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An Overview of Some Population-Development-Environment Interactions in Mexico

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Contents

Abstract

This paper encompasses overviews of Mexico's population, development, and environment and briefly discusses some population-development-environment (PDE) interactions in Mexico. First, a demographic description presents a retrospective view of mortality, fertility, literacy, age composition, migration, population density as well as a sketchy perspective of population growth and age composition. Next, the development overview considers past trends of some macro-economic indicators and reviews the performance of some prior government development policies. The overview of the environment discusses problems of soil and biotic erosion, water quality and quantity, and air pollution. Finally, some remarks about future population-development-environment interactions are presented. The need to establish a shared vision of PDE at the country level and to further expand the purposefulness of socio-ecological systems to reduce relevant uncertainty is highlighted.

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1. Introduction

The co-evolving dynamics of population, development, and the environment (PDE) are at the core of current development discussions. The three entities are by themselves difficult to grasp in clear terms. Their interactions add to this complexity and lack of causal understanding. Multidimensionality including, among others, simultaneously changing components such as health, education, nutrition, employment, income, and human, social, and natural capitals is especially problematic to disentangle in terms of linking specific causes with particular effects.

The main purpose of this paper is to briefly present and discuss some of the PDE interactions in the case of Mexico. Section 2 gives a summary of the demographic situation. In Section 3, a short presentation of the recent performance of some macro-economic indicators is provided. Section 4 discusses the problems of soil and biotic erosion, water quantity and quality, and air pollution in Mexico. Finally, Section 5 presents some remarks about future PDE interactions and suggests certain aspects that may need further elucidation.

Due to the nature of the topics covered, the paper only offers a selective overview and discussion of population-development-environment relationships in Mexico. Thus, it does not provide a comprehensive analysis of the problem, nor does it give predictions, nor is it about a detailed strategy on how to proceed on this problem.

2. Demographic Overview

This section briefly describes the main mortality, fertility, literacy, age composition, migration, and population density of Mexico's population.

In 1990, Mexico's population was approximately 84 million. Currently, the demographic transition is not yet at a stabilized phase (Jarque, 1993). Mexico's average annual growth rate was 3.4 percent in the 1960s; 3.2 percent in the 1970s; 2.3 percent in the 1980s; and 1.9 percent in the early 1990s (Cabrera, 1993). This decrease is partly attributed to the population policy, focused on family planning, initiated in the 1970s (Jarque, 1993; Cabrera, 1993; INEGI, 1994).

Decreased mortality has increased life expectancy. In 1930, the male population had a life expectancy of 35 years, while that of the female population was 37 years. In 1990, males could expect to live 68 years and females 72 years. Although mortality and infant mortality have, in general, decreased significantly, there are regional differences. For 1990, the richest states (e.g., Distrito Federal, Baja California, Baja California Sur and Nuevo León) had a lower rate of infant mortality, 2.5 percent, than the poorest states (e.g., Chiapas, Guerrero and Oaxaca), 6.0 percent (Jarque, 1993).

Fertility has been the main factor explaining the decrease in Mexico's population growth. In 1960, the number of births per woman's reproductive lifespan was 6.7, while in 1990, it was 3.1 (Zlotnik, 1993).

The sectoral change of the economy has been reflected in the employment distribution. During the last twenty years both the secondary and the tertiary sectors have increased their share in total employment. The shares for the former and the latter for 1970 and 1990 were 23 and 28, and 32 and 46 percent, respectively. In 1990, the primary sector still employed 23 percent of the labor force (Rendón and Salas, 1993). In addition, this sector has the largest share of the population living in the worst conditions.

During the period from 1970 to 1990, literacy in the population aged 15 or older increased significantly. Literacy for 1970, 1980, and 1990 was 74.2, 82.9, and 87.4 percent, respectively (Jarque, 1993; INEGI, 1992).

2.1. Age composition of Mexico's population

From 1970 to 1990, Mexico's age composition has experienced important changes, a result of decreased mortality and fertility. The peak of the population age pyramid is narrowing, while the middle and the bottom are broadening. The median age of Mexico's population increased from 22.3 to 25.3 years. The age dependency rate decreased from 1.04 to 0.68 (Cabrera, 1993; Jarque, 1993).

The decrease in fertility is clearly reflected in the relative proportion of the population cohort in pre-school age (under 6 years) which has decreased from 22 percent in 1970, to 15 percent in 1990. School population (aged 6-14 years) is increasing although at a very slow rate; it will have a negative rate at the end of the century. During the last 25 years the percentage of people under 15 years of age decreased from 48.5 to 36. From 1970 to 1980 and from 1980 to 1990, Mexico's population aged 15-65 had annual growth rates of 5.46 and 9.74 percent, respectively (Rendón and Salas, 1993). In both cases, the growth rate was higher than that of the population reflecting the combined effect of decreased fertility and changes in age composition. One of the most important changes is the aging of the population. Although the age group over 65 years is at present just over 4 percent of the total population, its growth rate increased from 3.7 percent in 1970 to 4.2 percent in 1990 (Jarque, 1993). However, by and large Mexico's population is still very young since approximately 50 percent has an age equal or lower to 25 (Ham, 1993). One of the major development problems is how to provide school and employment opportunities to the young-middle age cohort.

2.2. Urbanization and population density

From 1940 to 1970, Mexico experienced a period of sustained economic growth with GDP average annual growth rates of over 6 percent (García, 1988). This economic

expansion concentrated in the main urban centers which were the main attraction points for migrants from rural areas. Of late, the pattern of rural-urban migration has changed. During the last 15 years, inter-state migration has significantly increased (Alba, 1993). A new migration pattern has emerged which is characterized by urban-urban migration and metropolitan-urban migration (Ruiz, 1993).

Inter-state and external migration increased significantly during the period 1950 to 1990 (Alba, 1993). For instance, from 1980 to 1990 approximately 2.5 million persons migrated to the United States (Alba, 1993). The main contributors to this external migration were the states of Jalisco, Michoacán and Guanajuato. These flows are largely explained by both repulsion forces (poverty) and social capital (established social networks of migrants in the United States). Regarding inter-state migration, in 1960, just around 5.5 million people were living in a state different to that in which they were born. In 1970, this amount increased to 7.5 million, and in 1990, it was 15.4 million (Alba, 1993). The main change in inter-state migration was that of the Distrito Federal from a high attraction to an expulsion entity (Alba, 1993). For the period 1980 to 1990, net migration was highest for the Estado de Mexico, with 1.355 million persons; Baja California, with 302,000; Quintana Roo, with 172,000; Morelos, with 171,000; and Chihuahua, with 136,000. For the same period, the main losers of population were Distrito Federal, with 1.991 million persons; Veracruz, with 175,000; Oaxaca, with 132,000; and Guerrero, with 98,000 (Alba, 1993; CONAPO, 1993; INEGI, 1992).

In 1990, the most populated states were Estado de México, with 9.8 million inhabitants; Distrito Federal, with 8.2 million; Veracruz, with 6.2 million; Jalisco, with 5.3 million; and Puebla, with 4.1 million. Most of the population is concentrated in a central zone of the country running from east to west. Population density in this east-west corridor is increasing. In the past, the geographical distribution of the population was characterized by a bipolar pattern of great concentration in a few areas and a huge dispersion in small localities. Due to rural-urban and urban-urban migration this pattern is changing. In 1990, the urban population, defined as those living in urban settlements with 5000 inhabitants or more, was approximately 65 percent (INEGI, 1992; Jarque, 1993). Due to continuing migration and to population growth, this proportion is expected to increase.

The largest cities are experiencing smaller growth rates than medium-size cities owing to changes in relative attractiveness which have included a saturation effect and diseconomies of scales (e.g., increased pollution, traffic, crime) in the largest urban centers; a geographical effect (e.g., increased attractiveness and government's policy attention due to NAFTA) in the case of northern cities; and the increased provision of jobs, goods, and services in medium-size cities. In 1990, medium-size cities comprised 23.5 percent of the total population, while in 1970 this proportion was just 16.6 percent (Ruiz, 1993; Jarque, 1993).

However, the number of small localities (less than 5,000 inhabitants) increased from 96,000 in 1970 to 155,000 in 1990. For 1990, the annual growth rate of the population of these centers was 0.7 percent, while that of urban centers was 4.75 percent (Jarque, 1993). Recent government policy aims to "promote" rural-urban migration and to provide public investment in urban centers. It remains to be seen whether or not such a policy will only amount to a shift of poverty from rural to urban centers.

In 1990, Mexico's population density was 41 persons per square kilometer. At the national level, there are important differences between the central region and the rest of the country. In some states density is high, such as in Distrito Federal (e.g., 5494),

Estado de México (e.g., 457) and Morelos (e.g., 242), while in some northern and southern states such as Durango, Campeche, Chihuahua, Quintana Roo, Sonora and Baja California Sur, population density is between 4 and 10 persons per square kilometer. If not related to other interacting socio-economic factors, population density is of little use because it will only indicate the potential availability of physical space per inhabitant. For a long time, it has been a stated government policy to promote a more evenly spatially-distributed development (PND, 1995). Judging by the results, so far, government policy has had a minor effect *vis a vis* economic forces and factors other than space considerations.

Assuming annual growth rates of 1.71 and 0.71 for the years 2000 and 2025, the projected population will be 100.5 and 130.8 million persons, respectively (Ordorica, 1993). On the basis of these projections, the main changes suggested are: 1) a decrease in population aged 0-14 from 32.1 million in 1990 to 30.1 million in 2025; 2) an increase of population aged 15-64 from 48.1 million in 1990 to 88.9 million in 2025; and 3) an increase of population aged over 65 from 3.6 million in 1990 to 12 million in 2025. These changes will have implications on education and social welfare policy.

Current population policy is based on a more comprehensive approach than hitherto recognizing the interrelationships between population, the economy, and the environment. A decrease in population growth is being advocated via different media and through the implementation of diverse programs focusing on reproductive health, while allowing couples to decide on their family size. Although the rate of population growth has not decreased as expected in the 1970s and 1980s (Cabrera, 1993), a downwards trend in the demographic transition seems to be well established. Shifting from the quantitative to the qualitative, a key population component, which to date has been neglected, is the question of its "quality." That is, the need for increasing both human and social capitals. In this regard, further attention to the development possibilities at the social realm is central. Currently, the generation and maintenance of development possibilities of the current population and of those originating from the momentum of the population require prime attention.

3. Development Overview

This section discusses past trends of some of Mexico's most important macro-economic indicators. It is recognized from the outset that although several indicators are referred to, none provides a complete picture of the situation. In particular, some economic indicators have been criticized for disregarding social and environmental costs, house labor, and a series of activities that do not enter into the formal channels of monetary interchange. For instance, an increase in GDP may have to do with the effects of weather in agricultural output or with the reconstruction work following disasters caused by hurricanes, earthquakes, or recessions. Similarly, as currently estimated, it may not take account of deterioration in household productivity. Social systems may increase the divorce or criminal rates in ways that dissipate the income flows within families or which diminish the effectiveness of child rearing. In a similar vein, most references to development make no allusion to the velocity of circulation of ideas, a crucial component for increasing the probability of innovation and for augmenting the accumulation of intellectual capital. For further details on indicators of development see, among others, McGranahan *et al*. (1979) and Jackson and Mares (1994). Despite

the potential shortcomings of the indicators referred to below, the nature of the country's development is such that probably they are sufficient to depict it clearly.

3.1. Past and current trends

From 1940 to 1980, Mexico's GDP grew at an annual average of 6.5 percent (García, 1988; World Bank, 1994). During this period the economic growth approach was based on import substitution which included measures such as 1) tariff protection and quantitative restrictions; 2) fiscal incentives and subsidized credits to sectors deemed as priority; 3) restrictive regulations on business entry and operations; and 4) restrictions on foreign investment.

The high economic growth obtained during this period could not be maintained because it was beset with inefficiencies and low-productivity growth. The legacy of this period, the so-called "stabilizer period", was: 1) a highly concentrated income distribution; 2) a protected industry incapable of competing in the global market; 3) an outdated productive base in the economy coexisting with a small number of modern and competitive enterprises; and 4) a deficient attention to the effects of economic growth on the state of the environment.

3.2. Income distribution

In 1990, the grouping of households according to income levels on the basis of the number of minimum wage earnings (at the time the minimum wage was approximately 68 dollars/month) showed the following distribution: 1) 53 percent of households had incomes lower than two times the minimum wage; 2) 42 percent of households had incomes between 2 and 10 times the minimum wage: and 3) 5 percent had earnings higher than ten times the minimum wage (INEGI, 1990).

In 1992, the 20 percent of the population with the highest income received 54 percent of the total national income, while the poorest 20 percent received only 4 percent (Anonymous, 1995b). Similarly, the Gini coefficient was 0.52 for 1989 and 0.57 for 1992 (IADB, 1996), indicating a decreased income share for the low and middle-income sectors of the population. The increasing income distribution disparities have impaired the government's much sought increase in savings (PND, 1995). Moreover, the concentration of income distribution has compounded with the loss of purchasing power. For instance, the real GNP per capita in 1994 represented only 93 percent of that corresponding to 1981 indicating a general decrease in the population's purchasing power during the last fifteen years (Anonymous, 1995a). This situation is even worse if the poorest and middle-income sectors of the population are considered. Furthermore, although more access to credit and better repayment conditions could substitute redistribution of income as a way of attaining increases in the purchasing power of the population, such options are not available because of the current monetary and fiscal policies and the problems of the banking system. Such factors, an aftermath of the 1994 economic crisis (see below), are currently constraining economic recovery.

A World Bank study (Burki and Edwards, 1995) points out that despite the measures and sacrifices carried out since 1982, little progress has been made towards breaking out of the quagmire of poverty. Departing from the current state of the national economy and the needs and aspirations of the population, the challenge, from an economic perspective, will be to achieve high rates of economic growth, which will be needed to

reduce the absolute levels of poverty in the country. The statement of this challenge assumes that growth at the aggregated level manifests in improvement of the living conditions of the poor which in the past has not always been true.

Addressing the needs of the poorest strata of the population and giving due consideration to environmental protection is not simply a social issue, but increasingly a political one. Of late, this has been amply evidenced by increased social insecurity and unrest in most of the country. Thus, the preservation of a desirable biophysical environment will largely be a function of being able to maintain and/or create a better social environment.

3.3. The import substitution model

The economic model followed during the "stabilizer period" referred to above, was the so-called import substitution model. Its fundamental feature was the protection of the domestic industry. Such a protectionist approach was not appropriate to successfully take up the challenges of the 1980s and 1990s. This has been amply evidenced by the economic performance of the last 20 years.

The results of the public sector intervention in Mexico contrast remarkably with those in South Korea and Singapore, as well as with those in Japan and Germany, even when in the Mexican case we also have the state co-working with both labor unions and entrepreneurs. Thus, the differences suggest that the quality (or lack of) of state intervention during the import substitution model was the main explanatory element of the results attained rather than state intervention *per se*.

The import substitution model was financed until the mid-1960s by exports of the agricultural sector. These decreased due to increased domestic demand, the leveling off of the expansion of the agricultural frontier, and to decreased productivity. The former originated from both population growth and increased standards of living (in some sectors of the population). The latter stemmed from the increasing incorporation to agricultural production of marginal lands and also from the cumulative effects of unfavorable terms of trade of the agricultural sector in relation to the rest of the economy. Thereafter, oil exports became one of the main sources funding public expenditure.

3.4. The maquiladora industry

Until the mid-1980s industrial development was steered through several protectionist measures (e.g., tariffs, import quotas, and regulations on property rights) and subsidies. This approach resulted in an outdated and non-competitive industrial base.

An exception to the inward-looking approach to national industrial development was the maquila program initiated in the mid-1960s. It allowed 100 percent foreign ownership and provided incentives to attract foreign-owned manufacturing. It first located along the USA-Mexico borderlands and more recently throughout all of Mexico.

During the last two years, exports have had a contrasting performance to the rest of the economy, experiencing a growth at constant prices of 28.1 percent for 1980 and 19.8 percent for 1995 and the first 5 months of 1996 (Banco de México, 1996g, 1996i). In 1995, export growth attenuated the decline of the GNP by more than 3 percentage points. It otherwise would have been higher than 10 percent (Banco de México, 1996a).

The in-bond industry has grown into an important component of Mexico's economy. Its exports represented, in monetary terms, 42, 44, 43, and 41 percent of total exports for 1991, 1992, 1993, and 1994, respectively (Banco de México, 1996g).

During the period 1980-1990, the maquila industry created 300,000 new jobs providing 75 percent of all manufacturing jobs (Rendón and Salas, 1993). Maquiladora employees have increased from 546,588 in December 1993 to 689,420 in October 1995 (Anonymous, 1996). Value added and employment in the maquiladora industry had annual growth rates of 19.7 and 13.1 percent for the period 1985-91 (World Bank, 1994). Although, most are low-wage low-quality jobs, maquiladora's employment has provided an important "buffering" effect during several years of recession in the rest of the economy.

However, less than 2 percent of all inputs used in the maquiladora industry are provided by national suppliers. The proportion of imported inputs has been very large and almost constant during the last three decades (Rendón and Salas, 1993). Increased industrial activity in the border area with associated growth in the use of scarce water resources and in hazardous waste generation has compounded with the undermined ability of federal, state, and local governments to fund environmental cleanup and regulation of industries. A SEMARNAP report for 1995 indicates that from 993 visits to maquiladoras in the northern border more than 66 percent of the plants were not in compliance with existing environmental regulation (SEMARNAP, 1996). However, the type, intensity and duration of the anomalies are not reported. So, with the scarce available information it is not possible to construct an accurate picture of the nature of the problem.

The prominence of the maquiladora industry in total job creation and in total exports (and imports) in conjunction with the low insertion of national suppliers renders the national economy, and in particular the northern borderland region, susceptible to potential changes in the in-bond industry and, perhaps more importantly, raises questions about the capability of national suppliers to seize opportunities, as has been the case in several Asian countries. In a wider context, this lack of human and social capital may constrain the realization of the potential opportunities opened up by NAFTA and other integration agreements. Likewise, this lack of competence expressed at the individual, social, and institutional levels may partly explain the main development manifestations of the recent past. The development abilities at the social and institutional levels are increasingly lagging behind those at the individual level and therefore increasingly hampering overall development.

3.5. The recurrence of economic crises

Development in the 1970s was dependent on oil exports and external borrowing. Decreased oil prices in the early and mid-1980s coupled with increased foreign debt (e.g., in 1981, the government's primary deficit, debt excluding interest payments, reached 8 percent of GDP, compared to 0.4 percent a decade earlier) and an inefficient public intervention in the economy (e.g., implementing expansionary fiscal policies) lead to the severe financial crisis of 1982 which resulted in balance of payments difficulties, currency devaluation, explosive inflation, and capital flight.

In 1982, a sharp currency depreciation was followed by a stringent fiscal and monetary policy. A primary deficit--non-interest public expenditure minus public revenues--of 8

percent in 1981 was turned into a surplus average of 4.5 percent of GDP for 1983-87 (World Bank, 1994). As a result the economy stagnated. From 1983 to 1992, there was an annual decline in per capita GDP of 0.8 percent (Anonymous, 1995a) .

The government's stabilization program was mainly focused on the balance of payments disregarding components necessary for the growth of the economy, such as the diminishment of macroeconomic distortions through growth stimulation and increased efficiency, including price reforms, trade political measures such as liberalization and devaluation, reduced government expenditures as well as removal of institutional constraints to flexible responses of the private sector (World Bank, 1994; Opschoor and Jongma, 1996).

The 1982-1988 administration started some market-oriented reforms, obtained GATT membership in 1986, and established a healthy balance of payments. In 1982, government policy shifted from a public lead growth to a private sector lead approach. The banks were re-privatized; public sector participation decreased from a total of 1,155 public sector enterprises in 1982 to about 200 in 1994. The first phase of privatization generated over US$ 22 billion, mainly derived from the sale of both the banks and the telephone company. Privatization plans of the current administration include: the power generation system; transportation and distribution of natural gas; some (secondary) branches of the petrochemical industry; airports; and the railway system (PND, 1995).

The oil industry has remained in the hands of the state because such provision is stipulated in the national constitution. However, there is private sector participation through subcontracting, and there are law proposals to allow the participation of the private sector in the petrochemical industry. There has been some pressure to privatize Petróleos Mexicanos, the parastatal oil company. This has been met with resistance because of its importance to the government in terms of revenues, and because privatization may turn costly in political terms (e.g., proposals to privatize the secondary petrochemical industry have been challenged on legal grounds by the opposition in congress).

The privatization proceeds were basically used to reduce domestic public debt which in real terms was diminished by 40 percent in 1992 (World Bank, 1994). However, such relief did not last long because current total external debt amounts to US$ 158.298 billion (IADB, 1996; Banco de México, 1996h). The government strategy of obtaining new loans to pay interests and/or principal of previous loans, has alleviated short-term payment problems, but at the same time, it has augmented total debt and shifted the problem to the medium and long terms.

After the economic recession and high inflation (e.g., in 1987 inflation reached 157 percent) of the 1982-1988 period, the Salinas administration managed to obtain the proceeds from privatization (see above), large inflows of foreign investment[1], the rescheduling of the foreign debt (the annual interest relief from the Brady Plan was estimated at US$ 1.3 billion (World Bank, 1994)), and the establishment of stabilization deals ("pactos") between entrepreneurs, government and labor (The Economist, 1995; Burki and Edwards, 1995; Banco de México, 1996a, 1996b, 1996c, 1996d, 1996e, 1996f).

[1] Net capital flows into Mexico were 8.2, 24.9, 26.5, 30.9, and 11.5 US$ billion for 1990, 1991, 1992, 1993, and 1994, respectively (IMF for 1990 and 1991, and CEPAL for 1992 to 1994 as quoted by Burki and Edwards, 1995). On a country basis, these flows were the largest in the Latin American region.

Despite these achievements, GDP growth has been sluggish. Annual GDP growth rates were 3.3, 4.4, 3.6, 2.8, 0.7, 3.5, -7.0, and 5.1 for 1989, 1990, 1991, 1992, 1993, 1994, 1995, and 1996 respectively (Anonymous, 1995a; Banco de México, 1996a, 1996b, 1996c, 1996d, 1996e, 1996f, 1996j). Economic recovery is being constrained by high interest rates (e.g., for most of 1995 and 1996 nominal interest rates have been higher than 30 percent) which are helping to stabilize the peso, restrain inflation, and reflect credit constraints originated by the crisis in the banking system.

The Salinas presidency pioneered an overhauling of the management of the economy including legal, tariff, tax, regulatory, and privatization reforms. These reforms pioneered the approach toward the free market that many less developed countries have followed. The current administration has basically continued deepening the same economic model.

The current account deficit was allowed to increase excessively. The current account deficit, as a percentage of GDP, was 5.1, 7.5, 6.4, and 7.7 for 1991, 1992, 1993, and 1994, respectively (Burki and Edwards, 1995).

Too much reliance was given to short-term foreign investment, and not enough long-term investment went into the productive base of the economy. Public sector savings were not as high as needed to counteract the boom in private consumption. The development of human resources and the provision of infrastructure, among others, did not allow the attainment of productivity gains that would have permitted the increase in exports necessary to balance the current account.

The criticisms on stabilization and reform programs by Ramirez (1993), Singer (1994, 1996), and Opschoor and Jongma (1996) clearly depict what has occurred in Mexico during the last two decades. A brief description of some of the main concerns follows.

3.5.1. The economic measures enacted have focused on the short term

Despite applying--probably not very well--structural adjustment, stabilization, and growth programs, Mexico suffered severe financial crises in 1976, 1982, and 1994. Growth for the last 15 years has been meager. Mexico's population now has a lower average income than in 1980 (The Economist, 1995). Crisis recurrence and worsening standards of living are very indicative of the lack of effectiveness of past administrations. For long-term sustainable development, account should also be taken of the state of natural capital, of specific operating conditions at different levels of aggregation, and of the need to create an evolving balance between market and non-market considerations. Given the current development difficulties, most attention and actions are focused on the short term. Paradoxically, the government defends the lack of socio-economic development in the short term stating that the economic model followed will produce positive results in the long term. The misreading of the situation during the Salinas administration, the fragility of the national economy to external shocks, and the uncertainties of the long run suggest that, by and large, short- and medium-term results either close or facilitate the opportunities of the long term. Disregarding the interplay between different time horizons may jeopardize long-term development.

3.5.2. Economic growth has been prioritized without giving due regard to other relevant economic factors

The productive base of the economy is facing liquidity and survival problems. The 1994 crisis may be partly attributed to excess consumption and low domestic savings (Burki and Edwards, 1995; Anonymous, 1995a; The Economist, 1995). Less reliance in short-term foreign investment and increased domestic savings are being advocated by the government (PND, 1995). The banking system is facing a very high rate of loan payment defaults because families and enterprises were caught heavily indebted since they were planning on the basis of an expansionary scenario. Banks and borrowers have been supported by special programs from the Federal government (Banco de México, 1996a). However, due to the severity of the recession, loan defaults are still high. The health of the banking system is considered a key component for the running of the national economy. Nonetheless, as pointed out above, by and large, income growth has not been attained, nor has it significantly increased capital formation. Apart from the emphasis in growth by the economic system, by and large, cultural forces and belief systems, group dynamics, and individual psychology do continue to give primacy to consumption rather than to savings and the protection of the environment.

3.5.3. Infrastructure has been neglected as a result of decreased public expenditure

During most of the 1980s and 1990s, with few exceptions, investment in infrastructure has been grossly neglected. For instance, public investment declined from 12.9 percent of GDP in 1981 to 5.6 percent of GDP in 1987 (World Bank, 1994). From 1988 to 1993 there was a large investment in road infrastructure. The government's response to the 1994 crisis included fiscal measures such as reduction in the real level of public expenditure particularly targeting programs other than those constituents of the basic social safety net which were expected to decline by 20 percent (Burki and Edwards, 1995).

To successfully compete in an increasingly globalized economic system, substantial investments are required for building and improving the quality of roads, power generation, water supply, and telecommunications. Large investments are needed in infrastructure. During the next decade infrastructure investment requirements will amount to 4.5 percent of Latin America's GDP (Burki and Edwards, 1995), which should increasingly be derived from the private sector since public expenditure will continue to be stringent and public sector participation will be confined to the provision of the right framework for the working of the markets, as well as of buffering entities such as safety nets.

The national development plan 1995-2000 envisages an increased private sector participation in the building, ownership, and operation of the rail system, telecommunications, seaports, airports, power generation, roads, as well as in storage, transport and distribution of natural gas (PND, 1995). The past unsuccessful private sector participation experiences in the construction and management of roads, suggest that amendments should be made regarding the time horizon of the concessions, the setting of user fees, regulations aimed to achieve a proper long-run maintenance of infrastructure, and also to the connectivities between privately and publicly-run roads.

3.5.4. Weak industrial development hampers the whole development program

The industry's non-attainment of the theoretically expected gains from the open economic policy is being reflected in the overall economic performance of the country. The conjunction of tight fiscal and monetary policies, the contraction in demand, and the increased exposure to international competition has seriously constrained the functioning of a large part of the industrial base. Small and medium size enterprises have been particularly affected, which 1) constitute a major source of employment; 2) have low capital reserves and less capability to respond to the economic shock suffered, and; 3) have, by and large, not been conscious enough of the implications of their new and rapidly changing working environment. Such impaired vision jeopardizes the formulation and implementation of a continuous adaptive strategy. When there is no clear visual system-environment, we observe a parade of fashionable partial and ineffective approaches. For instance, in the corporate world we have, among others, total quality management, downsizing, and re-engineering. At the country level, we have experienced the import-substitution model; stabilization programs based on balance of payments; structural adjustment programs aimed at achieving economic growth; and more recently structural adjustment programs relying on second generation reforms and paying attention to both economic growth and the environment. The former have shown their shortcomings, while the latter approach is as yet little more than a policy statement. For a more comprehensive view of development policies as a necessary condition to minimizing backwardness see, among others, Levy and van Wijnbergen (1992) and Maler and Munasinghe (1996).

3.5.5. Decreases in public expenditure have been detrimental to the development of human and social capital

Between 1982 and 1989, real per pupil expenditure diminished at an average annual rate of 8.5 percent (World Bank, 1994). Basic education was the most affected and, paradoxically, the component in the educational sector most in need of quality improvement and investment. For a country with a schooling average of 6 years (Jarque, 1993), this is hardly the required investment in human and social capital.

Overall quality of education seems to have diminished in the last two decades. In addition, owing to the lack of employment opportunities and low salaries for those graduating from technical schools and universities, many young people are less enthusiastic about pursuing middle- and higher-level education. This is a step back from the 1960s, 1970s and 1980s, when going into education was perceived as a means for personal growth and for improving one's family welfare.

With the economic crisis approaching two decades it may be reasonable to expect a negative impact on the health of the population through decreased welfare and access to health services. The largest contributions to population growth are originating from the poorest sector of the population, thereby increasingly adding new inhabitants to the country's population who are more likely to have experienced or to experience in the future some sort of health disorder. For instance, in northern Yucatán, a changed status of children's growth has been observed, as a result of changes in land tenure in the region and in the economy (Morán, personal communication). An undernourishment of children higher than 80 percent has been found in some rural communities in the state of

Yucatán (Cuanalo, personal communication). Although undernourishment has been an endemic condition in certain sectors of the population, the nutritional status of certain social groups has worsened. For example, the Rarámuris, an indigenous group inhabiting the northwestern Sierra Madre Occidental, has suffered famine during the last two years. Which effects the failed development policies have had on the nutritional status of the population at large are unknown. The cumulative and multiplicative manifestations of these effects are difficult to determine but there might be some unpleasant ones. The cases mentioned above may reflect more the lack of solidarity of the development process rather than the scantiness of economic growth. This same lack of solidarity, now mainly in the middle class, was shown during the settlement of the numerous debt defaults to the commercial banks, which were an aftermath of the 1994 economic crisis. In this case, most of the manifested risks were charged to the borrowers, while both lenders and government may be at least as responsible.

The recently proposed changes to the health and pensions scheme (IMSS, 1996) aimed to make it self-financing and feasible in the long term, while needed for the reproducibility of the system, will entail serious access difficulties to a large part of the population as a result of current levels of unemployment (5.6 percent of the economically active population according to INEGI, as quoted by SHCP, 1996); underemployment (probably around 25 to 30 percent); and wages (see previous section on income distribution).

Reduced public expenditure limits the possibilities of increasing accessibility to sanitation services and safe drinking water which for 1994, were for the rural and urban population 12 and 85 percent, and 49 and 94 percent, respectively (CIA, 1996).

Estimates of the life literacy expectancy index (Lutz, 1995), a product of age-specific mortality rates and age-specific proportions literate, using data from the 1990 census resulted in 56.9 and 42.2 years of life in a literate state for the urban and the rural population, respectively. In addition to the differences by place of residence large index differences were found for the northern and southern states. In the latter, substantial gender differences were found (Medina, 1996). This study showed important educational and health differences by region, state, and place of residence (urban vs. rural).

An integrated assessment of the effects on society of recurrent reduction expenditures on education, health, nutrition, and welfare, especially regarding their implications for future development, has yet to be carried out.

3.5.6. The role of the private sector has been grossly over-estimated

Although public sector participation was and is beset with clear inefficiencies, the radical swing giving primacy to the private sector has been encountering its own problems. For instance, private sector participation in building and operating roads has resulted in a mess (The Economist, 1995). The revenue projections turned out to be too rosy (e.g., many toll road projects have large cost over-runs, low traffic, slow traffic growth, and negative financial returns (World Bank, 1994)). Furthermore, a heavier reliance on private roads resulted in the neglect and deterioration of public roads.

Privatization of the telephone company simply replaced a public monopoly by a private one, although liberalization of the long-distance market started in 1997. Likewise, there is suspicion that in many privatization deals lucrative favors were handed over to a

selected group of persons. Furthermore, there are inconsistencies of standing regarding the role of the public sector. For example, during the Salinas administration the private sector embraced the trade and legal reforms, promoting its higher participation in the economy. However, after the 1994 crisis this same private sector has been demanding protection and support from the public sector. They are asking for similar privileges to those enjoyed during the period of the import substitution model. An unbalanced share of benefits and costs of development interventions, especially in difficult situations, questions the appropriateness of the relationship between business, state, and community.

Judging by the results so far, it seems that the set of economic, fiscal, and monetary policies has not been able to produce enough positive synergetic effects. The set of measures followed may not have been as comprehensive and integrated as might have been required. A heavy reliance has been given to the control of inflation and to fiscal health at the cost of stagnating the economy. At moderate levels of inflation (expected inflation levels for 1996 and 1997 are 27.5 and 18.7 percent, respectively (SHCP, 1996)) it would be very costly to reduce it further. Thus, at this stage other components may need to be prioritized. For example, the government is calling for an increase in domestic savings. Although a required measure, this makes little sense to the large proportion of the population who have been struggling economically for the last 15 years. As privatization continues, the future government's room for maneuvering is narrowing since the proceeds from privatized firms might not be available because a few and the less attractive ones are being left in state control. If the corresponding firms are privatized, measures such as an increase of domestic tariffs (e.g., gasoline, natural gas, and electricity) will no longer be possible.

After nearly two decades of "sacrifice" people are asking whether there may be other ways.[2] Some politicians and civil society organizations are calling for an alternative model of development. However, taking into account the current worldwide drive toward the increasing role of market forces, including compromises derived from membership to NAFTA, OECD, WTO, and several regional and bilateral trade agreements (e.g., with Chile, Colombia, Venezuela, Ecuador and most Central American countries) as well as the current economic situation which severely limits the room for maneuvering, the calls for a renewed prominence of the public sector under the current environment seem to offer no further advantages than the current development model. However, the socio-economic results of such a model suggest that a serious rethinking and possibly an overhaul are needed. At the international level, mainly due to the deepening of the social and environmental deficits of neoliberal policies, there is an embryonic tendency towards Keynesianist policies (Singer, 1996).[3]

Probably the problem is not the model *per se* but how it has been implemented by the government and the main social actors. Participatory democracy, transparency,

[2] The assessment of the applied development models has been carried out in narrow terms without giving due attention to the socio-ecological deficits. A related and central element in development, the cultural one, especially regarding the relationships between identity and self-worth with development, has been, in practice, by and large, disregarded.

[3] This social embryo is supported by the center-left victories in both the United Kingdom and France. Disappointment with the results of neo-liberal policies is widespread in Latin America. However, such lack of satisfaction has not yet been reflected in substantive changes in the development approach followed.

accountability, a greater awareness of the two-way relationships between particular development interventions and the wider context, and the corresponding actions seem to be in short supply. That is, in whatever magnitude the future development can be influenced by the people, the approaching of such potential will be a function of what people are able to do and what they will fail to develop. The increased number and influence of civil society organizations, although a positive sign, raises questions regarding the appropriateness of their conceptual and philosophical underpinnings and especially the lack of proved procedures concerning how to attain the effective participation of the people in the inducement of their own future. The deepening of the structural change process with the "second generation" reforms (Burki and Edwards, 1995) may point to the same end. However, changing the nature of politics and of institutions entails substantive changes at all levels, especially regarding how the individual could participate more productively in group life. The government has a very important role to play in enabling this to happen and in obtaining positive and consistent development results that will increase trust and confidence at the societal level.

It seems that in rushing to an increased private sector participation, not enough attention has been given to the role of the public sector in creating, maintaining and changing the proper environmental conditions in which the markets could be developed and work effectively. Maintaining or increasing environmental resources needs an increased capacity of the state to mediate economy-environment interactions. Development appears to require an appropriate combination and working together of the market; an efficient and competent public sector as well as the right set of institutions in society. The latter should encompass both the creation of new institutions and the reform of old ones. As yet this tri-partite blend (e.g., markets, public sector and institutions) has to be rendered operational.

4. Overview of the Environment

This section discusses in a sketchy fashion some of the main environmental problems: soil and biotic erosion, water quantity and quality, and air pollution. Since the paper is not of a comprehensive nature, only the problems considered to be the most important ones are treated. Considering the multidimensionality of PDE interactions and, therefore, the possibility of obtaining the same results departing from different states or of attaining different results starting from similar points, it is difficult to determine causality relations. For this reason, simple relations such as those between population and forested area or between population and water availability are not considered here. It is assumed that PDE interactions are more complex and that they are, by and large, a product of the quality of human affairs.[4]

[4] The nature of the PDE problems is of such breadth that they cannot be properly tackled from the viewpoint of scientific disciplines such as economics, demography, environmental economics, political science or sociology. It seems that the research effort should focus on the realm of the interrelationships between institutions and the processes involved in the operation of the social system. Only within this framework will it be useful to cite and exchange figures on pollutant levels and changes by state concerning air, water, food, population, energy consumption, raw material shortage and the like.

4.1. Soil and biotic erosion

Mexico's richness in natural resources is such that we may ask whether or not the availability of natural resources is related to successful development. In the past, a considerable abundance in natural resources was not used to improve development as required. Currently, growing environmental problems are taking place at the same time that socio-economic deficits are exacerbating.

Owing to geographical, climatic, geological, and topographical reasons, Mexico's biodiversity is one of the richest in the world (CONABIO, 1996a, 1996b). According to the number of species, Mexico's place in the world is first in mammals and reptiles, sixth in butterflies, seventh in birds, and third in angiosperms. Mexico also has a very large number of total (e.g., 36,000) and endemic (e.g., 24,000) plant species (CONABIO, 1996a, 1996b, 1996c). Furthermore, Mexico is one of the richest geographical areas worldwide of wild relatives of crop genotypes (CONABIO, 1996a, 1996b). Because of the occurring biophysical conditions, the coast of the Gulf of Mexico and the Caribbean is the region with the largest number of plant species. It is an open question whether or not the richness in biodiversity will manifest in tangible benefits for the development of the population. The answer to such a question for the case of natural resources as a whole has been negative so far.

In Mexico, deforestation and soil erosion have been the result of the combined effects of, among other things, increased population; shrinkage of the agricultural frontier; decrease of land productivity; worsening of terms of trade of agriculture in relation to the rest of the economy; land tenure and land reforms which have not been suitable for the preservation of land, flora, and fauna; the demand for certain agricultural commodities; government policies giving cheap credit for pasture establishment and cattle production; and the lack of significant alternative sources of income for the rural population (Barbier and Burguess, 1996; CONABIO, 1996a, 1996b; UNEP, 1992).

Land use changes/cover such as those originating from deforestation and non-adequate land management practices have accelerated land and biotic degradation. Approximately 15 to 20 percent of the total land in the country is either severely or extremely eroded (SARH, 1988, as quoted in SEDESOL/INE, 1993). SEMARNAP (1996a) estimates that 80 percent of the country's land is eroded. The percentage of eroded land varies according to the definition used. Undoubtedly, the erosion situation is very serious. Soil and biotic deterioration are most severe in the states of Oaxaca, Tamaulipas, Sonora, Chihuahua, Tlaxcala and Baja California Sur. Soil degradation may severely reduce land productivity including the provision of non-rival goods.

Although biodiversity losses are not known with certainty, in many areas environmental degradation is already severe and still continuing. Approximately 15.6 percent of a total of 1 417 457 square kilometers of forest land has no original vegetation due to disturbance. Likewise, around 12 percent of temperate forests and 26 percent of tropical forests have less than 40 percent of their original vegetation (CONABIO, 1996a). Despite the large number of plant and animal species (or because of them) there are several endangered species. From the 411 species unique to Mexico, 124 are in danger of extinction (INEGI, 1995).

Biotic deterioration is of paramount importance in ecozones, in arid and mountain zones, and in the tropical areas. More than 5 percent of Mexico's flora is in danger of extinction (Winograd, 1995; CONABIO, 1996a, 1996b, 1996c). Environmental

degradation and the reduction in the quality of rural life may be exacerbated by diminishing supplies of wood and other non-commercial fuels. Deforestation involves the loss of rich agricultural topsoil and hardships for those whose way of life depend most on rural resources. The use of non-commercial fuels is mainly carried out by the rural population and is largely confined to cooking. Traditional fuels represented only 5 percent of the total energy consumption in 1993. For the same year, the per capita and household traditional fuels energy consumption was 2,755 and 13,775 megajoules, respectively. The former has decreased 9 percent since 1973 (UNSTAT, 1995).

In addition to soil and biotic deterioration, there are several irrigated areas (e.g., in irrigation districts in the states of Baja California, Sonora, Sinaloa, Chihuahua, and Coahuila) with serious soil salinization problems (INEGI, 1995).

In an effort to preserve biodiversity the government has increased the area of natural protected areas to a total of 7.8 million hectares in 1993 (INEGI, 1995; CONABIO, 1996a). Unfortunately, the increase in protected areas has not been accompanied by proper management. This has been the result of, among others, the lack of an integrated vision and research agenda of resources which will incorporate the management of protected areas as one of its components; the worsening of the economic conditions which have resulted in an increasing inability by the government to exercise adequate control and functioning of the reserves; and the lack of an adequate involvement and participation of the local population which, not uncommonly, feels disassociated from the natural resources to be protected, as they face access restrictions and do not perceive direct benefits to them from the management proposed for the reserves. Most research work carried out so far remains immersed in taxonomic and inventory studies.

Soil and biotic erosion are correlated through the implied changes to the biophysical environment to water problems. Considering the current situation of the natural resource base and its implications for the economy, soil and biotic erosion may constitute one of the most pressing environmental problems at the national level.

4.2. Water quantity and quality

Water quality and quantity problems usually occur in different geographical locations, although in some cases they may be interlinked. The major proximate causes of water resources problems may include climatic conditions, level of socio-economic development (or lack of), mismanagement of the resource, and lack of an integrated and comprehensive vision in conceptualizing and acting upon the resource.

The combined effects of, among others, increased population, the continuing of the process of urbanization, inefficient water management, and the increasing socio-economic deficits (e.g., poverty, unemployment, social inequalities) are increasingly exacerbating water quality and water quantity problems.

Water availability problems are being observed in many rural areas and urban centers in the northern and central part of the country, where population, industrial and other economic activities are highly concentrated. Less than one-third of the nation’s water resources are located in the arid and semi-arid zones which comprise 75 percent of the territory, and where most of the largest cities, industrial facilities and irrigated lands are located and where more than 85 percent of the country’s GDP is generated (INEGI, 1995).

Water resources are increasingly non-sufficient to supply the high water demand. Water supply in some northern cities has been rationed for several years. This trend is bound to increase since water demand will continue to increase and the supply of water will be costlier and scarcer. Increased competition for water is resulting in overwithdrawal of water from surface water bodies and from underground aquifers as well as in conflicts between competitive uses of water between sectors, urban and rural areas, neighboring cities and states. At the northern border, common surface and underground water resources may originate binational problems. Since some underground and surface aquifers have already lower replenishment than withdrawal rates, a reduction in the extraction of underground water may be due. Water supply problems in the northern and central parts of the country might worsen due to the potential vulnerability of these areas to global environmental change.[5]

The purposeful conciliation of mismatches between different kinds of limits (e.g., geographical, administrative, political, ecological, economic, long-term, short-term, micro level, macro-level) is at the center of many of our most important problems. Unfortunately, misunderstood political reforms are inciting "regional fundamentalism" and the loss of community sense at different organizational levels. Thus, in some problematic cases it has been difficult to rationalize the different orders involved.

Water quantity and water quality problems are increasingly having compounding effects since decreasing availability of water is occurring at the same time that contamination of surface and groundwater is increasing. Water use is shifting from primary sector activities to those of the industrial and service sectors. This change is promoted by government policies aimed at increasing water use efficiency. This is being operationalized through the creation of water markets (World Bank, 1994). However, under the current production and financial conditions of the agricultural sector (e.g., for most producers agricultural activities are non-profitable) the proposed changes may worsen an already difficult situation. That is, maintenance or improvement of natural resources seems to be tied to the improvement of the social conditions.

Water use changes may imply changes in the quality of water as well as in its use in space and time. Water use driven only by the markets, while possibly achieving efficiency gains, in economic terms, may not correspond to that leading to the "best" long-term evolution of socio-ecological systems. For instance, driven by the demand of the industrial and housing sectors, increasing amounts of water are supplied to Mexico City from distant and scarcer water resources in the countryside (Fundación F. Ebert, 1989). Of course, Mexico City's water and sewage systems do not "fully incorporate" external effects. Water supply is underpriced and the cost of sewage disposal is largely unaccounted for. Thus, the key question is to formulate and implement the right set of transitional policies and interplays of different degrees of internalization of externalities. Even when the government is increasingly attempting to use diverse economic instruments and incentives to protect the environment (PMA, 1996), a preventative, integrated, open, participative and systemic framework is not being implemented.

Water quality problems are sometimes related to lack of infrastructure, provision of drinking water and/or wastewater treatment facilities. Approximately 20 percent of the population lacks water service; 35 percent lacks any sewage connection; sewage

[5] As yet it is not possible to carry out accurate predictions at the regional level. However, some studies have projected an increase in evaporation and a decrease in precipitation for most of Mexico (Rosenzweig and Parry, 1994).

treatment covers only 16 percent of the effluent (Comision Nacional del Agua, 1991). Recent government policy has prioritized the construction and operation of wastewater treatment plants (PMA, 1996).

Industrial and human waste pollution is increasingly reflected in the incidence of common, in many occasions preventable, diseases such as cholera, diarrhea, hepatitis-A, and other water-borne diseases (Anonymous, 1996).

The lack of adequate infrastructure for the proper management of water resources has resulted in the severe degradation of various river basins and water reservoirs. It is estimated that 29 of the 37 hydrological basins of the country are contaminated (SEMARNAP, 1996b). The river basins more degraded are those of the Lerma-Santiago, Balsas, Panuco, and Coatzacoalcos (INEGI, 1991).

Small rivers and aquifers in many parts of the country have been seriously disrupted. In many cases, the pollution problems of large river basins may be traced to sets of small polluting and degradation point sources which, when aggregated in time and space, are increasingly impinging on the health of the ecosystems.

Underdevelopment manifests in a lack of a proper infrastructure for water management and use as exemplified by the availability of only a few wastewater treatment plants, and lack of efficient extraction, transport, distribution, and water storage equipment and facilities. Similarly, economic underdevelopment makes it more difficult to carry out an adequate treatment and management of diverse pollutant sources which may negatively impact water quality.

It is not unusual to find that a large proportion (on average between 50 to 60 percent) of the water diverted or pumped for irrigation does not actually reach the plants (FAO, 1991). Similarly, approximately 50 percent of the water supplied by municipal authorities is not paid for due to leakages, illegal connections, and poor billing and collections (Comision Nacional del Agua, 1991).

Likewise, end uses are frequently inefficient. For instance, the per capita water “consumption” of Mexico City is twice that of Paris (World Bank, 1994). Similarly, there are a number of technologies for irrigating crops that allow the attainment of high water use efficiencies. Unfortunately, their application is precluded by the economic environment. However, the previous considerations suggest that there may be large gains to be obtained just from management improvements in current practices.

Nitrate leaching into either groundwater or streamflow may cause eutrophication in water bodies such as Lake Chapala (in the state of Jalisco) and Lake Janitzio (in the state of Michoacán). Nitrate water concentrations higher than 45 ppm cause methaemoglobinaemia (a diminished oxygen carrying capacity of red cells) especially in infants (UNEP, 1992). Groundwater contamination is also common in areas where pesticides are heavily used. The population with the highest susceptibility to water pollution may be agricultural workers and their families given that they frequently use water for drinking purposes from irrigation channels or reservoirs. Owing to lack of access to medical services poisoning by agrochemical compounds is rarely reported except perhaps for acute cases (Carrillo, 1993).

Well-managed water drinking systems may significantly reduce such exposure. A system to monitor and enforce water quality standards is non-existent in most situations. In many cases, it is unknown whether the problem exists, and if it does, what is its nature.

Industry is a major source of pollutant discharges into water resources (EPA, 1988; World Bank, 1994). In Mexico, as in other developing countries, a small number of industries account for the major share of pollution. For instance, the main sources of water pollutants are the chemical, petrochemical, basic metals, cement, textiles, and pulp and paper industries (DDF, 1991; Mercado, personal communication; Wheeler, personal communication).

Pollution is not confined to large establishments. Cottage industries such as the tannery industry in León, brick production in Torreón-Gomez Palacio, and silver production in Taxco are important polluters (World Bank, 1994).

It is suspected that many industries, particularly small and medium-size industries and also some maquiladora plants, throw their waste into the drainage system. One-quarter of the hazardous waste from the maquiladora industry, approximately 44 tons daily, has an unknown end (Anonymous, 1996). However, large amounts of unaccounted-for hazardous wastes are not only restricted to the maquiladora industry, since this is not uncommon in most of the country.

Extensive new water and sewage treatment facilities that were touted by NAFTA proponents have not been completed. Reduced public expenditure on the Mexican side has left many required infrastructure investments on paper. This has happened despite a) the poor health conditions of several human settlements along the borderlands, and b) water and sewage infrastructure being at the top of public investment priorities.

Illegal dumping may impinge environment and public health. In 1994, thousands of migratory birds died of botulism in the Silva dam in the state of Guanajuato. Discharges of pollutants by industry seem to have been the cause. In the Lower Rio Grande/Rio Bravo, possibly due to industrial pollution, there has been an increase of anencephaly in babies, although a direct causal link between maquila toxins and anencephaly has not yet been established. In 1995, hundreds of dolphins, birds, and whales appeared dead on the Baja California seashore (SEMARNAP, 1996c). In the future, illegal waste disposal may provide some undesirable surprises.

It is necessary to develop water-use systems encompassing environmental, economical, and social aspects, explicitly considering potential external effects on other systems. An integrated and comprehensive assessment of water use is required if better informed decisions are to be taken and if sustainable water-use systems are to be achieved. For such purpose, it is required to carry out detailed studies of surface and groundwater characteristics as to properly assess a) the likelihood of salt water intrusion in nearby coastal areas, and b) the spatial distribution of water resources and likely water demand to avoid instabilities and the non-sustainability of surface and groundwater systems. Due to the complexity of the task and considering the not uncommon implementation problem, the active and creative participation of water users will be crucial.

4.3. Air pollution

In Mexico, the occurrence of air pollution problems are due to, among others, the combined effects of several of the following factors: particular geographical (e.g., semi-closed basins as in the case of Mexico City) and/or meteorological conditions (e.g., cold weather propitiating thermal inversions); industrial emissions; transport infrastructure conducive to congestion; high number of vehicles in a given space-time system; low vehicle fuel efficiency; bad running condition of vehicles; the characteristics of the fuels

used (e.g., gasoline with high lead content); inefficient transport systems; non-adequate inter-modal transport arrangements; provision of a deficient public transport service; and wrong paradigmatic approaches that still give primacy to the private car and to the construction of transport infrastructure.

The increasing urbanization of the country (Ruiz, 1993) together with the exacerbation of socio-economic conditions (see Section 3) are increasingly manifested in the worsening of air pollution problems.

Evidence indicates that conditions are increasingly exceeding air quality standards for S0x, N0x, O3, and PM10 (INEGI, 1995; PMA, 1996). The situation is currently more dramatic in Mexico City. The worsening of air pollution may be expressed by the number of days in a year with non-satisfactory air quality, defined as those with more than 100 IMECA[6] points, which for 1986, 1987, 1988, 1989, 1990, 1991, 1992, and 1993 were 263, 307, 328, 332, 328, 339, 334, and 328, respectively (INEGI, 1995).

It is noteworthy that approximately 80 percent of the inhabitants of Mexico City who do not own a car and suffer the effects of the traffic pollution do not complain about those causing the emissions.

Guadalajara, Monterrey and some of the most rapidly growing medium-size cities (e.g., Ciudad Juárez, Chihuahua, Torreón, Puebla) are experiencing conditions surpassing air quality standards for lead, carbon dioxide, and nitrogen oxides in certain spots and when certain environmental conditions occur. Medium-size cities may learn from the mistakes of the metropolitan cities. Taking steps now to induce a higher compatibility between economic, environmental and social development in small- and medium-size cities may have high pay-offs.

Air pollution effects on human health are not fully known, but they are substantial (World Bank, 1995; HCN, 1995; Schwartz, 1994; Hoek, 1992; Ricci, 1985; Rowe, 1985). Air pollution effects on human health have provided the basis for enacting the policy measures of the most recent air quality program for Mexico City, PRO-AIRE 1996.

In similarity with a pattern observed worldwide (UNEP, 1992), lead pollution has significantly receded due to changes in fuel composition. In contrast, ozone and particulate problems have worsened. In Mexico City, ozone pollution has been given more consideration by authorities, the media, and the public. So far, health effects of PM10 particulates and of diverse mixtures of pollutants seem to have been underestimated.

The main sources of air pollution are vehicle emissions, which contribute 98.1 percent of the total energy consumption (INEGI, 1995), industrial emissions, and human waste.

Total commercial energy consumption (TEC) for 1993 was 4,941 petajoules, an increase of 155 percent since 1973. The per capita energy consumption for 1993 was 55 gigajoules, an increase of 66 percent since 1973 (CDIAC, 1995). Considering an average of 5 persons per household (Anonymous, 1995b) the average household energy consumption for 1993 was 275 gigajoules.

[6] IMECA stands for índice metropolitano de calidad de aire (metropolitan index for air quality). The index ranges from 0 to 500 points.

Assuming an equal per capita energy consumption to the above (this assumption may be controversial since some stages and components of development may involve higher or lower energy per unit of output, and the evolution of lifestyles in the long run is beset with uncertainties[7]), and a projected population of 131 million for 2025 (CONAPO, 1993), TCE will increase by 45 percent. From the perspective of the country's global environmental commitments, this projection may jeopardize compliance of such agreements. In addition, increased domestic energy consumption may compete with the need to export petroleum.

The total carbon dioxide emissions (TCDE) from industrial processes for 1992 were 332,852,000 metric tons (CDIAC, 1995). Again, assuming per capita carbon dioxide emissions equal to those in 1992, and a population of 131 million, TCDE for the year 2025 will be 45 percent higher than for 1992. The per capita and household carbon dioxide emissions for 1992 were 3.77 and 18.85 metric tons, respectively (CDIAC, 1995). The total, per capita, and household carbon dioxide emissions from land use change for 1991 were 63,000,000, 0.7, and 3.5 metric tons, respectively. For the same year, the total, per capita, and household methane emissions from anthropogenic sources were 3,100,000, 0.03, and 0.15 metric tons, respectively (World Resources Institute *et al*., 1996).

In summary, TCE and its associated environmental impacts may substantially increase.

Industrial pollution may be defined as the product of the scale of production, size of affected population, and industrial pollution intensity. A country level study carried out by the World Bank (David Wheeler, personal communication) shows that the centers with the highest industrial output are the most polluted. Since Mexico's industry is highly concentrated (e.g., approximately 40 percent of the total industrial plants are located in the metropolitan area of Mexico City) and given that the scale of production will increase if economic growth is to take place, the greatest potential for decreasing pollution resides in improving industrial pollution intensity. However, as alluded to above, increased technological efficiency may manifest, at the aggregated, in an increased use of natural resources.

Substantial changes may be necessary simply to diminish industrial pollution intensity. For instance, in 1996, the number of Mexican industries complying with ISO 9000 standards were about 10 percent of their Brazilian counterparts (Whitzer, personal communication). ISO 14000 provisions are alien to most Mexican industrialists. So leap-frogging seems required in applying clean production technologies. Doing so will be difficult given the current status quo of industrial production. Particularly concerning is the maladaptation of industrialists with their increasingly competitive and turbulent environment. For example, most Mexican entrepreneurs perceive environmental regulation as a burden (World Bank, 1994). The need to increasingly incorporate the environmental dimension added a new complication to the already messy status of development in Mexico. The new, but in practice empty, discourse of sustainable development has added to the tools available in the rhetoric. However, it has changed few, if any, of the fundamentals of society's functioning.

[7] For instance, the energy intensity of GDP has reached a maximum and then declined in a number of countries. The energy intensity of UK's GDP has been declining since 1850, in the US since 1910, and in Italy since 1950 (Lee Schipper, 1996 e-mail communication). However, accounting procedures usually do not incorporate the withdrawal of resources from elsewhere (e.g., from other countries). Changes in pollution intensity may partly reflect changes in trade patterns (see Saint-Paul, 1994).

The human waste contribution to environmental air pollution originates from a compounded effect of the following factors: population density; poor supply of basic services such as drinking water, sewage systems, and solid waste collection and treatment; and cultural elements, expressed through human behavior, concerning less than adequate relationships between population and the environment in terms of population and environment health. Approximately 30 percent of municipal solid waste is not collected (PMA, 1996).

The correlation between income and demand for automobiles suggests that transportation-related emissions will increase as a function of the growth of the economy and the compounding effect of population growth as manifested in increased transport demand. Air pollution is expected to grow due to the continued process of population growth, the future increase in vehicle fleets, congestion of roads, and the metabolic activities of industry. What is less certain is whether or not there will be the corresponding evolution of the socio-economic conditions that will avoid the worsening and preferably facilitate the improvement of air pollution.

5. Remarks on Possible Future Population-Development-Environment Interactions in Mexico

Current calculations of the average ecological footprint of Mexicans, an estimated per capita number of hectares that will provide the required energy and consumption of resources of a given lifestyle in time, indicate 2.47 hectares for 1993 data, while the per capita available capacity, yield adjusted area, is only 1.82 hectares (Wackernagel, personal communication). Even when the ecological footprint calculation focuses on consumption, sidelining sink capabilities and, therefore, underestimating the ecological footprint, the above suggests that the sustainable capacity of the country's natural resource base has been already surpassed and that natural capital is increasingly being deteriorated.

Expected population growth (Ordorica, 1993), the continuing of the urbanization (Ruiz, 1993), and the growing needs for products and services, suggest that there will be a substantial increase in consumption and, therefore, of natural resources. This will exacerbate the overall anthropogenic impact on the environment. Future environmental impacts may be either diminished or increased depending on the nature of social development.

The continuation of the process of urbanization suggests a higher number of inhabitants having urban lifestyles which are associated with higher energy and resource consumption. The same trend will also be reflected in more land used for the built environment and the decrease of agricultural and natural land uses as well as an increased share of environmental space by urban inhabitants. This may negatively impinge on ecosystems crucial for maintaining local and regional biophysical and economic stability. The unsatisfied housing needs may increase health problems due to the insufficient provision of basic services.

Certainly, consumption and waste disposal will concentrate in urban centers but the geographical location of production processes will be more uncertain owing to the increasing trend of economic integration both regionally and globally. The latter will be more relevant in economic conditions allowing increased imports.

Uncertainties concerning from where and how many resources will be drawn and where the waste will be disposed preclude clear statements as to whether the associated processes will be detrimental/beneficial at the local, regional, and national levels. There may be very large differences in energy intensity and in environmental impacts between products/services depending on limit variations (e.g., parts of the life-cycle considered) and in the valuation system used. Therefore, explicit consideration ought to be given to materials-products life cycles, to specific regeneration and sink capabilities of ecosystems, and to the value system(s) considered.

In the future, structural changes are likely to be a powerful force of change as the country advances into the post-industrial knowledge-based economy stage. This evolutionary trend of the economy will be reflected in lifestyle changes with important implications for the state of the environment. Structural changes will include a longer life expectancy and the changing composition of the population toward the elderly, and the increasing importance of residential, service and leisure-related activities and consumption. It remains to be seen how the growth of the economy will constrain some of the structural changes referred to above, or in which specific circumstances population growth may constrain economic and social development and the preservation of the environment. Such development uncertainties will have implications for the future state of PDE relationships which are difficult to determine. Diverse arrangements of virtuous (e.g., further development of the green economy) and/or vicious (e.g., the deepening of the poverty-environmental degradation trap) evolutive cycles of population-development-environment may further polarize development between different sectors of society. Increased environmental deterioration and further economic and social polarization will make it more difficult to construct a social environment that will enable a proper stewardship of both the biophysical and the social environments.

Both supply and demand of social services will increasingly depend on individual decisions.[8] This is currently promoted by reforms to the social security system including a pension scheme run by private firms (IMSS, 1996), and by the downsizing of the state and the growing importance of the private sector. In some instances, direct government intervention will continue to be needed in the provision of safety nets and infrastructure if for no other reason than helping to provide the “right” investment environment for the private sector. Diminishment of the relative influence of the social/communitarian domain (understood in a comprehensive and inclusive manner) is paradoxically taking place when both the very nature of the PDE problems and their solutions mostly pertain to precisely such a domain.

The rebounding of domestic production and consumption will require a higher capital accumulation and substantial increases in productivity, which ought to be complemented by policies of the so-called “second generation” such as the development of infrastructure, a better education of the labor force, the reduction of policy-induced distortions, and the enhancement of international competitiveness (Burki and Edwards, 1995). The challenge is so demanding, even in terms of traditional economic growth, that there may be serious doubts as to whether what is needed will be achieved and if in doing so enough attention will be given to the protection of the environment. Current inefficiencies in the allocation and use of natural resources, and the prospects for

[8] However, not many people are perceptive enough to realize that the degree of freedom in their decision-making is largely determined by the structure of society.

continued degradation of critical ecosystems question the sustainability of even current levels of economic activities.

Further integration of agriculture into the market may increase environmental deterioration and contribute to the "selling out" of natural resources. Unfavorable socio-economic conditions in rural areas have fueled rural-urban migration and contributed to natural resource degradation. Such phenomenon may decrease human pressure on natural resources in some areas, but unfortunately that will not solve the development-environment problem. It may only shift the geography of poverty and the negative environmental impacts. Studies on the dialectic modalities of production and consumption activities with regard to the spatial distribution of generative and sink capabilities of ecosystems seem necessary (Wackernagel and Rees, 1996). This task should encompass the growing arrangements between the local, regional, national, and global levels.

The ecological function of agricultural systems has not been sufficiently considered (Norgaard, 1987). For instance, analyses of agricultural production related to the environment usually do not consider the value of non-rival goods which are typical of many environmental resources and services (e.g., fresh air, contributions to the maintenance and regulation of life cycles). It seems paradoxical that when, from the environmental viewpoint, there are reasons to give more attention to the preservation and improvement of production and sink capabilities of natural resources, the terms of trade of the rural population have worsened during the last three decades. Although a large amount of research has been done on the valuation and evaluation of natural resources, a great deal of uncertainty and conceptual problems do remain (Blamey and Common, 1994). To improve our accounting procedures we may need to explicitly consider consumption of non-rival goods and be able to conciliate multiple development viewpoints into a working, higher-order rationality.

If the unsatisfied needs for the provision of acceptable living conditions continue to increase, and industrial processes remain immersed in an inwards looking and short-term vision, and if the jointly created working environment by businesses, the government, and the community is maintained in disarray, then it is likely that pollutant discharges into natural resources and their depletion will continue to increase.

Some encouraging developments may derive from changes occurring in the external environment. Among others, these may include the following: the ISO 14000 provisions (Tibor and Feldman, 1996); NAFTA environmental side agreements (Housman, 1994; Bulmer-Thomas *et al.*, 1994); the increasing pressure worldwide from the green business lobby, targeted at the construction of a more environmentally-friendly framework; and specific environmental commitments originating from the country's participation in several international environmental agreements.[9]

In addition to the above, some of the studies and approaches sketched below can help to increase the understanding of PDE interactions and the formulation and implementation of development policies.[10]

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[9] Mexico is party to the following international agreements: Biodiversity, Climate Change, Endangered Species, Hazardous Waste, Law of the Sea, Marine Dumping, Marine Life Conservation, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution, Wetlands, Whaling, and Desertification (SEMARNAP, 1996; CONABIO, 1996a).

[10] The set of suggested technical studies will be complementary to and, when relevant, integrated with the political-organizational process outlined later in the document.

It may be necessary to include PDE studies at the individual, group(s) (including, households), business, government, and community levels. Inter-scale compatibility in space, time, and level of aggregation will require substantial conceptual and operational developments. In any case, the choice of the unit(s) of analysis shall be thoroughly justified.[11]

It seems necessary to operationally develop a meaningful amalgamation of the following five driving forces involved in shaping population-development-environment patterns:

1) The effect of structural and technological change and the search for economic efficiency (e.g., the influences of the national and international economies; especially in light of the "second generation" reforms and the increasing integration into the global economic system). Particular aspects to consider will include: a) incentive systems for incorporation of clean technologies and internalization of some externalities, and b) technological change and its impact in communication and information distribution.

2) The effect of cultural predispositions and the amenities-disamenities hypothesis (e.g., population-development-environment interactions as a result of prevailing preferences of families and companies). Since a large body of the literature concentrates on this and on point 1) above, incorporating aspects of the other components suggested seems necessary to increase understanding of the processes involved and to augment the likelihood of policy effectiveness.

3) The effect of the implicit or unintended policy hypothesis (population-development-environment as a function of implicit government policies. This will amount to carry out assessments of the ecological footprint of government policies at the local, state, regional and national levels, and suggests the importance of implementing an integrative and preventative rather than an ex-post, piece-mealing and retrofitting approach. Most sectoral policies have effects on other sectors, on the health and welfare of the population, and on the environment. Development policies shall be a consistent set creating synergies towards sustainability and not just be restricted to the work carried out by the ministry of the environment and natural resources).

4) The effect of the systematic exploitation, power and conflict hypothesis (e.g., population-development-environment as a product of a systematic exploitation of specific sectors or social groups by the larger economic and social system. Highly-skewed income distribution and government transfers may jeopardize not only the living conditions and development opportunities of the majority of the populace but also both the realized and potential development of the country).

5) The effect of uncertainty and the random effects hypothesis (e.g., the population-development-environment state at time x as subject to virtually unpredictable external influences. Future development policy ought to explicitly account for the diminishment of the country's vulnerability to shocks such as the one amplified by the financial markets at the end of 1994. The occurrence of natural hazards requires similar considerations). It may be complementary to the intertwining of the markets,

[11] A useful guide for determining the relevant unit of analysis in applied development efforts is to depart from the problem definition as formulated by the human components of the system facing the problem.

institutions, the legal framework, and social values, and serve to increase understanding of population-development-environment relationships.

In addition to the above considerations, applied work targeted at advancing PDE interactions may encompass a conjunction of measures dealing with:

1) The forces of resistance and change toward sustainability, namely, at the individual (motivation, perception, and cognition) and social (e.g., active promotion: world view, social denial, social compliance; and passive tolerance: veil of anonymity, growth addiction, bystander effect, "arguments-cannot-be-won") (for details on this, see Wackernagel, 1996) levels.

2) The institutional level including institutional and economic processes comprising, among other things, a) laws, regulations, strategies and policies (for a systems-based approach to policy making see, among others, Allen (1993) and Emery (1993)); b) public decision making processes; and c) public administration and organization (for further details on institutional processes including the design and re-design of organizations and institutions on more participative, creative, and adaptive grounds, and on the amalgamation of scientific and non-scientific knowledge, see Emery (1977, 1993) and Funtowicz and Ravetz (1991)).

Both the socio-cultural dimension (point 1 above) and the process of social organizational design, in terms of point 2 above, are two central components for progressing towards a better state of PDE relations. Both aspects have not received enough attention so far.

To provide proper policy guidelines concerning population effects on the environment, it is necessary to take into account the specific combinations, in space and time, of factors intervening in the evolution of socio-ecological systems, to be in a better position to determine what is happening and what may happen in the future. For such purpose, a multi-level, multi-dimensional, and dynamic scientific approach in conjunction with participative social organizational designs may provide the new pragmatic philosophical approach needed to tackle the complex nature of population-environment interactions. An innovative and comprehensive approach to PDE interactions in Mauritius, including an interdisciplinary understanding through history as well as through modeling is developed in Lutz (1994).

Population-development-environment interactions are complex and perplexing. Because of their nature, and despite the need to explicitly account for the biophysical environment, they are, and probably will continue to be, largely a function of man-to-man relationships. Considering the numerous failed development attempts of the past and in order to really apply the "best" conjunction of scientific and personal knowledge to improve population-development-environment interactions in Mexico, the kind of planning functions pointed out by Emery (1977, pp. 127) are necessary:

> 1) conducting some search process whereby the main parties to the proposed change can clearly identify and agree about the ideals the change is supposed to serve and the kinds of paths most in character with them;
>
> 2) designing a change process that will enable relevant learning to take place at rates appropriate to the demands of time. This being the time within which change must occur to avoid intolerable costs of not changing and the time by which decisions need to be made if adequate resources are to be mobilized; and

3) devising social mechanisms for participation whereby the choice of paths will reflect the intrinsic value of these paths for those who will have to traverse them.

This process will incorporate the technical, socio-cultural, and practical factors referred to above. It will be guided by a shared vision about the nature of PDE problems at the national level that will be consistent with other relevant spatial and temporal frameworks. Increased "quality of the population" in terms of human and social capital will be a necessary constituent of such a process. Likewise, the formulation and implementation of policies will be the responsibility of those suffering the consequences of development interventions. In the social mechanisms referred to above,[12] the policy expert can be a resource person, and the one who will be qualified to advise in which circumstances such social mechanisms ought to be used, how to conduct them, and who should be involved.

An evolutionary process as suggested above may provide the way to long-term self-reinforcing positive population-development-environment interactions and to the successful adaptation of socio-ecological systems.

In summary, further population increases in conjunction with the growing unsatisfied demands for good, services and job opportunities will manifest in an increased use of natural resources, augmented environmental degradation, and probably in an exacerbation of the already severe development problems. It is argued that most PDE interactions encompassed in failed development attempts may ultimately be attributed to the lack of a substantive and participative democracy. Solutions for circumventing such deficiency may partly be drawn from the post-normal science approach (Funtowicz and Ravetz, 1991) as operationalized in the development of a comprehensive, open, continuous and adaptive search process (Emery, 1977, 1993, 1994).

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[12] A widely used methodology grounded on conceptual and theoretical principles from open systems, social psychology, group dynamics, and epistemology was developed by Fred and Merrelyn Emery (Emery, 1993, 1994).

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