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New Evaluation Procedures for a New Generation of Water-Related Projects

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The World Bank
Washington, D.C.

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FOREWORD

The core of the World Bank Water Resources Management Policy is a comprehensive policy framework that recognizes appropriate management of water resources. Sound management relies, however, on large amounts of adequate and reliable information. Thus, information systems and appropriate use of information are critical for comprehensive water management.

The lending program of the World Bank in water resources includes new projects with substantial components designed to help enhance and modernize a country's capacity to collect, process, and use the most critically important input to the process of water management, information. Evaluations of the economic value of information associated with such projects are not straightforward.

This paper addresses the methodology of economic evaluation of water-related projects that create the need for a "new generation" of evaluation procedures and methods. The paper demonstrates the use of the methodology in the recently approved Mexico Water Resources Management Project. We hope this report will stimulate thought and debate about strategies that the Bank might use to develop evaluation methodologies that comport with the challenges posed by this class of projects.

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EXECUTIVE SUMMARY

Problems related to scarcity of water resources are increasing in many countries around the world. Improved water resources management may provide a sound economic alternative for increasing their available quantity and improved quality. Changes in the development of water resources have been seen lately. First, the more ideal sites for the construction of large dams and reservoirs have already been developed. Second, the growing demands for fiscal austerity in most countries have resulted in growing concerns with least-cost alternatives for meeting water needs. Third, awareness and concern have increased about the environmental impacts related to the construction of hydraulic infrastructures. And fourth, increasing competition by various sectors for scarce water resources is the result of growing population and increased economic activity. These changes have caused a fundamental shift in the way that water resources development is considered—a shift from looking to construction as a means for solving water needs to looking to improved management as the means for solving such needs. The focus on water resources management to solve a country's water resources problems is now viewed in qualitative as well as quantitative terms. This view introduces concerns about the efficient use of existing resources and the need for exploring ways that new mechanisms might enhance the incentives of water users to use water more efficiently.

This change from a "construction" to a "management" approach to solving a country's water problems alters the basic nature of assistance required by the water manager. This effect is described here as a "new generation" of water-related projects that the Bank is increasingly asked to consider. These projects aim to enhance and modernize a country's capacity to collect, process, and use the most critically important input to the process of water management: information. Thus, the goal of achieving substantive improvements in water-use efficiency and the improvement of water quality presupposes such detailed knowledge as how water is presently used, conditions of water supply, accurate and timely forecasts of meteorological events, alternative institutions for water management (e.g., basin planning organizations and water markets), and conditions requisite for their effective operation. Also presupposed are means of identifying information needs of individual water users and how such information can be made accessible to them in a timely manner. Generally, developing countries have neither the facilities nor the trained personnel required to achieve this goal. Thus the new generation of water-related projects at the Bank necessitates training of water managers to use that information appropriately.

These new generation projects are not associated with output of goods and services that are directly the results of the project. "Separable" groups of project beneficiaries cannot be easily identified or associated with specific features of the project.

Evaluations of the economic feasibility of such projects are not straightforward. There can be no question about the worth of this new generation of projects that upgrade the information infrastructure. The questions that do arise, however, are the following: How do we measure this "worth"? How do we evaluate the economic feasibility of such projects?

Obviously the Bank's new generation of water-related projects creates the need for a new generation of evaluation procedures and methods. This need motivates the present study. In this report we explore three approaches that might be used for the evaluation of such projects. Our intent is to stimulate thought and debate about strategies the Bank might use to develop these evaluation methodologies.

The three approaches to project evaluation are the following. First, the "inferential approach." It infers the feasibility (or infeasibility) of a country project from successes (or failures) of similar projects in other countries. Second, a descriptive or "anecdotal" approach. It evaluates a project's feasibility on the basis of past country experiences that demonstrate how proposed enhancements in information infrastructure would have resulted in measurable effects on social benefits. Third, the "minimum impact approach." Drawing on new "options" theories of investment under uncertainty, this approach evaluates the project's economic feasibility by considering the responses to two related questions: What is the minimum impact on measurable social values attributable to the project that would be required for its feasibility (a benefit to cost ratio of unity); and does there exist a reasonable basis for expecting such minimum impacts?

The Mexico Water Resources Management Project (WRMP) is the expository vehicle for exploring these three approaches. We provide greater detail concerning the substance of the WRMP, and then we evaluate the WRMP with an application of the three approaches.

1. INTRODUCTION: A NEW GENERATION OF WATER-RELATED PROJECTS

In the past, the World Bank's water-related projects have financed capital expenditures required to construct dams, reservoirs, and water distribution facilities. Such projects had the following two interrelated and distinguishing characteristics: (a) the output of goods and services was directly associated with the project (e.g., agricultural output from irrigation systems, power production from hydroelectric generating facilities, the avoidance of flood damages and recreation activities from impoundment facilities, and the provision of water supplies for cities and industries); and (b) "separable" groups of beneficiaries of the project were easily identified and associated with specific features or components of the project. Evaluations of the economic feasibility of such projects were straightforward. Characteristic "a" made it possible to estimate the net value of goods and services that will be produced by beneficiaries of each project feature. Characteristic "b" made it possible to allocate project costs among project features by using well-established separable-nonseparable cost allocation techniques.[1] Each project feature "served" a distinct set of beneficiaries.

Over the last decades concerns about water resources have changed dramatically. First, more ideal sites for the construction of large dams and reservoirs have been developed. Thus cost-effective opportunities for further construction activities have been exhausted. Second, most countries have increased demands for fiscal austerity. Thus growing concerns focus on least-cost alternatives for meeting water needs. Third, water scarcity has increased, the result of growing population and economic activity. These changes have resulted in a fundamental shift in water resources development—a shift from looking to *construction* as a means for solving water needs to looking to improved *management* as the means for solving such needs. Water resources management is now viewed in qualitative as well as quantitative terms. This view introduces

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[1] For an overview of these techniques, see Burness, H.S., *et al.* 1980. "U.S. Reclamation Policy and Indian Water Rights," *Natural Resources J.*, 20(4): 807–826.

concerns about the efficiency of using existing resources. It also raises the need to find new institutions that can enhance the incentives of water users to use water more efficiently.

This change from a construction to a management approach to solve a country's water problems alters the basic nature of assistance required by the water manager. This effect is described here as a “”new generation” of water-related projects that increasingly demand the Bank's attention. These projects aim to enhance and modernize a country's capacity to collect, process, and use the most critically important input to water management: *information*. Thus, the goal of achieving substantive improvements in water-use efficiency and the improvement of water quality *presupposes* such detailed knowledge as how water is presently used, conditions of water supply, accurate and timely forecasts of meteorological events, alternative institutions for water management (e.g., basin planning organizations and water markets), and conditions requisite for their effective operation. Also presupposed are the means of identifying information needs of individual water users and how such information can be made accessible to them in a timely manner. Generally, developing countries have neither the facilities nor the trained personnel required to achieve this goal. Thus the new generation of water-related projects at the Bank necessitate training of water managers to use that information appropriately.

Before discussing implications for project evaluation procedures, several recent projects considered by the Bank should be mentioned. They exemplify this new generation of water-related projects. The first example is the Pakistan National Drainage Program Project (NDP).[2] More than 20 percent of this project's cost covers the development of Pakistan's capacity to (a) introduce policy and institutional reforms related to water resources management, and (b) to strengthen capabilities to perform irrigation and drainage research that is a basic pre requisite for policy formation in the country. The bulk of these funds are to be used to upgrade and modernize the facilities and human capital required to gather and use information. A second example is the Mexico Water Resources Management Project (WRMP).[3] One hundred percent of this project's cost is used to (a) modernize and upgrade Mexico's capacity to generate,

[2] World Bank. 1966. “Pakistan National Drainage Program Project.” Staff Appraisal Report No. 15310-PAK. Agricultural and Natural Resources Division, Country Department 1, South Asia Region. Washington, D.C.:

[3] World Bank. 1996. “Mexico Staff Appraisal Report Water Resources Management Project,” draft. Natural Resources and Rural Poverty Division, Country Department II, Latin American and the Caribbean Region. Washington, D.C.

manage, and use hydrometeorological information (modernize and expand the National Meteorological Service); (b) modernize telecommunication and computation capacities used for water management; (c) measure and monitor systems for ground and surface water management and reservoir operations; (d) measure and monitor systems for water quality; (e) establish the River Basin Councils; (f) fund dam safety programs; and (g) establish the National Registries (this office oversees water rights and waste water discharges in preparation for Mexico's initiation of water markets and new enforcement mechanisms to control water quality).[4]

Several new generation projects have emerged in the Bank. They are characterized by significant investment data collection and information processing, use of information for decisionmaking, and investment in institutional development and capacity building. The India Hydrology Project[5] is summarized in Box 1, and the Morocco Water Sector Investment Project[6] is summarized in Box 2.

Box 1.1: India Hydrology Project

"The project concept is to assist the Central Government and the participating State water resource agencies in the development of valid, comprehensive, interactive, easily accessed, and user friendly data bases covering all important aspects of the hydrological cycle, and to the strengthening of the capabilities of the institutions concerned....The main objectives of the project would be to improve the institutional and organizational arrangements, technical capabilities and physical facilities available for measurement, validation, collation, analysis, transfer and dissemination of hydrological, hydrometeorological and water quality data within agencies at the Central Government and seven participating states....The project would generate substantial indirect benefits by improving the water resources and climate data base ... and making data easily available ... to users....Specific quantification of project benefits is not feasible because it is not possible to estimate the value of India's existing hydrological data, or to quantify the marginal benefit of any improvement to the hydrological data base resulting from project investments. Consequently, a conventional marginal economic analysis can not be made for the project. Instead, a risk assessment approach has been adopted which calculates the value that a rational agent would pay to acquire a data base to make a sound and realistic decision. Project costs would be paid for entirely through an increase of only 0.016% of extra agricultural production in the eight participating states.

[4] Another example of a project whose primary purpose relates to information is seen in the Indian National Hydrology Project. See "India: National Hydrology Project, An Economic Appraisal." *London Economics.* 24 pp. plus appendices. Report to the World Bank. London: September 1994.

[5] World Bank. 1995. "India Hydrology Project." Staff Appraisal Report No. 13952-IN. South Asia Country Department II, Agriculture and Water Operation Division. Washington, D.C.

[6] World Bank. 1996. "Morocco—Water Sector Investment Project." Yellow Cover Staff Appraisal Report No. 15760MOR. Maghreb and Iran Department, Natural Resources and Environment Division, Middle East and North Africa Regional Office. Washington, D.C.

Box 1.2: Morocco Water Resources Management Project

The Project includes four components: (a) policy reforms to develop the framework for long-term planning and management, improve water use efficiency by promoting the use of economic efficiency, and improve cost recovery; (b) institutional development to decentralize water management by establishing water river organizations. (c) capacity building by improving management, monitoring, forecasting, information processing, and control over water quantity and quality and development and introduction of new management practices and technologies; and (d) investment in physical infrastructure, such as dams, groundwater, flood control and waste water treatment.

While information is an increasingly important component in the management of water-related projects at a country level, regional activities focusing on information collection, processing, and dissemination among riparian countries are emerging as well. This trend is shown in Box 3, which describes the concept of Hydrological Cycle Observing System (HYCOS).

Box 1.3: The Concept of Hydrological Cycle Observing System for National and International Water-related Information Collection and Dissemination[7]

The World Bank and the World Meteorological Organization (WMO) have created a communication concept for the collection and sharing of hydrological information. This concept was guided by the World Bank's Water Resource Management Policy [8] and driven (so far)by the water resource management needs of several regions, including Sub-Saharan Africa, the Aral Sea Region of Central Asia, and the Mediterranean Basin. Although the World Bank's policy does not specify the need for information systems, it does have at its core the adoption of a comprehensive policy framework that recognizes that sound decisions need a considerable amount of adequate and reliable information. Thus Information systems are a key input for comprehensive water management. The concept evolved as follows.

From 1988 to June 1996 the World Bank, the UNDP, the African Development Bank, the French Ministry of Cooperation, the European Community, the WMO, UNESCO, and UNDESD carried out an hydrological assessment of nearly all the countries of Sub Saharan Africa (SSA). The program report recommended that the conventional hydrometric data systems be rehabilitated and reinforced with modern technology. The aim was to make them capable of delivering timely and high-quality data for inclusion in economic analysis used by government agencies for encouraging local and foreign investment in their countries. It was this economic imperative that led to the concept of the Hydrological Cycle Observing System (HYCOS). With the encouragement and the blessings of the President of the World Bank and the Secretaries General of the WMO and UNESCO, the concept of a World Hydrological Cycle Observing System (WHYCOS) was born. Its purpose was the support of sustainable development through improved water resources management worldwide as a virtual organization under the umbrella of the WMO.

The use of HYCOS as a tool for initiating comprehensive river basin development evolved further during the Central Asian Aral Sea Basin Program. During 1992–93, the heads of states of the five countries (Kyrgistan, Tadjikistan, Uzbekistan, Kazakstan, and Turkmenistan), which share the two rivers (Amu-Darya and Syr-Darya) that feed the Aral Sea, requested the World Bank, UNDP, and UNEP to assist them in their efforts to address the water management problems of that region. The rehabilitation of the regional hydrologic infrastructure following the HYCOS concept was key to providing the high-quality and timely information that the Regional Development Strategy Committee needs for advising the heads of state on regional water allocation issues.

A third experience is the Mediterranean Basin Hydrological Cycle Observing System (MEDHYCOS). Concerned with the region's vulnerability to its precarious water resources situation, this initiative is being undertaken by the Hydrological Services in the Mediterranean Basin.

1.1 Conceptual Framework

The "worth" of this new generation of projects that upgrade the information infrastructure goes without question. Mosley observes, "Information may be said to be the

[7] Based on Matthews, J. Geoffrey. 1996. "Communication for Bridging Different Water Perspectives." Paper presented at the Sixth Stockholm Water Symposium, Stockholm, Sweden, August 4-9.

[8] World Bank. 1993. "Water Resources Management." A World Bank Policy Paper. Washington, D.C..

'antidote' to uncertainty, or the 'raw material' from which decisions are made."[9] The questions that *do* arise, however, are the following: How does one *measure* this "worth"? How does one evaluate the economic feasibility of such projects? These questions stem from the two basic characteristics (see Introduction) of "traditional" projects that the Bank has considered. They are *not* characteristics of this new generation of projects. For instance, the Mexico Water Resources Management Project involves the modernization of diverse water-related information systems. Here "separable" groups of beneficiaries are not at all easily identified. Arguably every sector of society can be affected by improved meteorological forecasts, environmental improvements, improved reservoir management, and the rational, sustainable use of water resources. Because separable groups of beneficiaries are absent, assessments of the feasibility of individual project components are made particularly difficult (taken along with problems raised by characteristic "a" discussed below) because many components "serve" the same population.

Referring to characteristic "a" described in the Introduction, the primary objectives of this new generation of projects are not designed to increase the production of goods and services or to affect social welfare. Their objective is to "produce" information—the "raw material" of decision processes. The use of this raw material can be expected to affect the production of goods and services and general social welfare. But we have little or no means to transform changes in information to changes in the production of goods and services or other welfare effects.[10] More formally, if dI represents the change in information (still more confounding, often a change in the *quality* of information) that is expected to result from a project and dG is a

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[9] Mosley, M. Paul. 1994. "Economic and Social Benefits of Meteorological and Hydrological Services to the Water Sector." World Meteorological Organization, *Conference on the Economic Benefits of Meteorological and Hydrological Services*, WMO/TD No. 630: 78-82. Geneva, Switzerland.

[10] We acknowledge guidance in this regard from the existing literature concerning the "value of information" (as examples, see Rothschild, M. and J. Stiglitz. 1970. "Increasing Risk: I. A Definition," *J. Econ. Theory* 2: 225-243. Also see Rothschild, M. and J. Stiglitz. 1971. "Increasing Risk: II. Its Economic Consequences," *J. Econ. Theory* 3: 66-84) and investment under uncertainty (see Dixit, Avinash. 1992 (Winter). "Investment and Hysteresis." *J. Econ Perspectives* 6(1): 107-132. See also Dixit, Avinash K. and Robert S. Pindyck. 1994. "Investment and Hysteresis," *Investment Under Uncertainty.* Princeton: Princeton University Press; and Hubbard, R. Glenn. 1994. "Investment Under Uncertainty: Keeping One's Options Open," *J. Econ. Lit.* 32: 1816-1831). However, there are very few empirical applications of these bodies of theory that apply to the issues at hand: how do residents of flood zones or farmers adapt behavior to improved weather forecasts; how might reservoir managers adjust management plans to improved hydrometeorological information and what would be the effects of such adjustments? This is not to say that such relationships cannot be developed. Our position is simply that the present state of the art relevant for such relationships is, at best, at an infant stage.

change in (e.g.) the production of goods and services, in the relationship $dG = f(dI)$ we are ignorant of the form of f. Procedures and methodologies used in traditional benefit/cost analyses leave us well prepared to evaluate a *known* dG. With no means to transform dI to dG, however, the existence of these procedures and methods offers little comfort.

Obviously, the Bank's new generation of water-related projects creates the need for something of a new generation of evaluation procedures and methods. This need motivates the present study, which explores three approaches. Together or separately, they might be used to evaluate projects that intend to enhance the information infrastructure. The three approaches to project evaluation are the following. First, the "inferential approach." It infers the feasibility (or infeasibility) of a country project from successes (or failures) of similar projects implemented in other countries. Second, the descriptive or "anecdotal" approach. It evaluates the feasibility of a country project on the basis of past country experiences that demonstrate how proposed enhancements in information infrastructure *would have* resulted in measurable effects on social benefits. Third, the "minimum impact approach."[11] Drawing on the intuition of new "options" theories of investment under uncertainty,[12] this approach evaluates the economic feasibility of a project on the basis of responses to two related questions: What is the minimum impact on *measurable* social values attributable to the project that would be required for its feasibility (a benefit to cost ratio of unity); and does there exist a *reasonable* basis for expecting such minimum impacts?[13]

Clearly, these three approaches are not exhaustive of all possible approaches that might be appropriate for the task at hand. Too they are not "new" in the sense of suggesting lines of inquiry that have never been considered or used. What we view as "new" are (a) the notion of expanding such lines of inquiry in ways that serve as the primary assessment vehicle, as opposed to serving as a basis for data that support traditional benefit and cost analyses; and (b) the joint use of the three approaches for developing a preponderance of evidence relevant for a project's assessment.

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[11] The parallel between this approach and the "options" theory of investment derives from the "bad news principle" that characterizes decision rules implied by the theory. This principle implies that the rational investor's investment decision will be determined by the distribution of outcomes representing (in crude terms) worst case—minimum impact—events; "good news" does not enter the investment rule. See Dixit, *Ibid.*

[12] As examples, see Dixit, *op. cit.*; and Hubbard, *op. cit.*

[13] This is essentially the approach used in *London Economics*, *op. cit.* 1994.

Most importantly, we wish to make clear that the approach we explore in this paper is not offered as a panacea for project assessment. Given that one can only infer benefits attributed to a project from current, *aggregate* levels of economic and social activity in an economy, we are ill prepared to address aspects relevant for project assessment. Examples in this regard[14] include feasibility assessments of individual project components and assessments related to the optimal scale for a project. Thus, any application of our approach will require the analyst to pay attention to efforts that buttress numerical analysis of a project with careful qualitative analysis of these aspects. Such aspects would include analysis of the structure of a country's relevant institutions that ultimately determine the incentives of individuals and organizations to effectively transform improved information into social gains.[15]

Thus, our intent in this paper is to stimulate thoughts and debate about strategies that the Bank might use to develop evaluation methodologies that comport with challenges posed by this class of projects. To this end, we use a case study—the Mexico Water Resources Management Project (WRMP)—as an expository vehicle for exploring the three approaches. In Section 2 we provide greater detail concerning the substance of the WRMP. We begin our evaluations of the WRMP in Section 3 with an application of the "inferential approach." We suggest an application of the "anecdotal approach" to the WRMP in Section 4. In Section 5 we present an evaluation of the WRMP, using the "minimum impacts approach." We close with concluding remarks in Section 6.

[14] The authors gratefully acknowledge comments related to this topic offered by David Hughart.

[15] Thus, as suggested by David Hughart, "...(if potential beneficiaries of the project) are now being driven by the wrong set of incentives or other constraints that prevent coming to the right answers, simply improving better information may be the second or third priority."

2. THE WRMP

In Mexico, the density of population and economic activity generally is inversely related to the availability of water resources. Less than one-third of the nation's water resources are located within the 75 percent of territory that make up the arid and semiarid zones. Here most of the largest cities, industrial facilities, and irrigated lands are located. Also in these zones almost 85 percent of the nation's GDP is generated. Mexico's principle water administration agency, the National Water Commission (Comision Nacional del Agua, CNA), presently faces myriad challenges to its efforts to manage the quantity and quality of the nation's water resources. Federal commitments to meet basic nutritional requirements of Mexico's urban and rural poor depends on increased agricultural production. A large portion of this increase must come from an irrigation sector that desperately needs to be rehabilitated and modernized. Demands for water from urban and industrial growth, particularly in the northern half of the country, strain existing water supplies. Without the development of new water supplies or a reallocation of existing supplies, the demand is unsustainable. Inadequate treatment of waste waters in municipalities and the unregulated discharge of industrial wastes have degraded water quality in many rivers and lakes, threatening public health and safety. The nation's groundwater stocks are being depleted from enormous annual overdrafts, raising serious sustainability questions. In addition the groundwater is being contaminated by unregulated discharge of waste waters. Maintenance and upgrading of many dams constructed in the 1930s and 1940s, have been deferred. Thus concern for dam safety grows daily. And as a final example of challenges facing the CNA, Mexico's urban and rural centers are increasingly becoming vulnerable to flood and drought because the national meteorological data collection, processing, and forecasting systems are deteriorated and outdated. These challenges prompted recent federal legislation that empowers CNA to make strategic responses based on three interrelated activities: (a) the initiation of basin planning, (b) the establishment of *incentive-based* institutions for the allocation of water and for regulating water quality, and (c) global reform of CNA's information infrastructure. In terms of *effective* water resources planning, the CNA recognizes the critical and strategic importance of stakeholder participation in the preparation and implementation of any water plan. As a part of these activities, the CNA is presently (a) completing a program that transfers responsibilities for the operation and maintenance of irrigation facilities to water user associations; (b) completing a National Registry of water users that establishes *fungible* usufructuary water rights that can be traded in water markets; (c) establishing a system of water prices, paid by municipal and industrial water users, in an effort to provide incentives for water conservation; and, (d) as provided by a recently enacted Federal Rights Law, completing a registry of industrial firms that discharge wastes into water bodies (rivers, lakes ponds) and establishing industry-specific quality standards for discharged wastes.

The WRMP will buttress the government of Mexico's water sector policies by supporting the establishment of streamlined and efficient water rights administration, in accordance with the National Water Law. This step will provide the mechanisms for transfering water rights and for a functioning water market. Both these efforts will help allocate water toward more productive uses (i.e., improving the economic efficiency of water use). This step is to be done in a dynamic setting where water demands are continuously changing, while simultaneously protecting against aquifer depletion, protecting the water rights of third parties and reducing point-source water pollution. The government has made good progress in identifying and registering current water users and discharges since the 1992 publication of the National Water Law and its 1994 regulations. But still many issues remain related to the administration of water rights. These issues must be resolved if the government hopes to ensure that water markets achieve their desired objectives. Some of these issues include facilitating the registration of existing water users, implementing a modified fee schedule for extracting and discharging water, training CNA staff so that they can better protect against aquifer depletion and possible negative third-party effects, and adopting volumetric pricing.

2.1 Information as the Key to the CNA Strategy: Objectives of the WRMP

Reliable data of water quantity and quality are fundamental requisites for success in implementing CNA's strategy described above. In this context, "reliable data" means *reliable* in the sense of being comprehensive in content, time, and space, Basic to this strategy is decisionmaking and policy formulation in regard to the operation and management of water resources systems, the enforcement of water use and quality regulations, and investments in information infrastructure. The quality and effectiveness of such decisions and policies will depend on the quality of the data and information available to the CNA's decisionmakers.

The following examples underscore the critical importance of reliable information for these functions:

Basin planning as contemplated by the CNA's strategy for River Basin councils will necessarily involve trade-offs and sacrifices if water uses are to be brought into line with existing water supplies and substantive improvements in water quality are to be realized. The depth of thought by stakeholders considering plans that entail the sharing of sacrifices is directly related to stakeholders' confidence in the reliability of data used to compare alternative plans. The CNA's acquisition of such critical data will require major upgrading in such things as the number and reliability of hydrological observation and monitoring sites in both surface and groundwater areas and interconnected computerized databases.

Improved efficiency in the management and operation of surface water supplies, as well as operationally efficient and effective responses to flood and drought conditions, requires reliable *and timely* hydrometric and meteorological data. Providing these data requires access to state-of-the-art meteorological technologies and facilities, as well as modern hydrometric, telemetric, and radio communications systems.

If the CNA, in conjunction with the River Basin Councils, is to promulgate policies to reduce groundwater overdrafts it must have detailed data and assessments that characterize affected aquifers. Such data and assessments derive only from modern, comprehensive monitoring and information systems and modern computerized modeling techniques.

The promulgation *and enforcement* of water quality standards cannot work without reliable water quality data -- "reliable" in these terms may extend to standards that can withstand judicial scrutiny in cases where a CNA finding of noncompliance with water quality standards is challenged in the courts. The availability of such data requires the existence of state-of-the-art water quality laboratories, the establishment of national water quality monitoring and information systems, and water quality assessments.

The CNA's strategy involving reliance on some forms of water markets as a means for reallocating water from low- to higher-valued uses is predicated on (a) reliable information concerning water availability, and (b) the existence of well-defined water rights. The establishment of such rights is dependent on the completion of the National Water Rights Registry.

Dam safety is an important part of the CNA's plans to improve the efficiency and effectiveness of water resources management at reservoir facilities. Standards for dam safety, required investment programs for upgrading or redesigning reservoir configurations, and effective emergency preparedness programs require information and data that derive from (a) extensive dam inspection, (b) hydrological evaluation of dams, (c) design studies for corrective actions, (d) instrumentation and data analyses, and (e) real-time monitoring systems.

Thus the overall objective of the WRMP is the following: To provide the information infrastructure and training required to generate the basic information needs of the CNA's strategy for responding to the challenges of water quality and quantity management in the contemporary Mexican environment.

The activities to be financed with the WRMP involve an investment presently valued at 2,123 million NP ("new pesos"; approximately US$283 million). For this data see Table 2.1. The activities are organized in the table according to the eight CNA departments (Gerencias) responsible for implementing them.

The WRMP's output clearly does not fit standard approaches to project evaluation. The *intended* benefits or values expected from the WRMP derive from enhancements in the way that data collection and data use are organized in decisionmaking processes The next three sections discuss how the approaches described in Section 1 are used to evaluate the economic feasibility of the WRMP.

3. EVALUATING THE WRMP: THE INFERENTIAL APPROACH

A large part of the WRMP's budget is to be used to upgrade and modernize Mexico's capacity to gather meteorological and hydrological data and disseminate it. Table 3.1 provides examples of results from studies in countries that attempt to estimate ex post benefit-cost measures for new upgraded technologies put in place to improve the quality of data and information. Whatever arguments one might have with methodologies used in one study or another,[16] these results provide overwhelming evidence of the benefits that accrue to society from investments that enhance the quality of meteorological and hydrological data.

The source of benefits measured in the studies cited in Table 3.1 derive from such things as benefits from enhanced information systems that improve weather forecasts, reservoir management, and water resources planning. The beneficiaries of such improvements are agriculture, public health and safety, transportation, and the industrial and public sectors. Still other studies provide compelling indicators of the feasibility of investment projects that enhance the quality of hydrological information for other dimensions of end-uses akin to those relevant for the WRMP. For example, London Economics[17] and Solomon[18] report estimated benefit-cost ratios for projects that upgrade facilities for collecting and disseminating *streamflow* data intended to reduce errors in streamflow measurements used to manage reservoirs; their benefit-

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[16] In particular, a number of these studies rely on the "contingent valuation method," a valuation method that is extraordinarily controversial at this point in time. However, few if any economists, even those with the most anti-cvm bent, would argue that biases in values derived with the method would affect the feasibility conclusions suggested by results reported in these studies.

[17] *London Economics*, *op. cit.* 1994; see also reference to Ingledow, T.E. & Associates. 1970. "Hydrometric Network Plan for the Provinces of Newfoundland, New Brunswick, Nova Scotia and Prince Edward Island." Report for Department of Environment. Vancouver, B.C., Canada.

[18] Solomon, S.I. 1976. "Worth of Data." In H.W. Shen, ed., *Stochastic Approach to Water Resources*. Fort Collins, Colorado.

cost measures were 2.81:1—21.2:1 and 7.1:1, respectively. Cordery and Cloke[19] estimate benefit-cost measures for collecting and archiving data used for the design, sizing, and management of water impoundment facilities at 1.7:1, and for the management of major dam structures at 2:1. Annual benefits to small farmers in Mali from improved agrometeorological data are reported as avoidance of lost cereal production in the amount of 205,500 kilograms; savings of pesticide applications of 3 liters per hectare; and a 60 percent increase in the production of millet, sorghum, and corn.[20]

A subcomponent of the meteorological component of the WRMP deals with *the commercialization* of hydrological and meteorological information. Thus it is appropriate to comment on current trends and their success in other countries to form public-private partnerships for commercializing hydrological and meteorological information. As noted by Ellis and Ballentine: "Every business is influenced by the weather to some degree."[21] Successful commercialization of weather information requires the development of designs for displays of hydrological and meteorological information that satisfies the needs of private users of such information (i.e., as emphasized by Lumsden,[22] *user value* is a key organization objective for joint, public-private collaboration to commercialize hydrological and meteorological information). A number of countries have realized remarkable success in forming public-private partnerships that have satisfied these needs. Japan and France are two examples. In 1993, Japan initiated a collaborative program between the Japanese Meteorological Agency and twenty private meteorological companies to serve a market for weather information. This market was estimated to amount to US$200 million per year.[23] In France, the Direction de la Meteorologie

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[19] Cordery, Ian and Peter S. Cloke. 1994. "Benefits to the Community of Collecting Streamflow Data." World Meteorological Organization, *Conference on the Economic Benefits of Meteorological and Hydrological* Services. WMO/TD No. 630:145-148. Geneva, Switzerland.

[20] Togola, Yaya. 1994. "Economic Impact of Agrometeorological Informations Application in Sahelian Agriculture System: An Example in Mali." World Meteorological Organization, Conference on the Economic Benefits of Meteorological and Hydrological Services. WMO/TD No. 630: 164-167. Geneva, Switzerland.

[21] Ellis, John A. and Vivienne Ballentine. 1994. "The Meteorological Information Self Briefing Terminal: A Collaboration Success." World Meteorological Organization, *op. cit.*: 203. See also Hunt, Roger and Malcolm Jessop. "Benefits of NMHS and Third Party Collaboration in the UK." World Meteorological Organization, *op. cit.*: 192-196.

[22] Lumsden, John. 1994. "Bringing a Benefits Orientation to the Marketing of Meteorological and Hydrological Services." World Meteorological Organization, *op. cit.*: 213.

[23] Sakurai, Kunio. 1994. "Benefits to End-users of NMHS/Private Sector Collaboration in Japan." World Meteorological Organization, *op. cit.*: 189.

Nationale (Meteo-France) was formally separated from the Ministry of Transport and given the status of a separate federal entity. It was charged with the task of commercializing the meteorological information it generates.[24] As a result of introducing a videotex system and imposing charges for telephone answering services previously provided free of charge, commercial revenues from the sale of hydrological and meteorological information increased as a percent of Meteo-France's budget (in constant francs). Revenues went from 2-4 percent to 15 percent during the four-year period 1989–1993.[25]

However compelling the benefit indicators seem for projects designed to improve and commercialize the quantify and quality of hydrological and meteorological data, it is important to recognize that such indicators and measures are limited in terms of making the full, relevant case for such projects. One dimension of this issue[26] is succinctly stated by Stewart:

> "...none of the [analyses such as those reported above] have evaluated the worth of hydrological data *with respect to ecologically sustainable development* and in most cases the beneficiary is easily defined..."[emphasis added]..[27]

Stewart expands his emphasis on the contemporary importance of extra benefit and cost dimensions of hydrological data in the following way:

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[24] Duvernet, Francois, *op. cit.*

[25] *Ibid.* The potential market for rainfall and climate information in another country, Zambia, is seen in the number of requests for such information (by sector) reported in "The United Nations Development Program (WB-UNDP), SubSaharan Africa Hydrological Assessment SADC Countries, Country Report, Zambia." (December 1990). Some 620 (1,574) requests for rainfall (climate) data are reported for the period 1981–1984.

[26] Still another dimension of "value" that is most often not included in benefit-cost measures is the impact that better hydrological and meteorological data can have on the prevention of loss of lives. For a related discussion related to meteorological forecasts, see Thornes, John E. 1994. "The Economic Benefits of MET Services to Road Winter Maintenance in the UK." World Meteorological Organization, *op. cit.*: 178–180.

[27] Stewart, Bruce J. 1994. "The Value of Hydrological Data." World Meteorological Organization, *op. cit.*: 64.

> "Basic data, once collected for the development of the resource, is now essential for the management of the resource under the principle of ecologically sustainable development. The importance of basic data has in fact increased rather than decreased because of this shift in emphasis. Water resource engineers and hydrologists must educate the policy and economic decisionmakers, and the community at large, as to the essentiality of this basic information source."[28]

In closing, the inferential approach to assessing the feasibility of a proposed project relies on ex post measures of benefits and costs that have been shown to accrue to similar projects in other countries. A rigorous application of this approach would require efforts that were *not* made in the examples given above, that is, efforts to identify studies where such "similar" investments may have been shown to be *infeasible*. Thus an attempt should be made to identify characteristics of feasible and infeasible projects and compare such characteristics with those relevant for the project under consideration. The relative weight of resulting comparisons (in terms of the inferred feasibility of the project under consideration) would depend on how much the proposed project shared characteristics of successful (feasible) projects.

[28] *Ibid.*

4. EVALUATING THE WRMP: THE ANECDOTAL APPROACH

This section examines two sets of selected experiences in Mexico. Both sets relate to the quantity and quality of hydrological and meteorological data. One set concerns the magnitude of damages born by the Mexican population arising from hydrometeorological phenomena. Such damages would surely be affected by the WRMP. The second set concerns Mexico's experiences with a pilot project for the formation of River Basin Councils as a central part of basin water planning. The purpose of these examinations is to provide a basis, however limited and speculative, for drawing inferences as to values that might reasonably be expected to accrue to Mexican society from the WRMP.

4.1 THE POTENTIAL VALUE OF ENHANCED METEOROLOGICAL AND HYDROLOGICAL DATA FROM REDUCED FLOOD AND DROUGHT DAMAGES

With its extended coastlines and concentrations of people and economic activity in close proximity to the Atlantic *and* Pacific coasts, Mexico's geography and topography make it extremely vulnerable to effects of hurricanes and northward moving cold fronts. Data in Table 4.1.1 describe damages from all hydrometerological phenomena (rain storms, floods, droughts, freezes, hail and wind storms) in Mexico during 1987–1994. On average, the annual damages from these causes are as follows: a partial or total loss of production from some 1.4 million hectares; a loss of some 38,000 head of livestock; and costs associated with human suffering resulting from the destruction of more than 27,000 homes, evacuated more than 133,000 people from their homes, a loss of life for 181 people, and serious injuries suffered by more than 100 people.

The largest part of these damages from hydrometerological phenomena arise from floods and droughts. Monetarily, the greatest losses in the agricultural and forestry sector are caused by drought. Referring to Table 4.1.2, annual losses from drought averaged 1 billion NP per year over the period 1979–1994 (compared to average annual monetary losses of 302 million NP from floods over the period 1973–1994; see Table 4.1.3). Indeed, the 1994–1995 drought in Northern Mexico (not reflected in Table 4.1.2) resulted in extraordinarily large damages; the full extent is not yet known. The potential losses caused by this drought are apparent from the loss of irrigated hectares in three affected areas: the Culiacan Irrigation District (a decline in irrigated acreage of 40,455 hectares); the Delicias Irrigation District (a loss of 69,212 hectares—*87 percent of hectares under irrigation during the 1993–1993 agricultural year*); and the La Comarca Lagunera Irrigation District (a loss of 28,728 hectares). CNA professionals believe that the magnitude of losses from drought (such as those given in Table 4.1.2 and those ongoing in Northern Mexico) would have been substantially reduced if reservoir managers had had available to them more reliable hydrometeorological forecasts and more reliable and more timely data concerning streamflow.

Damages from floods in Mexico are particularly costly given associated costs in human suffering. The human costs—the loss of homes, the loss of life, and personal injuries—reported in Table 4.1.1 are caused by floods. Human losses are not to trivialize monetary losses caused by floods to the agricultural sector, however. Annual average losses of 302 million NP (see Table 4.1.3) are anything but trivial; they represent an enormous burden for the Mexican farmer. The vulnerability of Mexico to recurrent floods is illustrated in Table 4.1.4. It describes the frequency of floods experienced by Mexico between 1950 and 1994. Mexico has experienced more than *3,500* significant floods over this forty-four year period. Many Mexican States, particularly those along Mexico's eastern and western coasts, are virtually assured of experiencing multiple flood episodes each year.

To appreciate the importance of WRMP components designed to upgrade and modernize Mexico's capacity to produce timely and reliable hydrometerological data, it pays to look beneath the gross, national measures of flood damages described in Tables 4.1.3 and 4.1.4 to the more local effects of floods in Mexico. The northwest coastal state of Sinaloa is a case in point. Exceptional flood years in this state occurred in 1943, 1949, 1960, 1978, 1981, and 1990–91. Following this discussion, the extraordinary flood of 1990–91 is examined.

Five "principle" flood episodes were reported for the state of Sinaloa in the year 1994.[29] The following chronologically describes these events and associated damages:

July 30, 1994: in the vicinity of Madero, Sinaloa, 82 milimeters of precipitation is received within a twenty-four hour period. Roadway landslides obstructed vehicular traffic.

August 18, 1994: 103 milimeters of rainfall are reported in the municipalities of Culiacan and Sinaloa de Leyva. Roadway landslides and flooding obstructed vehicular traffic.

August 28, 1994: in and around the municipality of Culiacan, 55 milimeters of precipitation occur. Roadway landslides and flooding obstructed vehicular traffic.

September 2, 1994: 112 milimeters of rainfall is reported in the northern part of the city of Culiacan. Reports of damage caused by flooding include 150 houses; 750 persons with monetary damages; 2 deaths; vehicle damage; interruptions in electrical energy supplies, and problems in vehicular traffic.

October 14, 1994: Hurricane Rosa makes landfall, bringing 83 milimeters of rainfall and winds of more than 150 kilometers per hour. Reported damages include torn roofs of 1,225 houses; 2,350 persons with monetary damage; 4 deaths; 12 persons injured; one ship sunk; fallen trees; interruptions in electrical and telephone service; interruptions in potable water services; 33,240 hectares of croplands damaged; landslides and flooding of lowlands and roads. In the municipality of Mazatlán, 35 squatters were evacuated.

Consider next an "operational anatomy" of the 1990–91 flood in the Rio Fuerte, located in the northern part of the state of Sinaloa. Engineers Sancho y Cervera and Acosta Godinez[30] describe the almost hour-by-hour process of reporting data on actual *and predicted* rainfall in the basin and upstream river flows to those responsible for the operation of the Miguel Hidalgo

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[29] Comision Nacional del Agua, Subdireccion General de Administracion del Agua, GASIR.-SHO. 1994. "Principles Inundaciones y Danos." *Proyecto de Pronostico y Reglas de Operacion.* Anexo 2. Mexico, D.F.

[30] Jaime E. Sancho y Cevera and Antonio Acosta Godinez. 1993. "Avenidas del Rio fuerte, Sinaloa del 28 de Diciembre de 1990 al 2 de Enero de 1991." *Revista Ingenieria.* LXI: 5-20. Mexico, D.F..

Dam. The report also describes how these data were analyzed and decisions were formed regarding releases.

The amount of precipitation received in the Rio Fuerte River Basin during the seven-day period (December 28, 1990, to January 2, 1991) was without precedent. For example, on December 28, 29, and 30, rainfall in the area averaged, 59.0 milimeters, 98.5 milimeters, and 49.0 milimeters, respectively. The combination of peak flows and total volume of water in the upper Rio Fuerte River presented decisionmakers with astonishing conditions. While there were no deaths reported, damages were staggering: 287 houses in 33 villages were destroyed; *42,000* people were forced to evacuate their homes; and 60,000 hectares of seeded land were destroyed with a loss in gross farm revenues of more than 90 million NP. Sancho y Cervera and Acosta Godinez estimate that more than US$10 million would be required to repair damages to the Miguel Hidalgo Dam and to irrigation infrastructure in the basin.

Sancho y Cervera and Acosta place particular emphasis on the lapse of time between events that took place -- the amount of precipitation and resulting build-up of river flows -- and decisionmakers' awareness of these events. The lack of real-time information—critical information during periods of flood—lead them to conclude that the recurrence of damages like those in 1990–91 can be ameliorated or eliminated *only* with investments in facilities that enable decisionmakers to have the forecasts and event data in front of, rather than behind, ongoing events. They also stress the urgent need to modernize Mexico's hydrometeorological forecasting procedures. They call for state-of-the-art technology and the training of individuals responsible for hydrometeorological forecasts and data dissemination and the installation of telemetric systems in the Rio Fuerte River Basin.

4.2 BASIN PLANNING WITH COMMUNITY HELP: THE LERMA-BALSAS EXPERIENCE

As mentioned in Section 1.B, an important element in the CNA's strategy for improving water management in Mexico is the creation of River Basin Councils. They would be made up of representatives of stakeholders in the basin, and they would play a major role in the preparation and implementation of basinwide water management plans. Particular emphasis was given to considerations related to *incentives*: how much of the implementation of basin plans requires sacrifices by the basin's citizens. Such sacrifices are considerably more palatable when these same citizens participate in the development of the plans.

WRMP's financial resources would be allocated to these and related planning and management activities that involve the collection, use, and analysis hydrometeorological data and information. On what basis might one expect that such an expenditure is feasible in a benefit-cost sense?

Such a basis is provided by Mexico's experience with what might be regarded as a pilot project for the creation of River Basin Councils: the existing Lerma-Chapala River Basin Council. The Lerma-Chapala Basin includes a surface area of 54,300 kilometers^2 and includes all or parts of five states: Guanajuato, Queretaro, Mexico, Michoacan, and Jalisco. In the basin is one of Mexico's largest inland lakes, Lake Chapala, located on the outskirts of Mexico's third largest city: Guadalajara. Average annual precipitation is 735 milimeters per year, and average flows in its major rivers—the largest is the Rio Lerma—is 5.2 million milimeters^3 per year. The basin, which includes parts of the heavily industrialized Valley of Mexico and the industrial cities Toluca and Lerma, has become one of the most industrialized regions in Mexico. It accounts for more than one-third of the country's industrial GNP. Unfortunately, until recently it also ranked third in the nation in the level of contamination of its rivers and streams.

The Lerma-Chapala River Basin Council was originally created in April 1989.[31] The major concerns of the council when it was formed were unsustainable withdrawals (mining) of water from the basin's groundwater resources, overuse of surface water resources, and dramatic declines in water quality in Lake Chapala—a unique environmental and recreational asset to the region and to Mexico. The decline in Lake Chapala's water quality was attributable to two sets of conditions that had evolved over previous decades: a decline in freshwater infusions, particularly from the Lerma River, as a result of continuously increasing upstream diversions of water for irrigation; and the contamination of river waters from unregulated and untreated waste discharges by municipalities and industries.

It is instructive to review the *major successes and major failures* of this pilot project. The following are the major accomplishments of the council over the period 1991–1994.

[31] The Consejo was initially called the Asemblea de Usarios; following the enactment in December 1992 of Mexico's National Water Law, its title was changed to Consejo de Cuenca in January 1993.

Forty-eight new treatment plants, treating more than 1.5 billion m^3 of waste water per year, have been constructed in the basin. More than 30 percent of the costs for these treatment plants have been paid by private or semiprivate concessions. Contributions to these costs have also been made by Mexico's PEMEX and the Federal Electricity Commission. The construction of an additional 112 treatment plants (70 to 80 percent of them are to be financed by private concessions) is planned for the 1995–2010 period.

An agreement was established among stakeholders—including representatives of the governors of each of the five basin states—to reduce surface water diversions in the basin and to make a specific allocation of water to Lake Chapala. The Lake Chapala allocation required the establishment of "allocations" of water to the upstream segments of each water course. It placed limits on upstream surface water diversions by farmers. The reduced allocations were then registered in the National Public Water Rights Register. They are legally binding. Water users themselves agreed to these reductions to preserve the quality and sustainability of their basin.

The CNA, in conjunction with the council, arranged a sale of rights to use groundwater between a group of farmers and the city of Queretaro. By design the resulting decrease in irrigation pumping exceeded the amount of water to be used by the city. Two ends were then contemplated: the market transfer of water from low- to higher-valued uses; and *a net reduction* in groundwater mining in the basin.

Prices for water use charged to municipal and industrial water users were dramatically increased -- from .30 NP per m^3 in 1987 to 1.40 NP per m^3 in 1994. Now more than half of *all* water fees collected by the CNA each year (throughout the entire nation) derive from the Lerma-Balsas Basin.

Because of these accomplishments, water quality in Lake Chapala has improved by *46 percent*; plumes of contaminated water no longer extend across the lake; they are now limited to small areas at points where rivers flow into the lake.

These are remarkable accomplishments by any standards, and more so in light of Mexico's past experiences, given the fact that these actions were initiated and implemented under the auspices of a private-government partnership: the River Basin Council. A primary lesson learned from this experience is the potential effectiveness of basin water plans when local groups, including governors of affected states, are directly involved in the planning and implementation process.

A review of the River Basin Council's failures is equally instructive for assessing the WRMP. The following are major unresolved problems as they are viewed by CNA and non-CNA members of the council.

By Mexican law, businesses and industries that discharge waste waters into streams are required to be registered with the CNA. They must pay a fine if the quality of their discharges exceed standards established by the CNA. Substantive compliance with these laws would greatly improve the quality of the basin's rivers and streams. The CNA's Regional Office in the basin has been notably *unsuccessful* in enforcing these laws, however. A large number of firms are not registered, and there are good reasons to suspect that discharges from many firms exceed standards. This lack of success is attributed to one major cause: *the lack of reliable data.* Thus, the CNA has too few monitor facilities along the basin's rivers, and it has great difficulty in proving that contamination in any one stretch of the river is caused by a particular industry's waste discharges. Companies in the basin have had notable success in judicial challenges to CNA-imposed sanctions as a result of the CNA's lack of defensible supporting data. Thus, surface water quality in the basin remains at poor levels, and it will likely continue until the CNA's capacity to measure and monitor water quality is substantially improved.

While the Basin has achieved a degree of success in reallocating water among users, a great deal more should be accomplished. Efforts are stymied by lack of reliable information on water quantity and quality.

Given growing water scarcity in the basin, it is recognized that substantial increases in the availability of water could result from increases in the efficiency of water use in the irrigation sector. Existing inefficiencies in that sector derive from the antiquated infrastructure used to distribute water for irrigation use. Thus, the rehabilitation and modernization of the basin's irrigation infrastructure could make additional water supplies available for high-valued uses.

It is not clear that market transfer of groundwater rights will always have the desired effect of reducing groundwater mining. Taking into consideration the effects of return flows to the aquifer and a good understanding of the aquifer's hydraulic characteristics are necessary to evaluate the impacts on the aquifer of water rights transfers. The basis of the problem here is the lack of reliable information concerning the spatial interactions of water over the large area of the aquifer. Presently, the CNA does not have the monitoring facilities or the hydrogeological modeling and assessment studies that would allow such issues to be resolved.

The basin is subject to recurrent periods of flood (see history of floods for basin states in Table 4.1.4). There are now only twenty-seven streamflow measurement stations in the basin. Adequate management of river flows during flood as well as nonflood periods would require many more stations. Thus, the effects of floods could be substantially reduced and the overall efficiency of water management in the basin could be improved with state-of-the-art facilities for hydrological and meteorological data and for modeling and analysis of the data.

In closing, the anecdotal approach—using existing country experiences—shows the benefits that may accrue or the cost that may be prevented or reduced from investment in enhancing quality of meteorological and hydrological data. Anecdotal information is site-specific; it can be used to infer project benefits that might be reasonably expected to accrue to other relevant sites in a country as a result of the project's implementation.

5. EVALUATING THE WRMP: THE "MINIMUM IMPACT" APPROACH

5.1 THE MINIMUM IMPACT APPROACH: A SUBJECTIVE PROJECT EVALUATION PROCESS

The "minimum impact" approach to evaluating a water-related project is based upon the following line of argument. Let V measure the pre-project level of social benefits created in the water resources sector. In a typical benefit-cost study of project feasibility one estimates the relationship $\frac{B}{C}$, where C measures project costs and B measures *the changes* in V that are expected to result from the project. A (minimum) requirement for a demonstration of project feasibility is that $\frac{B}{C}=1$. For our purposes, define α as the ratio $\frac{B}{V}$ such that $\left(\frac{B}{V}\right)\cdot V=C$. Then *minimum* conditions for project feasibility are described as $\frac{\alpha \cdot V}{C}=1$, or $\alpha=\frac{C}{V}$.

As argued earlier, projects like the WRMP do not directly generate benefits of the sort included in *B*. It creates information, and *its use* can be thought of as improving decisionmaking processes involved in such things as the operation and management of natural resources and environmental systems and the design and implementation of public investment programs. Thus, we will have access to measures relevant for an estimate for V, but we cannot measure B.

While we may not know B, we do know the minimum value B *relative to* V that is required for the project to be feasible. This minimum value is implied by α.[32] As long as B is sufficiently large as to result in $\alpha=\frac{C}{V}$, then the feasibility condition $\frac{B}{C}=1$ is satisfied.

[32] Of course, since $\alpha=\frac{B}{V}=\frac{C}{V}$, this implies that the minimum value of *B* is *C*.

The reader should be aware of the similar, but different notation used here and in Section 1 of the report. In Section 1 the variable dG was used to measure the change in the level of goods produced as a result of additional or better quality information. Here we use the variable V to describe change in the level of pre-project benefits as a result of the additional or better quality information. The reason for the change in notation is because here the benefits from the use of information cannot be assigned to a particular segment in society; therefore, the benefits are assumed to be used by all social segments.

The "minimum impact" approach then focuses on the measure α, which *can* be estimated using values that are known -- C -- or that can be estimated, however imperfectly: V. The resulting project evaluation process is not an objective one: knowledge of α does not establish as fact that the implied minimum level of benefits will result from the project. Rather, the evaluation process suggested by the minimum impact approach is subjective. Given the measure α -- the percentage change in the present level of social values in the water sector required for project feasibility—and using whatever information that can be brought to bear on the issue (e.g., results from applications of the "inferential" and "anecdotal" approaches discussed above)—the evaluation process involves the following question:

The Minimum Impacts Question*: Are there compelling reasons for expecting that the project will, at a minimum, result in benefits that are a-% of V?*

In the following discussion we apply the minimum impacts approach to the WRMP. We begin by developing measures relevant for V which, along with project costs C, are then used to calculate estimates for α. We then turn to the critical project assessment task, which requires an effort to respond to the "minimum impacts question."

5.2 ESTIMATING CURRENT VALUES V IN MEXICO'S WATER SECTOR

In terms of potential impacts from the WRMP, current values that are relevant for our estimate of V would consist of present levels of hydrometeorological-related social costs and social benefits that accrue to a wide range of sectors in Mexican society. In an effort to identify potential sources for such benefits and costs, we begin by formulating a comprehensive list of possible costs and benefits *without regard to our ability to measure them*. Thus, we know at the outset that we will be unable to quantify benefits or costs associated with present levels of many (if not most) of the potential sources listed below. The rationale for beginning with a comprehensive list of potential sources for WRMP-related impacts is the following. Our ultimate task is to address the "minimum impact question" given above. Of direct relevance for any discussion of *compelling* reasons related to expectations for project benefits is the extent to which our estimated *measure* of V is comprehensive. If it is not (and juxtaposition of our list of all potential sources of relevant values to those that we can measure makes clear that it is not), our resulting estimate for α is extraordinarily conservative; this result is clearly pertinent for our response to the minimum impact question.

Our list of possible benefits and costs that might reasonably be affected by the WRMP are set out in the following five impact categories, and several subcategories (see Table 5.2.1).

We now consider the measurement question: how can we estimate current values in Mexico that are defensibly associated with any of the components listed above. In the following text we address this question for each of the five impact categories.

C_1: Social costs (damages) associated with natural, hydrometeorological phenomena

Consider the following components of impact category C_1.

C_{11}: Agricultural damages from intense rainfall.

C_{12}: Agricultural damages from freezes, hail, excess humidity, and winds.

C_{15}: Value of homes lost from floods.

C_{16}: Social costs of personal damages or injuries attributable to floods.

C_{18}: Nonagricultural effects from weather navigation, transportation, private industry, public utilities.

In qualitative terms, the social costs born by Mexican society from these sources of damages are made manifest by our earlier discussions in Sections 3 and 4, as well as by data given in Table 4.1.1. We do not have access to data that would allow for their quantification in monetary values, however. Thus such values will not appear in our estimate for V or in our critically important measure for α. The result, of course, is that our estimate for V will be underestimated, and arguably by a substantial amount. For example, consider the general "weather" effects included in C_{18}. Remembering Ellis and Ballentine's observation, "Every business is influenced by the weather (and also "hydrological information") to some degree,"[33] it is reasonable that potential effects from the enhanced hydrological and meteorological information to be derived from the WRMP extend across virtually *all* sectors of the Mexican economy. Notwithstanding our inability to measure these effects in Mexico, indications of the potential magnitudes of relevant values are implicit to data given above in Table 3.1. This underestimation of V must be kept in mind during our later efforts to respond to the minimum impact question.

C_{13}: Agricultural damages from floods.

Average annual damages from floods in the agricultural and forestry sector are reported in Table 4.1.3. For purposes of this analyses, the annual value, *302 million NP*, is associated with this WRMP component.

C_{14}: Agricultural damages from drought.

Average annual damages from drought in the agricultural sector are reported in Table 4.1.2. For this analysis, the annual value, *1,021 million NP* is associated with this WRMP component.

C_{17}: Social costs of lives lost in floods.

While estimates for monetary damages for flood-related loss of life is not reported in Table 4.1.1, it is possible to deduce a reasonable lower bound for such values. Considerable literature focuses on efforts by economists to estimate the monetary value of premature death. Estimates range from as low as around US$1 million to as high as US$10 million per life saved.[34] It is known that average annual loss of life in Mexico attributable to natural hydro-meteorological phenomena (over the 1987–94 period; see Table 4.1.1) is 180 persons. It is also known that a "substantial" proportion of such losses are attributable to floods. In this analysis, it is assumed that 80 percent (144) of these lives lost are caused by flood, and value loss of life at

[33] Ellis, John A. and Vivienne Ballentine, *op. cit.*: 203.

[34] As examples, see Viscusi, W. Kip. 1994. "Mortality Effects of Regulatory Costs and Policy Evaluation Criteria." *Rand J. Econ.* 25(1): 94-109; Spring, Meng, Ronald A. and Douglas A. Smith. 1990. "The Valuation of Risk of Death in Public Sector Decision-making," *Canadian Public Policy*, 16(2): 137–144; and Broome, John. 1985. "The Economic Value of Life." *Economica* 52(27): 281–294.

the lower bound of received estimates (million; 7.5 million NP).[35] This assumption brings to this component an annual value of *1,080 million NP*.

C_2: Environmental quality—Water

Two estimates of value are relevant for this component: a value that reflects potential reductions in social costs that can be reasonably expected from data-enhanced improvements in the management of water quality in Mexico; and a value that reflects potential improvements in decisionmaking concerning investments in water supply and wastewater treatment systems. In terms of this first value, Mexico's National Institute for Geographic and Informatic Statistics (Instituto Nacional de Estadistica Geografia E Informatica—INEGI) has developed a national accounting system. It includes production effects on the nation's stock of environmental and natural resources assets. One of these accounts includes estimates for annual costs associated with the pollution of Mexico's water supplies. INEGI's latest (1990) estimate for the annual social costs associated with water contamination is *5,725 million 1996 NP*.[36]

A few comments about methods used by the INEGI to estimate social costs associated with degraded water quality are warranted, given what would appear to be a basis for regarding the estimate as substantially understating this value (cost). Data concerning municipal, industrial, and agricultural uses of water are incomplete, but not grossly so. The INEGI's database includes 218 water basins that account for 77 percent of Mexico's land area, 72 percent of its industrial production, 98 percent of land under irrigation, and 93 percent of the population.[37] Estimates are obtained for water use and discharge for each of these sectors There does not appear, however, to be a differentiation as to discharge to receptors affecting surface water quality and groundwater quality—in terms of social costs, those associated with the

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[35] For examples of loss-of-life values on this order used in other assessments of WRMP-like projects, see Tumsaroch, Smith. 1994. "Economic Case for the Projected Modernization of the Meteorological Services in Thailand." World Meteorological Organization, *op. cit.*: 51–54; and Thornes, John E., *op.cit.*, 1994.

[36] INEGI's estimate of 2,180 million NP in 1990 pesos is inflated to January, 1996 pesos using the Indicie Nacional de Precios Productor for 1990 (12,157.4 [1980 = 100]) and July, 1995 (26,726.1); then July, 1995 [1994=100] (143.395) and January, 1996 (171.279).

[37] Instituto Nacional de Estadistica Geografia e Informatica, *Sistema De Cuentas Economicas y Ecologicas de Mexico (SCEEM)*. Tomo IV (Serie 1985–1990): 25. Mexico, D.F.

contamination of groundwater would be expected to be much greater than corresponding costs associated with the contamination of surface waters. *One measure* of contamination is used: Biological Oxygen Demand (BOD); thus, contamination effects from such things as metals are not considered. Estimates for BOD loads deriving from municipal, industrial (by industry type), and agricultural discharges are obtained, then the volume of water treated in existing treatment plants is subtracted. The resulting estimate for nontreated discharges are then valued (costed) by the cubic meter cost of treating municipal residual waters in Mexico City.[38]

In terms of the investment-related values, it is surely obvious that the quality of investment decisions is positively related to the quality of data used in the decisionmaking process (e.g., "...investment decisions by the public sector or private industry depend significantly in some way on good hydrological data").[39] Thus, potentially important sources for "value-generating" activities that will benefit from the WRMP are decisionmakers, public and private, who will be planning and implementing investments that relate, however indirectly, to Mexico's hydrological and meteorological environment. In these regards, Mexico's CNA has formulated an investment plan for "water supply and sewage."[40] The plan calls for a series of investments over the period 1995–2000; the present value of the investment (using a 7 percent discount rate) is US$37,625 million NP.[41] Given the lack of information about related, relevant investment plans by other federal agencies, by municipalities, and by private industry over this period, the annualized equivalent value of US$37,625 million NP (using $r = .07$, $t = 6$) is used as a surrogate measure for the magnitude of relevant, annual investments of this type that could be affected by the improved array of data forthcoming from the WRMP. This value is *7,894 million 1996 NP*. This value is then included as a value relevant for this component. The total value relevant for component C_2 is then 5,725 million NP plus 7,894 million NP, or 13,619 million NP.

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[38] *Ibid.*, p. 27.
[39] *London Economics, op.cit.*: 2.
[40] CNA. 1995. "Programa Sectorial del Agua 1995-2000." (Junio): 35. Mexico D.F.
[41] 1995 pesos inflated to January 1996 pesos using the Indicie Nacional de Precios Productor for July1995 [1994=100] (143.395) and January 1996 (171.279).

C_3: Rational, sustainable, use of the nation's natural resources

As was the case with category C_1 , we are unable to estimate current values that are generated in the following components of category C_3. Caveats in terms of resulting underestimates of V detailed in earlier discussion then apply with equal force in the case of these excluded values.

C_{33}: Forestry resources.

C_{34}: Soil.

C_{35}: Fisheries, wildlife, and ecological resources.

Values for the remaining components of category C_3 are estimated in the following ways.

C_{31}: Surface water.

The way the WRMP will affect the rational and efficient use of the nation's surface waters will derive from two activities: the completion of the National Registry of Water Users; and the "administrative monitoring and control of residual water dischargers." Completion of the Registry of Water Users is a fundamental part of Mexico's efforts to establish the conditions for effective markets for water rights. Indeed, the Registry *establishes* the "rights" that can be exchanged within the context of a market institution.

Estimating a value that might be associated with Mexico's success in creating conditions that increase the efficiency of water use *via* market or marketlike transfers of water from low- to higher-valued uses is difficult; it is made difficult by a lack of knowledge of such things as the precise institutional form that will characterize such markets (a topic that will require careful consideration by the Mexican government), the volume of water that might be involved in trades, and the price at which rights might be exchanged. An estimate for such a value can be made, however, based on the following assumptions: an annual marketing of water from agricultural water users *only* in irrigation districts of 1 percent of current (1994–95) annual water use (i.e., an annual marketing of *usufructuary* rights to approximately 354 million cubic meters of water); a trading price equal to 150 percent of a conservative estimate for the marginal value product of water used for irrigation, approximately .44 NP/m^3.[42] The resulting annual value is *156 million NP*. The assumptions behind this value may be viewed as unnecessarily conservative. Arguing against this interpretation, however, is the following fact: In deriving this value, considerations related to enforcement costs and potential external or third-party costs that might attend water rights transfers have not been included.[43]

Looking next to the "administrative monitoring and control of discharges," two considerations are relevant for values associated with this activity. The CNA recently completed a pilot project involving ninety-nine industrial firms. The quantity and quality of their discharges of waste waters into public water bodies were intensely audited. At a cost of 1.6 million NP, the project resulted in the collection of *18.9 million NP* in unpaid (more than four years) discharge fees. This amount would have been greater if the CNA had access to the kinds of data that would have allowed their successful response to industry challenges of their findings). This result implies a benefit and return-to-cost ratio of 11.8-to-1—a clearly impressive return. Costs associated with the application of procedures tested in this pilot project to an additional 3,300 firms is a part, but only a part, of the budget allocated to the SGAA noted above. A more comprehensive value relevant for this component derives from an estimate of the total, potential collection of discharge fees from polluters. The relevance of this datum derives from the implications of "full regularization" of polluting entities for providing incentives for the optimal use and management of public water bodies in general, and surface waters in particular. This value is estimated in the following way. Fees collected in 1995 totaled 79 million NP (in 1996 values). This amount is estimated to cover only 35 percent of relevant discharges from Urban and industrial origin.[44] The annual deficit in fees collection is then estimated to be $(1/0.35-1)\cdot 79$ million NP, or 147 million NP. Assuming that information infrastructure provided

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[42] Most studies of irrigation in the United States suggest US$50/acre foot as an average value for the MVP of water in agriculture; this estimate is given support by records of farmer-to-farmer sales of perpetual water rights in the Western United States at prices around US$500/af (which implies an annual rental value of $50/af with a 10 percent discount rate); For example, see Cummings, R.G. and V. Nercessiantz. 1992. "The Use of Water Prices for Enhancing Efficiency in Irrigation: Case Studies in Mexico and the U.S." *Natural Resources J.* 32(4). Thus, we use $75/af, 562.5 NP (at 7.5NP = US$1), divided by 1270 m^3/af, or .44 NP/m^3. We note, however, that as an estimate of water rights prices from trades between farmers and municipalities, this figure may be quite low. As but one example, the City of Albuquerque, N.M., has a posted price of $1,600/af that it is willing to pay farmers or any other users for water rights.

[43] These and related issues are discussed in Cummings and Nercessiantz, *Ibid.*.

[44] CNA. 1995. "Programa Sectorial del Agua 1995–2000." (Junio): 12. Mexico D.F.

by the WRMP results in the elimination of this annual deficit into perpetuity, relevant annual benefits are then *147 million NP*.

Thus, our total estimate for annual values relevant for this component is 303 million NP.

C_{32}: Groundwater.

Included in INEGI's national accounting system described above is an estimate for the annual value (cost) to Mexico associated with the depletion of groundwater resources. Of course, an important part of the WRMP focuses on the development of information systems that will allow the CNA to develop rational policies designed to reduce groundwater mining — to rationalize water use with an eye on goals related to *sustainable* economic growth. INEGI's estimate for the annual value (cost) associated with groundwater mining is *2,725 million 1996 NP*.[45]

In using this datum for the purposes of this analysis, a few brief observations regarding methods used in estimating this cost are warranted. INEGI's estimate for social costs associated with groundwater mining involves (a) an estimate for the volume of groundwater mined in a given year (which requires information about groundwater pumping and recharge), and (b) the valuation of mined groundwater. Estimates for annual groundwater pumping are incomplete and underestimated, because there is not a complete registry of wells in Mexico, even though failure to register wells is illegal.[46] Annual recharge is estimated by applying an "average" infiltration factor to total annual rainfall, resulting in potential biases that are indeterminate. Estimates of mining so determined are valued at the cost of pumping water for potable uses.[47] This procedure underestimates social costs from groundwater mining for a number of reasons. For example, the procedure ignores the impacts of mining in lowering water tables, thereby "pushing forward" higher pumping costs to future generations. As a second example, the procedure ignores the increase in the scarcity value of water (as might be measured, e.g., by the least cost alternative means for replacing groundwater) imposed on future users and generations.

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[45] INEGI's estimate of cost is 998 million NP in 1990 pesos. Given that pumping costs are used by INEGI to value groundwater mining, this cost is inflated to January 1996 pesos using the Indice Nacional de Precios por el sector electricidad for 1990(11,319.2 [1980 = 100]) and July 1995 (25,875.6); and July 1995 [1994 = 100] (145.395) and January 1996 (171.279).

[46] Instituto Nacional de Estadistica Geografia e Informatica, *Sistema De Cuentas Economicas y Ecologicas de Mexico (SCEEM)*. Tomo III (Serie 1985–1990): 59. Mexico, D.F.

[47] *Ibid.*, pp. 60–61.

C_4: Agricultural production in the irrigation sector

C_{41}: Irrigation districts.

To the extent that prices for agricultural goods are established under reasonably competitive market conditions, it is common practice to take the market determined price as one measure of the social value of such goods. An alternative, and perhaps preferable, measure for social value would be net "surplus." It would include total willingness to pay consumers for the goods in question, net of price, and revenues to producers, net of production costs. Given the absence of data required for a reasonably credible estimation of surplus, this analysis opts for a measure based on what are presumed to be competitive prices.

It can be argued that an important activity of the CNA—an activity that would unquestionably be affected by the enhanced information provided by the WRMP—is the management of water resources in the agricultural sector; the result is (was, during the 1994–1995 agricultural cycle) the generation of social value in the amount of *24.3 billion 1996 NP.*[48]

In relying on this datum, we acknowledge that there exists bases for arguments that might suggest that this datum overestimates and underestimates relevant social value. The most obvious possible source of overestimation relates to the extent that prices for all goods included in this datum are competitively determined. On the other hand, since the datum measures only the value of agricultural production in irrigation districts, the value of agricultural products from many sources that can be expected to benefit from the wide range of information forthcoming from the WRMP is not included in this datum. This observation would argue for viewing the datum as a significant *underestimation* of relevant social value.

Following the rational argued in C_{21}, it is important to include in the values relevant for this component values that represent investments contemplated for irrigation districts. The CNA has formulated an investment plan for "irrigation and drainage."[49] The plan calls for a series of

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[48] The value of agricultural products produced in Mexico's irrigation districts in 1994 was 16.6 billion NP. This value is inflated to January 1996 pesos using the Indice Nacional de Precios Productores por el sector agricultura, ganaderia, silvicultura, y pesca for January 1994 (29,183.7 [1980 = 100]) and July 1995 (36,117.6); and series 8 indices for July 1995 (123.327) and January 1996 (146.067).

[49] CNA, *op. cit.*: 38.

investments over the period 1995–2000; the present value of the investments (using a 7 percent discount rate) is $16,027 million NP. Given the lack of information about related, relevant investment plans by other federal agencies, by entities in the nondistrict irrigation sector over this period, and plans by the CNA for the years beyond the year 2000, this analysis uses the annualized equivalent value of 16,027 (using r = .07, t = 6) as a surrogate measure for the magnitude of relevant, annual investments of this type that could be affected by the improved array of data forthcoming from the WRMP. This value is *3,362 million 1996 NP*.[50] This value is then included as a value relevant for this component.

C_{42}: Irrigation units; other small farmers.

More than half of Mexico's irrigated acreage lies outside of organized irrigation districts. These irrigating entities are primarily small farmers either in irrigation "units" or outside of any organization. In value terms, on average these entities account for 72 percent of agricultural output from irrigation. Thus, based on the same arguments as those given above, hydrologic and meteorological data from the WRMP can be expected to provide similar benefits to these farmers outside of irrigation districts. This annual value is estimated at *62.4 billion NP* [51]

C_5: Other sectors whose benefits partially derive from water usage

We are unable to provide monetary estimates for the following two components of category C_5. Obviously, these components involve values that would likely be impacted by the WRMP. Improved information on streamflows, lake levels, water quality and weather forecasts could significantly enhance recreational experiences; and improved knowledge on surface and groundwater availability and quality could be of vast benefit to industrial and municipal users. The underestimate of V resulting from the exclusion of these values must therefore be kept in mind during later assessments of the WRMP's feasibility.

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[50] July 1995 NP inflated to January 1996 NP by 1.1945; see explanations given above.

[51] The district irrigation sector accounted for, on average, 28 percent of the total value of irrigated agricultural output over the period 1945–1991 (Enrique Palacios-Velez. 1993. "La Agricultura de Riego." Report to the CNA by the FAO. October). Application of this ratio to the 20.5 billion NP (1995 pesos) value of agricultural output in irrigation districts in 1994 implies a value of production for the nondistrict sector of 52.7 billion NP. Inflated to January 1996 NP with PPI for Agricultura, Ganaderia, Silvicultura, y Pesca (series 9): July, 1995 123.327; January 1996: 146.067.

C_{52}: Recreation on rivers and reservoirs.

C_{53}: Municipal and industrial water users.

C_{51}: Hydropower energy production.

Hydroelectric power accounts for about 21 percent of Mexico's total annual production of electricity; hydroelectric power is used to meet peak power needs in the country. Given the importance of hydrometeorological information to this sector, for such things as developing forecasts of lake levels for use in formulating reservoir release policies for peak power, this sector will clearly benefit from the WRMP. The value relevant for our assessment purposes is the annual value of hydroelectric power that is produced: *6,800 million NP.*[52]

5.3 THE FEASIBILITY OF THE WRMP: RESPONDING TO THE "MINIMUM IMPACTS QUESTION"

Estimates for current levels of benefits and costs in Mexico's water sector developed above are summarized below. Values are given in millions of 1996 NP.

Agricultural damages from floods:	302
Agricultural damages from drought	1,021
Social costs of lives lost in floods:	1,080
Hydroelectric power production:	6,800
Social costs of degraded water quality:	13,619
Potential marketing of water rights; user payments for water use and discharge:	303
Costs of groundwater mining:	2,725
Value of irrigated agricultural production:	90,062
Total value:	115,912

[52] The value of total electricity production in 1994 was 22.2 billion. This value is adjusted to 1996 pesos using the Producer Price Index (1994 [1980=100]29,187.7 and July 1995, 36,117.6; July 1995 [1994=100] 123.327, January 1, 1996, 146.067): 32.34 billion 1996 NP. 21 percent, the proportion of total power production from hydroelectric facilities, of 32.34 = 6,800 million 1996 NP.

With annualized costs of the WRMP of 230 million NP, the implied value of α is .002.

We now turn to an evaluation of the WRMP with the minimum impacts approach. Of course, such evaluation entails a subjective consideration of the minimum impacts question:

Are there compelling reasons for expecting that the WRMP will, at a minimum, result in benefits that are 0.2 percent of 115,912 million NP?

In responding to this question, we recall that in Section 3 that ex post analyses of investment programs like the WRMP that are designed to improve the reliability of hydrological and meteorological information in many counties throughout the world suggest that benefits exceed costs, and often by a very large margin. Anecdotal evidence discussed in Section 4 suggests large potential benefits for the WRMP in specific instances where more timely access to more reliable hydrological and meteorological information would have resulted in obvious benefits to Mexican society.

Our analyses of measurable values currently in Mexico's water sector suggest a value of α = 0.2 percent. This value means that the WRMP's feasibility requires that it affect current levels of water-related benefits and costs by only two-tenths of one percent. Would expectations for such an effect be reasonable? A 0.2 percent effect on virtually any of the impact components discussed above is more than plausible, particularly given our persistent reminders of the many relevant values that are excluded from V, which is used to calculate α . For example, in terms of flood damages, such an effect from improved meteorological forecasts would derive from a reduction in the annual loss of life from 181 to 180.7—a savings of only one-third of a lost life. Would it be "reasonable" to expect annual effects of this kind? For a perspective, consider the following. In the Netherlands the estimated number of lives saved each year from reduced traffic accidents only (a reduction attributable to improved meteorological information) is estimated to be between twenty-five and sixty-three lives per year; a comparable estimate of some 200 lives saved per year is reported for the United Kingdom.

Here's another example: Referring only to potential payments of user fees for water use and water discharge, the importance of these payments derives from (among other things) the incentives that would be placed on polluting entities to rationalize the management of discharges of residual waters into the nation's streams *via* optimal investments in pollution-abatement technologies. The basic prerequisite for this optimization process is reliable information. In this regard, the requirement, as a condition for a feasible project, that these payments be affected by some 10 percent is virtually trivialized by the CNA's *demonstrated* success with a pilot project where the ratio of collections to expenditures was on the order of 12:1 (i.e., a demonstrated "benefit-cost" ratio of 1181:1).

We finally turn to a "required" (for project feasibility) two-tenths of one percent reduction in the social costs associated with groundwater mining. On its face it is reasonable to accept such a modest measure of success for the WRMP; it would require reductions in groundwater mining equal only to the amount of water required to irrigate 6 to 7 hectares.

The gross underestimate of values potentially affected by the project, resulting from both omitted values and understated values described above—and the small (two-tenths of one percent) impact on such values required for project feasibility—should suffice to persuade even the most skeptical person to acknowledge the project's feasibility.

CONCLUDING REMARKS

As scarcity of water resources increase in many places around the world, their improved management may provide a sound economic alternative for increasing both their available quantity and improved quality. Improved management of water resources has been addressed also by investment programs designed to improve the reliability of hydrological and meteorological information in many counties throughout the world.

Ex post analyses of such investment programs suggest that these programs, such as the WRMP, yield benefits that greatly exceed costs. Anecdotal evidence has been provided of the potential benefits of the WRMP by examining specific instances where more timely access to more reliable hydrological and meteorological information would have resulted in obvious benefits to Mexican society.

Using data that understate potential values relevant for Mexico, our "minimum impact" analyses suggest that a conclusion that the WRMP is indeed feasible requires only the most modest expectations for its success in affecting values of social significance in Mexico. Some degree of optimism for such expectations is justified by our considerations of incentive-related institutions in Mexico that are likely to "transform" improved information into social gains. These considerations are described in Section 1.1 as being a critically important part of any application of this approach. Examples include aspects of the WRMP that provide information as a basic requisite for Mexico's efforts to establish market for tradable water rights; this institutional change, we may expect, will provide incentives for more efficient use of water resources. Moreover, WRMP components that improve information related to water quality in Mexico's rivers and streams are based on appropriate incentives. This position follows from many instances wherein the CNA's efforts to enforce water quality standards have been rebuffed by the courts on the basis of failing to provide compelling evidence—*adequate information*—of a firm's noncompliance with established standards.

As with virtually any assessment approach used for project analysis, we must recognize that our conclusions concerning the likelihood of the WRMP's feasibility may potentially suffer from a number of limitations. Thus, while we may argue that the WRMP, *as it is presently structured*, would almost surely generate benefits in excess of costs, we have no basis for arguing that its present structure is "optimal." This is to say that different scales for the project or alternative allocations of project expenditures among project components might yield higher net benefits. As noted in Section 1.1, this genre of issues cannot be effectively addressed with the "minimum impact" approach.

Of course, considering the WRMP as it is presently structrured, the reader will draw his or her own conclusions about the plausibility of expecting the WRMP to have the "modest" impacts on relevant social values estimated in this study. We close the discussion of WRMP's feasibility with the following observations: Referring to the "expectation" of a project's impact on social values—0.18 percent in the case of WRMP (i.e., a "required" rate of return of 0.18 percent)—one might well inquire: What are the expectations for a required rate of return in other countries? We offer two examples: Referring to criteria for hydrological and meteorological programs in United Kingdom, Purnell cites the common goal of looking "...to maximize the net present value of the program expenditure within a minimum threshold rate of return of *6 percent* [emphasis added], as set by the Treasury Department."[53] Finally, Indian engineers reportedly look to a *10 percent* savings in overdesign costs as justification for a WRMP-like project.

[53] Purnell, R.G. 1994. "The Economics of Flood and Coastal Defense Measures In England: Policy and Appraisal." World Meteorological Organization, *op. cit.*: 109.

TABLE 2.1: CNA DEPARTMENTS AND THEIR PROJECT IMPLEMENTATION ACTIVITIES

CNA Department	Activity
National Meteorological Service (Gerencia del Servicio Meteorolóġico Nacional - GSMN)	Upgrade information infrastructure at the National Meteorological Service via modernizing and expanding facilities and equipment and training personnel.
Telecommunications and Computer Networks (T & C)	Modernize and upgrade telecommunication and computation capacities at all water management and planning facilities.
Surface Water and River Engineering Group (Gerencia de Aguas Superficiales e Ingenieria de Ríos - GASIR)	Modernize and upgrade measurement and monitoring systems for surface water management and improve reservoir operations.
Groundwater Group (Gerencia de Aguas Subterráneas - GAS)	Upgrade and expand measurement and monitoring systems for groundwater management related to both groundwater quantity and quality and improve aquifer management.
Water Quality and Sanitation Group (Gerencia de Saneamiento y Calidad del Agua - GSCA)	Modernize and upgrade measurement and monitoring systems for water quality; upgrade and expand National Water Quality laboratories; improve water quality assessments.
Technical Consultancy Group (Consultivo Técnico - CT)	Upgrade dam safety programs; initiate dam inspection program; design of corrective programs; development and implementation of emergency response programs.
Planning Subdirectorate (Subdireccion General de Planeación - SGP)	Upgrade planning capacity; form and strengthen River Basin Councils; initiate basinwide planning.
Water Rights Administration Subdirectorate (Subdireccion General de Administración del Agua - SGAA)	Complete and make operational the National Registry of Water Users; complete and make operational the National Registry of Water Dischargers; expand the development of industry-specific water quality standards for waste discharge. Included here are costs for an intensive program of inspection and measurement site visits of 2,500 industrial firms over the period 1996–2000 for the purpose of administratively monitoring and controlling industrial discharges of residual waters.

TABLE 3.1: PROJECTS INVOLVING THE PROVISION OF METEOROLOGICAL AND HYDROLOGICAL SERVICE AND INFORMATION REPORTED-MEASURES OF ECONOMIC FEASIBILITY

AUTHOR	COUNTRY	SERVICES PROVIDED BY PROJECT	FEASIBILITY?
London Economics	India	Provides hydrological data for water quality and quantity; establishes computer systems for electronic databases.	"...theoretical benefits of more reliable and spatially the costs...."[54]
Teske & Robinson [WMO[55], pp. 21-24]	U.K.	Meteorological Services provided to	
		Defense industry	L120 million/year.
		General public	L150-540 million/year.
		Gas/electric industries	L33-66 million/year
		Agriculture/fisheries	L140 million/year
		Manufacturing/construction	L110 million/year
		Transportation.	L246 million/year
Mason, B.J.[56]	U.K.	Meteorological services to the private sector.	BC 21:1
Henian [WMO, p.38]	China	Meteorological Services and Information.	B/C 39:1
Ngo Van Khoa [WMO, p.46]	Vietnam	Hydrometeorological services, timely warning/forecasting of floods *to agricultural sector*.	B/C 10:1
Sharov & Popova [WMO, p. 48]	Bulgaria	Introduction of new computer technology for meteorological services.	42% increase in services
		New telecommunications technology.	118% increase in services
Maunder, W.J.	New Zealand	National meteorological service.	B/C 17:1

[54] *London Economics, op. cit.*: iii.

[55] World Meteorological Organization, *op.cit.*

[56] "The Role of Meteorology in the National Economy." *Weather* 21: 382-393 (1966).

TABLE 3.1 (continued)

AUTHOR	COUNTRY	SERVICES PROVIDED BY PROJECT	FEASIBILITY?
Batjargal [WMO, p.72]	Mongolia	Hydrometeorological services:	
		1 percent increase in forecast accuracy	Reduced livestock loss of 100,000 head
		New, accurate, efficient weather forecasts.	120–160,000 head reduced loss of live-stock. Overall B/C 3:1.
Adams [WMO, p. 114]	U.S.	Meteorological services, long range	Annual value to agri culture,
		weather forecasts (an increase in accuracy from .6 to .8)	$145 million (2–3% of farmgate value).
Lomas & Gat [WMO, p. 118]	Israel	Meteorological services, predictions of frost to avocado industry.	B/C 46:1 to 57:1
Green & Herschy [WMO, p. 143]	U.K.	Streamflow gauging systems.	B/C 2.2:1
Cordery & Cloke [WMO, p. 147]	Australia	Streamflow data collection.	B/C 1.7:1
Parker et al., [UCB][57]	California	Daily evapotranspiration data	B/C 965.7:1

[57] Parker, Doug, David Zilberman, Daniel Cohen, and Daniel Osgood. 1995. "The Economic Cost and Benefits Associated with the California Irrigation Management Information System (CIMIS)." Final report (October 17), University of California, Berkeley, Department. of Agriculture and Resource Economics.

TABLE 4.1.1: DAMAGES FROM HYDROMETEOROLOGICAL PHENOMENA IN MEXICO DURING THE PERIOD 1987–1994

YEAR	AGRICULTURE/FORESTS (hectares)	LIVESTOCK (heads)	HABITATIONS	DAMAGED	DEATHS	INJURIES
1987	122,146	1,018	5,318	19,583	58	64
1988	3,090,817	74,683	31,171	192,545	417	106
1989	2,323,737	18,026	14,445	62,337	122	150
1990	872,602	18,333	32,221	203,402	190	179
1991	985,361	31,370	17,466	134,094	124	28
1992	1,201,674	2,569	22,034	108,137	154	96
1993	580,043	28,506	79,694	308,196	203	136
1994	2,078,847	128,810	16,907	36,947	178	109
Average	1,906,403	37,914	27,407	133,155	181	109

Source: Data from the Surface Water Group (GASIR), CNA. The damages considered correspond to rainfall events, floods, droughts, freezes, hail, snow storms, excess humidity, and high temperatures.

TABLE 4.1.2: AGRICULTURAL AND FOREST DAMAGES FROM DROUGHTS
1979-1994

YEAR	(millon 1996 NP)
1979	3,050
1980	801
1981	674
1982	1,200
1983	540
1984	593
1985	843
1986	599
1987	989
1988	1,061
1989	500
1990	589
1991	661
1992	989
1993	199
1994	3,033
Average	**1,021**

Source: GASIR,CNA. 1994 values converted to January 1996 NP with PPI for 1996/1994 = 1.433

TABLE 4.1.3: AGRICULTURAL AND FOREST FLOOD DAMAGES
1973–1994

YEAR	(millions OF 1996 NP)
1973	151
1974	353
1975	235
1976	704
1977	100
1978	335
1979	161
1980	353
1981	317
1982	420
1983	302
1984	344
1985	135
1986	132
1987	92
1988	318
1989	285
1990	330
1991	324
1992	406
1993	700
1994	152
Average	**302**

Source: Data from GASIR, CNA. 1994 values converted to January, 1996 NP with PPI for 1996/1994 = 1.433

TABLE 4.1.4: NUMBER OF SIGNIFICANT FLOOD EVENTS IN DIFFERENT MEXICAN STATES
1950-1994

STATE	NUMBER OF FLOODS
Aguascalientes	13
Quintana Roo	25
San Luis Potosi	26
Yucatan	32
Queretaro	32
Baja California Sur	37
Campeche	42
Morelos	42
Puebla	42
Zacatecas	43
Tlaxcala	52
Colima	58
Baja California Norte	62
Hidalgo	66
Nuevo Leon	75
Chiapas	89
Tabasco	90
Chuhuahua	106
Oaxaca	109
Coahuila	110
Nayarit	126
Siloa	127
Distrito Federal	133
Duango	140
Tamaulipas	144
Michoacan	144
Guerrero	160
Guanajuato	172
Mexico	204
Jalisco	263
Sonora	297
Vera Cruz	475
Total	**3,536**

Source:GASIR,CNA

Table 5.2.1: WRMP IMPACT CATEGORIES

Category Description	Subcategory Description
C_1—Social costs (damages) associated with natural, hydrometeorological phenomena that are nation-wide in scope.	C_{11}—Agricultural damages from intense rainfall. C_{12}—Agricultural damages from freezes, hail, excess humidity and winds. C_{13}—Agricultural damages from floods. C_{14}—Agricultural damages from drought. C_{15}—Value of homes lost from floods. C_{16}—Social costs of personal damages and injuries attributable to floods. C_{17}—Social costs of lives lost in floods.[58] C_{18}—Nonagricultural effects from weather, navigation, transportation, private industry, public utilities.
C_2—Environmental-quality water, which is nation-wide in terms of its relevance.	
C_3—Rational, sustainable, use of the nation's natural resources, nationwide in relevance.	C_{31}—Surface water. C_{32}—Groundwater. C_{33}—Forestry resources. C_{34}—Soil. C_{35}—Fisheries, wildlife, and ecological resources.
C_4—Agricultural production in the irrigation sector. The following components are included in this category for the purpose of recognizing important distinctions between the way that irrigation activity is organized in Mexico.	C_{41}—Irrigation districts. C_{42}—Irrigation units; other small farmers.
C_5—Other sectors whose benefits partially derive from water usage. This category is a "catch all" for relevant activities not included in Categories 1–4. We do, however, explicitly identify three perhaps obvious components that should be included here.	C_{51}—Hydropower energy production. C_{52}—Recreation on rivers and reservoirs. C_{53}—Municipal and industrial water users.

[58] As noted in Section 4, loss of life reported in Table G-2 is, *in the main*, attributable to floods. Data are unavailable that would allow us to distinguish between losses of life caused by flood and nonflood.

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