inventory of the biophysical resources.
- Definition of past and current land uses.
- Determination of resources capability limitation and land suitability.
- Determination of current environmental conditions.
- An in-depth analysis of the social economic factors, with emphasis on the population's use of land, water, crops and forest resources.

Objectives of the Plan

Environmental protection and rehabilitation of the catchment area is the major thrust of the Watershed Management Plan, this is achieved through:

- Reclamation of approximately 48.5 hectares in the sensitive areas in the upper basin.
- Protection and management of the remaining natural forest in the upper basin.
- Establishment and management of forest plantation were needed throughout the catchment.
- Implementation of sound soil and water management practices in erosion prone and environmentally sensitive areas, including application of agro-forestry techniques; and
- Training of Vincentian resource management personnel in watershed inventory methods and management techniques.

Achievement

During the execution of the development project some activities were achieved on the Watershed Management Plan:

- Re-establishment of the forest reserve boundaries.
- On-going education providing information on the importance of integrated watershed management is taken to communities and schools.

C Workshop with all relevant agencies, on the integrated approach to manage and protect the water resources as the challenges continues.

Achievements on Completion of Project

C Approximately 55% of areas identified in the 5-year Management Plan have been accomplished.
C Establishment of demonstration plot.
C On-going demonstration plots where they are exposed to methodologies and technologies.

Special Issues

Deforestation in the upper and middle basin impact on the wildlife and the people due to degradation of water, land and or vegetation.

C Water supply and quality
C Vegetation, fish and wild life habitat
C Land use
C Socio-economic

Findings From Study

To achieve success in the management of the Colonarie Watershed Management Plan will depend on how we address the human aspect. Noting that the majority of the population is poor, landless, young, with the basic primary education.

A. The stressfulness of the area can be seen in the following areas:

C ***Overdevelopment***

a. Removal of sand and gravel from the beaches and rivers.
b. Poor drainage system, increase the intensity of flooding on the low lands.
c. Increasing dumping of garbage in rivers, streams, drains and vacant lots.
d. Rearing of pig farm near to stream and rivers.

C ***Land Management***

e. Agricultural zoning.

B. Grow suitable crops bananas -vs- other crops.

C Agroforestry techniques
C Grow crops for marketing and processing.

Recommendations

Management of watershed/natural resources is the most vulnerable, yet little attention is paid to its development. To address the situation.

a. Public sector agencies CWSA, VINLEC and Forestry must coordinate their activities.
b. Identify needs and interest of the community.
c. Empower and mobilize community to take action.
d. Education and awareness of what is happening, the players who are responsible.
e. What the community can do, will do, must do for success.
f. Back up by Government Regulation and Regulators.

In conclusion I would like to address the following points:

1. Water Resource Management Systems can not be divorce from comprehensive Natural Resource Development and Conservation Programmes.
. Many important human behaviors which impacts the watershed are not and especially in rural situations can not be efficient or effectively legislated.

In such situations avoidance/compliance is motivated more by people participation and community empowerment through education and awareness rather than by mere policing.

3. The Regulatory framework for an effective Water Resource Management System must therefore begin with the views and needs of the community.
4. Legislation on use of Pesticides, Plastics, Land use logging, etc must be reflective, of the community's consensus which means community compliance comprehensive and enforcement.

If water is to benefit the community or if the community in fact own the water resources then certainly their ownership must be used for the greatest benefits of present and future generations.

The information obtained from these studies, led to the development of the Proposed Watershed Management Plan with emphasis on preservation, management and reclamation of private forest in the upper basin and environmental protection by the means of agroforestry and other soil conservation and water quality measures throughout the drainage. The development of the plan followed a systematic process of data, collection, analysis and identification of issues and related problem.

WATER RESOURCES MANAGEMENT STRATEGY PREPARATION IN TRINIDAD AND TOBAGO

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The Concept of Integrated Water Resources Management

Integrated water resources management entails a comprehensive and strategic approach to the medium and long term management and conservation of water as an economic and social resource consistent with the broader national goals and policies.

Comprehensive water resources management is wide-ranging and encompasses the physical, economic, social, environmental, health and the institutional factors. Collaboration and consultation with stakeholders must necessarily form an integral part of water resources management.

The development of a water resources management strategy for Trinidad and Tobago seeks specifically to design and develop comprehensive and integrated water resources management which will include appropriate strategies and policy measures for water resources management, an effective institutional framework, an adequate supporting legislative and regulatory framework, building-up of institutional capacity through upgrading of methodologies, technical systems and training, development of efficient information systems and an implementation plan for selected priority areas for action.

The strategies and policies developed in the water resources management strategy are to provide the integrating framework and give direction to future actions in other sectors.

Need for Integrated Water Resources Management in Trinidad and Tobago

The Management of the country's water resources has been constrained by several weaknesses and persistent problems which an integrated water resources management strategy seeks to address. The following background would provide a better understanding of the problems which have to be confronted.

Trinidad and Tobago, a country of approximately 5128 square kilometers, is richly endowed with surface and ground water resources. Up to the present time, the development and management of these resources have been carried out in the absence of a comprehensive strategic framework. The traditional loosely coordinated approach to water resources management has contributed to inefficiencies in resource utilization, periodic shortfalls in supply, and a gradual deterioration of the water environment.

The Water and Sewerage Authority (WASA), established in 1965 by an Act of Parliament was entrusted with responsibility for the development and control of the country's water resources. The focus of WASA has been primarily that of satisfying the demand from domestic and industrial consumers. The demand for water by other users has not been given effective attention although this may be due in part to the other sectors not knowing their water requirements. Water Resources Agency (WRA) was established within WASA in 1966 to collect, analyze,

document and publish hydrological data as well as to regulate the extraction of surface and ground water. The activity of WRA has led to the accumulation of a valuable body of data on surface and ground water resources. The question has been raised as to whether the Water Resources Agency is appropriately placed within the Authority which is the largest water provider.

Other agencies are also involved in the generation of data relevant to water resources management on a routine basis. They are the Ministry of Energy and Energy Industries, the Meteorological Services Division, the Institute of Marine Affairs, the Lands and Surveys Division, and the Central Statistical Office.

In addition to the Water and Sewerage Authority and the Water Resources Agency which have the primary responsibilities, several government agencies are involved in key and interdependent aspects of water resources management. Among these are: Drainage Division of the Ministry of Works and Transport, which has as its mandate the construction and maintenance of storm water and flood control structures in the catchments of all the major river basins. The Ministry of Agriculture, Land and Marine Resources, is responsible for the efficient use of irrigation water on farms, irrigation schemes, and forest management to promote watershed conservation. Responsibility for land use planning and regulating the development of land rests with the Town and Country Planning Division of the Ministry of Planning and Development. The Chemistry, Food and Drug Division, of the Ministry of Health, is responsible for monitoring agro-chemical residues and toxic chemicals. A new Statutory body, the Environmental Management Authority, was established under the Environmental Management Act of 1995 with overall responsibility for the development and implementation of policies and programmes for the effective management and conservation of the environment.

Apart from the loose coordination of the multiplicity of agencies involved in water resources management other weaknesses are evident. The institutional and legislative framework are inadequate to manage the water resources effectively for sustainable use and development. Variations in the quantity of available raw water contribute to instability in production capability and acute shortages. The regional supply/demand imbalances, are likely to be further aggravated by the emergence of increased demand for water in the expansion of the tourism sector and significant demand in the petro chemical industrial sector due to major investment at Point Lisas. A secular trend towards declining production capacity of some important surface and ground water sources has been observed.

Threats to water supply production quality and quantity have been caused by environmental degradation from sources such as squatting and slash and burn agriculture, quarrying, indiscriminate construction on steep slopes and removal of forest cover resulting in high run off rates in key watershed areas, and adversely affecting aquifer recharge areas. Surface and ground water resources have suffered pollution from malfunctioning municipal and privately owned sewerage treatment systems, and from waste water disposal practices in the absence of such systems. Water quality has been threatened by industrial pollution, leaking underground tanks for storage of petroleum products and toxic chemicals, residues from agricultural chemicals, land fills and the indiscriminate disposal of solid waste.

Water allocation and use patterns have been inefficient and there are inadequacies in the monitoring of point and non-point sources of pollution. In respect of data on water resources, measurement of ground water resources to reliably quantify the resource has been inadequate and the mechanisms for data and information exchange have not been satisfactory.

In attempting to address the many weaknesses a number of initiatives related to the improvement in the management of the country's water resources have been undertaken, including the preparation of a Draft Water Resources Management Policy for Trinidad and Tobago, the procurement of a private sector partner to manage the operations

of the water utility in the interim, baseline data collection, pre-feasibility and feasibility studies for priority programmes and projects in the water sector.

The Government of Trinidad and Tobago is committed to pursuing a new paradigm for water resources management, which involves the consideration of the water sector and the water environment in a holistic and integrated manner in relation to economic, environmental, technical, social and political considerations to provide a comprehensive framework for rational development and utilization of the water resources and a strengthened institutional framework for sustainable management of the sector.

The development of a comprehensive and integrated strategy for the management of water resources in the medium to long term is one element of the Water Sector Institutional Strengthening Project to improve the institutional framework of the Water Sector in the country towards which the Government has signed an agreement with the World Bank.

The Water Resources Management Strategy will be informed by other strategic national plans including the 7 year National Socio-Economic Development Planning Framework, the National Environmental Policy, Action Plan and Management Plan and the National Physical Development Plan.

Water Resources Overview

Water resources in Trinidad and Tobago is managed by the Water and Sewerage Authority through the division of the Water Resources Agency. Other responsibilities of the Authority are to provide an adequate, reliable and potable water supply and to effectively collect, treat and dispose of waste water.

The input to the water resources is rainfall and the available sources are rivers and aquifers. Basic data for the assessment of water resources is obtained from the hydrologic network which comprises a number of climatic, surface water and ground water data collection stations throughout Trinidad and Tobago. This data is processed to provide information on water balances and to ultimately meet the needs of users' applications. The basic hydrologic data and trends are published in three (3) annual data reports —surface water, climatic and ground water. The present data/information provided includes:

- *Climatic*. Daily, monthly and seasonal rainfall, rainfall intensities, duration frequency curves, distribution patterns, isohyetal maps, humidity, temperature, windspeed, evaporation, evapo-transpiration.
- *Surface Water*. Daily, monthly and seasonal discharges, low flows, peak discharges, recession curves, low and high flow frequencies, sediment discharge curves, water quality, isolines of runoff, flood levels, flood plain mapping.
- *Ground Water*. Water levels, ground water abstraction, safe yields, maximum sustained yields, subsurface mapping, well and aquifer parameters.
- *Water Balances*. Environmental Impacts of Land Use and Development in Various Watersheds.

Because of the fact that government policies and plans must be based on comprehensive reliable water data and information if they are to succeed, and if sustainable water development is to proceed, a consultancy to supply and install a telemetry hydrologic network is in progress to improve water resources assessment in the country.

However, water resources in Trinidad and Tobago appear to be adequate to meet the needs of the present and near future based on the trends in rainfall, the available surface and ground water resources and the projected development plans.

The average annual rainfall is estimated to be 11.3 x 106 m3 (2200 mm) of which about 6.8 x 109 m3 is lost by evapotranspiration and the annual mean runoff is 40% of the rainfall.

Rainfall during the rainy season at times plays tricks and falls much more intensely in watersheds void of surface reservoirs. This creates a shortfall in the volumes of water harnessed by the reservoirs and compounds the pressure already placed by leaks on the distribution of potable water.

At present 700,000 m3 of potable water is supplied daily of which approximately 70% and 30% are from surface and ground water sources respectively. In addition, approximately 13.2 x 106 m3 of surface water and 9.8 x 106 m3 of ground water are abstracted by licensed users.

However, it must be understood that the water resources available for use is not only dependent on the quantities available but also on its quality and the economic cost of producing it. The availability of this resource is impacted by environmental degradation and its use and misuse by the population.

Management Challenges

The overall challenge is reflected in the mission of the Water Resources Agency: "*to effectively manage and control the use of the country's water resources and to promote conservation, development and protection of these resources in a cost-effective manner for sustainable socio-economic growth.*"

This challenge should be viewed against the guiding principles which were set out in the International Conference on Water and the Environment in Dublin, Ireland in 1992, that:

Principle 1: Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment.
Principle 2: Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels.
Principle 4: Water has an economic value in all its competing uses and should be recognized as an economic good.

However, the fundamental management challenges at present are:

C *to decide as early as possible the position of the Water Resources Agency in the whole institutional and organizational framework and take the necessary action immediately to ensure functionality.*

For as long as the decision with respect to where the management of water resources will be in abeyance and the perception is that there will be eventual separation, the tendency will be to down play support for the Agency. This is reflected in the resources allocation such as funding, equipment and staffing including remuneration considerations.

C *To implement an appropriate organizational structure and attract and retain suitably qualified staff and develop the human resources.*

In the scenario in which water resources has been managed, the first difficulty here is convincing the Administrators of the need for the functions necessary to manage water resources effectively. Additionally, the attraction of suitably qualified local staff may not be simple as there appears to be a shortage of trained persons in the disciplines which make up water resource management.

Of utmost importance is the availability of suitable staff to work along with the consultant to facilitate the work on the strategy, enable technology transfer and assist in the implementation of the action plans emanating from the strategy.

The process of strategy formulation can be good training for staff with the appropriate knowledge base. This can help build national capacity for water management but further specialized training will also be required. Implementation of new methodologies and improved technologies is one of the benefits. Lack of appropriate counterpart staffing during the consultancy would be a great loss to the country in terms of technology transfer. The actions for effective water resources management are much too important to the future of the country and therefore staffing must be addressed seriously.

- To develop an adequate institutional and legislative framework to promote, coordinate an integrate between sectors and manager for sustainable use and development.

The institutional framework must address management of water resources in a coordinated integrated and holistic approach.

Laws and bye-laws must action effective management of the water resources including enforcement measures.

The legislation must address issues on water quality and quality plus the impacting factors, water allocation and use, economic considerations, conservation, protection and integrated management.

- *To encourage stakeholder participation and develop an effective communication system to consider/incorporate the views of stakeholders.*

To this end a consultancy to obtain stakeholder "buy in" is expected to be undertaken at the start of the water resources management strategy formulation. The benefits of this are to foster commitment and acceptance of the strategies and policies which are important to the successful implementation of the actions derived from the strategy.

- *To educate and public and change the culture of the population to appreciate that water has a cost and must be paid for by its users.*

- *To develop an effective Decision Support System.*

Specific Issues to be Addressed

Financing

Water is not only a social and environmental good but an economic good as well

Over the past few years one of the major limitations has been the weak financial position of the state owned public utility —The Water and Sewerage Authority (WASA). Only by moving towards self-financing will the whole population have access to the basic services related to the water resource and will it be possible to manage it effectively (UN/ECLAC, 1992).

However, self-financing demands that all customers pay for their services a custom which is changing slowly but which has not been the norm in Trinidad and Tobago. One drawback though is the fact that there are large

companies (some state owned) and sectors which still refuse to pay for abstracted water and hope to get the Government's support for "write-offs." This attitude indicates the need for fostering a greater understanding of the cost of water and the contribution required of users to facilitate the management and optimization of the water resource. Education of the public about water resources and its management cost is therefore necessary.

At present most of the projects are undertaken through loans from International Lending Agencies.

The Government has introduced private sector participation in the form of a management contract with Seven Trent/Wimpey to provide water services for three years. This is an effort to transform the Authority into a company with effective and efficient water services where the investments and provision of services do not continue to be in deficit.

It is expected that win-win finance options would be recommended for sustainable development financing. According to Professor Theodore Parrayoton from Harvard Institute in his paper "Win-Win Finance," a number of feasible and innovative options are available but they are constrained by inertia and lack of political will. Among the options suggested are:

- Removing or phasing out costly subsidies that distort the economy and subsidize wasteful consumption and environmental degradation.
- Demand —side management, e.g. water pricing that improves efficiency and conservation in use —this reduces the need to build and the cost of mitigating environmental impacts.
- Linking the supply of public infrastructure to the demand generated by new investments.

Capacity Building

It has been identified that many failures in water resources management are the result of insufficient trained staff and weak institutions

In an effort to overcome this problem which is a reality in Trinidad and Tobago, the Government has secured as part of its loan from the World Bank funds allocated to meet some of the training needs. However, one hurdle is the recruitment of suitably qualified staff to work during the strategy and obtain specialized training to assist in implementing the actions derived from the strategy.

It may become necessary for the Government to show its commitment by offering scholarships in the relevant fields. This will not strengthen the institutions immediately but will provide for their sustained development.

Another area of equal importance which is the provision of competitive remuneration packages to attract and retain persons to the field of water resources management.

Some areas requiring capacity development are:

- Demand management methods and planning.
- Integrated management approaches to river basins and coastal zones.
- Development of the capacity to analyze questions of resource management.

Water Resources Allocation

Apart from the sources which are dedicated to the supply of potable water for domestic purposes, generally the allocation of water resources is done on a “first come first serve” basis once the resource is available, meets the quality required and does not belong to a licencee. A few exceptions occur, one being the oil industry where certain aquifers in the South are dedicated for their sole use. Another exception is the Petrochemical Industries in Point Lisas for which large volumes of water must be supplied as mandated by the Government.

Over the years relatively little attention has been paid to the economic value of water in terms of water supply and uses of water systems. However this must be addressed in relation to sustainability.

The expectation of the strategy would be the prioritization of uses in the watersheds. This should be based on answers to questions taking into consideration the economic value of water, the people concerned, the impacts of development, the policies, efficient approaches and the financial consequences.

The value of water in different uses in watersheds is also an expected output and would be developed within the three major considerations for responsible use of water resources which are:

- To be sustainable, the use of the water resources should not exceed the carrying capacity of the environment. Development of water systems is limited by their geographical and environmental conditions.
- The use of water resources must ultimately be economically feasible.
- The use of resources must be socially or culturally acceptable for sustainable use.

Institutional Framework

Though the Authority is the major body responsible for water resources management, some functions of water management are vested in other sectors without an appropriate coordinating functional relationship and enabling legislation. The laws governing the functions are deficient with the result that certain over-lapping areas are not addressed adequately. An adequate institutional framework is of paramount importance to implement management policies. This framework must be able to transform policy into practice to achieve goals set in the management strategy formulation.

It is therefore the expectation that the institutional framework will be the organization and management aspects of water resources management and comprise:

- the structure of the organizations;
- their responsibilities and inter-relationships;
- the effectiveness of these organizations; and
- their relationship with the non-governmental or non-institutionalized management regimes.

It must also be noted that with increasing volumes of water being used and the intensification of use of water systems, continuous adaptations must be made to management structures.

This institutional framework must also be supported by a Decision Support System to assist the decision maker in finding adequate solutions to problems if it were to be effective.

Status of Water Resources Strategy Preparation and Lessons Learnt

A draft national water resources policy was prepared and will be reviewed and amended pursuant to the recommendations emerging from the first phase of the water resources management consultancy, following which the policy will be finalized and adopted.

The Government of Trinidad and Tobago has contracted a group of consultants comprising DHV Consultants BV, Delft Hydraulics of the Netherlands and Lee Young and Partners of Trinidad and Tobago to develop the Water Resources Management Strategy in conjunction with counterpart staff of the Water Resources Agency. The Contract was signed on June 12, 1997. The study will commence on July 14, 1997, and will be carried out over a period of fifteen (15) months.

The Ministry of Planning and Development the central planning and coordinating agency of Government was designated as Executing Agency. This action is a demonstration of the commitment to having a coordinated, holistic and integrated water resource management strategy for the country.

Arrangements have been made for oversight of the study at a high level to ensure political commitment, to incorporate a multi-disciplinary and cross-sectoral approach and obtain commitment to the strategy. A Committee of Ministers was recently established to coordinate and monitor the Water Resources Management Strategy. This Committee is chaired by the Minister of Planning and Development and comprises the Ministers responsible for public utilities, agriculture, health, works and transport, trade and industry and energy.

A Cabinet appointed Inter-Ministerial Technical Steering Committee was established in January 1995 comprising senior level experts convened by the Permanent Secretary, Ministry of Planning and Development and including the Permanent Secretary, Ministry of Public Utilities; the Director, Water Resources Agency; the Technical Director, Water and Sewerage Authority; the Director, Drainage Division, Ministry of Works and Transport; the Director, Town and Country Planning Division; and the Director, Regional Office North, Ministry of Agriculture, Land and Marine Resources. This multi-disciplinary, inter-sectoral committee was charged with the responsibility to prepare the Terms of Reference and undertake all preparatory work required for the recruitment of the Consultants.

The Technical Committee also has as its mandate to monitor the progress of the exercise to ensure that the deliverables are supplied in a timely manner by the Consultant, to evaluate the deliverables, identify and address policy issues which may arise and facilitate the avoidance and resolution of bottlenecks. The Technical Committee has the option to make arrangements for the procurement of outside specialists on a “short term” basis to review the work of the Consultants where required.

A small Project Implementation Unit (PIU) for four (4) persons headed by a Project Coordinator will function within the Ministry of Planning and Development to facilitate the work of the Consultants on a day-to-day basis, arrange for inter-sectoral coordination between the Consultants and the line agencies and service the Inter-Ministerial Committee as its Secretariat.

The Inter-Ministerial Technical Committee has given concerted attention to advancing the project to the present stage where the study is about to be commenced. The Technical Committee undertook the preparation of the Procurement Package which included the Terms of Reference, the Letter of Invitation, Instructions and Information to Tenderers and the Draft Contract. The element of this work which the Committee considered to be particularly critical were the finalizing of the Terms of Reference including the articulation of the Scope of Work and the

Deliverables, and the determination of the criteria for evaluation of the Technical Proposals. The Committee relied on the World Bank Guidelines in the preparation of the Procurement Package.

A parallel activity during the preparation of the Terms of Reference was the collation of data/information to inform the preparation of the strategy. This included the preparation of an inventory of policies, reports and documents on water resources management, economic treatment of water, the environment and international perspectives. The identification of all relevant data, aerial photographs and maps held by the various Ministries and agencies, sectors and other individuals required for use in the preparation of the strategy was also undertaken.

In response to the invitations to six (6) short-listed international consulting firms with expertise in water resources management, Technical and Financial Proposals were received from five of these firms. The evaluation of the Technical Proposals was undertaken by the Technical Committee to rank the firms in order of merit based on the criteria as listed in the procurement package. The first ranked group DHV Consultants, Delft Hydraulics Lee Young and Partners was invited to negotiate with the Inter Ministerial Steering Committee on all aspects of the project. The negotiations were undertaken through two rounds of negotiations in November 1996 and February 1997.

Lessons Learnt

The lessons learned from the preparatory work and the process of procurement of the Consultants are noteworthy and include the following:

- It is important to clearly identify the scope of work and the deliverables required from the consultants in order to determine the types and levels of expertise required on the Consulting Team and the resources to execute the study.
- The identification of the short list of experienced Consulting Firms in the area of water resources management contributed to the submission of a number of robust technical proposals from which the selection was made.
- It is necessary to devote close attention to the determination of the criteria for the evaluation of the proposals.
- Experienced professionals were required for the evaluation of the technical proposal. A key constraint to the prompt finalization of the intensive exercise of evaluation of the Technical Proposals was the limited available time of the senior professionals on the Steering Committee. Special arrangements had to be made to secure dedicated time of these officials to undertake the evaluation.
- It is important to have comprehensive preparations for negotiations. A sound knowledge by the client of the Terms of Reference, the Instructions to Tenderers and the identification of the concerns of the client with clear reasons contributed significantly to the efficiency of the negotiations.
- A major difficulty in the negotiations was the quality of local expertise proposed by the Consultant to participate as members of the local firm. The resolution of this deficiency required the submission of many options for consideration. The root of the problem, however, lies in the shortage of local expertise in the disciplines required for water resources management. Recommendations have been made in this paper on the enhancement of national capacity for water resources management.
- While agreement was reached on all points relating to the Technical and Financial proposals during the negotiations, further loss of time would have been avoided if the parties had signed off on the draft Contract by the conclusion of negotiations. The client's submission of the Contract for acceptance and signing by the Consultants after satisfactory conclusion of the negotiations triggered another series of discussions on the Consultants' concerns before final agreement could be reached.

Innovations

While many of the under-mentioned measures may have been instituted in other jurisdictions, the innovations for Trinidad and Tobago of the proposals for the reform in the water resources management sector include the following:

- The adoption of a holistic integrated approach to water resources management encompassing the institutional, legislative, human resource, economic, environmental and technological elements.
- A focus on the re-use, re-cycling and artificial re-charge of water.
- The application of Geographical Information Systems (GIS) in water resources management.
- The introduction of modelling in water resources management using software models.
- The participation of non-governmental organizations and the widest range or stakeholders in the development of the water resources management strategy.

Conclusion

The management challenges, issues and weaknesses previously discussed indicate clearly that to achieve sustainable use of water resources, environmental, social and economic considerations are imperative. The management focus must change from sectoral development to integrated management of resources use. For sustainability, integrated management must include the relations between different resources, their application for economic benefits and considerations of the users.

Water is the inextricable link in the environment. Similarly water and sustainable human development are inextricably linked. Effective water resources management implies coordinated management of various resources as water resources management cannot be separated from land use and the associated intensity of water use.
As stated by our Consultants from Delft Hydraulics “Integrated water resources management will view the use of resources in relation to social and economic activities and functions, and the water infrastructure needed for their use and control.”

INTEGRATED WATERSHED MANAGEMENT IN NORTH EASTERN PUERTO RICO

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Northeast Puerto Rico is presently undergoing a crisis in water supply management. This crisis is forcing fundamental changes in institutional policies and procedures regarding watershed management. This paper discusses the institutional and public response to the current crisis.

The island of Puerto Rico is one of the wettest in the Caribbean and has been blessed with abundant water resources. In addition, the highly urbanized landscape has one of the most extensive water supply and distribution systems in the region. Moreover, nearly 98% of the islands 3.6 million residents are supplied potable water from an extensive system of water diversions, reservoirs, and treatment plants that is operated by the Puerto Rico Water and Sewage Authority (PRASA).

Historically water resources have been abundant on the island and there has been sufficient capital to develop new sources and distribution systems. However in the past few years this situation has changed dramatically. For example, in 1994, lack of rain aggravated by a poorly maintained storage and distribution systems resulted in widespread rationing of water that lasted for several months. At it's peak, over 1.9 million people were without water for 36 to 40 hours at a time. On June 18 of this year a “24 hr on - 24 hr off” rationing scheme was also implemented for 700,000 people in the San Juan metropolitan area. These recent droughts combined with increasing urban expansion has resulted in increased public and private pressure to improve watershed and water supply management. Key issues that constrain this management include:

Limited Availability of Additional Supplies

Additional surface water supplies are limited since every major streams on the island has water diversions and sewage treatment plants. Furthermore, the best locations for building large reservoirs have already been used and ground water resources are limited in many parts of the island. Where large aquifers do exist they are being used to capacity or have pollution problems. Although new sources are limited, hydrologic studies indicate that there is sufficient water to meet current and future demands if the present sources are managed properly.

Increased Multiple Use of Water Resources

During the past decade there has been a large increase in the use of streams and estuaries for water-contact sports including boating, swimming and fishing. This use has resulted in public opposition to water extraction or sewage disposal in areas used for recreation. In response to these multiple uses, water withdrawal schedules are being modified to include minimum instream flows and there is considerable discussion regarding protecting and restoring aquatic habitat in areas that are extensively used for recreation.

Complex, and Deteriorating Infrastructure

The rapid urban expansion that has occurred over the past 30 years has resulted in a poorly integrated water distribution system that is difficult to manage, maintain or modify. In addition, large municipal water supply reservoirs that were built in the 1940's and 1950's have lost over 50% of their storage capacity due to sedimentation. The loss of this storage results in inadequate supplies of water during prolonged periods without rain.

Lack of Public Confidence in Water Authority

Many of the infrastructure problems that the island currently faces have been recognized by the public for decades. In the early 1980's the Puerto Rico Water and Sewage Authority was allowed to increase the amount they charge for water and sewage. The additional revenue created by these increases was to be used to improve the aging infrastructure and increase the quality of service. Unfortunately, much of the increased revenues were used to hire additional personnel and improve sewage treatment plants instead of improving the failing water supply infrastructure. In the meantime, demand for water and revenues have remained relatively stable, operating costs have increased, and the quality of service has decreased. Consequently, the financial community has lowered the authorities credit rating and has made it difficult for them to obtain additional credit for infrastructure improvement. In addition the public has lost confidence in the water authority and does not support additional rate increases.

While the water crisis is far from over, during the past few years local institutions and organization have developed various management strategies to address the complex situation. These changes include modifying operations to:

Improve the Operation of the Existing Water Supply and Distribution System

Comparisons of the volume of water filtered by water treatment plants and that billed to customers indicates that between 30 to 40% of the water that is currently produced is “unaccounted” for. Moreover, up to 40% of the water that is treated in water treatment plants is apparently “lost” to broken pipes, illegal water hook-ups or inaccurate metre readings. Reducing these losses from 40% to 20% would provide enough water to meet projected needs well into the next century. To reduce these losses and improve the operational efficiency of the water system, several institutional changes are being implemented. These include:

a. *Decentralization of the Water Authority*: The PRASA has traditionally had a highly centralized organizational structure. While this centralized structure may have been efficient in the past when building new water systems was the top priority, it has not been effective in dealing with the daily management of many diverse water systems. In an effort to decentralize decision making and allow local offices to be more responsive to problem, PRASA is currently undergoing a plan to decentralize purchasing and operations. This decentralization process is designed to allow local PRASA officer to purchase the materials needed to maintain water systems and thereby be more responsive to local problems. In addition local communities are becoming more involved with the management of their water systems and are studying the possibility of operating these systems at the municipal rather than regional level.

b. *Privatization*. For nearly 2 years certain PRASA facilities have been operated by the Professional Service Group (PSG), a private corporation that operates water supply systems throughout the world. Because this arrangement has only been operational for a short period, it is to early to judge the long-term effectiveness of this arrangement, which costs the authority 93.7 million dollars per year. However, the initial experience has

demonstrated that to be effective, the privatization process takes time to implement and requires that the responsibilities of the public and private organizations be clearly defined.

During the first year of the privatization effort in Puerto Rico, tensions developed between union and non-union workers, management and the professional engineering staff, and contractors and Authority employees. These tensions resulted because positions were eliminated, lines of authority and supervision were changed, and the employees felt a great deal of job insecurity. The initial contract also required that the corporation obtain approval from the Authority for all purchases greater than US$ 2000. This level of approval and the attempt to integrate the activities of the public institution and the private corporation has proved to be very cumbersome and ineffective. Negotiations are currently underway to allow the PSG greater freedom in managing specific sites.

c.*Emergency Services*. To cope with increasing complaints and operational failure, PRASA and the PSG have developed several public out-reach programs. These include a 24 telephone exchange where broken pipes and service failures can be reported and daily news reports in local newspaper. In general these services have been well received by the public. The local legislature has also proposed several additional solutions including a law that would provide credits to individuals who repair broken pipes or installing water conserving facilities.

Integrating Supply and Distribution Systems

The majority the island potable water comes from surface supplies. Unfortunately, the high spatial variability of rainfall that occurs in mountain regions of the islands often results in local water shortages. One potential solution to these local droughts is to integrate the supply and distribution systems over larger areas of the island. This integration should allow for greater exchange of resources during periods of low rainfall.

Several plans have been proposed and initiated for the regional integration of water systems. The majority of these plans require connecting individual water supply systems to a larger integrated distribution system. The success of these integrated systems will require well organized, real time supply management that is currently unavailable. In the meantime there is considerable public concern that integration will mean shifting water from older communities who have adequate supplies to new urban developments that don't. This attitude is particularly prevalent in suburban and rural communities who feel their water supplies will be sent to urban areas that are filled with both voters and broken pipes.

Regional waste water treatment plants are also being considered to replace many smaller and older plants that currently do not meet national water quality standards. While these plans are less controversial than those to integrate water supplies they have been opposed by groups with the “not in my back yard” attitude.

Interagency Co-operation

Due to the complex nature of water development, as many as 9 public agencies can be involved in permitting a new water development or urbanization. To reduce the time required for approval a “fast-tracking” approach has been implemented for several projects. Under this scheme, high level interagency working groups are organized to help the project obtain approvals quickly. Unfortunately, several of these “fast-track” projects have resulted in poorly designs projects that have needed costly modifications. In several cases, these “fast-track” projects have faced extensive legal battles for not following the procedures and regulations.

To improve interagency cooperation, the Department of Natural Resources has recently completed a integrated water plan for the island. This document, which was required by law, provides the overall guidance for developing water

resources on the island. Several interagency working groups have also developed guidelines to assist developers understand and comply with existing regulations. While the guidelines within these documents are only beginning to be implemented, their existence has been considered invaluable by professional involved in water resource management.

Conservation

Due to the historic abundance of water on the island, conservation has not been widely practiced. Consequently per capita water use is higher than most industrialized areas of the world. To reduce waste, public awareness campaigns have been developed and promoted. The local legislature is also considering developing tax-incentives for households that install conservation devices and increasing the marginal costs of water.

The success of these campaigns has been limited because the public has not been responsive to volunteer conservation since they believe large volumes of water are being wasted by broken pipes and poor management. Furthermore, many households have installed water storage tanks so that they will have sufficient water during periods of rationing.

In summary, the current water supply crisis in Puerto Rico has resulted in many institutional and policy changes. While it is unclear how effective these individual changes will be, it is apparent that integrated watershed and water supply management must be a dynamic process with ample public involvement.

CARIBBEAN SMALL ISLAND WATER ISSUES

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The Water Supply and Sanitation Collaborative Council was formed at the end of the international Drinking Water Supply and Sanitation Decade (1981 - 1990), when it was realized that the objectives which had been set for the water sector during that decade had not been met. However, the work which was started could not be abandoned simply because a particular deadline had not been met and as such it was decided to continue these noble efforts of supplying water to the entire population of the world. As a result of this realization, meetings of External Support Agencies, firstly in New Delhi and then in Dublin, ushered in the First Global Forum of the Water Supply and Sanitation Collaborative Council which was held in Oslo, Norway in 1991.

The Council carries out its work by the establishment and funding of working groups, networks and task forces as well as the organization of global fora. Some of the working groups are:

Operations and Maintenance

This working group, which was actually started before the First Global Conference in Oslo Norway, has identified the major issues in the production and distribution of the water resource as well as produced a number of tools which can be used in overcoming some of the major problems facing those who are charged with this task.

Gender Issues

Unfortunately, women are still the bearers of water in many parts of the world today. This working group addressed these problems and offered some practical solutions to alleviate the burden which is carried by these important members of our society.

Country Level Collaboration

Numerous countries are faced with the problem of having many major players involved in the national water sector with the result that there is often duplication of efforts, missed opportunities for funding, inappropriately applied technology, etc. This working group looked at tools for overcoming these problems and methods of sharing information between the various agencies involved in the water sector.

Water Demand Management

This working group started out as a section in the Operations and Maintenance Group, but because of the importance of this work and the interest shown by members of the Council, it was removed from under the O & M umbrella and given its own status as a separate working group. The work of this group is concerned with the efficient use and distribution of the water resource and gives insight to the many techniques which have been used in this area.

The list above is by no means exhaustive since at the time of the 3rd Global Forum in Barbados, there were some eight working groups, approximately four task forces and three networks in operation. Since that time, the work of a number of these groupings has been concluded and new groups formed to look new issues which have developed as a result of a changing world order.

One of the new working groups which was brought to life at the 3rd Global Forum was "Small Island States." The interest in these issues stemmed directly from the hosting of the United Nations Conference on Small Island Developing States, SIDS, in 1994 in Barbados as well as the efforts of a number of Council members from Small Island States.

The Council convenes Mid-Term Reviews one year after each Global Forum in order to keep abreast of the progress of the working groups, tasks forces and networks. It was at the Mid-Term Review of November 1996, that it was realized that not much progress had been made in the area of development of Small Island States Issues. In analyzing the nature of the problems which did not allow for the development of this working group, it was realized, inter alia, that geographical spread of the islands did not lend itself for easy coordination. It was decided that this problem should be overcome by grouping the islands into three zones: Pacific Group, Indian Ocean and Mediterranean Group and thirdly, the Caribbean Group. I have been asked to coordinate the efforts of the Caribbean Group. I would like to suggest that the way forward should be based on a simple five step plan:

- The identification of three or four major issues
- The identification of the target groups
- Identification of resources
- Identification of communication strategies
- A schedule of activities

Identification of Major Issues

In this regard, the presentation of papers and positions as well as the involvement of the delegates, will form the basis for highlighting the major issues facing the water sectors of the Caribbean. Already from the discussions which have preceded this presentation it is clear that the issues surrounding the management of watersheds will feature significantly in the final outcome of this conference.

Identification of Target Groups

These target groups could be both in or outside of the traditionally defined boundaries of the water sector. This part of the exercise is extremely important and unfortunately frequently overlooked. It will influence the selection of the appropriate communication strategies which are needed for the effective dissemination of ideas.

Identification of Resources

The identification of resources should not be limited to the financial institutions as sources of funding but the provision of technical resources should also be considered as important inputs to projects.

Identification of Communication Strategies

The selection of the correct communication strategy is an important aspect of effecting the change which is required for the significant improvements in the water sector which we seek.

Schedule of Activities

Arising from our deliberations at this conference, it is hoped that a schedule of events leading up to and beyond the Fourth Global Conference of WSSCC which will be convened in the Phillippines in November 1997, will be made.

INTER-AMERICAN WATER RESOURCES NETWORK (IWRN)
A STRATEGY FOR BUILDING PARTNERSHIPS IN THE AMERICAS

Mr. David Moody
Unit of Sustainable Development and Environment, OAS

Plan of Action for the Sustainable Development of the Americas

Water Resources Initiatives

- Protect public health by ensuring that drinking water is free from contaminants.
- Implement integrated water resources management using watersheds as planning units.
- Develop policies, laws and regulations that protect and conserve water resources.
- Promote hemispheric cooperation including information exchange.
- Improve access to appropriate technologies and transfer of information on policies.
- Cooperate in the development and improvement of pollution prevention and source reduction programs.
- Promote public participation in planning and decision making related to water.

Vision Statement

- Creating partnerships to protect and enhance public health, restore and conserve ecosystems, and support sustainable development through holistic approaches to integrated water resources management.

Goals

- Build Shared Understandings of Issues
- Clarify Water Resource Needs and Priorities
- Increase Access to Skills, Knowledge and Strategies
- Build a Network of Networks
- Create Collaborative Partnerships

Structure of IWRN

- Advisory Council
- Executive Committee
- Technical Secretariat
- Regional Nodes
- Country Focal Points
- Topical (Thematic) Nodes
- Members

Functions of Topical Nodes

- Collect and Distribute Information
- Advise on Technical and Scientific Issues

C Assist Country Focal Points Coordinate IWRN Activities
C Promote IWRN Activities

Functions of Country Focal Points

- Collect and Distribute Information
- Update Directories
- Identify topical nodes and members
- Coordinate IWRN Activities
- Organize National Dialogues on Issues

Strategies for Building Partnerships

C Regional Nodes to Coordinate Activities
C Establishment and Support of Regional Networks - RIGA
C Use of IWRN in Implementation of Water Studies
C Fostering Internships in Government and the Private Sector
C Workshops on the Tools of Integrated Water Resources Management

ESTABLISHMENT OF A CARIBBEAN WATER RESOURCES INFORMATION SYSTEM

Mr. John Bassier
World Meteorological Organization

International News

Before talking to you about a Global Water Resources Information System and more specifically how the Caribbean could contribute and benefit from such a system, I would like to share with you a few items of news which have recently appeared in the international press.

Water Crisis (The Independent, Friday 21 March 1997)

"At the beginning of the next century, one third of the world's nations will be permanently short of water."

"At any one time, half the people living in developing countries are suffering from diseases associated with poor water and sanitation."

International Herald Tribune (18 May 1997)

"Water diverted from California's third largest lake to supply Los Angeles has sucked lake dry and created an ecological disaster."

"On windy days, giant toxic clouds of fine salts and sand mixed with arsenic and cadmium from the lake bed force people to wear dusk masks or stay indoors."

"California would like to refill the lake but its impossible to wring that much water from Los Angeles."

United Nations

World Day for Water 1997 (22 March)

The theme for this year's celebration posed an important question: "The World's Water - Is there enough?"

- Commission on Sustainable Development (CSD) in 1994 called for assessment of the global freshwater situation.
- CSD considered freshwater report in April 1997.
- Special Session of UN General Assembly in June 1997 to consider global freshwater situation.

World Environment Day (6 June, Geneva) - Round Table Conference on Water and International Solidarity

Chaired by: Mr. Mikhail Gorbachev, President of Green Cross International

The questions which the Conference was invited to address included the following:

- Will there be enough water for mankind in the 21st Century?

- Are we taking the responsibility for protecting water resources to ensure supplies for future generation?
- How can the international community best respond to the water problems facing the world?

Pacific Press Publication In Its Ecotrends Series —Water in a Warmer World

Caption reads: "Water is already the most serious crisis facing the contemporary world and the future may well be a catastrophe."

UNESCO

UNESCO to convene in June 1998, an International Conference on the World Water Resources at the beginning of the 21st Century —the theme of this conference: Water— A Looming Crisis.

Caribbean Concern

Those items of news are only a selected few which I have used to underscore the growing concern about the global freshwater situation. The question which might be asked in the Caribbean is " Should this situation concern us?"

The question is rhetorical:

- Do we believe that the terrestrial, oceanic and atmospheric processes are all part of the same global energy cycle?
- Do we believe that events in one point in the cycle have an impact elsewhere in the cycle?
- Do we believe that the atmospheric conditions in Africa generate hurricanes in the Caribbean?
- Do we believe that sea surface temperatures in the Southern Pacific influence the climate in East Africa and the western parts of South America?

(The ENSO phenomena)

If we do —then the Caribbean should be concerned about the global freshwater situation.

Today there is agreement among scientists on the question of global warming. (The mean annual temperature of the earth's atmosphere has shown an upward trend). Sea level rise associated with global warning is certainly a matter of concern for the Caribbean. What is unclear at the moment is the likely impact of global warming on precipitation and hence on water resources.

WMO's Response

The concern about the global freshwater situation lead to a call by the Commission on Sustainable Development for improved knowledge about the water resources. WMO's response to this call has been to set up a programme for the establishment of the World Hydrological Cycle Observing System (WHYCOS).

What is WHYCOS?

WHYCOS is an acronym for a strengthened global programme for water resources monitoring and assessment.

WHYCOS is a worldwide programme aimed at improving co-operation at river basin, regional and global levels for the establishment of consistent and reliable water resources data information systems.

Why WHYCOS?

At the global level, there is:

“concern that at a time when more precise and reliable information is needed about water resources, Hydrological Services and related bodies are less able than before to provide this information, especially information on groundwater and water quality.” (UNCED, 1992)

Despite enormous expenditure over the past two-three decades in establishing and strengthening Hydrological Services, the situation in general today is not much such as IDWSSD and IDNDR.

Inadequate or unreliable hydrological data and information have constrained development of water projects and have impacted adversely on global programmes such as IDWSSD and IDNDR.

Hydrological data are critical in assessing the reasons for the observed rise in mean sea level as well as the likely rise in the projected global warming.

The WHYCOS Concept

- It is conceived as a tool for improving the collection, dissemination and use of high quality, standardized and consistent hydrological and related data at the national, river basin, regional and international levels.
- It is being implemented by WMO with financial support at present from the World Bank, the EU and France.
- It will create a world-wide network which will consist initially of 1000 benchmark stations sited on major rivers.
- Each station will monitor up to 15 variables.
- Stations will measure and transmit by satellite communication DCPs via geo-stationary and polar orbiting satellites to national, regional and global centres.
- WMO's WWW data transmission system will be used where applicable.

List of Variables

The slide shows 11 variables. The other 4 provide a diagnosis of the health of the system itself.

1. Water level
2. Water pH
3. Water conductivity
4. Water temperature
5. Dissolved oxygen
6. Turbidity
7. Air temperature
8. Rainfall

9. Relative humidity
10. Wind-speed
11. Net radiation

This list could be amended in accordance with the requirements of the particular country and the availability of the sensors.

Recent Initiatives: WHYCOS and HYCOS Components

Under the WHYCOS programme a number of regional projects have been developed and are at various stages of implementation. The current status is as follows:

MED-HYCOS	Being implemented with WB, WMO as Executive Agency. The data collected at the first MED-HYCOS stations installed in Tunisia and Croatia are available on Internet: Web Site: http://antares.mpl.orstom.fr/medhycos.
SADC-HYCOS	Project under implementation with funding from EU, WMO is the Supervising Agency.
AOC-HYCOS	The project document, prepared with support from France, has been submitted for funding to the French Government.
IGAD-HYCOS	A request for developing this component has been received.
ARAL-HYCOS	Draft project document prepared in line with WP Project framework and Swiss Funding.
CARIB-HYCOS	23 countries have agreed a letter of intent to participate in the project. A project document is under preparation.
CONGO-HYCOS	Project development supported within the framework of a Regional Meteorological, Climatological and Hydrological Information System funded by EU.
NILE-HYCOS	Project being developed with funding from CIDA.

Support for WHYCOS

- There is a strong support for WHYCOS within the UN system. It is seen as part of a future UN Water Information System.
- World Bank Technical Publication No. 263 " A Guide to the Formulation of Water Resources Strategy" has made a specific recommendation for the establishment of WHYCOS.
- WMO Congress (June 1995) noted that WHYCOS was particularly suitable for countries consisting of small islands and called for the development of a WHYCOS component for the islands of the Pacific and Caribbean.

CARIB-HYCOS

Plans are underway to develop a project —CARIB-HYCOS for the countries of the Caribbean region. This project was first proposed at a meeting of the region's hydrologists in Puerto Rico (1995) and strongly endorsed by the Regional Conference on Water Resources Assessment and Management Strategies held in Costa Rica in May 1996

and by the WMO Regional Association for North and Central America and the Caribbean (Bahamas, May 1997). Two WMO consultants will soon visit a number of countries to gather information for the preparation of the project document which will reflect the needs of the region and serve as the basis for seeking funds. This document will be circulated for comments and inputs from all the countries of the region and will be discussed at meeting of expert next year.

CARIB-HYCOS: Objectives

- Improve the capabilities to collect, manage, store and exchange hydrological data, particularly in small island states.
- Establish and strengthen regional and national capabilities in hydrological forecasting and water management.
- Improve integrated of hydrological, environmental and socio-economic data, as well as technical and scientific cooperation at regional level

CARIB-HYCOS: Expected Outputs

- Installation of a basic network of DCPs at benchmark hydrological stations, with real-time data transmission capabilities.
- Improved communications for real-time collection and exchange of data and products, through the networking of national centres via direct satellite links, WMO's GTS and the Internet.
- Trained personnel in network management and development of hydrological products to meet users' needs.
- Establishment of a regional operational co-ordination mechanism.

The question which might be asked is: Is the Caribbean ready or does it need such a high-tech system for hydrological data collection? Should we not try something more down to earth?

The answer is that we have tried such a system —over 10 years ago, under a UNDP/WMO project. The Caribbean Operational Hydrology Institute was establish as an extension of the CMI in Barbados. There was an operation component of the project which established monitoring stations in the English-speaking countries. (Members of CMO.) So everything was in place. Stations were established and technicians were trained to maintain and operate the network. But soon, the technicians moved on the with no immediate replacements, the system broke down.

If we are to judge by our experience in other parts of the world, External Support Agency are now insisting on the availability of design data as a pre-condition for funding water projects.

In the Caribbean, it is hoped the CARIB-HYCOS would contribute, at least partly, in addressing that problem of availability of hydrological data.

WATER CENTRE FOR THE HUMID TROPICS OF LATIN AMERICA AND THE CARIBBEAN CATHALAC NETWORKING IN THE REGION OF THE HUMID TROPICS OF LATIN AMERICA AND THE CARIBBEAN

Ms. Maria Conception Donoso, Director
Centro del Agna del
Tropico Humedo para America Latina y el Curibe (CATHALAC)

CATHALAC (the Water Centre for the Humid Tropics of Latin America) has been established under an agreement between the government of the Republic of Panama and the United Nations Educational, Scientific and Cultural Organization (UNESCO) to address the specific hydrological problems of the region under the framework of the International Hydrological Programme (IHP).

One of the main objectives of the Centre is to transfer Information, Knowledge and new Technologies to and between scientists and decision takers throughout the region, where decision takers are defined as all potential users of information on hydrological aspects of the region to plan future activities and plan sustainable management of water resources.

To realize this objective the Centre actively participates in the organization of workshops, seminars and conferences. Furthermore the centre initiates and participates in the elaboration of proposals to answer to the existing needs in research in the humid tropics of Latin America and the Caribbean. With the aforementioned activities CATHALAC tries to create the foundation that is a pre-requisite to improve and increase the accessibility of the existing information sources. Only through recognition of all existing sources of information the financial resources that are available for research can be efficiently utilized.

Since the establishment in 1992, the Centre has tried to construct networks within the region or to cooperate within the framework of existing networks. All these networks have one major objective in common, which is the sharing of information and exchange of knowledge through participation in cooperative activities. The regional centres of the International Hydrological Programme, the chapters of the IWRA, the research consortium of the Trade Convergence Climate Complex, the Large Scale Biosphere Atmosphere program, the Andean Amazon River Analyses and Monitoring program, and finally the Inter-American Water Resources Network. In the latter, CATHALAC is responsible as focal point for the coordination within the Mesoamerican region which covers Central America including Mexico and Panama.

Questions we have to ask ourselves after almost five years of continuous efforts to construct the necessary bases for regional networks are:

- What are the results of these networks until now;
- how were these results realized;
- what have been the major problems;
- what can we learn from past experience; and
- what should be the future activities to increase the impact of these networks and improve the results.

One of the main accomplishments of these networks is the regionalization and internationalization of research. It is now far more easier to identify the necessary partners for research and coordinated application of integrated water

management throughout the region. Examples of the regionalization of research are the AARAM project, the LBA program and the TCCC program which is now extended and can count on the active participation of research institutions from 15 countries in the region. The upcoming of the Internet has been of essential support and has allowed a more rapid construction of these international networks.

However, the use availability of the Internet and the possibility to transfer information at almost no cost has also caused an enormous flow of news and data, not all of which is happily received by scientists and policy makers. Therefore, an increasing need exists for networks to collaborate in and to coordinate data quality screening. This can be done separately by the participants of the network but might be easier to organize when executed by an institution especially made responsible for data and information quality screening. This, on the other hand, might not be the most feasible solution from an economic approach.

Another major problem for networking, especially in the developing countries including those in the Mesoamerican countries is that not all partners in the region have equal access to the electronic highway and therefore can not share information nor make use of the information that is available on the Internet. This tends to increase the differences that already exists between countries with different levels of development and could lead to unintentional exclusion of research institutions. This could and is partly be solved by dispersion of information by fax transmissions, but these networks are not as dynamic and flexible as those that can fully utilize the possibilities offered by communication through e-mail, and do consume more valuable time and money. Therefore these networks need an even more stringent evaluation of data quality.

One of the challenges in information exchange and construction of networks which do not turn out to be a one day fly, is to define a way to ensure that the presented information is of interest to all of the participants within the target group. So, first of all the limits of the target group have to be clearly set and secondly an outline has to be provided of which types of information are of interest and are needed within the target group and how this information can be made available through the target group. The presented information should not have a too wide angle neither should not be too diffuse as to assure that the participants in the network will not loose interest. On the other hand, to maintain the interest of all participants within the network, the offered information should not be directed too strongly to a specific area of interest.

Meetings as presented here in Trinidad and Tobago were scientists, policy makers and decision takers come together have to be utilized to define these criteria within the area of integrated water resource management within the Caribbean.

INTERNATIONAL SCIENTIFIC COUNCIL FOR ISLAND DEVELOPMENT (INSULA)
Dr. Ronald G. Parris, President
INSULA, Paris, France

Mr. Chairman, on behalf of the Secretary General of INSULA, Dr. Pier Giovanni d'Ayala and on my own behalf, I would like to thank the Caribbean Council for Science and Technology (CCST), the Government of Trinidad and Tobago and the various co-sponsors for the opportunity to participate in this meeting.

I would like to tell you a bit about INSULA and how I think we could contribute to addressing some of the issues being discussed here. INSULA or the International Scientific Council for Island Development is an international non-governmental organization affiliated with UNESCO, Paris. It was formally launched in 1989 at Brest, on the occasion of a meeting of UNESCO's Man and the Biosphere Program (MAB).

In the 1980's UNESCO seemed to be embarking on a tradition of "spinning off" institutions or at least helping to generate them. During my time with the organization in the early 1980's, we saw the creation of the Caribbean Council for Science and Technology, which appears to have grown from strength to strength. Well, INSULA was a more recent UNESCO spin-off, with the important difference of its non-governmental status. I note that this tradition of generating institutions has continued in the 1990's with the creation of CATHALAC.

Our mandate is to promote sustainable development in all regions of the world by encouraging scientific and cultural cooperation among islands, and by contributing to integrated planning and management of island resources. We publish an International Journal of Island Affairs, with the aim of creating a world-wide forum for the exchange of information and perspectives about islands.

INSULA has some 300 institutional and individual members, consisting of a multidisciplinary network of experts. In fact, INSULA is one large network with its secretariat in Paris and decentralized regional centres: at Palermo for the Southern Mediterranean, of Tenerife, Canary Islands and at Okinawa. Further decentralization is planned for the Caribbean, the Balaeric and Baltic Islands.

From its first General Assembly in 1989 to our recent European Conference on Sustainable Development held in Minorca in April this year as well as our meeting on Artificial Wetlands, held in Paris last week, INSULA has been giving consideration to issues of water resource management, waste management, coastal zone management, sustainable tourism and applied communication technologies.

In fact, some of the very issues we are discussing here received much attention at our Minorca meeting and are reflected in our European Commitment and Agenda for Action, the set of meeting recommendations for implementation. Integrated management of water resources, raising of public awareness and introducing incentives for water saving measures and so on. One departure, however, was the greater recognition of the role of culture in successfully implementing plans for water resource management in particular and in sustainable development in general. Dr. Donatus St Aimee told us about the difficulties "down-islanders" experienced in renting apartments in St. Thomas because of the perception that they used too much water. As an exchange student at the University of Toronto in the mid 1960's, I had a similar experience. Some of us from the Caribbean were renting from an Eastern European landlord on Spadina avenue, who daily monitored our water use because, as he said, people from the

Caribbean bathe too much. Just from these anecdotal experiences alone, it is obvious that culture (and social class) play an important role in water use preferences, conservation and willingness to pay for water.

INSULA has been developing or participating in a number of information networks in European islands, involving computer technology applications. One such project centered in the Balearic Islands is setting up information networks for tourism, including cultural information for tourists. We are also in the process of carrying out a pilot project that provides telematic services for European islands through a network of experts and service providers in the areas of tourism, health and education. The project is to be implemented by various island partners.

INSULA also collaborates closely with other information networks, such as the European Islands System of Links and Exchanges (EURISLES), set up in 1992 for the purpose of gathering statistical and documentary data about key island issues and making this information available through the use of information technology (coordinated from Corsica), ISLENET, a technical network in the field of energy management linking specialists from various islands and coordinated from Stornoway, off Scotland, the IMEDOC Network linking the Balaeric, Corsica and Sardinia islands, established in 1995. There is also a proposal to link the seven Baltic islands into a network of cooperation (Gotland, Aland, Bornholm, Saarema, Humaa, Rugewn and Oland).

What is the relevance of this for the Caribbean and the subject of our meeting? INSULA is very interested in initiating or collaborating in the development of similar or analogous information networks in the Caribbean regions that could help address some of the data management issues raised at this meeting (inadequate rainfall, conservation and leakage information, mismanagement of data, such as in the severe case of the loss of rainfall data for the period 1846-1920 in one Caribbean island, and inadequate consultation and collaboration with a wide range of specialists. Let me emphasize the importance of bringing into our net of specialists social scientists, such as anthropologists and sociologists, for as stated earlier, problems of water resources management are also cultural, especially on the demand side.

We at INSULA would therefore like to develop an on-line interactive data base on water resource management and related issues, highlighting best practices in the region and elsewhere. We would be ready also to collaborate with ongoing or planned initiatives of WMO, OAS, the Commonwealth Science Council and others.

The development of a shared regional information system for water resources management in the Caribbean could help deal with problems of data analysis and dissemination. INSULA is ready to form partnerships with public and private agencies in what has been called the emerging new structure of water resources management.

The benefits of information networks are obvious in the private sector. It is recognized that the new global economy will be based on the provision of services and exchange of knowledge and information through telematic networks. For example, such companies as Chase Manhattan, Shell and others have already been achieving impressive business results by incorporating "Lotus Groupware" (software that allows persons to work in groups and teams) and "Intranet" technologies (network like Internet or World Wide Web, but restricted to a limited group of persons) in their information systems.

Such software practices ("Lotus Notes," "Domino") allow the quick sharing of information or "best practices," so as to leverage intellectual assets and manage alliances and electronic markets in their business processes.

It seems to be that we need an analogous on-line system of best practices in the area of water resources management and other issues of sustainable development. This would tap into the various skill sets around the Caribbean as well as a global "virtual" human resource base.

Let me reiterate our interest in developing a regional shared information system as well as collaborating where possible with other ongoing initiatives. I would also like to take the opportunity of inviting you to join INSULA in developing its regional center in the Caribbean. We also invite your contribution to our International Journal as a forum for the exchange of ideas and information about sustainable development in general and water resource management in particular.

TOWARDS AN INTER-AMERICAN DEVELOPMENT BANK STRATEGY FOR INTEGRATED WATER RESOURCES MANAGEMENT IN LATIN AMERICA AND THE CARIBBEAN

Mr. Luis E. Garcia
Principal Water Resources Specialist
Inter-American Development Bank (IDB)

Foreword

This paper describes a proposed strategy of the Inter-American Development Bank (IDB or the Bank) for its involvement in integrated water resources management in Latin America and the Caribbean (LAC)2, in response to the mandates of its Eight General Resource Increase (IDB-8). IDB-8 specifically calls for the Bank to "develop and implement guidelines on water resources management which support an integrated approach to watershed management based on consideration of all sources and uses of water in a particular river basin" (IDB, 1994). IDB-8 also calls to develop viable fresh water sources and systems through a variety of initiatives, such as: developing and implementing guidelines; devising and employing integrated approaches that will converge over time upon least-cost solutions for investments in water resources development; identifying and preparing projects and project components, including water conservation programs; and encouraging better use of water resources and advances in water technology.

The proposed strategy has been discussed both internally within the Bank as well as externally with international organizations, NGOs and representatives of the water resources agencies from the LAC countries. A summary of the strategy is now being prepared for its presentation to the Policy Committee of the Board.

Key Water Resources Issues In Latin America and The Caribbean

Although the region is in general well endowed with vast and diverse fresh water ecosystems, there are extreme variations in availability within and between countries. Due to rapid population growth and trends in urbanization, tourism, rural development, and other developments, water withdrawals in Latin America are expected to increase substantially by the year 2025 (Davis, 1996). Increased demand means that the region's fresh water ecosystems are also under increasing stress.

In general, current water resources practices cannot deal effectively with these problems and are not sustainable from either an economic or environmental point of view (Serageldin, 1995). Elements that undermine the sustainable use of this vital resource are subsidized water delivery by centralized and overextended agencies; emphasis on regulatory approaches through centralized government, rather than market —or other incentive— based approaches; inadequate stakeholder participation; the absence or inadequate enforcement of legislation; inadequate data; scarcity of trained personnel; and a general emphasis on sub-sectoral, fragmented project-based water resource development without regard to integrated water resource management, including conservation of the environment (Lord and Israel, 1996; IDB San Jose Proceedings, 1996).

There is also a growing consensus in the international water resources community that fresh water is a finite and vulnerable resource, that its development and management needs an integrated participatory approach at all levels,

and that water has also an economic value in all its competing uses and should be recognized as an economic good (UNDP, 1994; GWP, 1996; WMO/IDB, 1996).

The Need For Integrated Water Resources Management

1. *Beneficial Uses of Water:* In this paper, the term beneficial use of water is applied broadly to any use that provides a service to society and/or the environment by removing water from its source, using its flow, or leaving it in place, such as potable water, energy, transportation, conservation of bio-diversity and wetlands, waste disposal and dilution, deposition of fertile soils in flood plains, etc. None of these uses are a-priori "good" or "bad." Any of these uses may be complementary to other uses or may enter in conflict with one or more uses.

2. *Water-use Conflicts*: Water use conflicts may be in volume and/or in quality. Conflicts are increased where water is scarce and the maximization of benefits from a single use —for example irrigation or hydropower generation— are attempted, without due regard for other possible uses of water from the same source, reservoir storage volume, or watershed.

   As a result of the increasing water use trends in LAC, it has been estimated that investments in water resources infrastructure in the order of US$100,000 million will be required within the next 20 years (WWF, 1996). Many of these investments will be in new reservoirs to regulate streamflow, thus increasing water losses from evaporation. And as a consequence of the region's patterns of water use, many sub-regional, basin, local and water use conflicts will appear or will be increased mainly in the region's highly populated water scarce areas. For example, the number of Latin American cities with a population exceeding 10 million inhabitants will increase, and it has been estimated that by the year 2025, about 85% of the total population in the region will be urban (United Nations, 1995), thus increasing water withdrawals and the instream use for transport of wastes.

   The forecasted increased demand for human consumption and agriculture or industrial uses, as well as new and expanding uses associated with tourism in some countries, means that surface and ground water resources as well as coastal areas, will suffer from increased pollution, increasing conflicts between the established beneficial uses and between these and the new uses and the environment, endangering land, freshwater and marine bio-diversity. The small island states of the Caribbean, with their high reliance on ground water and interaction between inland and coastal resources, face a number of unique future challenges.

   These trends will also cause serious effects in the region's freshwater ecosystems. Extensive wetlands are being transformed into rice fields, and new technologies are being applied to drain native wet grasslands for plantations with little consideration for the long-term groundwater needs of these areas. Shrimp farms have also replaced once-extensive mangroves in certain areas and dams and channelization are also potentially undermining important wetland resources (Bucher et al, 1996).

3. *Fragmented Approach:* When population and economic development pressures were relatively low and water use conflicts both in quantity and in quality were relatively rare, most countries in LAC reacted to the different types of water resources problems, specially the scarcity problem, by increasing investments in water resources development, as reported by ECLAC (1991). That is, by developing new sources of fresh water and increasing the supply for the corresponding beneficial uses. Emphasis was on sub-sectoral project-based water resources development, rather than on integrated water resources management.

4. *A Change of Paradigm*: In LAC, the changes in political and economic policies which have taken hold in many countries in response to the conditions of the "lost decade" of the 1980s, have had a noticeable impact on the treatment of water resources problems. More than in other regions in the world, some important characteristics and trends have started to appear (Lord and Israel, 1996). The central government's role is being redefined through a series of structural reforms, such as the expansion of market principles and privatization of state run enterprises, aimed at reducing direct government intervention in the economy. The decentralizing and liberalizing policies have given LAC water managers room to experiment and test new options, pioneering in many market-oriented, incentive-based measures. A number of incentive-based instruments are available to water managers and policy makers, including marginal cost pricing, groundwater use charges, water rights markets, effluent charges etc. Many have been contemplated or implemented in LAC and their adoption is likely to increase in coming years with the continued encouragement and support of international lending institutions and the accumulation of local experience.

   This is causing a shift of emphasis in the treatment of water resources problems, in accordance to generalized international and LAC consensus. The shift has been initially from an emphasis on water resources development (supply-oriented) to water resources management (supply and demand oriented), within the major water resources sub-sectors, mainly water supply, irrigation and hydropower generation.

   However, recent sub-sectoral attempts at piece-meal decentralization, decision making by isolated user groups or sectors, and privatization experiments in hydroelectric power generation, irrigation and water supply, have increased the fragmentation of sub-sectoral water resources administrative entities, making it more difficult for them to manage the process and reinforcing the need for coordination and for taking a more integrated approach to water resources management (Davis, 1996).

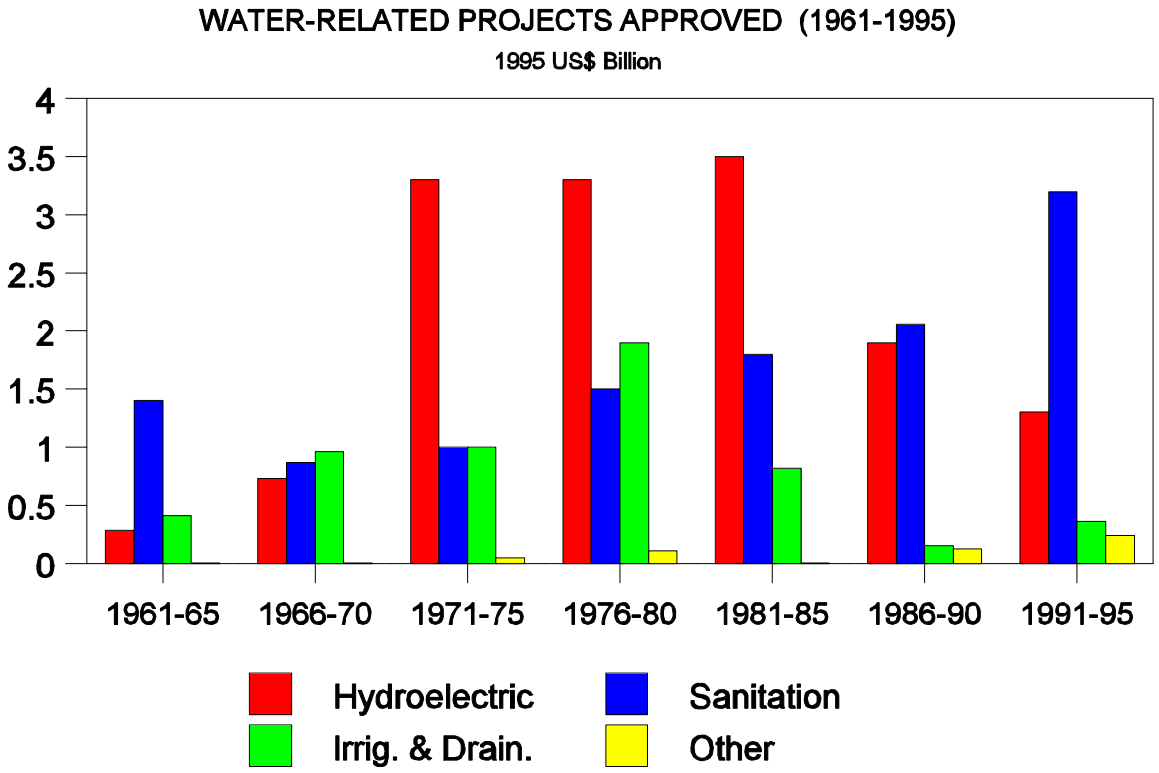
   Thus, many water resources organizations in LAC also favour a shift from a sub-sectoral approach in which projects and demands for uses such as water supply, irrigation or hydropower generation are considered in isolation, to an integrated water resources approach. This does not mean that all problems are to be solved at the same time, but rather favors a "thinking globally but acting specifically" approach, in which individual projects are confronted against a hydro-economic-social and environmental system framework, where demands for all beneficial uses of water from a given source, including ecological uses, are given due consideration. Integration occurs at the framework, not necessarily at the individual project level.

Paradigm Shift

Project-oriented Water Resources Development	**Sub-sectoral Water Resources Development**	**Sub-sectoral Water Resources Management**	**Integrated Water Resources Management (IWRM)**
Isolated projects for water supply, irrigation and drainage, hydroelectric generation, navigation, recreation, etc. Each project tries to maximize the benefits for that particular project. An implicit assumption is that a given source of water exists exclusively for that project. What happens with water-use return flows has lesser importance. Emphasis is on solving individual water use problems such as scarcity or public interest by augmenting the supply. May create serious conflicts between users and uses, but may be adequate if water is abundant and user requirements can be easily satisfied. May create serious environmental problems.	Projects for similar beneficial uses, but conceived within a sub-sectoral framework. Benefits for the sub-sector are maximized. An implicit assumption is that the sources of water exist solely for the purposes of that sub-sector; for example: irrigation, hydro-power, etc. Projects are generally derived from sub-sectoral master plans, such as irrigation and drainage, energy, water supply and sanitation, tourism, etc. Emphasis in solving problems by supply augmentation remains, but generally regarding the needs of a particular sub-sector. May solve conflicts between users, but may still create conflicts between uses. May be adequate under similar conditions as in the previous case and when only a few uses are predominant. May still create serious environmental problems.	Similar approach as before, but tries to solve water use problems such as scarcity, public interest, externality or open access, through infrastructure projects and/or institutional innovation. These projects and/or actions evolve from sub-sectoral re-structuring or modernization of the state programs (such as for the water supply and sanitation sub-sector, the energy sector, the agricultural sector, etc.), where benefits for given sub-sectors or sectors are tried to be maximized individually. For example, the unilateral assignment of water-use permits by the energy sector. It is a more efficient way to solve problems, especially when important conflicts exist between users or the scarcity is a consequence of the inefficiency of the providers. May still cause conflicts between uses. May still create serious environmental problems.	Similar approach as before, but individual projects and/or actions result from consideration of all uses, including the environment. Tries to solve conflicts between users and uses through increasing the supply but also through institutional innovation and managing the demand It usually responds better to the adjectives of "comprehensive", environmentally conscientious", " incentive- oriented"and "participatory" , that the water resources activities need to have associated with, in order to be sustainable.

Bank Financing in Water-Related Projects

The Bank belongs to what is called the IDB Group of financial institutions that provide support for the development efforts of its Latin American and Caribbean member countries. These institutions are: (I) the Inter-American Development Bank (IDB) which gives loans to Governments (95% of its lending program) and loans and guarantees to the private sector (up to 5% of its lending program); (ii) the Inter-American Investment Corporation (IIC) which provides loans and equity to the private sector in small and medium sized investment projects; and (iii) the Multilateral Investment Fund (MIF) which provides grants to Governments and non-profit private institutions, technical assistance and training, and equity to small and micro enterprise venture capital.



Since its creation, the Bank has been active in water with projects predominantly in sanitation, irrigation and drainage, hydroelectric projects but also other projects such as watershed management, flood control and waterway projects. Since 1961, the Bank has been investing almost one billion US Dollars per year in water-related projects, and this trend is expected to increase in the near future. The total amount of water-related projects over the years 1961-1995 amounts to US$32,270 million (in 1995 US$) which is 25% of total bank loans. Investments in hydroelectric projects dominate over the thirty-five year period (total US$14,298 million), followed by investment in sanitation projects (US$11,886 million). The figures for sanitation include water-related projects in the Bank categories of basic sanitation, water supply, sewerage and pollution control projects. "Other" includes water-related projects in the watershed management, integrated rural development, flood control, and waterway projects.

The Bank investments have mostly been sub-sectoral and project-based developments, with multipurpose projects being the exception rather than the rule. However, useful lessons have been learned during these past 35 years, and some interesting trends can be noted, in particular a new concern for the watersheds, the quality of receiving waters, management aspects within the water-use sub-sectors, and integrated water resources planning. Also, with the creation of the Bank's private sector loan window, the emphasis in hydroelectric projects is being substituted by other types of generation more amendable to private sector investments. A similar situation has started to develop in water supply, where the investors are only generally and not specifically concerned with sub-sectoral or sectoral water resources development and/or management.

A Proposed Bank Strategy for Integrated Water Resources Management

According to the Eight General Increase in the Resources of the Inter-American Development Bank (1DB-8), Bank programs in the water resources sector must reflect the socioeconomic and environmental needs of the borrower countries and serve the interest and needs of water users at the local and community level. Due regard must be given to conservation and sustainable use of all sources of water, taking an integrated management approach using the watershed as the basic management unit. IDB-8 also calls for the development and implementation of guidelines on integrated water resources management (IDB, 1994).

The strategy being developed by the Bank poses a comprehensive, incentive-oriented, participatory and environmentally conscientious approach, and intends to give operational guidelines for Bank operations in support of the efforts in the region towards a shift from an emphasis on fragmented (sub-sectoral) to an integrated (sectoral) approach and from an emphasis on development to an emphasis on sustainable management, recognizing the social, economic and environmental value of water, with due participation of the communities and the private sector and due consideration of social equity. It is expected that these guidelines will enable the Bank's operations in water-related projects, to support more efficient ways to allocate water and better ways to solve conflicts among competitive uses, and to conserve the ecosystems.

Goals

The proposed external goals of the Bank's Strategy are to support a process of changes regarding water resources issues following internationally accepted principles.

These changes —already initiated in LAC— aim to:

- More efficient ways to allocate and conserve water with due consideration of social equity;
- Better ways to solve conflicts among competitive uses and users, including environmental uses;
- Account for the social, economic and environmental value of water in the process of sustainable development; and
- Give due participation to the communities and the private sector.

Characteristics

The proposed focus of the strategy is intended to be on principles and on the application of instruments, not on the instruments themselves, such as privatization, tradable water rights, river basin councils, community participation, watershed management, or investments in civil works. How, these instruments will be used to reach the chosen objectives, needs to be clearly identified and agreed with each country on a case by case basis. However, the

dialogue with the countries is not proposed to be passive, in the sense that at the same time that information on the local conditions is obtained, information about how these instruments operate will be given to the countries.

Although some guidelines for analysis of water-related Bank projects are intended to be provided, the strategy is intended to be flexible, and thus, it cannot be a "cookbook". Different countries and regions within countries may be at significantly different levels of development and management with respect to water resources, they may have very different needs, and may have very different resources available to address water problems. It is proposed that the Bank strives to work within the existing political, legal, economic, and socio-cultural frameworks and management practices to the greatest extent possible, but will propose institutional changes in the water resources sector, when necessary.

The strategy is also intended to be adaptive and recognize that different water use problems as well as conservation of fresh water ecosystems may be structurally different, each type requiring drastically different approaches. It is intended to be a problem-solving strategy that recognizes the substantial assistance that the Bank can provide to water resources decision-making in LAC.

Guiding Principles

Six principles are proposed to serve as a guide for the development and implementation of Bank assistance programs in the water resources sector (Lord and Israel, 1996: IDB, San Jose Proceedings, 1996). These are: promoting comprehensive national water resources policies and strategies, focus on institutional innovation and capacity building; attention to both short-and long-term efforts for Bank action; conforming to Bank's and countries objectives and to internationally accepted principles; incentives for country involvement and for internal Bank coordination; and cooperation and coordination among international financial organizations.

Priority will be given to institutional analysis and change - both within the water-use sub-sectors and the water resources sector - over or at par with building physical infrastructure. Not only does water resources management consist mostly of institutional design and implementation, even the successful operation of individual projects depends fundamentally upon having appropriate institutions in place (Lord and Israel, 1996).

Many of the activities involved in integrated water resources management (demand management, community participation, or the preservation of ecosystems, for example) have little to do with building projects, and a continued focus solely upon infrastructure projects will fail to identify the needed institutional changes. The need for capacity building is not a one-shot affair. The process must be sustainable and thus, it needs to be systematic and continuous.

Developing an institutional structure - both within the water-use subsectors as well as in the water resources sector - which will lead to improved water resources management is a long run, indeed, never-ending process of experimentation, adaptation, learning, and improvement (Lord and Israel, 1996). Public and private decision makers need time to change ways of thinking and acting that have been long established. Likewise, the water users themselves need time to adapt to changing water management measures, practices, and rules. But there will be certain projects which are so obviously and urgently needed, community water supply or municipal wastewater treatment facilities for example, that no national strategy or river basin management plan will be required to confirm their desirability. Nevertheless, current knowledge concerning what constitutes good water resources management should play an increasing role in generating and evaluating proposals for such projects. An analytical framework such as the one proposed by Lord and Israel (1996) and described below could be useful for this purpose.

Analytical Framework

The application of the strategy requires the assessment of two situations. The first is the context in which policy is pursued and programs developed. It is composed of actors, whose actions are shaped by the environment, whether natural or man-made, and by rules. The rules define the relationship between actors and the environment and describe, for example, how costs and benefits are allocated among actors, how authority is distributed, who makes decisions and how, or who has access to what information. The second is the level at which actions and decision-making occur and, by extension, where integration occurs. For this purpose, three levels are considered: the operational or water use level, the organizational or water resource management level, and the constitutional or water policy and law level (Lord and Israel, 1996).

Actions at the operational or water use level affect the environment and are aimed at social well-being and the preservation of ecosystems. These actions include most of the water supply and sanitation, irrigation and drainage, hydroelectric and other internationally financed projects. The fundamental problems to be solved by improved water resources management also occur at this level. In a simplified manner, these problems can be classified as scarcity, externality, open access, or public interest. Examples of these types of problems are, respectively: farmers and the hydroelectric entity competing for the same streamflow volumes, a municipality discharging raw sewage into a stream, excess ground water pumping driving down the water table, and the preservation of a wetlands ecosystem (Lord and Israel, 1996). Solving them is what water resources management basically is, and requires changes in water use rules, which must occur at the water resource management level. At this level, plans and programs for utilizing water are designed, adopted and implemented. It may be impossible in some LAC countries, given the water resource management rules now in place, to adopt and implement the operational rules which could effectively address the scarcity, externality, open access, and public interest problems.

Creating an effective set of water resource management rules may require action at the water policy and law level. These higher level actions are important because a resulting ineffective set of water resource management rules virtually assures that basic water-use problems cannot be solved. Changing water policies and laws requires country-wide action at the highest political level. Changing water resource management and water-use rules, on the other hand, is often best accomplished at the individual basin level, where greater specificity is possible and where stakeholder involvement is more easily gained. Attempts to improve water resource management at the basin level, however, may be frustrated by inappropriate water laws and policies at the national level. These constraints need to be identified and addressed before major expenditure of scarce resources are allocated to making water resources management and water use changes at the basin level (Lord and Israel, 1996).

Strategic Instruments

It is proposed for the strategy to use the following instruments for integrated water resources management:

- Cost recovery
- Capacity building: o Institutional reform and innovation o Human resources development
- Stakeholder participation
- Decentralization
- Private sector participation
- Tradable water rights
- River basin councils

Much of the literature on water resource management advocates either one or a combination of several of these instruments to solve a wide range of water-use problems. There is little discussion about the soundness of searching for cost recovery mechanisms as a basis for financial sustainability, and that capacity building is the topic of the day. There also appears to be a general agreement that certain instruments, such as stakeholder participation, should be part of all integrated water management strategies, and decentralization is a reality which these strategies must cope with. However, there is a plurality of opinions on the inclusion of other instruments, like water markets and privatization, or river basin councils.

It is not the purpose of the strategy to specify how and when to use each of these measures, nor to encourage or discourage their use. These concerns should emerge from the national assessments and evaluations of local conditions and problems.

Countries have individual characteristics and specifics, thus there are no universal "cookbook" approaches to water management, a point policy makers and advisers should bear in mind when implementing schemes for water resources management.

When water is truly scarce, current systems of administrative based only on public administrative decision making usually result in inefficient allocations of water and alternative mechanisms for reallocation should be considered. Water markets are an economic tool that, if adequately implemented, provides a method to reallocate water from low value uses to high value uses, resulting in economic efficiency gains (IDB Washington DC Proceedings, 1996).

For example, identification of a water scarcity problem in a national assessment, supported by feedback from previous experiences and good practice analyses, could lead to a recommendation for institutional changes to facilitate water marketing, and, thus allow scarce water resources to flow to their economically most valuable uses. It might then be required that the changes in water resource management rules which would permit water marketing also contain provisions for long term viability, for avoiding monopolistic tendencies by effective beneficial-use clauses, for avoiding environmental degradation, and for assuring maintenance of adequate potable water supplies for the poorest users; goals which unconstrained free markets might fail to achieve.

Also it is not always clear how a water market would account for social and cultural effects; how the market would protect the environment; how monopolies and cartels could be avoided; and how to cope with externalities created by out-of-basin transfers (IDB Washington DC Proceedings, 1996).

The watershed or river basin council approach (equal to or similar to "France's Model"), is another example of incentive-based participatory mechanism for solving conflicts and allocate water between competitive users or uses, which in some instances has been considered as an alternative to market allocation (Kelman, 1996) - such as allocation by consensus. However, it is not entirely incompatible with market allocations, since the councils may decide —by consensus— to leave water allocation to the market within the irrigation sub-sector, for example, or between the irrigation and the water-supply sub-sectors.

The watershed or river basin council approach is recommendable to establish integrated water resources management strategies and to plan for water resources assessments nationally and subregional. In the subregional domain, this approach may be useful in solving problems related to water resources management of transboundary river basins, as a vehicle to promote subregional coherent water policies and legislation, which may become increasingly needed with present globalization and integration efforts and trends.

Nationally, it may also be advisable to establish basin committees or councils to coordinate the actions of several overlapping national organisms and administrative jurisdictions and to promote the role and responsibility of the various groups in the basin, to facilitate concentration as a problem-solving mechanism. It may also be a useful mechanism for achieving greater involvement by the stakeholders and to agree on schemes to account for opportunities costs.

However, it does not mean that basin committees or councils must be established across the board.

While it is true that most of these strategic instruments have been underutilized in LAC, it is also true and none is a panacea. Each is feasible in some situations and infeasible in others. Each is a promising solution to some problems, and is likely to be ineffective in solving others. And, each is really a general term, within which considerable variation may occur.

What is too often absent in the literature is a discussion about how and in what contexts to adopt and implement these strategic instruments, and in what specific forms. Their potential success or benefits of these measures should be evaluated relative to existing conditions in LAC countries and the possible long-term impact they could have on integrated water resources management, not on theoretical or academic models. As recommended by Lord and Israel (1996), the solution process should assess how local political, institutional, technical, economic and financial conditions match the requirements of the instrument under consideration.

Bank Instruments

The Bank has several instruments that can be used to assist member countries achieve improvements in water resources management. Among these are the country dialogue during preprogramming and programming missions, country and regional technical cooperations, trust funds, sector and hybrid loans, project-specific, private sector and small project loans, and co-financing. The Bank's Committee for Environmental and Social Impact (CESI), within its mandate, would assist the Regional Operational Departments in the implementation of the proposed strategy. CESI reviews the assessment of all Bank operations, whether they are loans or grants, and suggests ways to better comply with the mandates of IDB-8 regarding all social and environmental issues, including those concerning water resources.

The strategy proposes that the Bank, using all its available instruments, supports the development of integrated water resources strategies, policies and master plans; supports capacity building and the strengthening of institutions; and looks at both the urgent short-term needs of the population, as well as the medium and long-term needs of water resources institutional modernization. This is to be a gradual step-by-step procedure to move away from the fragmented, physical infrastructure-oriented approaches, towards an integrated approach, emphasizing also the institutional investments to provide sustainability to the process. The basic premise is that, in the face of limited resources, priority be given to those investments that conform to a strategic framework for the sustainable management of water resources. These strategies would be strengthened where they do exist, and would be promoted where they are lacking. For this purpose and with due consideration to local conditions and on a case-by-case approach, the strategy proposes that the Bank encourages and/or discourages institutional situations such as those shown as an example in the following table:

Table 1
Examples of Institutional Situations

Content	Examples of Situations to Encourage (Important Exceptions May Occur)	Examples of Situations to (Important Exceptions)
A. Water Resources Sector	1. Integrated Water resources management approach 2. Stakeholder empowerment and participation 3. Entity to coordinate "top-down" and " bottom-up" approaches 4. Market —or other incentive— oriented mechanisms to allocate the resource (examples are tradable water rights regimes and/or river basin councils) 5. Entity to coordinate and facilitate the process of water allocation placed independent of any specific water-use subsector, such as water supply, irrigation, hydropower 6. Provisions to ensure adequate water supplies to the poorest users 7. Comprehensive and balanced water resources sectoral laws and regulations 8. Water resources entity within —or linked to— the national environmental entity 9. Multipurpose projects 10. Watershed or river basin approach 11. Consideration of effects on coastal areas	1. Fragmental approach 2. Emphasis only on investments 3. Centralized, "top-down" decision making 4. Centralized government entity that allocates the use of the resource and procedures investment plans, programs, and projects 5. No relation to other natural resources and/or the environment 6. Proposed water resources sector restructuring solutions independent from modernization of the state plans and/or efforts, when they exist. 7. Absence of provisions to ensure adequate water supplies to the poorest users 8. Attempts to regulate the water resources sector through subsectoral water laws (that is, water laws originating and biased to the water supply, irrigation, hydropower, or other subsectors) 9. Water resources entity located within a given water-use subsector (that is, water supply, irrigation, hydropower)
B. Water Supply and Sanitation Subsector (in addition to A)	1. Compliance with the Bank's public utilities policy (regulatory, planning and water delivery functions in separate and independent entities). 2. Metering and cost recovery. 3. Stakeholder and water users participation. 4. Private sector participation 5. Decentralization or municipalization 6.Capacity building of decentralized entities .7. Reduction of non-accounted-for losses prior to development of new sources of supply. 8. Regulatory mechanisms in place prior to privatization 9. Maintenance of investments.10. Financial sustainability. 11. Long-term programming and investing by stages.	1. Regulatory, planning and water delivery functions within the same entity. 2. Subsidies (may be necessary in some cases, but must be transparent and targeted. 3. Centralization 4. Non-accounted-for losses 5. No relation to the water resources sector 6. Emphasis only on water supply with no consideration for wastewater disposal and treatment. 7. Conflicts with other uses

Content	Examples of Situations to Encourage (Important Exceptions May Occur)	Examples of Situations to (Important Exceptions)
B. Water Supply and Sanitation Subsector (in addition to A) Cont'd	12. Explicit relationship with the water resources sector, regulated by the water resources sector regulatory entity. 13. Waste water disposal and treatment as an integral part of water supply	
C. Irrigation and Drainage Subsector (in addition to A)	1. Cost recovery 2. Management or irrigation units by farmers and/or user associations 3. Added emphasis on in-farm operations 4. Rehabilitation of existing systems 5. Economic incentives for water conservation, especially groundwater 6. Maintenance of investments 7. Financial sustainability 8. Complementarity with other uses 9. Farm drainage as part of the project 10. Adequate disposal of irrigation return flows as an integral part of the project.	1. Subsidies (there may be exceptions. If so, they must be transparent, targeted and temporal). 2. Emphasis only on main delivery and drainage systems without consideration for in-farm drainage. 3. Groundwater depletion. 4. Conflicts with other uses.
D. Hydro-electric Subsector (in addition to A)	1. Compliance with the energy strategy being developed by the Bank Economic efficiency and effectiveness of tariffs 2. Financial sustainability 3. Complementarity with other uses	1. Isolated projects 2. Conflicts with other uses

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