

# Environmental Management of Water Resources in Mexico

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## ABSTRACT

*The environment has been receiving high priority in Mexico in recent years. The country however is presently facing numerous environmental problems. These problems are already severe, and the financial and human resources available are limited. While a good beginning has been made, much more remains to be done.*

## INTRODUCTION

Mexico is well known for having very high biotic diversity. Its geological history, orography, and extreme variation in rainfall from driest to the most humid regions, have contributed to a high environmental diversity, and development of remarkable ecosystems. Globally, Mexico is also recognized as one of the countries having a high social and cultural diversity, mainly the population located within the region known as **Mesoamérica**.

Mexico, a country with an approximate area of two million km<sup>2</sup> and a population of over 90 million, has evolved inversely to its water availability. Less than a third of the country's water is found within the 75 per cent of the territory in which most of the large cities, industrial facilities, and irrigated lands are located. Over-pumping of aquifers, costly river basin transfers to meet increasing water demands, and conflicts among competing users have increased over the past fifteen years, with the consequent economic, political, environmental, and social impacts [1].

The demand for water resources in Mexico has been on a continuous upward trend in recent decades due to the twin pressures of population growth and increasing per capita demand. The current population in Mexico is estimated to increase by more than twofold by the time the country reaches a hypothetically stationary population by the middle of the 21st century (see Fig. 1) [2].

Equally, as more and more people attain a higher

standard of living, their per capita water demand will increase as well. Hence, the main water challenge facing the country in the 21st century will be how to provide an adequate quantity and right quality of water in a sustainable and cost-effective manner for all different types of water uses for an ever increasing population.

On a national level, total water abstraction has increased to about 185,999 million m<sup>3</sup> per year, which accounts for 43 per cent of the country's renewable water resources,

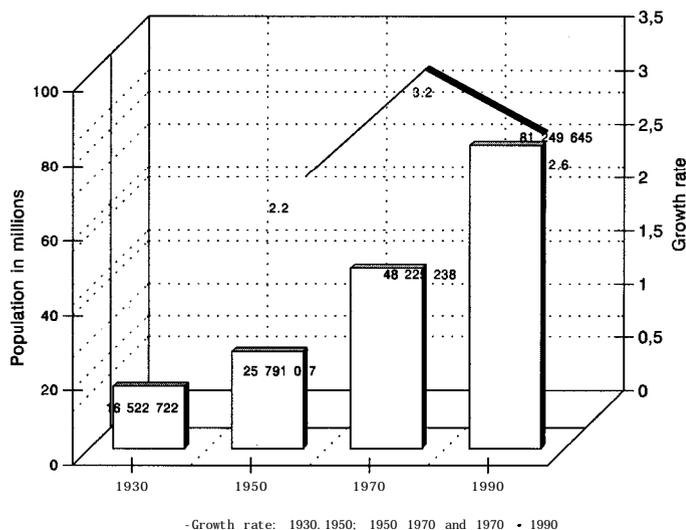


Figure 1. Mexico: Population and growth rates, 1970-1990. Source: INEGI, Socioeconomic Profile, XI General Census of Population and Housing, Mexico.

while the total consumption represents only 15 per cent of the total renewable water. Hydropower generation still accounts for the largest volume withdrawn (69 per cent), and irrigation accounts for over 80 per cent of the total consumption. The national water balance however, does not reflect the pressing problems affecting a large proportion of the country's aquifers and river basins. Regional water balances in over half of the country show considerable deficits, demonstrating the degree of groundwater overdrafting, as well as the increasing problem of water pollution. Although excessive concentration of population in a few selected urban areas and economic activities are definite factors contributing to these unbalances, it is undeniable that many of them are due to inefficiencies that have occurred over the last two decades [3].

The quantity of fresh water in Mexico that can be used by people at any given time is limited due to economic and technological reasons. It is now evident that nearly all the easily exploitable sources of water in the water deficit regions of the country have already been developed or are in the process of development. This means the cost of development of each new additional source of water is likely to be significantly higher in real terms in the future than what have been observed in the past. A recent review of the domestic water supply projects carried out by The World Bank, which included a project for Mexico City, indicated that the cost of development of each cubic meter of water for the next generation of projects is more than 1.75 times, and in many cases even three times, higher than that of the present generation [4]. Thus, clean water will only be available in the country in the future at a much higher unit cost than estimated at present, a fact that has generally not been recognized thus far.

Since water projects are highly capital intensive and environmental issues have become increasingly critical requirements for getting loans from development banks, Mexico must give priority consideration to these factors in order to continue to receive the necessary loans. It is no longer adequate to ensure that a project is technically feasible and that the total benefits exceed total costs to receive the necessary loans from major financing institutions. Unquestionably, the environment has now become an integral component of the international political agenda, and accordingly environmental feasibility of a project is now as important as the other two technoeconomic factors [5].

## GOVERNMENTAL STRATEGIES

Mexico is at present confronted with the twin problems arising from growing water scarcity and the more general need to conserve and protect the nation's natural and environmental resources. According to the 1994-1995 and 1995-1996 annual reports of the Ministry of Environment, Natural Resources, and Fisheries (Secretaria de Medio Ambiente, Recursos Naturales y Pesca, SEMARNAP) [6,7], Mexico has suffered during

the past decades an intense process of economic development with deficient environmental controls, as well as increasing growth in population. The industrial development pattern and other factors have promoted an irreversible process of urbanization, which, due to historical and institutional reasons, has contributed to the development of humongous centers of population and economic activities that are now directly contributing to severe environmental problems. The solution of these environmental problems would depend on a collective effort by the government and society as a whole.

On April 28, 1992, the federal government signed a loan agreement with The World Bank to design and implement an Environment Program for Mexico, which would be executed by the Ministry of Social Development [8]. The total cost of the project was US\$88 million, of which 50 percent represented the loan from The World Bank. The objectives of the program were:

- (i) to improve the capacity to implement actions on environmental protection and protection of natural resources (short-term); and
- (ii) to promote capacity building of the institutions and the development of policies that could meet the same national objectives more efficiently (long-term).

The program considered several aspects such as monitoring and control of pollution (water and air), environmental health, strategic planning, modernization of environmental management practices, strengthening of environmental policies, etc.

On the same date, the federal government signed another agreement with the Global Environmental Facility for a grant that would also be executed by the Ministry of Social Development. This grant would enable Mexico to implement environmental emergency plans, and develop and implement management plans for ten protected areas in the country, as well as to develop strategies for ecotourism.

As far as water resources are concerned, the National Congress approved a new National Waters Law (Ley de Aguas Nacionales) in December 1992 and additional regulations in January 1994. The National Water Law sets out broad objectives for the development and implementation of plans and policies for water resources management [9]. The responsibility for implementing the law was assigned to the National Water Commission (Comisión Nacional del Agua, CNA). The importance that the government bestows on the environment and the sustainable use of water resources can be noted from the decision to relocate the CNA from the earlier Agriculture and Water Resources Ministry to SEMARNAP.

The National Waters Law recognizes the importance of efficient water resources management and authorizes CNA to carry out this function with the objectives of achieving sustainable development and use of the nation's water resources [10]. This National Waters Law gives special attention to aspects of water quality both to protect human health and to preserve aquatic systems. The strategy is based on:

- (i) systematic monitoring and evaluation of water quality;
- (ii) establishment of a set of water quality standards;
- (iii) establishment of a discharge permit and effluent charge system; and
- (iv) construction of wastewater treatment plants and sewerage facilities.

Water users, both industrial and municipal, must comply with specific discharge conditions established by the CNA. They must pay for discharge rights to use national water bodies as carriers of their wastes, and they must inform the commission periodically regarding the quality of their discharges.

Mexican water resources policy, as presented in the Water Program 19952000 [ 1 ], is oriented toward ensuring the availability of water to satisfy the needs of the population and promote the development of economic activities in a manner that is environmentally compatible and sustainable in each region of the country,

An example of Mexico's efforts to improve national water management is the Water Resources Management Project (PROMMA), which the federal government signed with The World Bank [ 12 ] PROMMA is being executed by CNA, with the support of The World Bank. The total

stabilization plans for aquatic and riparian ecosystems; improvement of water resources planning at the river basin level with the participation of environmental specialists and river basin councils to ensure consideration of environmental issues; and improvement in allocation of scarce water resources, as well as promotion of water-use efficiency [12].

CNA has been working on many other actions related to better water resources planning and management from the environmental point of view [ 1,131. The 'program on water allocation and conservation includes the "Program on Efficient Use of Water and Energy," which has resulted in water application efficiencies related to irrigation; and the "Program on Efficient Use of Water," of which the objective has been to reduce leaks in water supply networks. Regulations regarding restrictions on groundwater use in several overexploited aquifers; water quality improvement programs; wastewater treatment regulations, as well as surveillance; aquatic weed control; and the establishment of coordination agreements between users, state, and federal authorities for regional problems, are all other examples of water conservation programs.

At present, the CNA implements programs on infrastructural development and operation, and emergency actions during floods and droughts. Priorities on the conditions of the most polluted basins in the country have been defined and actions have been taken. There are permanent programs on measurement and control of surface and ground waters as well as preservation and improvement of the quality of the water of the country through the operation of the national network of laboratories, and studies of classification of receiving bodies.

The CNA has embarked on the development of a "Program on Environmental Protection for the Water Sector." The objectives of this program would be to prevent and control environmental deterioration of water resources. On one hand, the program proposes to reinforce the surveillance and control of the planning, construction, and operation of the water projects of the country. On the other hand, it focuses on the quantity and quality of the water resources. The objective is to pursue the development of an integral program on environmental protection in close consultation within the different areas of CNA [14].

## ENVIRONMENTAL IMPACT ASSESSMENT

While Mexico has made significant progress in recent years in terms of infrastructure of water projects, more needs to be constructed to meet the future demands from an expanding population. Thus, Environmental Impact Assessment (EIA) is a critical necessity for the country to ensure that environment and natural resources are properly managed.

The EL4 of major development projects has been systematically applied to Mexico since 1988. However,

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cost of the PROMMA project will be US\$342 million, 54.5 per cent of which would be provided by The World Bank. Some of the main objectives of PROMMA are:

- (i) training and technical assistance;
- (ii) modernization of meteorological, hydrological, and climatological networks,
- (iii) streamlining and strengthening of water use administration;
- (iv) planning and information systems; and
- (v) modernization of the operation and security of dams and reservoir management.

The PROMMA Project could have a major positive effect on the environment. It would not finance any new development project for any new hydraulic infrastructure facilities. It is expected to ensure that sufficient environmental attention and expertise are brought to bear on regional water resources planning and management issues. The project is expected to: contribute to strong environmental benefits and provide the government with more adequate tools for detection of water contamination and pollution, and establishment and enforcement of discharge standards, thereby significantly improving water quality; identification and characterization of areas of unsustainable use of surface and groundwater; development of

prior to this year, the creation of environmental units within the Federal Government Administration set the basis for the legal adoption of EIAs. One of these, the "Intersectoral Commission for Environmental Sanitation" (Comisión Intersectorial de Sanidad Ambiental) designed the EIA procedural framework that was adopted in the *Law of Public Works* (Ley de Obras Publicas) in 1980 [5].

It was after the promulgation of the *Law of Public Works* (which considers the EIA studies as mandatory) in 1980, and the *Federal Law of Environmental Protection* (Ley de Protección Ambiental) in 1982, that what is now the Ministry of Social Development (Secretaría de Desarrollo Social, SEDESOL) developed the guidelines for the production of Environmental Impact Statements (EISs). The *General Law of Ecological Equilibrium and Environmental Protection* (Ley General de Equilibrio Ecológico y Protección Ambiental, LGEEPA) was promulgated in 1988 and amended in December 1996. By 1992, about 70 EISs related to water projects have been prepared [5].

The EIS is an important product of the EIA process, because it is this document that supplies information on environmental impact to the decision-makers. It is therefore vital to establish that the information in the document is of sufficient quality. EIS preparation is a vital procedural stage, which, if carried out effectively, can contribute to improve the quality of the EIA, particularly when it is complemented by a structured process for postproject EIA auditing.

In general, in Mexico the quality of the EIS for water projects represents a serious limitation for developing any postproject evaluation. This management process could be improved if more accurate impact predictions and cost of mitigation measures were included in the EIA. The development of more strict internal reviews of the EISs of water projects could result in standardizing their quality, identifying any issues not covered, inaccuracies in information, logical irregularities, or any conflicts apparent during the assessment process.

## PRIVATE SECTOR

The industrial sector is not just making an effort to comply with the regulation related to wastewater discharges and water reuse and conservation programs. From a broad environmental perspective, from 1982 and up to now, the industries associated with the Confederation of Industrial Chambers (Confederación de Cámaras Industriales, CONCAMIN) have developed a proposal for a National Program for Environmental Protection that would help them to identify the main problems related to pollution and develop implementable solutions; have participated actively in the development of the General Law of Ecological Equilibrium and Protection of the Environment; established a Commission on Ecology (Comisión de Ecología), with the objectives of developing links between the environmental authorities and industry,

developing solutions, offering technical and documentary support, and promoting the participation of industry in actions that could help to ameliorate the impacts of industrial activities on the environment.

Due to the social, political, and economic implications of environmental deterioration, CONCAMIN has established a Directorate of Ecology (Dirección de Ecología), which is responsible for advising and providing services to industries regarding environmental issues. It has started the Center on Ecological Information for Industry (Centro de Información Ecológica Empresarial) with the participation of industries from the whole country; and took the lead in developing the Agreement on Environmental Improvement (Pacto para el Mejoramiento Ambiental) and signed it with the federal government. In 1995, CONCAMIN signed the Program on Environmental Protection and Industrial Competitiveness (Programa de Protección Ambiental y Competitividad Industrial) [15] with the SEMARNAP. This program includes joint objectives, actions, and commitments, from both the federal government and industries, and has contributed to better interactions between environmental authorities and the industrial sector. In 1996, the industrial sector invested more than US\$2,500 million [16].

## PEMEX: ANOTHER EXAMPLE OF A COMPLIANCE EFFORT

In 1990, the Mexican Petrol Company (Petróleos Mexicanos, PEMEX) initiated a program of water conservation. The main objectives of this program are to reduce the intake of raw water in refineries by reusing it as much as possible, and to minimize the volume of effluents produced. In order to comply with the legislation on quality of wastewaters discharged and avoid fines, the program considers developing the necessary technology, and analyzing the necessary technical, economic, and ecological factors for optimal wastewater management, as well as investing in the necessary modifications of the existing infrastructure. The program includes the construction of urban wastewater treatment plants, the construction of the treatment plant for one refiners and the implementation of a project on integral use of water in five more refineries. The strategies include new investments, technologies, and the participation of the private sector [17].

The objectives of the program on integral use of water are to comply with present and future regulations on wastewater discharges and avoid economic sanctions; to minimize total abstraction of water from rivers, reservoirs, and wells; and to secure a reliable water supply for the processes within the refineries. With the implementation of this project, Pemex will avoid using 37.7 million m<sup>3</sup> of raw water annually.

The present legal and infrastructure frameworks allow the private sector to have an important opportunity to establish a role for themselves in water and wastewater

management. If they seize this opportunity, the private sector can play a significant role that could be of direct economic benefit to the country, and in the process they could have a beneficial effect on the environment.

## HEALTH AND ENVIRONMENT

Environmental management can often be directly related to health issues. At present, 80 per cent of the Mexican population have access to drinking water, 67 per cent to drainage, and only 19 per cent to sanitation services (see Fig. 2) [2]. This, however, means that there are still 16, 27, and 66 million people respectively who still do not have access to the above three services. The most severely affected populations are those who live in the marginal urban and rural areas [6].

In 1991, the CNA launched a Program on Clean Water (Programa de Agua Limpia) due to outbreaks of cholera in the past. During the 1995-96 period, an estimated 9.5 million people from 639 municipalities of the 31 states of the country benefited from chlorination, disinfection, and sanitation activities (see Fig.3) [2]. From 1991 to 1994, the mortality of children under five years of age from waterborne diseases decreased by 30 per cent. The program also included workshops on basic sanitation and hygiene for the education of people in poor areas [1].

In Mexico, the Ministry of Health has a General Directorate on Environmental Health, whose programs are focused on improving the quality of life of the population through agreements and collaborative joint efforts between the various concerned ministries, local governments, and communities. This Directorate is implementing several major programs in rural areas. For example, they are carrying out diagnoses of the health problems in various rural areas because of lack of clean water and the absence of sanitation facilities. Another emphasis has been to develop local and implementable

programs for improving the living conditions of the population, inter alia, methods of cleaning the water sources, and the importance of their proper maintenance from economic, environmental, social, and health points of view, programs on awareness, health education, etc. They have succeeded in involving the local communities and the associated institutions from the different sectors in working in an integrated fashion to improve overall quality of life of rural people [18].

## BACKGROUND OF THE WATER ENVIRONMENTAL POLICY

Because of the topographical conditions and human settlement distribution, extraction, processing, and distribution of water in Mexico represent a very major challenge to the concerned institutions. The high percentage of Mexicans who are still marginalized from access to water and sanitation services represents a major challenge to the country.

The inefficient use of water in the agricultural sector represents over 80 per cent of the total national consumption. The inefficiency and wastage in both agricultural and domestic sectors are having adverse impacts on the country's ground water; the levels of contamination due to discharge of municipal, industrial, and agricultural contamination are increasing steadily. The losses in municipal water distribution systems are generally higher than 40 per cent, and the amount of wastewater properly treated is still very low.

In recent years, the demand for water has exceeded the surface and ground water that can be sustainably abstracted in numerous areas. This has produced hydro-ecological imbalances due to the overexploitation of aquifers and reuse of untreated or partially treated water, and pollution-related problems [19]. Beyond the technical and legal solutions required to solve the conflicts that arise

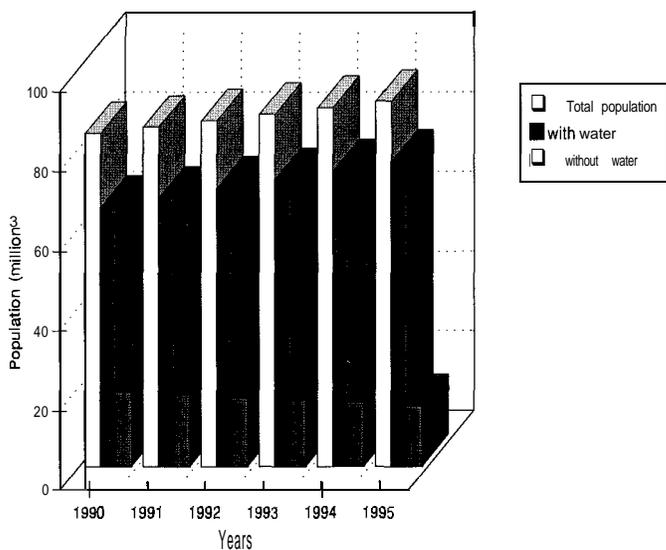


Figure 2. Distribution of drinking water at the national level, 1990-1995. Source: CNA/UPRPS/National Information System (CNA, 1995).

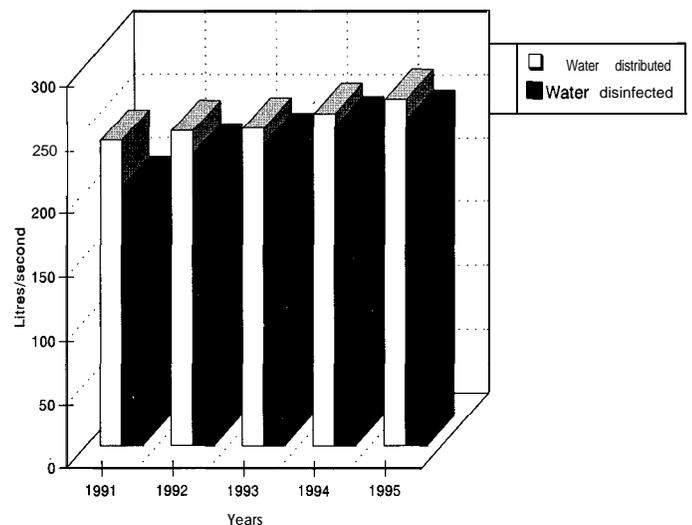


Figure 3. Water disinfected at the national level, 1990-1995. Source: CNA/UPRPS/Department of Clean Water (CNA, 1995).

between the various users [20], the users themselves must contribute to the development of alternate solutions. To optimize these self-help mechanisms, the work must advance with systematic evaluations in order to provide feedbacks on what has been achieved and/or what is feasible. Sustainable development needs more than an environmental policy: a concerted effort by all concerned is necessary within the overall framework of the policy.

## CONCLUDING REMARKS

In spite of different institutions adopting environmental policies, it is now clear that development and environment are part of an integrated process affected by the extent of past economic and demographic growth, at the same time tightly linked within the context of future world economic development and population growth [21]. It is essential that the environment be given high priority at the highest level of government, in order for various authorities to successfully coordinate programs and actions within the public sector and between the public and the private sectors. Isolated actions with no general policy framework are not likely to result in any tangible results in the medium term. It is necessary to engage the interest of society, NGOs, and the media [22].

Equitable regional economic distribution within the country should be a long-term objective, as should the impacts of the environmental policies, which should specifically consider the carrying capacity of the ecosystems. Therefore, medium- and long-term planning programs should be regularly reviewed, updated, and reinforced. Even though appropriate legislation is a fundamental requirement, it will not generate sufficient conditions to promote the protection and restoration of the environment. It is thus necessary to put complementary emphasis on other mechanisms, among which are economic instruments, education, training, research, and public participation.

There is an urgent need for a more integral approach to managing small- and medium-size enterprises in terms of their environmental impacts. It has been a most difficult task to design and successfully implement environmental protection measures for medium- to small-scale industries all over the developing world. Mexico is likely to be no exception. Accordingly, both private and governmental sectors should develop and implement joint programs for these purposes.

Environmental protection, being a public necessity, faces severe constraints for its implementation and financing, since any benefit accrued is primarily societal in nature, but the costs will have to be financed by individuals, either through taxation or levies. The environmental policies and programs need to be defined, formulated, and implemented through public consultations and an increasing governmental budget, as well as with private and social actions.

Environmental policies should consider the challenges

imposed by economic globalization, the need for development, and employment generation, as well as the need and demand of the society for sustainable development [23]. Environmental policies should be linked to changes in lifestyles and, at the same time, to societal preferences for sustainability and economic growth. It is very clear now that those developing countries that have strict environmental policies and laws have, in general, failed to implement them. Economic and trade issues need to be specifically considered. In most cases, actions related to environmental protection strategies require both substantial large investments and changes in the lifestyles of the people. Assuming both these factors can be simultaneously handled, they will contribute to improvements in environmental quality and higher living standards on a long-term basis.

Sustainable development demands a deeper knowledge of the interactions among economic, social, and natural systems to make efficient decisions that would affect both the environment and social welfare in the long term. Only efficient technologies, production, and consumption processes will not contribute to the long-term process of sustainable development. Information, education, research, and sociocultural factors are equally important

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elements, since they will result in new attitudes and participatory behavior from society as a whole.

While Mexico has made a good beginning on the environmental management of the water sector, the whole process — as in other sectors — started somewhat late. Much still needs to be done to change the attitudes and mindsets of most water professionals at all levels so that they are intrinsically convinced that sustainable water development is simply not possible without explicit considerations of the environmental factors. This will be difficult to achieve until and unless a clear environmental policy for the water sector on a national basis is developed that could be acceptable to all levels of government, as well as to the private sector, NGOs, and the general public. It will not be an easy task, but it is one challenge the country must face squarely and successfully. There is simply no other alternative.

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## Xth World Water Congress

Melbourne, Australia

March 11-17, 2000