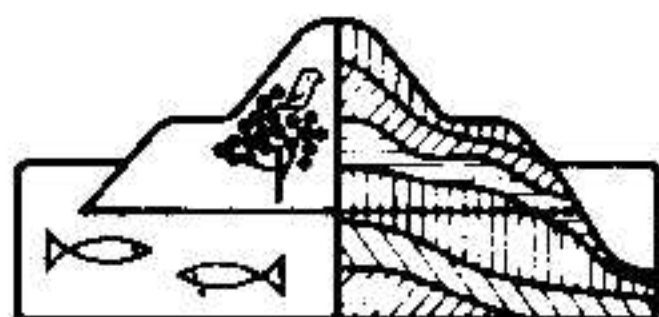


PUERTO RICO'S WATER RESOURCES PROBLEMS AND RESEARCH NEEDS

PROCEEDINGS OF WORKSHOP NUMBER ONE
JULY 10-12, 1974



**DEPARTAMENTO
DE RECURSOS
NATURALES**

WATER RESOURCES
RESEARCH INSTITUTE
MAYAGUEZ CAMPUS



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PROBLEMS AND RESEARCH NEEDS

Proceedings of Workshop Number One

Sponsored By

THE WATER RESOURCES RESEARCH INSTITUTE
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MAYAGUEZ CAMPUS

And

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By

Editing Committee

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INTRODUCTION:

The relationship between natural resources and human affairs is absolute. Composed of renewable and non-renewable components, the natural resources supply is fixed in time and/or space. The land resources base of Puerto Rico is fixed in space while the water resources base is fixed in time, i.e., through the hydrologic cycle we can expect only a certain amount of rainfall over any given time period. While factors such as population size and distribution, degree and direction of economic development, and the role of technology are important, ultimately the future of Puerto Rico depends on the way its fixed supplies of water and land are managed.

The purpose of the workshop was to make an assessment of Puerto Rico's water resources needs, determine the problem areas which restrict the fulfillment of such needs, and identify research and public policy necessary to resolve these problems.

The workshop followed the American assembly format in which small groups of participants with a chairman and a scribe discussed a list of logically arranged questions. The results were assembled into a manuscript which was discussed the next day by a general assembly using parliamentary procedure. A Draft of this final document was approved at that time. However, four points require clarification:

1. The document represents the consensus of the majority of the participants expressed in group discussions and as approved by the general assembly. Due to the procedure, there are sections of the report which were considered controversial and unacceptable to a minority of the participants. Therefore, individual participants should not be held responsible for specific statements in this report.

2. The participants understand that water use involves aspects that are non-consumptive (allow for recycling and reuse) and others that are consumptive (reuse is not possible). To avoid confusion the participants defined the term "water use" to include both types of use.

3. In the report data are presented to substantiate some of the assumptions and problems statements. This information was obtained from "The 1973 Water Resources Assesement for Puerto Rico" prepared by the Department of Natural Resources, in which the original data and references may be found. The scientific merit of this information was not questioned in the workshop.

4. This document establishes broad research needs and policy. A detailed list of individual projects was neither possible within the time framework, nor necessarily the objective of the first workshop. Subsequent workshops will dwell on specific research needs and priorities.

CONSTRAINTS THAT AFFECT ISLAND WATER RESOURCES:

The following are the basic constraints affecting island

water resources:

1. Total natural water input to Puerto Rico is fixed. The amount of rainfall over the island sets the limit on water availability. The mean annual rainfall for the island as a whole is about 75 inches per year. Desalinization constitutes one means to add to the total available water, but only at a substantial cost to society. Water recycling, on the other hand, does not add to total water input, but rather assures more efficient use of available supplies.

2. Rainfall distribution and natural water storage is not uniform throughout the Island. Data compiled by the Department of Natural Resources show the uneven distribution of upland runoff and groundwater and the regional variation in water balance for the island (Table 1 and Figure 1).

TABLE 1. WATER BALANCE FOR PUERTO RICO (in./yr.)

Planning Division	Rainfall	Runoff	Groundwater recharge	Evapo-transpiration
I- Northern Area	79	21	7	51
II- Eastern Area	92	40	5	47
III- Southern Area	60	17	8	35
IV- Southwestern Area	77	30	2	45

3. Within Puerto Rico, demand for water increases daily. In 1970 PRASA reported domestic water use at 195 mgd. By 1990 projected use might approach 500 mgd. In addition, by 1990 industrial water use might increase by a factor of 4 over its

present estimated demand of 175 mgd. Finally, agricultural water use is also expected to increase from 220,000 acre-feet per year in 1970 to over 270,000 acre-feet by 1990.

4. In spite of projected increases in water demands in all sectors of the economy, all water uses should coexist. The term water uses includes the natural sector which contributes to the economic wealth of the island through its many indirect services. Jobs and self sufficiency depend upon a diversified economic base. Thus, despite the uncertainties of future developments, both on a regional and world-wide basis, it is required that viable industrial and agricultural production alternative be maintained.

BASIC PROBLEMS IN PUERTO RICO - STRATEGY FOR SOLUTION, RESEARCH NEEDS AND PUBLIC POLICY RECOMMENDATIONS:

A. WATER USE IN GENERAL HAS INCREASED SHARPLY

PROBLEM:

With the growth of industry, urbanizations, and agriculture, the demands for water use have increased and will continue to increase dramatically. Furthermore, changes in water use patterns affect all sectors of society, and the introduction of new users may affect existing users.

STRATEGY:

Since water is a limited resource whose demand is increasing sharply, strong water conservation measures should be pursued.

This might require changes in public attitudes, jurisprudence, and in the structure of government.

Research needs include:

1. The systems of supply and use by watershed units;
2. Water demand estimates by ecosystem type, crop type, industrial type, commercial type, etc.;
3. The potential for reuse, particularly in the industrial sector;
4. The economic role of water in the various sectors of our economy (forest, industry, agriculture, urban, etc.)
5. Review of non-conventional methods for desalinization of sea water with the objective of searching for an economically feasible process;
6. The quantification of actual water cost, delivered to the site of use;
7. The development of a system for cost accounting, (social, economic and ecological costs) associated with the procurement and use of water.

POLICY:

A strong water conservation policy should include:

1. Reduction of water consumption;
2. Reuse of water;
3. Public education;
4. Establishment of ground and surface water use controls;
5. Revision of construction practices to provide for water conservation;
6. Augmentation of metering systems;
7. Improvement of land use policies (i.e. earth movement permit-

as required in the Virgin Islands).

8. Zoning to include water resource considerations.

Metering policies should be re-evaluated not only to reduce consumption but also to improve documentation of the quantity of water consumed by each user. All large flat rate consumers should be metered, including schools, governmental institutions, etc.. Channelization should be limited to extreme cases, where no other alternative to local problems is feasible (i.e., Bayamón). Additionally, rate structures and public policies should be established to discourage high rates of water use where it is technologically feasible to reduce consumption.

B. THERE IS A LACK OF ADEQUATE PLANNING CRITERIA AND METHODOLOGY TO SOLVE CURRENT AND GROWING MULTIPLE WATER USE CONFLICTS.

PROBLEM:

The current water resource planning process in Puerto Rico is inadequate. Water and land constitute limited resources which are essential to the very survival of the island, yet no integrated, long range conservation and development planning has been initiated. Furthermore, there is a severe lack of sensitivity to water resource needs in the current short range planning process.

Water resource development projects characteristically have long design lifetimes and represent large public investments. All sectors of the Puerto Rican system depend upon this resource

and interact with one another through their competition for water. Therefore, it may be said that water integrates all sectors of the Puerto Rican system. Yet, the dynamics of this interaction are neither well understood nor included in the current planning process.

Adequate long range planning projections do not exist for economic activity or water use. Current development and industrial location land use policies neither reflect water resource constraints, nor quantify the value of competing water uses. Moreover, existing water law is completely inadequate to protect current users from new development. Finally, inter-agency coordination for water resource conservation and development is lacking.

STRATEGY:

A completely integrated approach for quantifying and evaluating water and other limited resources should be developed. Water cannot be considered alone, but must involve a portion of the entire human-environmental system. Supporting research activities should include:

1. The development of improved industrial demand projections and identification of the sensitivity of industry to water price and availability;
2. Evaluation of the marginal value of water in a variety of applications, the quantification of resource development constraints, and the development of 50-year projections based on a range of alternative futures;

- 3. Commonwealth regulation of water use and distribution in the best interest of the public. In the legal sense, water use should be considered a privilege rather than a right. There should be equitable allocation of water and priorities should be established to determine which uses should be curtailed, and to what degree under drought conditions;
- 4. Restructuring and up-dating of water law, taking into consideration all constraints and recommendations of this report.

POLICY:

Funding must be allocated commensurate with the importance of the water resource so that a comprehensive planning methodology may be developed and implemented. A permanent mechanism for mandatory inter-agency planning should be implemented and viable planning objectives which are compatible with the long range resource constraints and stability of the Puerto Rican system must be developed and disseminated (see Appendix).

C. CURRENT REGIONAL WATER DISTRIBUTION SYSTEMS ARE INADEQUATE.

PROBLEM:

Population and economic growth in Puerto Rico have centralized activities in certain areas having the needs for importation of water. Furthermore, local drought conditions may occur in one area of the island and not in another.

An integrated water distribution system could provide a reliable water supply to areas of concentrated human activity. However, the construction costs of such a system would force the commonwealth to search for more economic alternatives, particularly with respect to location of water intensive industries and improved water conservation practices. The development of large distribution systems must be preceded by systematic studies to determine their practicability as compared to other water supply alternatives

STRATEGY:

The development of large water distribution facilities should be viewed as one alternative in a comprehensive island-wide water supply study. Other alternatives should include relocation of major water users and intensive conservation practices. Long range benefits, costs and conservation must be emphasized. Potential water resource development sites should be identified as a part of the study so that they may be preserved for future resource development. Moreover, it should be possible to determine the approximate costs associated with supplying increasing amounts of water to different parts of the island as well as site location decisions for various types of development. Additionally, the total amount of water ultimately available could be determined. Such an approach would allow the selection of the most desirable alternative or combination of alternatives, to meet island needs.

Research should be conducted to determine:

1. The most efficient distribution system which could be

developed. The total costs and benefits of water transfers should be investigated. This is particularly important with respect to subsidizing additional population growth on Vieques and Culebra through importation of water.

2. Total economic and water use impacts of a variety of pricing policies. Viable water use projections need to be developed, particularly with respect to the industrial and agricultural sectors.

POLICY:

1. A comprehensive island-wide water supply study should be undertaken in the immediate future to quantify the developable water supply and the costs associated with various levels of development.

2. Land management activities should be geared toward improvement of water quality and conservation of water supplies.

D. WATER QUALITY CONTROL IS INADEQUATE

PROBLEM:

Municipal, agricultural, and industrial wastes have degraded the quality of the island's waters, and pollution, sedimentation, and eutrophication (nutrient enrichment of water) problems exist as a result of inadequate controls.

Poor soil conservation practices result in the removal and transport of sediments during heavy rains and cause losses in soil productivity as well as damage to urban areas and natural systems, all of which can be measured in dollar losses

to the economy. Sewage effluents raise contamination levels, particularly during periods of low flow, and promote eutrophication, making water unavailable for certain uses. Costly procedures are then needed to restore water quality and the aquatic environment.

STRATEGY:

Critical water quality areas, effluent sources, and specific pollutants should be identified. Next, plans and policies should be devised to cope with the problem and restore water quality to acceptable levels.

Research is needed on the following subjects:

1. Pollutational loads of certain effluents such as agricultural run-off;
2. Investigation of water quality parameters including sediments on an island-wide basis;
3. Reevaluation and expansion of the present hydrographic sampling network to satisfy current growth patterns and data needs;
4. Inventory of location, geological characteristics, and number of existing waste injection wells and the quality and quantity of chemical substances being injected into deep aquifers;
5. Evaluation of water quality deterioration on natural systems and wildlife including barrier reefs;
6. Possible employment of ecological means to solve aquatic weed problems;
7. Development of adequate bioassays for the specific aquatic conditions of Puerto Rico;

8. Potential of waste recycling using land treatment;
9. Evaluation of surficial geological modification on the environment and on water quality and supply.

POLICY:

Regulation of pollutant discharges to water bodies requires the control of both point and non-point effluents.

1. Control of soil erosion, a major non-point pollutant source, should be attempted through the regulation of earth movement, plus the application of the soil capability classifications and soil and water conservation practices to urban and agricultural land (including reforestation programs, sediment traps on exposed soil, land use control, etc.).
2. Point source should be monitored and training of treatment plant operators should be improved.

E. CURRENT AND PLANNED LAND USE CONSUMES OR DESTROYS NATURAL RESOURCES AT AN UNSUSTAINABLE RATE.

PROBLEM:

Puerto Rico is a system composed of natural, agricultural, urban and industrial subsystems, all of which are necessary to the maintenance of the island system. At the base of the island system is the natural subsystem, which is vital to the survival of the human subsystems. Yet, due in part to the economic boom of the past 30 years, limited natural resources are being consumed at an increasing rate without concern for the long term consequences of the high rate of resources consumption and environmental deterioration. The most widespread problems may be related to the current trend of improper and ununiform

land use, creating conflicts with groundwater recharge and soil conservation, and causing flooding problems. The impact of land use decisions on water resource conservation is not adequately evaluated nor even adequately understood. Environmental quality is relegated to a very low value because it is a "public" resource which does not have a readily identifiable dollar value.

STRATEGY:

The structure and function of the Puerto Rican system should be documented and modeled so that different resource consumption policies may be tested in a rational fashion, including the effects of interactions between the various subsystems within the larger system.

The natural subsystem is intimately linked to the human subsystems, providing essential free services including maintenance of water quality, soil formation and conservation, aquifer recharge, recreation, microclimate control, tourist appeal, and maintenance of overall environmental quality. These services which the natural subsystem provides to the human subsystem must be quantified and made an integral part of any analysis of growth. A computation of the dollar equivalent value of these free services might be a useful method of quantifying their true value with respect to economic subsystems.

Topics requiring additional study include:

1. Relationships between the land and the hydrologic cycle, including land and drainage basin characteristics, land use,

- sediment, production and soil loss, and groundwater recharge;
2. Delineation of the critical natural areas and evaluation of their functions with respect to the entire island system;
3. Quantification of the dollar equivalence of ecological services that are derived from natural systems;
4. Identification and quantification of man's current and projected damage to ecological systems including the cost of foregone "free" ecological services which are lost due to the damage of natural systems.

POLICY:

Land and water resources are intimately related. To enable improved resource management and utilization, a vigorous and well planned land use policy must be formulated and implemented. This policy formulation should strongly consider:

1. Implementation of a permanent "Super-Zoning" system to effectively zone domestic, industrial, and agricultural land use;
2. Amendment of five-acre criteria for rural development;
3. Tax exemption for permanently zoned agricultural land or urban boundaries;
4. Measures to eliminate land speculation in flood plains.
5. Strong control of sedimentation from construction sites;
6. Preservation of critical natural areas;
7. Upgrading the procedure and format for Environmental Impact Statements (EIS) including emphasis of EIS employment as a planning document rather than a justification tool, and establishment of appropriate qualifications for EIS preparation.

F. THERE IS SUFFICIENT BASIC INFORMATION AVAILABLE TO OUTLINE SOLUTIONS TO WATER RESOURCE PROBLEMS, ALTHOUGH SIGNIFICANT INFORMATION GAPS STILL EXIST.

PROBLEM:

Information regarding water, land, and related resources, on a unit area basis, is as abundant for Puerto Rico as anywhere in the world. Nonetheless technical information gaps still exist. Unfortunately, many studies and/or suggested policy statements have been submitted without implementation plans. Because of this, much of the information may not become available to the decision making process. Accurate water resource management is dependent on the type of detailed information generated by a continuing comprehensive research program.

STRATEGY:

To meet present and future research needs a long-term program should be initiated. Since funds are generally scarce, research should have practical interest and be conducted on a priority basis which reflects needs. The starting point for all studies is a comprehensive literature review and dissemination of information to cooperating individuals and/or agencies. Basic water resource information required for Puerto Rico includes:

- 1) Soil infiltration rate relationships;
- 2) Effects of development in mountains regions upon coastal ecosystems and water quality;
- 3) Effects of land use changes in evapotranspiration patterns;

- 4) Physiography and geology of watershed basins with particular emphasis on groundwater and surface water interactions;
- 5) Determination of discharge and flow duration;
- 6) Agricultural water consumption;
- 7) Localized climatology;
- 8) Data to implement P.B. Regulation No. 13 (Floodable Areas);
- 9) Data of socio-economic nature, by watershed;
- 10) Data on mechanism for aquifers recharge in areas where recharge occurs;
- 11) Data on water quality, sedimentation, and natural critical areas, by watershed.

POLICY:

1. The government should improve the water resources data bank to provide all water-related information within the reach of researchers, government planners, and universities and to facilitate the theoretical interpretation of these data;
2. It should also encourage research and technical studies to fill the gaps that exist on the current data base.

G. THERE IS INADEQUATE SUSTAINED AWARENESS AT ALL LEVELS FOR PUERTO RICO'S WATER RESOURCE PROBLEMS.

PROBLEM:

Although Puerto Rico's water resources are limited, and are being depleted daily through inadequate conservation, no active awareness of these problems is apparent. Water is currently being rationed in San Juan (July-August, 1974), and the South Coast is undergoing a severe drought. However, when

these conditions are past the water resources problem will fade from the forefront of public awareness and will not surface again until the next "crisis" occurs.

The problem of transitory awareness is to be anticipated from the general public. However, it is deplorable that the knowledgeable leaders within the public, agriculture, industry, and government have neither demonstrated an active awareness for water resource conservation and development, nor the need for provision of essential legislative, financial, and planning support in order to solve water problems. This may be due to the inability of the water resources agencies to communicate effectively with other areas of government and the private sector.

The Department of Natural Resource is the key Commonwealth water resources agency, responsible for flood damage abatement, water supply development, and resource conservation. Yet, the water resources planning effort in the Department is so inadequately supported that its effectiveness is marginal.

STRATEGY:

The general lack of concern for water resources should be remedied by a multi-media educational program stressing resource awareness and conservation. A more fundamental step would emphasize water resources education in the public schools, starting in the elementary grades, and reinforced at each subsequent level. The hydrologic cycle, dependence of Puerto Rico on water, simple water quality concepts, resource conser-

vation, and perhaps a visit to a water body or sewage treatment plant should be included in the program.

The water resources program at the university level, should be expanded to generate qualified professionals with the technical expertise to resolve the island's increasing water problems. Non-specialized courses on Puerto Rico's natural resources should be made an essential part of university education.

A specific research need would include:

Educational program for public schools to generate resource awareness. Basic research in human behavior might establish reasons for man's insensitivity for his resources and suggest possible solutions to this problem.

POLICY:

1. The educational programs outlined should be developed and implemented;
2. Water resources agencies should educate the public leaders more actively regarding water resources problems to generate much needed support.

SOCIOECONOMIC IMPLICATIONS OF WATER RESOURCES MANAGEMENT:

The participants are in agreement that water, natural resources, industry, agriculture and urban systems are all interrelated and interdependent. Modern society can no longer consider one of these subsystems more important than another. To do so may cause long term imbalances in the social, natural

and economic sectors of society.

Imbalances affect both the quality of life and the standard of living of society. For example, the mismanagement of a mountain forests in Puerto Rico affects the economy through losses resulting from the unavailability of the resource as well as excessive expenditures for controlling the associated downstream increases in floods, water eutrophication, erosion, sedimentation and drought! The same action has social effects including loss of recreation opportunities and social changes resulting from new land use. Finally, quality of life is affected through the elimination of the aesthetic values and other indirect services originally provided by the forest environment.

This workshop recommends that natural resource management, and water management in particular, be recognized by the Puerto Rican society as essential to the social and economic welfare of the Island. These resources make positive contributions to island happiness and survival, and their proper management becomes a necessity of modern man and not an obstacle to his progress.

APPENDIX

Water Resources Planning Goals And
Objectives for Puerto Rico

As Outlined By The
U.S. Army Corps of Engineers,
San Juan, Puerto Rico

WATER RESOURCES PLANNING GOALS AND OBJECTIVES FOR PUERTO RICO

1. Flood Protection and Flood Plain Management

To prevent or control damage from flooding.

CPO 1-a. Provide economical protection up to the 200 year flood in urban flood-prone regions.

CPO 1-b. Accord flood protection and flood plain management with priority to current and projected urban areas in Puerto Rico, in that order.

CPO 1-c. Maximize the use of non-structural measures compatible with land use requirements in achieving desired levels of flood protection throughout Puerto Rico.

CPO 1-d. Optimize the employment of flood plain lands for such compatible uses as agriculture and recreation with initial emphasis on urbanizing areas.

CPO 1-e. Develop a tentative 10 year Action Plan.

2. Improvement of Navigation Facilities

To provide for efficient use of water resources for transportation and navigation.

CPO 2-a. Insure the availability of harbor facilities which are adequate to support the growing Commonwealth economy.

CPO 2-b. Optimize the use of waterways in the San Juan Area for urban transportation consistent with environmental needs.

CPO-2-c. Insure adequate and safe small boat and recreational boating harbor facilities consistent with increasing demand for these facilities.

3. Regional Water Supply Management Systems

To provide for efficient development and conservative use of domestic, agricultural, and industrial water supplies.

CPO 3-a. Maximize the availability of water in any surface water development project consistent with other needs.

CPO 3-b. Insure that an adequate supply of potable water is available to satisfy the needs of every inhabitant.

CPO 3-c. Optimize the use of water conservation measures.

CPO 3-d. Maximize the use of groundwater sources while safeguarding the long term availability.

CPO 3-e. Optimize the use of groundwater recharge techniques in water shortage areas.

4. Regional Wastewater Management Systems

To provide for the efficient reuse of treated or renovated wastewater and byproducts.

CPO 4-a. Develop a management system which is in compliance with the requirements of P.L. 92-500.

5. Outdoor Recreation Facilities

To provide for an equitable distribution of water based recreation.

CPO 5-a. Incorporate recreation facilities in current and future water resources development projects.

6. Water Quality Control

To improve and safeguard our water resources from continued degradation by water-borne wastes.

CPO 6-a. Comply with P.L. 92-500 and the Federal and Commonwealth water quality criteria.

CPO 6-b. Eradicate schistosomiasis island-wide by 1980.

CPO 6-c. Minimize the effects of sedimentation in any water resource development project.

7. Fish and Wildlife Conservation

To protect and enhance natural fish and wildlife population.

CPO 7-a. Protect, enhance and maintain natural communities, of which fish and wildlife are a part.

CPO 7-b. Wisely utilize fish and wildlife as food sources and recreation elements.

8. Beach Erosion Control

To protect beaches from excessive erosion and prevent destruction of shoreline property and associated coastal land.

CPO 8-a. Minimize deterioration of the coral communities particularly along Puerto Rico's north coast.

CPO 8-b. Increase knowledge of sand transport processes, and their effects on coral communities particularly along Puerto Rico's north coast.

CPO 8-c. Identify and structurally or otherwise solve immediate beach erosion problems in the study area.

CPO 8-d. Structurally or otherwise protect present and potential beach recreation areas.

9. Other Environmental Enhancement Measures

To minimize air and noise pollution, protect archeologically, historically, culturally, and scenically important sites, and accomplish other measures necessary to insure the enlightened use of natural resources.

CPO 9-a. Control, enhance, and protect the quality of the total human environment in keeping with population, commercial, agricultural, and industrial trends.

CPO 9-b. Protect, enhance, and maintain those natural amenities important to man's esthetic well-being.

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