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CURRENCY EQUIVALENTS

Floating Exchange Rate (1992-1994)= US$1.00 = Rls 1620 Rls 1.00 = US$0.000689

MEASURES AND EQUIVALENTS

1 microgram (ug)	=	10^{-6} gram
1 centimeter (cm)	=	0.394 inches
1 meter (m)	=	3.280 feet
1 kilometer (km)	=	0.620 miles
1 square kilometer (km^2)	=	0.386 square miles
1 hectare (ha)	=	2.470 acres
1 cubic meter (m^3)	=	35.310 cubic feet
1 billion cubic meters per year (bcmy)	=	35.310 billion cubic feet per year
1 kilowatt hour (kwh)	=	1,000 watts per hour
1 part per million (ppm)	=	1,000 parts per billion (ppb)
1 mega watt (MW)	=	1,000,000 watts
1 kilogram (kg)	=	2.205 pounds
1 metric ton (t)	=	2,205 pounds
1 million tons oil equivalent (MTOE)	=	1,000,000 tons of oil equivalent energy (TOE)

GLOSSARY OF ABBREVIATIONS

BOD	-	Biological Oxygen Demand
CFL	-	Compact Fluorescent Light
DOE	-	Department of Environment
EHD	-	Environment Health Department
EIA	-	Environmental Impact Assessment
ERR	-	Economic Rate of Return
FRO	-	Forest and Rangeland Organization
GDP	-	Gross Domestic Product
GOI	-	Government of the Islamic Republic of Iran
IBRD	-	International Bank for Reconstruction and Development
IPM	-	Integrated Pest Management
IRI	-	Islamic Republic of Iran
LPG	-	Liquified Petroleum Gas
MEAF	-	Ministry of Economic Affairs and Finance
MOA	-	Ministry of Agriculture
MOE	-	Ministry of Energy
MOJ	-	Ministry of Jihad-e-Sazandegi
SCR	-	Selective Catalytic Reduction (of NOx)
SNCR	-	Selective Non-Catalytic Reduction (of NOx)
TM	-	Tehran Municipality
Rls	-	Iranian Rials
SFYP	-	Second Five-Year Plan

GOVERNMENT OF ISLAMIC REPUBLIC OF IRAN
FISCAL YEAR

March 21 - March 20

ISLAMIC REPUBLIC OF IRAN

ENVIRONMENT STRATEGY STUDY

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ISLAMIC REPUBLIC OF IRAN

ENVIRONMENTAL STRATEGY STUDY

Preface

The Islamic Republic of Iran is very conscious of the need to protect the environment and to adopt a sustainable development growth strategy. Accordingly, the protection of environment and natural resources are included in Iran's Constitution as a fundamental goal of the Republic. The Government of Iran has established an Environmental High Council headed by the President of the Republic, and a Department of Environment headed by a Vice-President. Recognizing the importance of environmental protection and the need for international cooperation in this field, the Government of Iran has invited the United Nations Development Program (UNDP) and the World Bank to work with it in developing an environment and sustainable development strategy for Iran in a cooperative manner.

The first phase of this work was launched in early 1993 with the formation of some twenty national working groups, with participation from the Department of Environment, the Planning and Budget Office, and several Ministries including Economic Affairs and Finance, Agriculture, Education, Energy, Health, Housing and Urban Development, Industry, Jihad-e-Sazandegi, and Transport. Experts from University of Tehran, Sherif University, Azad University, as well as from Non Governmental Organizations participated in the working groups. UNDP provided the funding for the national experts, and the support provided by Mr. Schulenberg, UNDP Resident Representative in Tehran is gratefully acknowledged. The Department of Environment in collaboration with the Planning and Budget Office organized a national conference in April 1993 at which the preliminary conclusions of the national working groups were presented and discussed. Following the discussions, twenty national reports were prepared by August 1993.

The second phase of the work began in September 1993, during which international experts visited Iran and discussed environmental issues and problems facing Iran with local experts and UNDP Resident Office. This report synthesizes the work of both the national and international experts. Following discussions of this report with the Government of Iran and its finalization, the final phase of the strategy work is expected to be launched by the Government of Iran in the context of an Environmental Management Project. It is expected that the Department of Environment with support from other Ministries will prepare a national action plan for environment. The plan will be continually implemented, monitored, and updated by the Government.

ISLAMIC REPUBLIC OF IRAN

ENVIRONMENTAL STRATEGY STUDY

Executive Summary

Introduction

1. Iran has embarked on a fundamental transition to a more market-oriented economic system. The actions and policies to support these goals need to be intricately linked to those for improving the quality of the environment. In this regard, an environmentally and economically sustainable development strategy should become a major underlying objective of the Government's future strategy for the economic transition, and the next Five-Year Plan.

2. Pollution, environmental degradation, and poor natural resource management are problems throughout Iran, although the extent and types of problems vary greatly around the country. Heavy industrialization, vehicle use, and urbanization contribute to air pollution problems in Tehran, and to a lesser extent in other cities such as Isfahan, Tabriz, and Mashad, while inefficient agricultural development has damaged rangelands, croplands, and forests in the countryside. Ground water pollution is a growing problem in most cities because of the lack of municipal waste water treatment facilities.

3. Systemic factors have contributed to these environmental problems since price controls and subsidies have led to low efficiency of resource utilization. Macroeconomic and pricing policies induced serious economic distortions which are, on balance, were detrimental to the environment. These include heavy subsidies for energy, water, and agricultural chemicals, which lead to wasteful consumption of resources, more resource-intensive forms of production, and higher pollution. Because of the over valued exchange rate prior to 1993, when the official exchange rate was about Rls. 70 per US$ compared with a market rate of about Rls 1400 per US$, the price of primary energy products and electricity was also low. While the exchange rate has been adjusted to market levels, the energy price adjustments are lagging, and local prices are about 10% of the border prices. As discussed in Chapter 2, the low energy prices do not give sufficient incentive to the people and industry to conserve energy and invest in energy efficient processes, equipment, and vehicles. Wasteful energy use is not only a loss to the economy, it also leads to excessive emissions of particulates(TSP), sulphur dioxide(SO_2), and nitrogen oxides (NO_x) with serious health consequences.

4. The problem was exacerbated by the Iraq-Iran war, which drained the country of financial resources that could have been used for improving environmental and natural resource management. The war also led to the destruction of forests and natural resources in the south-western parts of the country, and accompanying oil spillage contributed to the pollution of coastal areas.

Urban Environment

5. With a population growth rate of about 3% per year, environmental problems are likely to become more significant in the future, unless measures are taken to improve environmental and natural resource management. The urban population of about 33 million in 1993 already accounts for 57% of the total and is expected to double by year 2010. Therefore environmental problems such as air pollution will require relatively more attention. As discussed in Chapter 2, air pollution in most of the major cities is already serious, Monitoring data indicate that annual average ambient air concentrations in Tehran of SO2, NOx, TSP and lead by far exceed WHO and World Bank guidelines (40 to 340% over maximum allowable values). Even in other cities such as Mashad, Tabriz, Isfahan, and Ahwaz, the concentration of TSP is consistently in the range of 200-400 ug/m^3, which is 2 to 4 times World Bank recommended maximum value.

6. The poor urban air quality is mainly due to excessive consumption of fossil fuels, use of more polluting fossil fuels, and the use of old and often inefficient technology in the metallurgical and chemical industries. The lack of incentives and adequate training are also problems contributing to inefficient operation and maintenance in industries, which increase pollution problems. Current projections show that the problem will become more serious in the future, and by year 2010, about 45,000 additional premature deaths will occur unless actions are taken now to reduce air pollution. Fortunately, several "win-win" solutions, i.e. those that will bring both net economic as well as environmental benefits, are available, so that the burden on the economy is reduced. These options include efficient energy pricing, which will reduce premature deaths by about 13,000 per annum and bring economic benefit of $4.7 billion due to fuel savings. Similarly, another option, reducing gas flaring and substituting the use of high sulfur fuel oil by natural gas will prevent an additional 21,500 premature deaths annually. Reduction of gas flaring would also have a high economic rate of return, in excess of 30% per annum.

7. Drinking water quality in major urban areas is generally good, but since water is not priced at full cost, sufficient effort to conserve water is not made. This is more of an economic than an environmental problem, since total urban water demand remains less than 10% of the total. Still it has some environmental consequences because higher consumption of water results in a larger amount of waste water, which creates water logging, and pollutes the irrigation waters used in some areas such as Varamin south of Tehran. The most dangerous and toxic water pollutants in urban areas are discharged from industries, such as chemical and metallurgical industries, tanneries and electroplating workshops, and recycling or safe disposal of such waste is essential. Several options for improving industrial waste water treatment are discussed in Chapter 3, Section C. This includes "win-win" solutions such as introduction of more efficient and waste minimizing processes along with better training of industrial workers. This should have both economic and environmental benefits. Other low cost options include grouping industries together and providing common waste treatment facilities to benefit from economies of scale. Urban solid and liquid hazardous waste would need improved collection and disposal facilities. Otherwise they would add to the pollution load of water and air. Not enough is known about sources and quantities and a solid waste management study has been proposed.

Rural Environment

8. Rural environmental problems mainly involve those of sustainable natural resource management and they are dealt with in Chapter 3. Deforestation, over grazing, and conversion of marginal rangelands to croplands are contributing to increased soil erosion and desertification. Because of the loss of nutrients and productivity Iran loses about $500 million a year. Soil erosion in watersheds is particularly serious and about 5 million ha. or about 1/3 of all crop lands in Iran are degraded, and about 1 billion tons of soil are lost to erosion each year. Better incentives in the form of more secure land tenure would help together with the adoption of more conservation oriented farming practices. Investments in watershed protection, forestry, and rangelands will help to conserve soil while producing economic rates of return of more than 10%, and helping to reduce poverty. These "win-win" types of investments should be accorded a high priority.

9. Water resource use (73 billion cubic meters per year) is also causing concern. Most of the water (over 90%) is consumed in rural areas, and while the overall water balance is still positive, unsustainable extraction of ground water is occurring in some areas. Although Iran has the highest per capita water availability in the Middle East (2,150 m3 per year), water is not evenly spread, and only 10% of the country has enough water for agriculture. Consequently, approximately 36% of arable land and 48% of all crops are irrigated. For irrigation water, prices are set on the basis of the gross income per hectare for each crop (averaging 4% of gross income), and thus bear no relationship to the costs of supplying water in different areas. Since agriculture accounts for most of Iran's water use, this is a serious distortion for a country which has regionally imbalanced water supplies. On average, water prices charged by Iran's 14 independent Regional Water Boards cover 97% of operating costs, but are too low to cover capital costs. This does not give sufficient incentive to conserve water or to switch to less water intensive agriculture and crops. It also creates budgetary problems, which affect the maintenance of the irrigation system, reducing water availability of.

10. In addition to these economic/efficiency costs of poor water use, excessive use of water also has led to environmental degradation in the form of increased salinization and waterlogging where there is poor drainage, and increased runoff and water erosion. There are now 2 million hectares of saline land in Iran (annual increase is 100,000 hectares per year), and 100,000 ha suffer from waterlogging. Water quality also suffers mainly due to excessive use of fertilizer and pesticides in irrigated areas, which is caused by price subsidies, which in the case of urea is only 5% of the import parity price.

Intersectoral Issues

11. Inter-sectoral environmental issues are developing. Industrial use of water, though small (about 3%), produces toxic discharge of heavy metals which pollute water used for agriculture. This is causing concern as heavy metals could build up in the soil and ground water, and become concentrated in the food chain with a negative impact on the health of the population. Similarly, industrial air emissions of copper and SO_2 from the copper smelter at Sarchasmeh are adversely affecting agricultural production near the smelter. Soil erosion in rural areas are leading to accelerated siltation of water reservoirs used for urban water supply as in the case of Sefid-Roud Reservoir which supplies Tehran. These inter-sectoral issues will require greater attention when investments are made in the future, and for this the Department of Environment (DOE) needs to strengthen its policy analysis and environmental assessment review capacity.

Protecting National and Global Heritage

12. Iran has a rich natural and cultural heritage, which are of global significance. The ancient Iranian Empire extended from Greece to India and Iran was on the silk route between the West and the Orient. This rich history has produced numerous archeological sites, which are of national and global significance. Some of the sites are already well known such as the Susa hill, excavated by French between 1886 and 1979, and where the tablet depicting Hamurabi's Code of Law was discovered, and Takht-e-Jamshid (Persepolis) near Shiraz. However, there are many other important archaeological sites, which are not yet excavated. Several of these were destroyed during road construction e.g. Tappeh Giyan dating back to 5th millennium BC. More careful review of archeological sites are needed as a part of the environmental assessment of development projects.

13. Iran's biodiversity and natural heritage is also rich because it is at the junction of four major geo-ecological regions. Accordingly, Iran possesses the most diversified biological region amongst the south-western Asian countries. It supports some 7,000 plant species, 500 species of birds, and 148 species of mammals. Iran is one of the centers of origin of commercially important plants such as wheat, and is therefore particularly rich in biological diversity of commercially important plant species. Iran has been in the forefront of biodiversity conservation and the international convention for wetlands protection, the Ramsar Convention, was first formulated in Iran at Ramsar on the Caspian coast. The wetlands of Iran are particularly important as they are the resting grounds for several important migratory birds such as the Siberian Crane, Flamingoes, and Pelicans. Threats to this heritage, include activities such as uncontrolled grazing, hunting, mining and road construction. Iran also borders two important international waters, the Caspian Sea, which is the source of the world famous caviar, and the Persian Gulf, which has been the center of equally famous pearl fisheries since the antiquities. These waters are facing pollution from international sources. Support for biodiversity protection of National Parks/wetlands such as Urumieh, Shardigan, and Harmoun, the reduction of greenhouse gases from transport sources, and prevention of the pollution of international waters (Caspian Sea and Persian Gulf) should be considered from international sources such as the GEF, because of the substantial international environmental benefits.

Legal and Institutional Framework

14. Policy makers in Iran have expressed a strong commitment towards protecting the environment. Articles 45 and 50 of the new Constitution of the Islamic Republic of Iran (approved in December 1979) express this strong commitment in a formal manner, giving the Government wide ranging authority and obligations to protect the environment, with Article 50 focusing on protection of environment, in general, and the article 45, on the protection and management of natural resources, such as soil, water, forests, and rangelands. In addition there are 14 laws and regulations covering various aspects of the environment, including the Environmental Protection and Enhancement Act of 1975, which designates DOE as the authority for controlling activities harmful to environment. In addition, several laws are under preparation. However their effectiveness has been limited for several reasons. First, there is insufficient emphasis on prevention of problems through prior review of investment proposals and designs, which need to be linked to existing procedures for environmental screening and assessments. Second, in carrying out environmental assessments greater emphasis is needed on proper evaluation of alternative designs including those that would minimize waste, emissions and discharges. Third, there is a need for greater emphasis on an integrated approach towards minimization of waste, emissions, and discharges, so that reduction in the pollution of one environmental medium does not lead to the increased pollution of other media. Fourth, resources for monitoring and enforcement of existing standards are

inadequate, and the use of economic incentives to encourage environmentally responsible behavior is limited. And fifth, public education and awareness concerning existing environmental standards and regulation is lacking.

Priority Action Plan and Recommendations

15. The list of actions and investments needed is long and is dealt with in detail in the main report and the twenty volumes of background papers mentioned in Annex 1. However, in view of the financial constraints and implementation capacity limitations, in the short to medium term it is essential to focus on the highest priority actions. These actions have been chosen on the basis of a criteria which maximizes health benefits, sustains development, and prevents irreversible loss of heritage at the minimum economic cost to the economy. These are discussed below.

Action 1. Phase-out implicit price subsidies of polluting substances, such as fossil fuels, by March 1998. (Ministries of Planning and Finance). Following this, the Government should begin to levy pollution charges to internalize the external environmental costs. Strengthening environmental information system and analytical capacity (Action 5) would an provide appropriate basis for implementing pollution charges. Funds collected from such charges should be put into an environmental fund for improving environmental quality (DOE).

Rationale: Burning of fossil fuels produces harmful emissions such as SO_2, NOx, and particulates. The level of these emissions in Iran's major urban areas is already much higher than maximum recommended levels, and it is projected that by the year 2010, about 45,000 additional premature deaths per annum would result from such emissions. Improving incentives for conservation of energy would moderate the increase of demand for these fuels. It will improve incentives for investments in more energy efficient vehicles, appliances, industrial processes, and thermostats, which have high economic rates of return, but would not be seen as advantageous by consumers unless price subsidies (currently about 90% of the border prices for the consumption of fossil fuels) are reduced. The reduction of subsidies will have both environmental and economic benefits. It will reduce projected premature deaths by about 13,000 per annum and will have net economic benefits (due to fuel savings, which can be exported) of about $4.7 billion per annum. Safety net arrangements should be in place to mitigate negative social impacts (para 17). The safety net arrangements can be funded from increased revenues. Other polluting substances such as pesticides, which are also subsidized, should also have their price subsidies removed. This will provide incentives to farmers to switch to less polluting and more economic, Integrated Pest Management (IPM) techniques.

Action 2. Progressively substitute more polluting fuels such as high sulfur oil by natural gas (Ministry of Petroleum). The first step should be to switch thermal power stations in major urban areas such as Tehran, Tabriz, and Isfahan from fuel oil to natural gas by March 1997 (Ministry of Energy).

Rationale: Iran has the second largest reserves of natural gas in the World. Because of transportation difficulties for export markets (high investment costs for pipelines and LNG carriers), the opportunity cost of natural gas is amongst the lowest of all fossil fuels. It is also the cleanest burning. Therefore by switching from other fossil fuels, it is projected that by the year 2010 Iran can reduce annual premature deaths by 21,500 and at the same time get net economic benefits of about $2 billion per annum.

Action 3. Implement a priority investment program of projects of the "win-win" type, that is investments that will bring both environmental and economic benefits. This includes projects for watershed and forestry management (Ministry of Jehad), natural gas flaring reduction (Ministry of Petroleum), transport efficiency and environment management (Tehran Municipality), and electric power efficiency including natural gas based co-generation (Ministry of Energy).

Rationale: Soil erosion is estimated to cost the economy about $500 million per year as both the sustainability of agricultural production and urban water supply are affected. Watershed and forestry projects would have high priority as they would meet three of the Government's high priority objectives, environment, growth, and poverty alleviation. Similarly, other projects such as the natural gas flaring reduction, transport efficiency and environmental management, and electric power efficiency projects, have high priority as they will meet both environmental and economic efficiency objectives.

Action 4. Address water pollution problems from the urban household and industrial sectors through reform of water pricing, institutional framework, and efficient investments. Detailed preparation of the Tehran Sewerage Project is on-going and it should be possible to complete preparation by December 1995 (Tehran Water and Sewerage Authority and Tehran Municipality). Along with the investment preparatory work, water sector studies should be launched and the water master plan updated.

Rationale: Although drinking water quality is adequate in most cities, waste water treatment is not. This creates problems for the rural sector as it affects quality of agricultural output. It also pollutes ground water. The problem is especially severe in Tehran, Mashad, and Tabriz as they lack central waste water treatment capacity. Charges for the service would need to be levied to assure that there is sufficient incentive for conservation and recycling (especially in the industrial sector) as well as to assure financial resources for adequate operation and maintenance. The institution would need to be run on a commercial basis to assure cost-effective investment and operation. Arrangements for safe disposal of solid waste and liquid hazardous waste would need to be made in conjunction to avoid their being dumped in the waste water and overloading the waste water treatment capacity. Safety net provision would be needed along with water price reform.

Action 5. Strengthen environmental institutions, in particular the Department Of Environment (DOE), through staff training, formulating and implementing regulations for environmental impact assessment, and establishing a high quality environmental information system which would provide the basis for environmental impact assessment and the creation of greater environmental awareness. Local environmental training and education capacity should also be strengthened. Following this, DOE should initiate regional environmental studies to provide analytical basis for its coordinating role in multi-municipal situations. Detailed project preparation should be done by DOE during 1994, with a view to start implementing a project in 1996. Financial assistance for project preparation could be requested from the UNDP.

Rationale: While pricing reforms will provide better incentives for resource conservation and pollution reduction, they will not be sufficient. It will take time to go to full price reform including pollution based charges, and in the interim greater reliance on careful monitoring and environmental assessment will be needed. Furthermore, environmental information monitoring would be needed to make pollution based charges work in the future. The quality of environmental information collection as well as its analysis and use for policy formulation would need to be strengthened.

Action 6. Implement projects to protect biodiversity (through better management of protected areas, national inventory of plant genetic resources, and biodiversity survey) ,and international water pollution mitigation (Caspian Sea and the Gulf). DOE should seek funding from the GEF for eligible investments and planning studies.

Rationale: These actions would help improve national environment management, as well as to preserve the global heritage, and would reemphasize Iran's status as a responsible member of the world community. They would also enable Iran to fulfill commitments made at the Rio conference and to participate in international conventions on biodiversity protection and global climate change.

16. The above list of actions are only the highest priority actions to be taken in the short to medium term. There are many more priority actions that need to be taken, such as air pollution mitigation in the metallurgical industries and refineries, SNCR technology in power plants, which are mentioned in greater detail in the main report and background papers. The actions mentioned above, especially policy reform, would not be easy to take, and implementation considerations to assure acceptability and sustainability of these reforms are discussed below.

Implementation Considerations and Social Impact

17. The main problems would be the social impact of implementing pricing reforms for fossil fuels and water. While raising prices to reflect true cost would assure environmental and economic efficiency, the price increases may have negative social consequences as the poor and even the middle class, who are already suffering from the consequences of inflation, would need to pay more in the short term for these commodities, while the supply response due to greater economic efficiency will only be apparent in the medium to longer term. There is also a danger of policy reversal as the price increase may not be acceptable to a large section of the population. To avoid the social consequences, the Government should consider a broad-based social safety net or income supplement scheme, which would ensure that the majority of the consumers do not have any negative financial consequences, as long as they do not increase their consumption of these commodities either directly or indirectly (in the form of electricity). For instance, the current consumers could be given coupons or income supplements to cover the cost of the increase in the price of water and electricity, based on their past consumption levels (and not the future levels). This will assure that for those that do not change their consumption levels, there will be no net impact on income, whereas those that reduce consumption will improve their financial position. An upper limit on coupons or income supplements could be placed.

ISLAMIC REPUBLIC OF IRAN

ENVIRONMENTAL STRATEGY STUDY

Chapter 1: DEVELOPING ENVIRONMENTAL STRATEGIES

A. Introduction

1.1 Iran has embarked on a fundamental transition to a more market-oriented economic system. The actions and policies to support these goals need to be intricately linked to those for improving the quality of the environment. In this regard, an environmentally benign and economically sustainable development strategy should become a major underlying objective of the Government's future strategy for the economic transition, and the next Five-Year Plan.

1.2 Pollution, environmental degradation, and poor natural resource management are problems throughout Iran, although the extent and types of problems vary greatly around the country. Heavy industrialization, vehicle use, and urbanization contribute to air pollution problems in Tehran, and to a lesser extent in other cities such as Isfahan, Tabriz, and Mashad, while inefficient agricultural development has damaged rangelands, croplands, and forests in the countryside. Ground water pollution is a growing problem in most cities because of the lack of municipal waste water treatment facilities.

1.3 With a population growth rate of about 3% per year, environmental problems are likely to become more significant in the future, unless measures are taken to improve environmental and natural resource management. The urban population accounts for 57% of 1993 population of 62 million. This is expected to increase to 60% by 2003 because of rural migration, so urban related environmental problems such as air pollution will require relatively more attention. This is discussed in Chapter 2 on the mitigation of air pollution, which shows that air pollution in most of the major cities is already serious, mainly due to excessive consumption of fossil fuels, use of more polluting fossil fuels, and the use of old and often inefficient technology in the metallurgical and chemical industries. A lack of incentives and adequate training are also problems contributing to inefficient operation and maintenance in industries, which increases pollution problems.

1.4 The rural environmental problems are mainly those of sustainable natural resource management and this is dealt with in Chapter 3. Deforestation, over grazing, and conversion of marginal rangelands to croplands are contributing to increased soil erosion and desertification. Because of the loss of nutrients and productivity Iran loses about $500 million a year. Economic policies which gave more incentives for conversion from rangelands to croplands contributed to this problem, along with insecurity of land tenure. Water resource use is also causing concern. Most of the water (over 90%) is used in rural areas, and while overall water balance is still positive, unsustainable extraction of ground water is developing in some areas. Inter-sectoral problems are also developing. While the industrial use of water is small (about 3%) toxic discharges of heavy metals into water used for agriculture is causing concern as heavy metals could build up in soil and ground water, as well as get concentrated in the food chain with negative impact on the health of the population. Strategies for dealing with this problem are also discussed in Chapter 3 on sustainable management of land, water and marine resources.

1.5 Overall, the Environmental Strategy Study provides an overview of the specific environmental problems of the country to assist the Government in developing its own National Environmental Action Plan. The study :

a. identifies the types of pollutants, their main sources and locations, and their primary impacts, with a view to clearly defining and prioritizing existing pollution problems;

b. analyzes the causes of existing environmental degradation including both policy and institutional factors;

c. reviews the existing framework for environmental management (i.e., the legal and regulatory framework, the institutional framework, and the economic framework);

d. provides recommendations to the Government on setting priorities in the environmental field based on cost considerations, and on policies and strategies for reducing existing levels of pollution and environmental degradation; and

e. identifies high priority programs for strengthening of environmental and natural resource management (aimed at both government and nongovernment organizations) which could be financed by the World Bank and/or other donors.

B. Economic Policy Framework.

1.6 Macroeconomic and pricing policies induce serious economic distortions which are, on balance, detrimental to the environment. These include heavy subsidies for energy, water , and agricultural chemicals, which lead to wasteful consumption of resources, more resource-intensive forms of production, and higher pollution. Because of the over valued exchange rate prior to 1993, when the official exchange rate was about Rls. 70 per US$ compared with a market rate of about Rls 1400 per US$, the price of primary energy products and electricity was also low. While exchange rate has been adjusted to market levels, the energy price adjustments are lagging, and local prices are about 10% of the border prices. As discussed in Chapter 2, the low energy prices don't give sufficient incentive to the people and industry to conserve energy and invest in energy efficient processes, equipment, and vehicles. Wasteful energy use is not only a loss to the economy. It also leads to excessive emissions of particulates(TSP), sulphur dioxide(SO_2), and nitrogen oxides (NO_x) with serious health consequences. If present plans for price reform and economic restructuring are undertaken in the future, the resulting turnover in the capital stock and equipment would benefit the environment through the adoption of more environmentally benign technologies. In the meantime, however, important distortions continue to persist.

1.7 In agriculture, subsidies have led to shifts in land-use patterns and technologies, further aggravating resource degradation. These include fertilizer and pesticide subsidies due to low prices (e.g. urea farm gate prices are about 5% of the import parity price even after doubling of the farm gate prices in 1992), irrigation subsidies which have encouraged inefficient use of water (irrigation efficiency is about 25-30%), exchange rate and credit subsidies which have favored mechanization of agriculture, (the number of tractors tripled during the 1980s), and input subsidies for cereal/wheat which have led to conversion of rangeland to cropland at the rate of 1.5% per year during the 1980s.

1.8 For irrigation water, prices are set on the basis of the gross income per hectare for each crop (averaging 4% of gross income), and thus bear no relationship to the costs of supplying water in different areas. Since agriculture accounts for over 90% of Iran's water use, this is a serious distortion for a country which suffers from shortage of water supplies in most parts of the country. Moreover, irrigation subsidies further distort agricultural land-use patterns. On average, water prices charged by Iran's 14 independent Regional Water Boards cover 97% of operating costs, but are too low to cover capital costs. In addition to economic efficiency costs, this also encourages over use of water leading to environmental degradation.

C. Legal Framework.

1.9 Policy makers in Iran have expressed a strong commitment towards protecting the environment. Articles 45 and 50 of the new Constitution of the Islamic Republic of Iran (approved in December 1979), express this strong commitment in a formal manner, giving the Government wide ranging authority and obligation to protect the environment, with article 50 focusing on protection of environment, in general, and the article 45, on the protection and management of natural resources, such as soil, water, forests, and rangelands, in particular.

1.10 The Article 50 states:

> "In the Islamic Republic of Iran, protection of the environment, in which the present and future generations must lead an ever-improving community life, is a general obligation. Therefore, all activities, economic or otherwise, which may cause irreversible damage to the environment, are forbidden."

1.11 The Article 45 of the Constitution further authorizes the Government to approve legislation concerning the protection and utilization of natural resources, such as seas, lakes, rivers, other public bodies of water, mountains, rangelands, and soil, which are regarded as national and public properties.

1.12 Laws: Even prior to the promulgation of the new Constitution and its environmental articles, Iran had several laws concerning environmental protection and they continue to be valid. In addition to the Constitutional provisions, the main rules and regulations of Iran, dealing with environmental protection are as follows:

a. The Municipality Law of 1965, as amended in 1973: This is the first law in Iran with reference to air and noise pollution. It also requires Municipalities to designate and announce locations for solid waste disposal (including sewage sludge and construction debris). Most of the provisions regarding air pollution have been superseded by later laws. However, the responsibility for air pollution control within city limits is still delegated to the Municipality (Section 55, item 20), which has the authority to relocate polluting industries to less densely populated areas and to demolish them within the city limits.

b. The Game and Hunting Law of 1965, amended 1974 : The Law regulates wildlife and fisheries management to prevent over-exploitation. DOE is made responsible for establishing appropriate standards and issuing permits. The responsibility for the management of marine fisheries has been delegated to a Government owned fisheries company (Shillat) following a subsequent law on unauthorized fishing (1979).

c. Coastal Zone Properties Act of 1967 : prohibits private ownership and exploitation of coastal zone and wetlands. The coastal zone is defined as marine shoreline extending 60 meters from the high tide level.

d. Protection and Utilization of Forests of 1967, amended 1975 : The Law regulates the protection of both forests and rangelands.

e. The Plant Protection Rule of 1967: The Plant Protection Organization (PPO) is given the responsibility to i. publish list of permitted chemicals for plant protection; ii. formulate procedures for safe use of such chemicals; and iii. control import, production, packaging and sale of such chemicals.

f. Environmental Protection and Enhancement Act of 1975 (EPEA): The Law was enacted shortly after the Stockholm Conference of 1972, and incorporated many of the recommendations of the Conference. It designated the Department of Environment (DOE, para 1.16), which had been created earlier in 1971, as the authority responsible for controlling any activity considered damaging to the environment (article 1).

g. The Air Pollution Control Rule of 1975, and Law of 1994 (AP) : The provisions of EPEA with respect to air pollution were further elaborated in the AP, which was approved by the Council of Ministers and a Parliamentary Committee in 1975, and the Law finally enacted in 1994. It defines the responsibilities of DOE regarding air pollution to include i. identification of sources of air pollution; ii. determination of acceptable levels of air pollution; iii. inspection and monitoring of operation of factories, businesses; iv.designation of vehicle emission monitoring centers; v. provision of technical assistance any privately operated emission monitoring center; and vi. development of programs to encourage and instruct industries to mitigate air pollution. It also prohibits the production or import of vehicles with emissions exceeding standards set by the Government.

h. The Conservation and Expansion of Urban Green Areas Law of 1980: stipulates that cutting down of trees within city limits is illegal, unless accompanied with planting of at least twice as many trees as are cut. The Municipality is responsible for implementing the law.

i. Water Distribution Act of 1982 : The Law deals with sustainable management of water focussing on both quantity and quality of water. With respect to pollution of water, the Law (#6, 46) makes the owner operators of water wells and *qanats* (traditional well/canal systems) responsible for preventing water pollution, and water supply companies to have their water purification and waste water treatment systems approved by the Government (#47). Ground water extraction by wells with discharge of more than 25 m^3 per day require permit from the Department of Energy to guard against over-exploitation of the aquifer.

j. Water Pollution Control Rule of 1984 : The rule provides the enforcement mechanism for water pollution control provisions of EPEA, focussing on monitoring, inspection, and relocation of polluting industries and other sources. DOE is given the responsibility for enforcement, with the co-operation of other Government agencies. Sewage discharge standards were set by the Environmental High Council (EHC, para 1.15) in 1993 following the recommendations of DOE.

k. Dug Well Drilling Rule of 1985 : Sewage from septic wells are required to be disposed in compliance with environmental and health considerations (#57).

l. Radiation Control Law of 1989: The Law gives the Atomic Energy Organization the responsibility to monitor, and regulate the use of radioactive substances in order to protect the current population as well as the future generations from its harmful effects.

m. Water and Sewage Companies Law of 1990 : The Law gives the responsibility for the collection, treatment and disposal of sewage to each Province's water and sewage company.

n. Environmental Health Rule of 1992: gives the Ministry of Health and Medical Education, the responsibility to evaluate the impact of pollution on human health and to submit recommendations to the Government.

1.13 In addition to the above, several laws and regulations covering fisheries, marine environment, soil pollution, and noise pollution are presently under preparation. From the above it is clear that a large collection of laws, regulations, and standards governing environmental management exist, However their effectiveness is not as much as the Government wishes for several reasons. First, there is insufficient emphasis on prevention of problems through prior review of investment proposals and designs, which need to be linked to existing procedures for environmental screening and assessments. Second, in carrying out of the environmental assessment greater emphasis is needed on proper evaluation of alternative designs including those that would minimize waste, emissions and discharges. Third, there is a need for greater emphasis on an integrated approach towards minimization of waste, emissions, and discharges, so that reduction in the pollution of one environmental medium does not lead to the increased pollution of other media. Fourth, resources for monitoring and enforcement of existing standards are inadequate, and the use of economic incentives to encourage environmentally responsible behavior is limited. Fifth, public education and awareness concerning existing environmental standards and regulation is lacking.

1.14 Enforcement of existing environmental regulations and standards is also a problem due to limited monitoring resources. Moreover, enforcement was especially lax during the Iran-Iraq war, since many factories claimed exemptions from pollution control requirements on the grounds that they were strategically important. Consequently monitoring and enforcement have been neglected for some time and now need to be strengthened. Greater reliance on pollution fines is needed. At the moment the primary instrument to reduce environmental damages is the threat of plant closure, which is a blunt instrument and lacks credibility in cases where closure will result in significant economic dislocation.

D. Institutional Framework

1.15 The Environmental High Council (EHC) : EHC is headed by the President of the Republic and it includes two Vice-Presidents, ten Cabinet Ministers, the Attorney General, and four appointed experts as members. EHC decides environmental policies and strategies and approves environmental standards. It is assisted by four coordinating councils on different aspects of environment including councils for environmental programs, environmental research and information, environmental education and awareness, and the newly created environmental and sustainable development council. The fact that the President of the Republic himself chairs meetings of EHC, stresses the importance that Iran places on protection of the environment. Since all economic Ministers are members, it allows for broad participation within the Government while deciding on environmental policies and strategies. The Department of Environment (para 1.16) acts as the Secretariat for EHC.

1.16 The Department of Environment(DOE) is responsible for controlling any activity considered damaging to the environment (para 1.12). In addition, it serves as a coordinator, through EHC, among the many Ministries which are charged with specific aspects of environmental management. The Department has a staff of approximately 3000 nationwide, of which 270 are professionals (110 of which are in Tehran).

1.17 Sectoral Ministries and Municipalities also have units dealing with environment. In particular, the Ministry of Health, has a section dealing with environmental health issues. It has carried out monitoring of air pollution with a view to measuring its impact on human health. Similarly the Tehran

Municipality has a section dealing with environmental matters and is monitoring air quality in Tehran. Ministries of Industry and Petroleum also have environmental sections. Finally, the Planning and Budget Organization is establishing an Environment Directorate to provide an additional opportunity to integrate concern for environmental protection and natural resource management into the budget-making process during the preparation of five-year plans.

1.18 In general, the problem of environmental and natural resource management in Iran is not one of inadequate institutional structure or laws, but of other factors, such as:

a. Lack of adequate resources at the Department of Environment to effectively carry out its management and coordinating responsibilities;

b. Too little emphasis in the Department of Environment towards controlling urban related pollution problems as compared to the protection of the natural environment;

c. Decline in number of specialists with graduate level training from 53 in 1978 to 5 in 1993;

d. Lack of economic incentives to reduce pollution and prevent natural resource degradation; and

e. Lack of awareness in many sectoral Ministries concerning environmental and natural resource management because of inadequate inter-ministerial and intra-ministerial coordination.

Resource Planning and Cross-jurisdictional Issues

1.19 Air and water pollution cross administrative boundaries. For instance, emissions from power plants and refineries just outside Tehran municipality do affect the population within Tehran municipal boundary. Similarly, untreated sewage from within the city pollutes agricultural areas to the south of the city. Similar issue affects use of fresh water, which for major urban areas such as Tehran, has to be brought from other administrative areas. The National Water Plan had envisaged a Bureau of Water Planning in the Ministry of Energy and a water planning division in each Regional Water Organization. The jurisdictions of these Water Boards are coterminous only in some cases with the hydrographic or river basins. For instance, the Tehran Water Board's jurisdiction extends beyond the boundaries of the Tehran province and covers, apart from the Karaj and the Jaj-e-Rud rivers flowing towards the south, rivers like the Lar as well, flowing toward the Caspian Sea. The Regional Water Boards, under the Ministry of Energy have the mandate for allocation of water among irrigation, drinking water supply and other uses. Priority allocation was considered to be an important policy and management instrument by the National Water Plan. Such priority allocation was also considered essential to meet drinking water supply needs in several locations of the country. The Boards are also part owners of the water supply and sewerage companies as in the case of Tehran.

1.20 Water quality standards, however, are set up and monitored by the Department of Environment. Based on these standards, the Tehran Water Board has to determine the water supply and waste water loads for the different parts of the metropolitan region. Apart from the Tehran region, water quality problems have been identified in other urban areas and river basins as well, in the country. The 1978 Water Plan listed 25 major urban locations in 6 of the 8 hydrographic regions (Tehran, Tabriz, Bandar Abbas etc.) as having significant raw water quality problems. Schools of Public Health in Tehran and other universities supervised by the Ministry of Health have identified heavy metals pollution in ground water and endemic fluorosis as serious problems in many parts of the country. Isfahan, Shiraz, and Mashed as well as smaller cities like

Kerman, Nehavand and Birjand are affected by water pollution. While untreated industrial discharges are considered to be a major source of pollution in some cities, contaminant migration in ground water is caused significantly by untreated sewage. In addition, the use of fertilizes and pesticides in Iran has been high, resulting in heavily polluted runoff from agricultural fields.

1.21 The Institute of Standards and Industrial Research have established norms for waste water discharges by industries. The stream quality standards as well as norms for municipal waste discharges are determined by the Department of Environment. The Ministry of Construction (Jihad-e-Sazandegi) is responsible for rural water supply, while water supply and sewerage companies have this responsibility in urban areas. The concern of the Ministry of Agriculture with water quality is limited to its application in irrigation use.

1.22 Though a number of organizations are thus involved in issues of water quality an organizational mechanism for their coordination to ensure water quality in any given region is not available. In the event, some activities may be subjected to strict adherence without much benefit to the overall situation. For instance, in the northern part of Tehran municipality, small area of about 2000 dwelling units is served by a sewerage system with activated sludge treatment plant. The Plant has been working well and achieving a treated effluent of only 20 B.O.D. but this treated effluent, which is comparable to potable water, is discharged into a polluted drainage canal thus rendering the treatment plant redundant. To cite another example, in the Varamin irrigation area it is reported that farmers continue to use the water from the Firuzabad and Soorke Hissar canals, which are heavily polluted but also carry nutrients. Additionally, the water from the Jaj-e-Rud irrigation canal and tubewells is also used. These examples serve to illustrate the need to relate water quality standards to field conditions and devise financial, regulatory and organizational arrangements to secure their compliance.

Recommendations

1.23 Environmental Institutions, in particular the Department Of Environment (DOE) should be strengthened, through staff training, formulating and implementing regulations for environmental impact assessment, and establishing a high quality environmental information system which would provide the basis for environmental impact assessment and for creating greater environmental awareness. Local environmental training capacity should also be strengthened. Detailed project preparation should be done by DOE during 1994, with a view to start implementing a project in 1995. While pricing reforms will provide better incentives for conservation of resources and reduction of pollution, they will not be sufficient. It will take time to go to full price reform including pollution based charges, and in the interim greater reliance on careful monitoring and environmental assessment would be needed. Furthermore, environmental information monitoring would be needed to make pollution based charges work in the future. For this it is necessary to strengthen the quality of environmental information collection as well as its analysis and use for policy formulation. For co-ordination on air and water quality issues in multi-municipal situations, DOE will need to play a greater role. Following the strengthening of DOE capacities, regional environmental studies should be implemented to provide the analytical basis for EHC and DOE's coordinating role.

Chapter 2: MITIGATING AIR POLLUTION

A. Overview

2.1 With a population growth rate of 3.2% per year, environmental problems are likely to become more significant in the future, unless measures are taken to improve environmental and natural resource management. The urban population of about 33 million in 1993 already accounts for 57% of the total and this is expected to double by year 2010. Therefore environmental problems such as air pollution will require relatively more attention. As discussed in this chapter, air pollution in most of the major cities is already serious, Monitoring data indicate that annual average ambient air concentrations in Tehran of SO2, NOx, TSP and lead by far exceed WHO and World Bank guidelines (40 to 340% over maximum allowable values). Even in other cities such as Mashad, Tabriz, Isfahan, and Ahwaz, the concentration of TSP is consistently in the range of 200-400 ug/m^3, which is 2 to 4 times World Bank recommended maximum value.

2.2 The poor urban air quality is mainly due to excessive consumption of fossil fuels, use of more polluting fossil fuels, and the use of old and often inefficient technology in the metallurgical and chemical industries. A lack of incentives and adequate training are also problems contributing to inefficient operation and maintenance in industries, which increases pollution problems. Current projections show that the problem will become more serious in the future, and by year 2010, about 45,000 additional premature deaths will occur unless actions are taken now to reduce the pollution of air (Section C and Annex 2). Fortunately, several "win-win" solutions, i.e. those that will bring both net economic benefit as well as environmental benefits, are available, so that the economic burden on the economy is reduced. These options include efficient energy pricing, which will reduce premature deaths by about 13,000 per annum and will bring additional economic benefit of $4.7 billion due to fuel savings. Similarly another option, reducing gas flaring and substituting the use of high sulfur fuel oil by natural gas will prevent an additional 21,500 premature deaths annually. Reduction of gas flaring would also have a high economic rate of return in excess of 30% per annum.

B. Air Quality and Health Impact

2.3 Monitoring data, by Environmental Health Department and Department of the Environment, indicate that annual average ambient air concentrations in Tehran of SO2, NOx, TSP and lead by far exceed WHO and World Bank guidelines (Table 1).[1] While levels of HC, and CO are also high, currently WHO and World Bank guidelines do not exist.

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1 The monitoring data are incomplete. Concentrations were not monitored or reported for all twelve months.

Table 1: Air Pollution Concentration
(annual averages in Tehran 1989-91)

		Average Concentrations	Guidelines* WB	WHO	% above guideline WB	WHO
SO_2	ug/m^3	140	100	40-60	40%	130-250%
NO_2	ug/m^3	250	100		150%	
TSP	ug/m^3	180	100	60-90	80%	100-200%
Pb	ug/m^3	2.2		0.5-1.0		120-340%
CO	ppm	11				
HC	ppm	10				

* WB is World Bank's guideline; WHO is World Health Organization's guideline.
Sources: DOE and EHD (Iran).

2.4 The monitoring data presented in Table 1 do not reveal the large differences in concentrations across Tehran. Monitoring by the Environmental Health Department indicates that SO2 concentrations vary by as much as a multiple of 2.5 and TSP by 4 from the north district to the center and south district of Tehran (Table 2). Likewise, concentrations of lead are as high as 10 times WHO guidelines in some sampling sites. Since more of Tehran's urban poor live in the Southern parts of the city, the poor bear a higher burden of the health impact of air pollution.

Table 2: Variations in Ambient Air Quality in Tehran
(ug/m^3)

	SO_2	TSP
District 1 (North)	168	53
District 12 (Center)	443	198
District 17 (South)	309	227

Source: Environmental Health and Sustainable Development (1993) - Iran.

2.5 Ambient air concentrations of SO2 and TSP have been monitored in other cities of Iran such as Mashad, Tabriz, Isfahan and Ahvaz in recent years by the Environmental Health Department. Annual average concentration levels of TSP are consistently in the range of 200-400 ug/m^3 at the sampling sites in these cities, while SO2 concentrations are below or very close to WHO guidelines. The reasons for the large difference in concentration levels of TSP and SO2 are likely to be the high levels of particulate from natural sources, that the monitoring station in for instance Isfahan is near the steel and cement plants which release large amounts of fugitive TSP at ground level. However, as populations in these cities are growing at over 5% per annum, the air pollution could double over the next 10 to 15 years. Therefore preventive and mitigative actions is required in the secondary cities also along with better monitoring of air pollution.

2.6 High ambient air concentration levels of pollutants such as TSP and SO2 are associated with higher rates of respiratory problems and premature deaths (Dockery et al 1993, Ostro 1992, Pope et al 1991). A preliminary study in Iran shows a high correlation between high ambient air concentration levels of TSP and SO2 and headaches and bronchitis in school children in Tehran (Annex 1, Environmental Health 1993). Nitrogen oxides can also cause direct health problems as well as indirect ones by creating ozone which also causes respiratory problems and is considered to be carcinogenic. The most serious health impacts of lead emissions are neurodevelopmental effects in children that impair their intelligence, and hypertension and related cardiovascular conditions in adults. High concentration levels of CO reduce the oxygen carrying capacity of the blood, and can cause headaches, fatigue and reduced mental alertness.

Contributing Factors

2.7 Almost all economic activities require energy inputs, and thus inevitably cause air pollution and/or environmental degradation. The level of pollution depends critically on the following factors:

- level of GDP;
- sectoral composition of GDP;
- input mix in production processes (energy vs. capital and labor);
- type of production processes;
- energy fuel mix;
- efficiency of energy using equipment and appliances;
- pollution abatement equipment;

2.8 These factors are influenced by economic as well as environmental policies. An acceptable rate of economic growth does not necessarily have to be at large costs to public health and the environment. Some policies, in fact, can contribute to growth as well as reduced pollution, and other policy options are often available to reduce pollution at very low cost.

Energy Consumption

2.9 Domestic consumption of energy has increased at a high rate in Iran in the past 15 years. The annual growth in final energy consumption was 5.7% over the period 1977-91 or 118% in total. The largest growth occurred in the residential/commercial sector with increased provision of electricity and use of home appliances, and expansion of the service sector. The residential/commercial sector is now the largest energy consuming sector, followed by transport and industry. The relatively low energy growth rate in the industrial sector was due to the low output growth in this sector during the 1980s when imported inputs and parts were scarce (Table 3).

Table 3: Energy Consumption (1977-91)

	1977		1991		1977-91
	Mboe	%	Mboe	%	Annual Growth
Final Energy					
Residential/commercial	60	29%	161	36%	7.4%
Transport	58	28%	106	24%	4.4%
Industry	56	27%	106	24%	4.7%
Agriculture	11	6%	34	7%	8.3%
Others	20	10%	35	8%	4.6%
Total	205	100%	442	100%	5.7%
Primary Energy					
Petroleum products	179	80%	353	67%	5.0%
Natural gas	27	12%	154	29%	13.3%
Hydro	7	3%	11	2%	3.3%
Solids	12	5%	10	2%	-1.3%
Total	225	100%	528	100%	6.3%

2.10 The growth in final energy consumption was significantly higher than GDP growth during the last decade. Data from the Central Bank of Iran on energy consumption and from the World Bank on GDP growth suggest that energy intensity increased in the order of 50-60% from 1980-91 or annually by 4.2%, which is significantly higher than in the average lower-middle income economy.

2.11 The large increases in final energy demand during 1977-91 was met by increased domestic supply of petroleum products and natural gas. Hydro and solid (coal and fuel wood) energies play an insignificant role in total energy consumption. Petroleum product consumption in primary energy grew at an annual rate of 5%, while natural gas consumption grew at more than 13% per year and now contribute almost 30% to primary energy consumption (Table 3). Consumption of natural gas in 1991 was 54% of total energy consumption in the power sector, 42% in industry and 20% in the residential/commercial sector. The relatively low percentage in the residential/commercial sector is primarily because the gas grid has not yet reached rural households (43% of population) while most power and large industrial plants are along the grid. Secondly, the household connection charge of Rls 200,000 may discourage poorer households from using natural gas.

2.12 The energy intensity (koe/GDP) in Iran in 1991 was 0.50 according to World Development Report 1993 (WDR '93), which compares favorable to the average of lower-middle income economies at 0.69. But cross-country comparisons are subject to the exchange rate problem in converting GDPs to a common currency. The official exchange rate in Iran was until recently substantially overvalued. Conversion at this exchange rate would indicate a relatively low energy intensity as presented in WDR '93. However, if GDP in 1992 is converted at the floating exchange rate, the energy intensity (koe/GDP) was about 1.30 which is almost twice as high as the average lower-middle income economy (Table 4).

Table 4: Energy Intensities (koe/GDP)- 1991[1]

Middle income economies	0.54
Lower-middle income	0.69
Upper-middle income	0.48
Morocco	0.24
Tunisia	0.37
Turkey	0.45
Algeria	1.00
Bulgaria	1.90
Iran (lower-middle income)	
(1991)[1]	0.50
(1992)[2]	1.30

[1] World Development Report 1993.

[2] GDP converted at the floating exchange rate of Rls 1400 per dollar (May 1992).

Industrial Sector

2.13 The industrial policy has been one of import substitution in favor of relatively heavy polluting industries, quantitative and non-quantitative trade restrictions have been severe, the exchange rate in Iran has until recently been heavily overvalued, and real energy prices have been declining substantially through the 1980s and early 1990s. The low energy prices have induced very little incentive to conserve energy and improve efficiency in all sectors of the economy. This issue will receive further discussion in a later section. At this point, the industrial policy, and trade and macroeconomic distortions will be discussed. Overvalued exchange rates and other anti-export policies have also constrained the growth of industries in which Iran may have comparative advantage, such as more labor intensive industries that are often less polluting. The anti-export bias has also reduced the foreign exchange supply.

Transport Sector

2.14 Air pollution from transport is a serious problem in Tehran, in particular of NOx, CO, HC and lead. Demand for motorized private transport does almost universally increase with higher levels of income, but macro, trade and industrial policies in Iran have exacerbated the problem. Most of the vehicles in Iran are domestically produced. The average age of the private vehicle and bus fleet is more than 15 years with an engine technology from the 1960s with very low fuel and emission efficiency.

2.15 The turn-over rate of the vehicle fleet is extremely low, in part because of a relatively low level of domestic production of vehicles. It is likely that production levels have been affected by the exchange rate policy and anti-export bias that have constraint the availability of foreign exchange, and thus reduced the industry's access to imported vehicle components. With the low supply of new vehicles, older and more polluting vehicles remain on the roads longer than otherwise. Furthermore, import restrictions have been high in order to protect the domestic automobile industry. This policy has contributed to very limited access to foreign vehicles that are less polluting, and very little incentive for domestic auto producers to improve fuel efficiency. Of course, if trade restrictions were removed, the total number of vehicles is likely to increase, and counteracting measures, such as higher gasoline prices and increased public transport, could be needed to control pollution.

Electricity Generation.

2.16 The power sector remains a significant source of SO_2 and NOx emissions, despite large conversions to natural gas in this sector. Macro, trade and sectoral policies impact pollution from the power sector for the most indirectly through impacts on aggregate energy consumption and electricity demand in Iran.

2.17 If these policies have resulted in a more energy intensive economy, pollution from the power sector is higher than otherwise. But sector specific policies also contribute to a higher level of pollution from the power sector. An example is the policy of using high sulphur fuel oil in several of the power plants.

Residential/commercial Sector

2.18 The residential/commercial sector is the largest energy consuming sector in Iran, but the fuels consumed are relatively cleaner than those consumed in the industrial and power sectors and increased use of natural gas has reduced air pollution. However, low energy prices and lack of energy conservation measures have contributed to a higher level of energy consumption and air pollution.

Sectoral Air Emissions

2.19 Annual emissions of main air pollutants have increased significantly in Iran with the more than doubling of energy consumption during 1977-91. Estimates based on industrial structure, processes, and production, and sectoral fuel and natural gas consumption in 1991, place aggregate SO2 emissions at about 860 thousand tons per year, NOx at about 550 thousand tons, TSP at about 220 thousand tons and lead emissions at about four thousand tons. The sectoral contribution of each pollutant differs substantially across pollutants (Table 5). In addition, emissions from natural gas flaring are in the order of 370,000 tons of SO2 and 20,000 tons of NOx. About 55% of these emissions are from off-shore and 45% from on-shore sources. The on-shore sources of these emissions are in the province of Khuzestan with a population of 3.2 million of which 1.2 million are rural.

Table 5: Air Emissions from Sectoral Sources (1991)
('000 tons)

	Res/comm	Industry	Agricul	Transp	Power	Total
SO2	45 (5%)	452 (53%)	37 (4%)	31 (4%)	293 (34%)	859
NOx	36 (7%)	98 (18%)	36 (7%)	185 (34%)	191 (34%)	546
TSP	30 (14%)	105 (48%)	12 (6%)	24 (11%)	46 (21%)	217
Pb		1.0		1.0-4.0		2-5

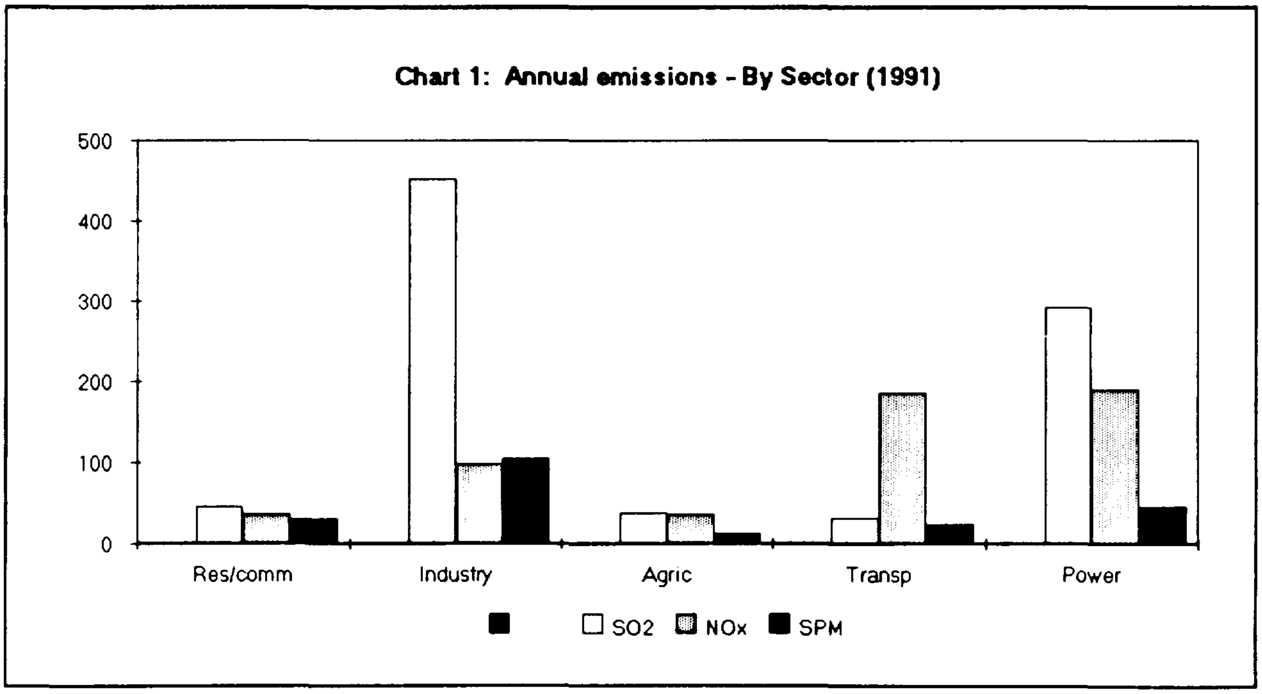
2.20 The high level of SO2 from the industrial sector (Chart 1)is in large part due to refineries and metal industries; about 40% of industrial SO2 is from refineries, and about 25% from the Sarcheshmeh metal smelter. The remaining 35% is distributed among the remaining industries. The high level of SO2 from the power sector, despite the fact that more than 50% of energy consumption is natural gas, is due to use of large amounts of heavy fuel oil with a sulphur content of about 3%.

2.21 About 70% of annual NOx emissions are from the transport and power sectors. NOx emissions per unit of energy from fossil fuels are substantially higher in the transport sector relative to industry, agriculture and residential/commercial sectors. In particular, the NOx emission coefficient per unit of fuel for diesel consumption in the transport sector is believed to be about twice as high as for gasoline, and natural gas conversion in the power sector is likely to significantly reduce NOx emissions in that sector by about 20% without low NO_x burners.

2.22 The high level of TSP from the industrial sector is primarily from the steel industry and cement plants, estimated to about 70% of total industrial emissions. Emissions from diesel consumption in the transport sector could well be higher than presented in Table 5, but emission tests of diesel vehicles in Iran would be needed to confirm this.

2.23 Also emissions of mercury, copper, fluorine, and aluminum and other hydro carbons are occurring, mainly from the industrial sector (See Annex 3).

Note: Emissions are in thousands of tons per annum, and exclude emissions from gas flaring of about 370,000 tons of SO_2 and 20,000 tons of NO_x.



Energy Prices and Subsidies

2.24 The high growth rate in energy intensity in Iran has significant environmental and economic costs. Low energy prices, relative to world prices as well as relative to prices in most other developing countries, have not provided sufficient incentives for conservation (Table 6).

Table 6: Domestic Energy Prices - 1993
(as a ratio of opportunity cost)

	Petroleum Products	Natural Gas	Electricity
Residential/commercial	0.05	0.07	0.07
Industry	0.04	0.02	0.10
Agriculture	0.04		0.02
Transport	0.14[1]		
Power	0.03	0.03	

[1] Diesel 0.03; gasoline 0.17.

2.25 Total subsidies amount to US$11.4 billion (Table 7), given that domestic energy prices are almost all less than 10% of their opportunity cost or economic value, with the only exception of gasoline.

Table 7: Energy subsidies (1993)
(US$ billion)

Petroleum products	7.5
Natural gas	1.7
Electricity	2.2
Total	11.4

C. Projected Air Emissions

2.26 Energy demand is expected to increase substantially over the next two decades to year 2010. The growth rate will depend to a large extent on future GDP growth, economic policies and energy efficiency measures. The Government has recently introduced a series of economic policy reforms. These include substantial devaluations and subsequent liberalization of the rial in March of 1993, reductions in quantitative trade restrictions and import tariffs, decontrol of most commodity prices except a few essential commodities and energy, and privatization efforts of state owned industries (although this has proceeded at a slower rate than what the government intended). These economic policy reforms can be expected to have significant long run impacts on structure of production and consumption, and thus on energy demand. It is expected that the GDP will grow at an annual rate of 4.5% over the period 1991-2010, industry at a rate of 7.5%, agriculture at 3.5%, and services at 3.5%. If energy prices continue to be highly subsidized as at present (para 2.24), energy demand is expected to grow at about 5.7% per annum, about the same rate as in the past (Table 8).

Table 8: Energy Demand Projections (1991-2010)

	Ratio of energy demand in 2010 to 1991	Annual Growth
Res/comm	3.0	6.0%
Industry	3.6	7.0%
Agriculture	2.1	4.0%
Transport	2.1	4.0%
Final energy	2.7	5.4%
Primary energy	2.9	5.7%

2.27 The rate of growth in the residential/commercial sector is projected at a higher rate than output growth because households are expected to become increasingly energy intensive with growing incomes and increased urbanization. The rate of growth in energy consumption in this sector was in fact as high as 7.4% during 1977-91. Projected growth rate in the transport sector is the same as the rate during 1977-91. Under these energy demand projections, final energy demand will increase by a multiple of 2.7 from 1991 to 2010. Based on sectoral emission coefficients, SO2 emissions are projected at 2.6 times higher in 2010 than in 1991, TSP emissions at 2.5 times, NOx emissions at 2.7 times and lead emissions at 2.1 times higher (Table 9). Because of the high rate of increase in natural gas consumption, gas flaring is likely to be reduced to a minimum over the forecast horizon to year 2010. Emissions from flaring are therefore not included in the forecasted growth of emissions from 1991 to 2010.

Table 9: Emission Growth (1991-2010)

	Ratio of emissions in 2010 to emissions in 1991				
	SO2	NOx	TSP	Pb	Energy
Residential/commercial	2.5	3.0	2.6		3.0
Industry	2.7	3.2	2.7		3.6
Agriculture	2.1	2.1	2.1		2.1
Transport	2.1	2.1	2.1	2.1	2.1
Power	2.4	3.0	2.5		4.0
Total	2.6	2.7	2.5	2.1	2.9

2.28 Given the already high ambient air concentration levels of these pollutants in Iran, the increase will have substantial cost to the society, in terms of increased mortality and morbidity of the population (para 2.29). Such increases must be deemed unacceptable and policy options to reduce emissions at least cost must be examined.

Projected Health Impacts

2.29 A projected increase in TSP, SO2 and Pb emissions in the order of 150, 160% and 110% respectively are expected to have significant health impacts. Not only does emissions increase substantially, but the population exposed to air pollution is estimated to double from 1991 to 2010, to an estimated 35 million (50% of urban population). As the urban population increases, the geographic area of emission sources and exposed population is likely to increase. If the area increases by 50%, the average annual concentration levels of SO2 are estimated to increase by 70% (from 140 to 240 ug/m^3) and of lead by 40% (from 2.2

to 3.1 ug/m^3) as a result of the large increase in emissions. However, the average concentration levels of TSP is estimated to increase only by about 30% (from 180 to 240 ug/m^3) because of the high background level of TSP. Nevertheless, the estimated health effects of increases in TSP concentrations are still higher than effects of increases in SO2 and lead concentrations. The estimated premature deaths are presented in Table 10, based on studies of the relationship between health impacts and ambient air concentrations of TSP, SO2 and Pb in OECD countries. The estimate is conservative in so far as it does not take into account the impact of other emissions such as NOx, Hg, Cu, HC etc. where the health impact is not easily quantified.

Table 10: Annual Health Impacts of Emission Increases
(difference between year 1991 and 2010)

	Increase in annual Health Impacts		
	SO2	TSP	Pb
Premature deaths	18,800	22,900	3,350
Morbidity (person years)	7,000	120,000	86,000

Pollution Abatement Policies and Strategies

2.30 There are many alternative strategies available to reduce emissions from fossil fuel consumption. The cost of each option can differ substantially and it is therefore of importance to evaluate those that appear to involve less cost. Some reduction strategies seem more appropriate than others in the case of Iran. These include efficient energy pricing and efficiency measures, natural gas expansion and some transport sector policies. Further options, at low cost, include introducing low pollution process technology in refineries and metal industry, improved maintenance of control equipment in industrial plants, and installation of low-NOx burners and co-generation in future power plants. End-of-pipe abatement technology is often the most expensive alternative and these should have low priority, since many no cost and low cost options exist. Several of these options are listed in Table 11.

Energy Conservation Potential and Pricing

2.31 There is a large scope for energy conservation in the residential/commercial sector of both petroleum products/natural gas and electricity provided the incentive framework is improved through reduction of price subsidies. Thermostats could be introduced on individual space heaters and in housing/commercial units with central heating. Decentralized metering could be installed in buildings with central heating. Efficiency standards could be established on heaters, burners and boilers. This would all help to conserve consumption of petroleum products/natural gas. The main targets for electricity conservation should be lighting, refrigeration and air cooling which consume more than 60% of electricity. About 90% of light bulbs are domestically produced

Table 11: Pollution Reduction Strategies

Strategies	Main Benefits
Efficient energy pricing	Reduced air pollution; Increased export supply of fossil fuels; Increased government revenues; Reduced investment requirement in electricity supply;
Natural gas expansion	
Primary sectors: -residential sector -industrial sector -power sector	Reduced air pollution; Increased export supply of oil/petroleum products;
Energy efficiency standards	
-household appliances -heaters and furnaces -transport vehicles -industrial equipment	Reduced air pollution; Increased export supply of fossil fuels;
Transport sector policies	
-maintenance and tune-ups -public transport -trade and industrial policies -lead free gasoline	Reduced air pollution; Increased export supply of fossil fuels; Reduced congestion costs; Reduced incidence of traffic accidents;
Process technology	
Primary sector: -large scale industrial plants (steel, refineries)	Reduced air pollution; Reduced energy consumption; Higher product quality giving higher export income.
Abatement technology	
Primary sector: -power sector -large scale industrial plants	Reduced air pollution.

and the ballasts consume 25% of the total energy of the lamp, which is rather inefficient. Efficiency standards should be introduced on the domestically produced light bulbs. Additionally, market introduction of compact fluorescent lamps (CFLs) would result in significant energy savings. Domestically produced refrigerators (80% of the market) consume 20% more electricity than foreign models. Standardization and labeling should be introduced. Efficiency standards and labelling should be introduced on air coolers and regular maintenance and cleaning performed (see Mehr 1993). However changes in the consumption pattern in the residential sectors are likely to come more slowly because of information and financing problems. Energy efficiency gains in the industrial sector could be substantial, and perhaps more easily realized since the number of actors are fewer. It is estimated that overall technical energy conservation potential is as high as 30-50%, although this would require major investments. However, an estimated 20% of energy consumption could be saved at no or low cost. Energy savings potential is particularly high in the basic metals, non-metallic, and chemical industries which consume almost 45% of energy in manufacturing industries. These low cost investments typically have economic rates of returns far in excess of the opportunity cost of capital of 10 to 12%. Such investments, the so called "Win-win" investments could produce substantial economic benefits as well as environmental benefits.

2.32 In order for many of the above measures for conservation to be effective, an appropriate incentive structure would be established for energy consumers. At current energy prices consumers have very little incentive to conserve energy even with metering and thermostats on heaters and in housing units. Standards would also be less effective because the turn over rate of appliances, burners and boilers would be lower at low energy prices. There would also be no incentive to purchase more efficient lamps such as CFLs. A CFL costs about US$10, but lasts eight times longer and uses 20% of the energy of a regular light bulb. Its use becomes economic if electricity prices are raised above US$0.01 per kWh and also a system for collection of used bulbs is established to prevent Mercury pollution from used bulbs. At current electricity prices in Iran, there is no incentive to purchase a CFL. However, if electricity prices are raised to long-run marginal costs of US$0.06 per kWh, the annual rate of return is more than 100%. Similarly, at current gasoline prices vehicle owners have no incentives in terms of fuel savings to tune-up their vehicles regularly. Recent test studies in Tehran indicate that gasoline vehicles of age 8 years or older (90% of the fleet in 1991) would use 15% less gasoline if they are tuned-up regularly. At current gasoline prices this amounts to US$13.5 in annual fuel savings for the average owner, while the cost of a tune-up is about US$15. However, if gasoline were priced at its economic value the savings would be about US$85, or equivalent to more than five tune-ups.

2.33 Most energy sources are substantially underpriced in Iran relative to their opportunity costs. Raising energy prices would induce consumers of energy in all sectors to conserve and increase the efficiency of energy. The removal of subsidies will not immediately translate into reductions in energy demand, but it would moderate future increases in energy demand. It has also been argued that energy demand in Iran is very price insensitive due to the low cost share of energy in production cost or consumption expenditures, insufficient "market behavior" due to large state involvement, and significant constraints on technological options or availability of more energy efficient equipment and appliances. With respect to energy cost, this may be the case for marginal changes in energy prices. But if energy prices are raised to their opportunity cost, the cost share should approach that in most other countries. With respect to market behavior and technological constraints, the economic policy reforms that Iran has implemented and are likely to implement in the future will make Iran a more "open" economy with a larger degree of free markets. Thus economic agents, whether producers or consumers, are likely to have more access to more energy efficient equipment and appliances and incentives to minimize costs. This should all suggest that energy demand will become increasingly sensitive to energy prices.

2.34 Estimated reductions in energy demand depends critically on the values of the price elasticities. There is a large empirical literature that presents estimates of short and long run price elasticities for most sectors in both developed and developing countries. However, these estimates are for marginal changes in energy prices, while in the case of Iran removal of energy subsidies involve large changes in energy prices. Thus the relevant elasticities can be expected to more (absolute value) than the marginal elasticities. The values applied to Iran are in most cases in the range -0.1 to -0.15. This will reduce sectoral energy demand by 17 to 26%, and the total demand by 23%. The reduced demand for energy will reduce emissions by 18% for TSP, 18% for SO_2, and 20% for NOx and 23% for lead (Table 12).

Table 12: Impacts of Efficient Energy Pricing on Emissions

	Res/comm	Industry	Agriculture	Transport	Power	Total
SO_2	-25%	-11%	-23%	-23%	-26%	-18%
NOx	-24%	-23%	-23%	-19%	-17%	-20%
TSP	-25%	- 9%	-23%	-37%	-25%	-18%
Pb				-23%		-23%

2.35 It is clear that projected emissions in Iran in 2010, even with efficient energy prices, will be substantially higher than in 1991. But estimated reductions below 2010 baseline levels from efficient energy pricing are quite significant. The next policy option to examine is increased natural gas expansion in view of the cost and pollution reduction benefits of switching to natural gas.

Natural Gas Expansion

2.36 Increased use of natural gas in future expansion of energy supply will be environmentally beneficial. Consumption of natural gas in 1991 was almost 55% in the power sector, and about 40% and 20% in the industrial and residential/commercial sectors respectively. In view of the substantial availability of natural gas, 60% to 65% use of natural gas by the industrial and residential/commercial sectors should be feasible by the year 2010. Estimates of emissions reductions of SO2, NOx and TSP based on natural gas expansion and efficient energy pricing are presented in Table 13. Lead emissions reductions remains the same as under efficient energy pricing.

Table 13: Emission reduction from Pricing and Gas Conversion

	Res/comm	Industry	Agriculture	Transport	Power	Total
SO_2	-71%	-28%	-23%	-23%	-99%	-53%
NOx	-26%	-37%	-23%	-19%	-34%	-30%
TSP	-67%	-21%	-23%	-37%	-94%	-44%

* Emissions of HC from the res/comm sector are less than 1.5% of total HC emissions, thus the
percentage large increase is insignificant.

2.37 Total emissions of SO2 and TSP will be substantially lower than under the scenario of efficient energy pricing alone, while total emissions of NOx will be only slightly lower. Emissions of SO2 and TSP from the power sector will be almost eliminated. Total SO2 reductions are more than 50% and TSP reductions more than 40%, while NOx reductions are 30% Even with these reductions, total emissions of all the pollutants will still be higher than in 1991 (Table 14). SO2 emissions are 21% higher than in 1991, NOx emissions 85% and TSP emissions 45% higher. Thus additional measures are needed to further reduce emissions.

Table 14: Air Pollution in Iran Year 2010
After Efficient Pricing and Natural Gas Conversion
(2010 EP & NG)

	Ratio of emissions in 2010 to emissions in 1991 after EP & NG
SO2	1.21
NOx	1.85
TSP	1.45
Pb	1.62

Process and Abatement Technologies

2.38 The remaining emissions of SO2, TSP, NOx and Pb are still higher than in 1991, although significantly lower than the 2010 baseline levels. Of the remaining SO2 emissions, 86% are from industry; 38% of NOx emissions are from the power sector, 30% from transport, and 17% from the industrial sector; 72% of TSP emissions are from the industrial sector (assuming that gas flaring is stopped while expanding natural gas use), and a substantial part of all Pb emissions are from leaded gasoline. Given the distribution of emissions after estimated reductions resulting from efficient energy pricing and active natural gas conversion, the industrial sector should be targeted for further reductions of SO2 and TSP, the power and transport sectors for further reductions in NOx, and the transport sector for reductions in Pb. The costs of further SO2 and TSP reductions in the industrial sector and NOx reductions in the power and transport sectors depend on the abatement choices and the levels of targeted reductions. Costs and benefits of these technologies as well as lead free gasoline discussed in para 2.43.

D. Costs and Benefits of Emissions Reductions

2.39 **Efficient Energy Pricing:** As mentioned in para 2.34, efficient energy pricing combined with efficiency standards and investments are estimated to reduce energy demand by 23%. If domestic energy prices are gradually increased to efficient levels, i.e. to economic value of energy at end-user levels, energy consumers have added incentives to conserve energy by better "housekeeping" and investments in energy saving devices that have high economic rates of return. The net economic benefit of raising energy prices is the economic value of energy saved less investments in energy savings after both are discounted at the opportunity cost of capital of 10% per annum. The estimated average unit investment cost of annual energy saved is US$300/TOE. Total annual net economic benefits (constant 1993 US$) and emissions reductions obtained from a policy change to efficient energy pricing are substantial (Table 15). Annual energy savings (toe) are largest, and about the same, in the residential/commercial and industrial sectors. However, total net economic benefits are substantially higher in the residential/commercial sector. This is because the economic value per ton of oil equivalent consumed is higher in the residential/commercial sector (large quantities of diesel oil, kerosene and LPG compared to heavy fuel oil in the industrial sector). Net economic benefits of reduced electricity consumption are presented under the power sector in order to estimate benefits per ton of emissions reductions. Net economic benefits are the economic value of reduced electricity consumption in the residential/commercial, industrial and agriculture sectors, i.e. the long-run marginal supply cost of electricity, less investment costs of electricity savings in the same sectors. Total emissions reductions are largest in the power and industrial sectors.

Table 15: Costs / Benefits of Efficient Pricing
(year 2010)

	Emissions Reductions				Total costs (Benefits)
	SO2	TSP	NOX	Total	
	000 tons				US$ mill.
Residential/comm.	29	20	21	70	(1,369)
Industry	142	26	73	241	(494)
Agriculture	18	6	17	41	(268)
Transport	15	12	95	122	(837)
Power[1]	184	29	99	312	(1,773)
Total	388	93	305	786	(4,741)

[1] Emissions reductions result from reduced electricity consumption in the res/comm, industry and agriculture sectors.

2.40 Aggregate estimates are presented in Table 16. Total annual net economic benefits are in the order of US$4.7 billion and net benefits per ton of pollution reductions are about US$5,800 in constant 1993 dollars. Estimated health benefits of reduced pollution resulting from efficient energy pricing are also presented. It is estimated that a total of 13,250 premature deaths are avoided from reductions in SO2, Pb, and TSP.

Table 16: Costs / Benefits of Alternative Strategies
(year 2010)

	Efficient Energy Pricing		Natural Gas Expansion		Low-cost Process and Abatement Technologies	
Emissions Reductions (000 tons)						
SO2	390	(18%)	780	(43%)	445	(43%)
TSP	90	(17%)	150	(32%)	140	(45%)
NOx	305	(21%)	135	(12%)	40	(4%)
Pb	2.1	(23%)				
Economic Costs (Benefits)						
Total mill US$	(4,700)		(1,950)		150[1]	
US$ per ton[2]	(5,800)		(1,900)		240	
Health Benefits (Premature deaths avoided)						
SO2	6,500		13,100		6,600	
TSP	5,200		8,400		8,100	
Pb	1,550					
Annual Abatement Costs Saved[3] (US$ million)						
SO2	270		550		180	
TSP	220		370		340	
NOx	80		35		0	
Pb	110					
Total	680		955		520	

1 Annualized investment costs.
2 Total costs (benefits) divided by total reductions of SO2+TSP+NOx.
3 End-of-pipe abatement technology in oil-fired (3% sulphur) power plants: FGD at US$700 per ton of SO2; ESP at US$2,500 per ton of TSP; SNCR at US$250 per ton of NOx; lead free gasoline at incremental cost of US $0.03 per liter.

2.41 If Iran does not raise energy prices, but is committed to reduce pollution, costs of pollution reductions could in fact be quite high. An equivalent reduction in SO2 emissions by investments in end-of-pipe technology (FGD) in fuel oil fired power plants is considered for the sake of comparison. If the useful life of investments is ten years and annual emissions reductions over the ten year period are discounted at 10 percent, annualized costs of SO2 emissions reductions would be in the order of US$270 million in constant 1993 dollars (Table 16). Costs per ton of emissions reductions depend on the size of the power plants and sulphur content in the fuel oil used. The size considered here is a 500 MW power plant, and the sulphur content of fuel oil in oil-fired power plants is currently 3 percent. In this case, costs of SO2 reductions are in the order of US$700 per ton. Similarly, equivalent reductions in TSP and NOx emissions in power plants by investments in ESP and selective non-catalytic reduction technologies respectively would cost about US$300 million. Equivalent reductions of lead from introducing lead free gasoline would be about US$110 million at US$0.03 per liter. (Table 16). The economic implications of pollution reductions resulting from efficient energy pricing compared to investments in end-of-pipe abatement technology are striking, a difference of about US$5.3 billion. Even if emissions reductions from efficient pricing are lower and investments in energy savings are higher, efficient pricing is a superior strategy compared with end-of-pipe abatement investments.

2.42 **Natural Gas Expansion:** Increased expansion of natural gas in the residential/commercial, industrial and power sectors instead of using petroleum products could substantially reduce emissions of SO2, TSP and to a lesser degree NOx. The option that involves least investment costs is to use natural gas to the extent possible in future expansions of residential/commercial buildings, industrial plants and power plants. The net economic benefit of using natural gas is the difference between the economic value of the petroleum products currently used and the economic value of natural gas. The value of natural gas is the long-run marginal cost of supply at end-user level (Table 17). Since the economic cost of natural gas use is amongst the lowest, and the environmental benefits, the highest, there is a clear case for aggressive substitution of other petroleum products by natural gas.

Table 17: Economic and Environmental Costs of Energy Sources

	Economic Costs (US$/TOE)	Environmental Externality Costs (Premature deaths/MTOE)
Gas oil (diesel)	194	310
Heavy fuel oil	83	880
Kerosene	204	60
LPG	186	40
Natural gas	86	10
Electricity		
-industry	650	
-res/comm	710	

Source: World Bank Energy Assessment Report. 1993, and mission estimates

2.43 As shown in Table 16, the total annual net economic benefits would amount to almost US$2 billion. In addition, emissions reductions of about one million tons per annum would prevent more than 21,000 premature deaths. If Iran does not expand the use of natural gas at a higher rate than is assumed under the baseline scenario, the annual costs of equivalent emissions reductions of SO2, TSP and NOx from investments in end-of-pipe abatement technologies would be in the order of US$955 million.

2.44 An alternative strategy for SO2 and TSP reductions could be to rely exclusively on natural gas expansion instead of combining efficient energy pricing and natural gas conversion. This would involve additional use of natural gas equivalent to the energy reductions resulting from efficient energy pricing. The impact on emissions on SO2 and TSP would be similar to that of a combined strategy, although emissions of NOx would be about 200,000 tons higher. However, the economic benefits would be significantly lower of relying on natural gas expansion alone. This is because the economic unit cost of natural gas is estimated to about US$35/TOE higher than the annualized investments costs in energy savings, and because of the large net benefits foregone of not reducing electricity consumption. In fact, a strategy that relies exclusively on natural gas expansion would involve annual net economic benefits of US$3.5 billion by year 2010, compared to more than US$6.5 billion in total net benefits from a combination of efficient pricing and natural gas expansion. Furthermore, an expansion of the use of natural gas in the residential/commercial, industrial and power sectors to fully compensate for foregone reductions in energy demand if energy prices were raised to efficient levels is not feasible. This is because total reductions in energy demand in all sectors resulting from efficient pricing are larger than the remaining petroleum consumption in the residential/commercial, industrial and power sectors.

2.45 **Process and Abatement Technologies:** While efficient pricing and natural gas expansion will bring substantial economic and environmental benefits preventing some 34,000 deaths annually, they will not be sufficient to reduce emissions below 1991 levels, which already are substantially higher than WHO and World Bank standards (Table 1). Additional actions would be needed to mitigate air pollution. The stress should be to first use several low cost technology options that are available before going to high cost technologies that are now being used in the developed countries. Industrial restructuring with improved supply of spare parts and improved training of staff can reduce process leakages and increase economic efficiency of plants while reducing pollution. Some of other low cost options and their benefit / costs are discussed below:

SO2: More than 70% of estimated remaining industrial SO2 emissions are from metal smelters and refineries. The copper smelter in Sarcheshmeh uses an outdated production technology. Investments in low SO2 emission process technology combined with production of sulfuric acid from the SO2 in the furnace gases would reduce emissions by more than 95% and at the same time reduce the energy demand by 50% It is also possible to provide sulfuric acid based on the present process gas continuing low concentration of SO2. The resulting SO2 reduction will be in the order of 90% but without energy savings. The investment costs, given data on gas flows and concentration of SO2 in gases from the present process, would be about US$40-50 million and the operating costs about US$4-5 million per year. The reductions of SO2 would amount to about 110,000 tons per year. If the useful life of the investment is ten years discounted at 10 percent, costs of SO2 reductions would be in the order of US$100 per ton. Investments in low-SO2 emission technology would keep costs of SO2 reductions well below end-of-pipe abatement technology such as scrubbers at power plants, which would cost about $700 per ton. Process options for sulphur reductions are less expensive than end-of-pipe (FGD) at power plants. Costs of reducing the sulfur content in fuels refineries will range from US$250 per ton to as high as US$1000 at small refineries with low sulfur content in the crude. Thus refineries should be identified in which costs of SO2 reductions are the lowest. Emissions reductions in the range of US$250-500 per ton of SO2 is likely for all the major refineries in Iran. The remaining emissions from all sectors would be about 600,000 tons, or 70% of SO2 emissions in 1991 (Table 18).

TSP: More than half of total remaining TSP emissions, or 80% of industrial TSP emissions, are from large industrial plants such as steel and cement plants. Low cost options exist for TSP reductions in the industrial sector. Many large steel and cement plants are equipped with duct control equipment, but poor maintenance and lack of spare parts result in relatively high emissions. Estimated reductions from improved maintenance could be in the order of 125-150,000 tons. The remaining total TSP emissions would be around 175,000 tons, or about 80% of total emissions in 1991 (Table 18). The costs per ton of further TSP reductions from stationary sources depend to a large extent on the particulate concentration in the raw gas flow from the emission source as well as the size of the source. Costs per ton are generally lower for TSP reductions from larger sources (economies of scale) at power plants and cement plants, and are estimated to be about US$2,500.

NOx: Reductions of NOx emissions can be achieved at a relatively low cost in the power sector. All new gas-fired power plants should be equipped with low-NOx burners at minimal additional cost per KWh. The investment costs of selective non-catalytic reduction (SNCR) technologies are in the order of US$5-10/KW resulting in approximately 40% reductions of NOx emissions. This implies a median cost of about US$250 per ton of NOx if the useful life of the investment is ten years discounted at 10 percent. Costs of retrofitting existing plants with low NOx burners would be more than twice as high per ton of reductions. Further reductions of NOx emissions in the power sector would be expensive given costs of existing technology. Selective catalytic reduction (SCR) technology would involve a cost of more than US$1,000 per ton of NOx, although such technologies could reduce emissions by as much as 90%. NOx could also be reduced by increasing the efficiency of existing power plants through co-generation, which should become possible once the power plants switch to clean natural gas. Since investments in co-generation often produce economic benefits in excess of 10% ERR, this option would reduce emissions at no additional economic costs. The remaining NOx emissions from the power sector after installing SNCR technology would be in the order of 340,000 tons per year, and 980,000 from all sectors. This emission level is about 80% higher than in 1991 (Table 18).

Pb: The costs of reducing lead emissions, beyond fuel reductions from tune-ups, by introducing lead free gasoline is in the order of US$0.03 per liter. This implies a cost of US$100,000 per premature death avoided. However, lead reductions have substantial additional health benefits in terms neurodevelopmental impacts on children. If these impacts are valued in terms of future income loss and premature deaths avoided are valued at US$100,000, the health costs of leaded gasoline are about US$0.10 per liter which is more than three times higher than incremental costs of lead free gasoline.

The total annual costs of the low-cost process and abatement technologies for SO2, TSP and NOx reductions are in the order of US$150 million, or on average about US$240 per ton of SO2, TSP and NOx reductions. The estimated health benefits of emissions reductions from low-cost process and abatement technologies include more than 14,500 premature deaths avoided from reduced SO2 and TSP emissions (Table 16). This implies that the average costs of abatement of SO2 and TSP are about US$10,000 per premature death avoided. However, if end-of-pipe abatement technologies are selected for SO2 and TSP reductions, the costs would be US$520 million higher (Table 16).

2.46 **Transport Sector:** Significant emissions reductions can be achieved by improved maintenance (tune-ups) at net economic benefits, i.e. economic value of fuel savings less tune-up costs (Table 12). Further low or no cost options include improved vehicle fuel efficiency. Fuel efficiency could improve by 40% for gasoline vehicles, which would result in substantial reductions of SO2, TSP, CO and HC emissions if not NOx. The incremental engine cost on new vehicles would be in the order of US$500 per vehicle, while the present (economic) value of fuel savings discounted at 10% would be about US$1800 for the average vehicle. This implies an ERR of 60%. However, the costs of emissions control technology are relatively expensive. Other technologies, such as the installment of 3-way catalytic converters in new vehicles would be expensive, at about US$1000 per ton of NOx reductions. However, there will be additional benefits of CO and HC reductions. These technologies should receive lower priority at this time, but could be introduced in five to ten years time after further analysis, and after having completed the lower cost actions.

Table 18: Residual Air Pollution in Year 2010
After Efficient Pricing, Natural Gas Expansion
and Low-cost Process and Abatement Technologies
(2010 EP, NG, AT)

	Ratio of emissions in 2010 to emissions in 1991 after EP, NG, AT
SO2	0.7
NOx	1.8
TSP	0.8

E. Recommendations

2.47 The main priority actions to control air pollution are as follows:

a. Consideration should be given to raising energy prices to the level of its long run marginal cost for electricity and natural gas, and the opportunity cost for tradable products. However, a safety net would be need to be provided to the majority of current consumers who are poor, through vouchers or other means to ensure that any negative social impact is mitigated;

b. Investments in expanding natural gas supply through the control of gas flaring should be given the highest priority. To ensure that the investments are made in efficient manner and after investments maintained and operated in an efficient manner, the Government should consider appropriate institutional reforms, including corporatization or privatization, as feasible, but while ensuring that Government collects rents through royalties and taxes;

c. Electricity generating plants near major population centers, such as Tabriz and Tehran, Isfahan, should be converted to gas fired generation as a matter of priority. While using gas consideration should be given to increasing generation efficiency through the use of cogeneration technologies;

d. Plans for rehabilitation of major polluting industries such as the copper smelter at Sarcheshmeh and refineries near Tehran and Tabriz, Isfahan, should be prepared with a view to increasing efficiency and reducing emissions;

e. Natural gas supply to household sectors in major urban centers should be expanded, giving due consideration to any need for financing of household connections;

f. Minimum energy efficiency product standards should be set by the Ministry of Energy in co-operation with DOE and the Ministry of Industry, with a view to increasing economic efficiency and decreasing air pollution;

g. Lead free gasoline should be introduced and priced lower than leaded gasoline in line with externality cost of using leaded gasoline;

h. Car tune-up should be encouraged, following pricing reform, through public information campaigns;

i. Monitoring of air pollution should be encouraged by local Governments, but DOE has an important role in providing technical support through reference laboratories, and cross checks for calibration purposes; and

j. Health and economic effects of pollution should be monitored for policy formulation purposes through collaboration between DOE, Ministry of Health, and educational / research institutions.

Chapter 3: MANAGING LAND, WATER AND MARINE RESOURCES SUSTAINABLY

A. Overview

3.1 Iran is endowed with substantial land resources covering 165 million ha., and a coastline stretching over 2,800 km. However the sparse average annual precipitation of about 250mm (range 25 to 2000 mm) and mountainous terrain limit agricultural production to 50% of the land area. Cultivated agricultural lands occupy only 11% of the total area (16.5 million ha.). Forest and rangelands, including marginal and scrub lands, occupy 37% of the land area (61 million ha). The remaining land area (2%) is under urban use. Iran's limited productive land resource is threatened because of over-exploitation due to the high population growth rate of 3.2% per annum, which has doubled the population over the last 25 years. The over exploitation is also due to economic policy, which has subsidized farm inputs and encouraged conversion of fragile forest and rangelands into croplands even in areas where cultivation accelerates soil erosion and gradual decline in fertility. While reliable estimates of the cost of land resource degradation is not available because of inadequate monitoring of land resources, preliminary estimates show that Iran is annually losing about Rls. 850 billion (about US$ 500 million) annually due to land degradation, with the major part of this loss coming from deforestation, soil erosion in watersheds and inefficient use of water in irrigated areas. While contamination of land from water and air borne pollution is an emerging problem in urban and peri-urban areas, the problem is currently estimated to affect less than 5% of the land area. However, care is needed to ensure that the magnitude of the problem doesn't expand, and better monitoring of the effects of industial and hazardous waste on soil and water pollution is needed.

3.2 Sustainable management of fresh water resources is an increasing problem, both in terms of quality and quantity. While the country has the highest per capita availability of fresh water in the Middle East (2,150 m^3 per year), the water is not evenly spread. Local shortages, specially in major urban areas can be felt. Also, the rain water and surface run off, which supplies about 45% of the demand, is highly seasonal and shortages in the summer months do develop, leading to unsustainable ground water extraction in many regions.

3.3 Most of the water (over 90%) is used in agriculture, and there is substantial scope for improving water use efficiency through policy, institutional, and investment actions. On average, water prices charged by Iran's 14 independent Regional Water Boards cover 97% of operating costs, but are too low to cover capital costs. This does not give sufficient incentive to conserve water or to switch to less water intensive agriculture and crops. It also creates budgetary problems, which affect the maintenance of the irrigation system, reducing availability of water. Better cost recovery would assure that the limited water supply brings greater benefits. Water quality problems are also developing in both rural and urban sectors, but the quality of drinking water in major urban areas such as Tehran is generally good. The greater problem is with the disposal of waste water from industrial, commercial, and household sources. Of the pollutants, heavy metals are specially hazardous as they accumulate in the food chain and are carcinogenic. Unfortunately, around several urban areas, polluted water is used for agriculture. Even though the quantity of water used by industry is only about 2% of the total, safe disposal and treatment of this water is essential so that it does not contaminate the remaining water as well as productive land.

3.4 Sustainable management problems also affect the country's ample marine resources, including fisheries, but problems of over-exploitation are less severe. The total annual catch of about 300,000 tons in 1991 is less than the estimated maximum sustainable catch of 1.5 million tons. However some caution is necessary because the high valued species, such as sturgeon in the Caspian Sea from which the World famous caviar is produced, and shrimp from the Persian Gulf

/ Oman Sea area, catches are close to maximum limits and care is needed to ensure that regulation of exploitation is continued to prevent degradation of the resource base. Pollution of the marine environment could also affect fisheries production in the future and would need to be controlled.

B. Land Resources

Soil Erosion - Extent and Cost of Degradation

3.5 About 5 million hectares or about 1/3 of all cropland in Iran are seriously degraded, and approximately 1 billion tons of soil are lost to erosion each year. This is by far the most important natural resource management problem from an economic perspective. Soil erosion is believed to reduce agricultural productivity by 2-5% per year (damages are estimated at 300 Billion Rials per year), on average.

3.6 For the country as a whole, erosion rates average 10-20 tons per hectare, while soil erosion in lands used for continuous crops and in crop/pasture rotation range from 42-47 tons/hectare/year, and losses in forests and perennial pasture are negligible. This is in comparison to figures of 2.5-12.5 tons/year which are considered to be acceptable in soil conservation practice. Soil erosion has led to degradation of 59% of the land area of the country's 17 major water catchments, with losses averaging about 20-30 times the natural rate of soil erosion for Iran (estimated at 0.5-0.6 tons/hectare/year).

3.7 Losses of nutrients due to soil erosion are on the order of 75 kg of nitrogen, 24 kg of phosphorous, and 8 kg of potassium/year for each hectare of arable land. Soil erosion from wind and water is acute because of intensive cultivation on steep slopes. This is especially a problem in areas where rain is infrequent, but characterized by heavy outbursts. Some rainfed areas are on slopes greater than 20%, and it is estimated that about 1 millimeter of top soil is lost each year because of water erosion.

3.8 Soil erosion contributes to heavy siltation problems which reduce major dams capacity by 100 million cubic meters per year according to the Ministry of Jihad's Forest and Range Organization (approximately 0.6% of storage capacity). This has implications for both the supply of drinking water for urban areas such as Tehran, as well as irrigation and agricultural production in the rural areas (see Box 1).

3.9 The economic costs of soil erosion are estimated at around 300 Billion Rials per year (based on 2-5% decline in agricultural productivity), and represent the largest economic losses associated with poor natural resource management. Soil reclamation efforts will need to focus on those lands where the effects on agricultural productivity are greatest and reclamation costs lowest. Site specific cost-benefit analyses will need to be carried out. Low-cost measures for soil erosion control (i.e., those under $100 per hectare) are likely to be justified, but the more expensive capital-intensive measures (i.e., those above $400-500 per hectare) are unlikely to be economic. For Iran, reclamation costs are estimated at 200,000 Rials/Hectare ($133 per hectare), which compares reasonably to figures of $100/hectare in Mexico, and $100-$300 for micro-catchments in Israel and Australia. However this level of reclamation costs would be justified only for the more productive lands, as the costs are roughly equal to gross agricultural output per hectare in Iran, which was 198,000 Rials/Hectare in 1992 (about $132 per hectare using floating exchange rates).

3.10 For both cropland and rangelands, the damages are on the order of 2-3% of gross output per hectare, which is in line with other estimates of soil erosion damages. Capitalizing the annual damages at 10% to reflect the present value of the soil erosion damages yields a figure of 59,000 Rials per hectare

Box 1. : Sefid Roud Reservoir

For the Sefid Roud Reservoir (the major drinking water supply for Tehran), the average rate of sedimentation is 8 tons/hectare/year -- the highest for any reservoir area in Iran. Moreover, since this reservoir has the largest drainage area of any reservoir in Iran (54,000 km2), the economic costs of sedimentation are likely to be higher than anywhere else in the country. Over 200,000 hectares of farmland are irrigated by the reservoir of the dam, which also produces hydropower for nearby villages and industrial plants.

Although estimates of the economic damages of sedimentation in the reservoir are not yet available, the lifetime of the dam has been reduced by 50% (from 100 to 50 years) because of annual sedimentation of 2% of its capacity in the dam reservoir (the highest for all of Iran). Soil losses in the badlands area (only 5% of the watershed area) are as high as 1000 tons/hectare/year, and have contributed to a decline in the surface volume of the reservoir from 1,800 billion m3 to 900 million m3 in 25 years.

Soil conservation on adjacent agricultural lands is of paramount importance for minimizing siltation of the reservoir. Buffer zones should be established around the badlands to minimize the siltation effects of soil erosion, since reclamation would be prohibitively expensive for such land. Better agricultural practices, which will increase productivity of the land while conserving soil and water need to be introduced. Experience with such improved practices in the Solo Watershed in Indonesia shows that vegetative moisture and soil conservation techniques can have rates of return of over 20% per annum, and this ensures that both the economic and environmental goals are met and farmers adopt improved practices readily.

(about $37) which is only about 28% of average reclamation costs (Table 19), or areas where off-site benefits ar substantial as in the case of the Sefid-Rud reservoir (Box 1), which supplies Tehran's large urban population.

Table 19: Income and Soil Erosion Damages in Iran, 1992

Type of Land	Annual Gross Income Per Hectare (Thousand Rials)	Annual Damages from Soil Erosion per Hectare (Thousand Rials)	Present Value of per Hectare Damages Capitalized at 10% (Thousand Rials)
Cropland	466	16.5	165
Rangeland	100	1.5	15
All Agricultural Land	198	5.9	59

Source: World Bank Calculations based on Data in Report on Services for Agriculture and Rural Development in Iran and Reports of National Specialists. Per hectare damage estimates are averaged over all hectares, and not just damaged land.

Causes of Soil Erosion

3.11 While geological and natural processes contribute to soil erosion, human activities have become major contributors of accelerated soil loss in Iran today. Removal of vegetation cover through clear cutting of forests without replanting, overgrazing of rangelands, and conversion of marginal rangelands into farm lands are considered to be the main contributing factors (Table 20).

Table 20: Human Activities Contributing to Soil Erosion
(Percentage Distribution)

Human Activity	Percentage Contribution to Land Degradation
Removal of Trees and Vegetation Cover	43
Conversion of Marginal Rangelands into farm lands	23
Overgrazing of Rangelands	22
Other Agricultural Activities Destructive to Environment	11
Industrial Activities 1/	1

1/ While the contribution of industrial activities towards soil erosion is small, its impact on soil pollution is much larger and estimates vary anywhere from 1 to 15 %.
Source: National Specialists' Report on Agriculture and Environment

Rangelands.

3.12 The conversion of marginal rangelands into farmlands, and overgrazing of existing rangelands contribute substantially (45%) to land degradation and soil erosion. While functioning rangelands cover about 50 million ha., For management purposes some 90 million hectares are classified as rangeland. Of this only 16% is in good condition, 66% in fair to weak condition, and 18% in poor condition. Livestock populations are estimated at roughly 3 times the feed production capacity of existing rangelands, and have grown at approximately 2.2% per year since the early 1960s. If this trend were to continue, livestock populations would be roughly 50% higher in 2010 or 4.5 times the present capacity of the rangelands. While larger livestock population could be sustained based on purchased feed, this is expensive and the tendency amongst rural herders is to overgraze lands, because of a lack of incentive for proper sustainable management of the rangeland, poverty and current income needs, inadequate technical extension services. On average, rangeland productivity is declining at approximately 1.5% per year and contributes only 25% of feed supply requirements. Combined with the other impacts of soil erosion which reduce agricultural productivity at least 2% per year, the effects of rangeland degradation are significant.

3.13 If these trends in soil erosion and rangelands degradation were to continue unabated until 2010 and food demand increased only 2% per year (which is significantly below current population growth rates), ceteris paribus, Iran would only be able to meet 50% of its food requirements as compared to 1993. Unless measures are taken to improve agricultural productivity and/or reduce the negative impacts of poor rangelands management and soil erosion, continued degradation will have significant foreign exchange and economic implications.

3.14 Price distortions and subsidies. The ploughing up of grazing areas for subsidized wheat production, has increased pressure on existing rangeland. Subsidies for equipment and agricultural chemicals contributed to the ploughing up of previously uncultivated natural grazing lands, often without regard to contours, and this has further exacerbated soil erosion. As much as 30% of common rangelands have been converted since input subsidies for wheat (which were aimed at promoting grain self-sufficiency) led to the conversion of rangeland to cropland at the rate of 1.5% per year during the 1980s. It is estimated that over the past 50 years 20-25% of all rangeland (20 million hectares) has been ploughed up for conversion to cropland, with half of the decline occurring since 1977. Much of this land is not suitable for cultivation since yields decline by as much 50% in the first 2-3 years of production.

3.15 Even though many of these converted lands are eventually abandoned due to the precipitous declines in crop productivity, the range vegetation and shrubs which have been ploughed out do not grow back naturally. Instead, generally unproductive and invading plants grow back, unless reseeding programs are undertaken. The government has reseeded 717,000 hectares of rangeland which had been previously converted to cropland, but this is only about 3.6% of the total amount of rangeland which was converted to cropland. The conversion of grazing land to cropland because of distorted incentives has exacerbated the problem of overgrazing on remaining rangelands. Estimates of the financial and economic returns of restoring such rangelands in Chahar Mahal, Kohkiluyeh, Isfahan, Fars, Mazandaran, and Khorasan are in the vicinity of 20%. The costs of reclaiming one hectare of rangeland are estimated at 30,000 Rials per Hectare, which is much less than the average damages/potential benefits which are estimated at 74,000 Rials per hectare ($47 per damaged hectare) of degraded rangeland per year. Policy changes to remove incentives for further inappropriate conversion of rangelands into marginal croplands are needed as well as investments to rehabilitate degraded lands.

Forest Lands

3.16 Removal of trees and vegetation cover is now estimated to contribute about 43% to soil erosion in Iran (para 3.11). Forests, with sufficient soil cover in the form of mulch, bushes or grasses, protect soil from erosion much better than annual crops. Unfortunately, forest area in Iran has reduced from 17 million ha. in 1960 to only 12 million ha. in 1990. Clearing of land for agricultural use, forage production and grazing, and firewood and charcoal production reduced forests by 30% over the last thirty years, with a decline of 50% in the Caspian and Zagrosian forests. Approximately 8 million ha. (67%) of forests are now degraded, and crown densities vary from 60-90%. For the Caspian forests, where the rate of decline was 3.5% per year from 1980-1993, the forest cover would decline by about 50% by 2010 if this trend continues. Since the environmental and land utilization pressures on the forests are greater outside of the Caspian forests, these areas account for a disproportionate amount of the hectares lost to deforestation each year. They account for approximately 75% of the annual deforestation, while 25% occurs in the Caspian forests (on a hectare basis). Based on the data for 1986-1992, the pace of deforestation now about 200,000 ha. per annum.

3.17 Overexploitation: Pressure on the forests primarily derives from overgrazing, clear-cutting for cropland, and fuelwood demand in more remote areas. For example, in the Zagros and Alborz mountains, grazing takes place in both the forests and on rangelands. Even in areas under reforestation grazing is allowed in 1/5 of the area under reforestation for 20 years each on a rotating basis, and there are no grazing fees in the forests. According to the Forest and Range Organization of the Ministry of Jihad, the annual cut of fuelwood is approximately 6.3 million m3 per year, of which 3.7 million m3 is nonmonetized consumption of fuelwood. Since the sustainable yield level is 3.9 million m3 per year, the annual harvest exceeds the sustainable yield by about 62%. Measures to improve the efficiency of fuelwood use, substitute alternative fuels for fuelwood, and improve harvesting operations in the commercial forests will be required to arrest this trend. In addition, efforts will be required to ensure that afforestation focusses not only on the physical amount of replanting, but also on the quality of replanting (in terms of species and management). Otherwise, there is no guarantee that afforestation/reforestation efforts will adequately compensate for the excessive cutting of trees which presently exists. Agricultural land clearing is apparently under control now, but overgrazing continues to be a persistent problem in all forest areas due to enforcement limitations. Illegal cutting of forests for fuelwood is an increasing problem in more remote areas, but the economic feasibility of substituting natural gas or other fuels for fuelwood would require careful evaluation in these areas. Given the high costs of distribution to more remote areas, natural gas substitution is unlikely to be a viable option in the near future.

3.18 Economic Losses: In addition to the loss due to soil erosion, losses of wood due to poor forest management are estimated at a cost the economy about 255 Billion Rials or 1.3 Million Rials per deforested hectare ($805 per hectare), which is about average with respect to the costs of most reforestation efforts which would ordinarily cost $500-1,000 per hectare. However, this average figure masks the regional differences. For the Caspian region where the most valuable forests are located, annual damages/wood losses are estimated at 231 Billion Rials or 4.6 Million Rials per hectare of damaged forests ($2,919 per hectare), while for the rest of Iran damages of 10-20 Billion Rials would only represent about 100,000 Rials per deforested hectare ($63 per hectare) since these forests are less dense and the wood is used primarily for fuelwood.

3.19 Reforestation: The primary management problem is not one of forestry practices, since reforestation efforts appear to be relatively well-managed, and reforestation have been going on in the North for approximately 25 years with 100 year rotations. Annual reforestation has also increased from 20,000 hectares in the mid 1980s to 84,000 hectares in 1991. Still, this is not enough to keep pace with current rates of deforestation. Currently management plans exist for only a part of the forest area (1 million ha.) and this will need to be expanded. Greater participation from rural communities is needed for which extension services would need to be strengthened. Incentives for protection and management of community forests would need to be strengthened by giving longer term property rights to the community.

Mitigation Options:

3.20 Based on the preliminary calculations above, some lessons can be drawn from the experience of other countries. A review of the Bank's experience in soil conservation indicates that control technologies can range in cost from $10 to over $1000 per hectare. Given the estimate of $59/hectare in damages from soil erosion ($103 for cropland and $10 for rangelands), and $133/hectare for average reclamation costs, measures which are less capital-intensive are likely to be the only ones which could be justified in Iran (e.g., lowland terraces, land shaping and smoothing, contour ploughing, graded banks, improved range management, revegetation, limited agroforestry), while more expensive technologies (e.g., ridging, bench terracing, and check dams) would appear to be more expensive, with limited applications.

3.21 It should be pointed out that evidence indicates that contour banks (bunds) and check dams have a limited life span of only 2-5 years unless they are well-maintained, and at slopes above 11% they are filled rapidly with silt. Thus, the efficacy of such control measures is likely to be limited to soils which have adequate drainage, and are not on steep slopes. It is estimated that, on average, structural measures are three times as expensive as biological methods such as revegetation through improving rangelands management, and that structural measures are more likely to suffer from operational and maintenance problems.

Other Environmental Issues

3.22 Desertification, waterlogging, soil contamination, salinity, and alkalinity which result from poor drainage and agricultural practices are less significant, with economic damages estimated at least 11 Billion Rials per year, almost all of which are from salinization. Sand dune encroachment is believed to be under control at this time, however, and thus future efforts should focus on preventive measures through community involvement. In addition, increased mechanization of agriculture (subsidies were about 50% or 116 Million Rials in

1991/92, and the number of tractors increased three-fold during the 1980s) has contributed to greater soil compaction which has reduced drainage, ploughing up of marginal rangelands, and increased the likelihood of salinization. Consideration should be given to reduce subsidies.

Pollution from Solid and Other Hazardous Waste

3.23 Wasteful use of fertilizers and pesticides is contributing to soil contamination, although only very limited research has been carried out to document the effects. Improper utilization is believed to be affecting both soil and water quality. Overall, fertilizer use averaged 135 kg/hectare, which is not excessive from an agricultural point of view, but the fertilizer use is concentrated on irrigated land, where it averages 376 kg/hectare. There is over-use of urea, which leads to pollution of water. Fertilizer subsidies were 360 Million Rial in 1991/92 -- nearly 2/3 of all agricultural subsidies -- and prices were only 10% of world prices until recent increases were approved for the first time in 10 years. Pesticide consumption of about 50,000 tons in 1991/92 is similarly concentrated in irrigated areas and on horticultural crops. The use is excessive because of price subsidies, and this reduces the incentive to adopt more environmentally friendly and economic Integrated Pest Management techniques. The phase-out of subsidies would have both environmental and economic benefits.

3.24 Use of contaminated wastewater for irrigation, and discharges of industrial and domestic wastes have adversely affected agricultural land near some urban areas (e.g., southern Tehran, Isfahan, Zanjan). It is believed that this could become a serious problem in the future since concentrations of lead and cadmium will increase to unsafe levels if the heavy metal content of industrial discharges continue. Improved pre-treatment or sewage treatment should therefore be encouraged (See also Section C on water resources, in particular, the industrial sources of pollution, para 3.41). For example, the Cadmium content of the soils near the Zanjan River already exceed existing standards by five times. Since fertilizer contains Cadmium, a product standard for Cadmium, setting maximum allowable concentration, is essential. Industrial emissions from industries such as the copper and lead smelters also lead to depositions, which can affect agricultural production.

3.25 New soil quality and pesticide monitoring efforts (monitoring of pesticide residues has not been carried out since 1981) will hopefully begin to gather better information on runoff of agricultural chemicals, and pollution effects on the soil, groundwater, and surface water. This will be necessary to establish the seriousness of the environmental and economic impact of misuse of agricultural chemicals, and the effects of dangerous pesticides such as lindane, dieldrin, and aldrin which are still used in Iran, but have been phased out in most countries. Similarly, there is a need to evaluate the effects of the burial of unused toxic pesticides on groundwater and soil quality. Finally, there is a need to carry out a survey concerning salinization which is considered to be an increasing problem, while desertification appears to have been addressed in most of the areas where reclamation efforts have the potential for success.

3.26 Municipal and industrial solid waste, especially hazardous waste, are also contaminating the soil and through it the aquifer. However, there is little systematic data collection outside Tehran and Isfahan. In Tehran, municipal solid waste collection has improved considerably in recent years (Annex 4), and a special effort has been made to improve handling of hospital wastes. Other hazardous waste are largely unmanaged. Similarly, in Isfahan, while municipal solid waste collection system is good and some composting has been tried for some years, there is still no reliable system for separating and treating hazardous waste. Also, solid waste from abattoirs in Isfahan are routinely dumped into the central sewer system, fouling up the central treatment plant. A strategic plan for solid waste management, with particular emphasis on hazardous waste, is needed for major cities and industrial areas in Iran. Annex 4 summarizes the current situation and makes specific recommendations about needed planning studies and other priority actions, such as training and institutional reforms.

Recommendations.

3.27 The following actions are recommended:

a. Watershed management plans should be developed for each of the 17 major watersheds in Iran, in order that integrated strategies for soil erosion control (which take into account the impacts of alternative land uses such as forestry, rangelands, and croplands) is developed;

b. Site specific cost-benefit analyses should be carried out of the economic impacts of soil erosion and alternative soil erosion control technologies, in order to ascertain where investments should be undertaken first;

c. The focus of soil conservation measures should be on biological systems (e.g., vegetation regeneration through improved rangelands management), and those lands which can be adequately reclaimed with such low-cost measures;

c. Buffer zones should be established nearby to steeper slopes and badlands which are beyond economic reclamation, and these lands should be discontinued for use in arable agriculture so that natural revegetation can begin;

d. Extension services should include training of farmers in soil conservation practices such as contour ploughing, optimal crop/pasture rotation, water conservation practices to reduce runoff and water erosion, and on integrated pest management (IPM) techniques to reduce the use of harmful pesticides;

e. Land tenure arrangements should be evaluated to ascertain the extent to which modifications would induce more environmentally benign soil conservation management by ensuring that nomads and settled villagers are provided secure tenure for their land; and

f. Monitoring of soil quality, salinization, waterlogging, and other forms of land degradation should be instituted to better develop an information base concerning potential impacts. In particular, a soil monitoring program to measure metal and pesticide pollution should be put in place. However, investments should be kept to a minimum in the short-term until these problems are better understood through resource inventories and land-use surveys, and their economic impacts can be quantified.

g. A project should be considered to improve watershed management and reduce soil erosion by focussing on the design and implementation of watershed management plans. The project should simultaneously address the issues of environmental/natural resource degradation and its relationship to rural poverty;

h. Marginal lands which have been converted from rangeland to cropland because of incentives distortion should be restored to their original use where feasible, since this would serve to reduce soil erosion and alleviate pressure on existing rangelands.

i. For nomadic and transhuman rangeland management, equity issues will need to be addressed. Because of the increased pressures of rural poverty, these groups are especially vulnerable to the adverse economic impacts of rangelands degradation. Extension programs for enhancing community participation in improving rangelands used by nomads and transhumans in more remote areas will be imperative for its success;

j. Coordination between the Ministry of Agriculture and the Ministry of Jihad needs to be improved, and their research roles need to be expanded to include monitoring of rangeland conditions;

k. As proposed, the Rangeland and Livestock Management Project (planned to start in 1994) should provide financing for specific investment, institutional strengthening, and community participation measures aimed at improving rangelands management in Chaharmahal, Kokiluyeh, Isfahan, Fars, Mazandaran, and Khorasan, in order to improve the livelihood of the poorest nomadic and transhuman herders who live on these lands;

l. A more complete forest inventory and forestry management plan for each of Iran's major forest areas should be prepared, since presently only 1 million hectares are covered by such plans;

m. Reforestation and afforestation efforts need to more closely examine the types of species which are/should be replanted in each forest area, the marketability of the wood and other products (fodder, dry fruits etc.) which will be produced; and the potential for agroforestry as an instrument for watershed management and soil conservation in areas where soil erosion has adversely affected agricultural productivity;

n. Forestry institutions should be strengthened to improve forest management and conservation of existing wood resources, and privatization of forest industry plants should be implemented in the near future to improve the overall performance of the sector, possibly through a forestry project;

o. Product standards for maximum cadmium concentration level in fertilizers should be set, along with a program for phasing out very toxic and slowly degradable pesticides; and

p. A national plan for solid and other hazardous waste management should be prepared with emphasis on major cities and industries.

C. Water Resources

Background

3.28 The availability of water resources in Iran determines the scope, location, and the sustainability of all human activities. With two of the worlds most arid deserts, Dasht-E-Kavir and Dasht-e-Lut covering nearly a third of the country, agricultural as well as urban areas in Iran are located mainly near the foothills of the mountains surrounding these deserts. The eastern zone of the country where these two great deserts are located has 70% of the land area but only 30% of the population. In comparison the western zone has 70% of the population and the bulk of the water resources i.e., surface runoff and ground water, as well as 60% of the precipitation.

3.29 Total annual precipitation in Iran is between 400 and 440 billion cubic meters (bcm), with most of it being used where it falls, evaporates or percolates into the ground. Precipitation in Iran is mostly in spring and winter though the Caspian littoral zone receives summer rains as well. While average precipitation is about 250 to 300 mm, it varies from as low as 10 mm in the deserts to 2000 mm in the southwestern Caspian. Runoff is as seasonal as precipitation. The steep slopes and relatively spare vegetative cover does not moderate the flow. With the exception of snowfed streams, runoff in most streams is intense for short periods. Storage reservoirs are therefore an essential aspect of water management. In 1978 about 10 bcm of water was the capacity of 13 dams or reservoirs. Present estimates are not available but the storage capacity is stated to have increased considerably. The maintenance of this capacity from the problems of siltation is crucial to any water management program in the country.

3.30 About 90 to 100 bcm reaches water courses, and is available for regulation and distribution. However, because of seasonality and location, only about a third of this is estimated to be diverted for agriculture, industrial and drinking water purposes, both rural and urban. Groundwater also has been a significant source for agricultural use as well as for drinking water supply, currently supplying more than half of the total water use of 73 bcm. There are over 200 ground water basins, with annual sustainable availability of about 55 bcm, and current use is about 70% of this level on average, though in several basins ground water extraction exceeds recharge levels. Since prehistory these resources have been tapped in higher grounds and conveyed to the surface of lower plains through "qanats" for village use and irrigation. Qanats (underground tunnels bringing water from mountain aquifers to agricultural areas) have been the traditional method for conveying water in the countryside, but like modern irrigation systems, maintenance was neglected during the 1980s due to the war and reduced oil revenues.

3.31 On the demand side, the agriculture use predominates with over 90% of total use. The municipal, power and industrial requirements are currently only about 7% (Table 21). The urban use is increasing rapidly, and in some densely populated areas such as the Tehran Province, the demand already exceeds local supply, requiring heavy investments in water storage and conveyance infrastructure (para 3.37).

Table 21: Water Sources and Uses 1990

Source:	billion cm	Percentage
Surface Runoff Use	32.9	45%
Ground Water Withdrawal	40.3	55%
Total	73.2	100%
Use:		
Rural		
Agriculture	67.4	92%
Other Rural	0.8	1%
Subtotal	68.2	93%
Urban		
Industry, Power,&Mines	2.0	3%
Other Urban	3.0	4%
Subtotal	5.0	7%
Total	73.2	100%

3.32 Although Iran has the highest per capita water availability in the Middle East (2,150 m3 per year), water is not evenly spread, and only 10% of the country has enough water for agriculture. Consequently, approximately 36% of arable land and 48% of all crops are irrigated.

Irrigation -Sustainability Issues

3.33 Pricing. For irrigation water, prices are set on the basis of the gross income per hectare for each crop (averaging 4% of gross income), and thus bear no relationship to the costs of supplying water in different areas. Since agriculture accounts for over 90% of Iran's water use, this is a serious distortion for a country which has regionally imbalanced water supplies. On average, water prices charged by Iran's 14 independent Regional Water Boards cover 97% of operating costs, but are too low to cover capital costs. This does not give sufficient incentive to conserve water or to switch to less water intensive agriculture and crops. It also creates budgetary problems, which affect the maintenance of the irrigation system, reducing availability of water (para 3.34).

3.34 Maintenance. Capital investment and routine maintenance in irrigation decreased to the point where there is now a heavy demand for rehabilitation and completion of irrigation systems. Operation and maintenance of irrigation systems, water conveyance, and on-farm water use efficiency are all poor, in part because of low water prices, and cheap access to pumping technologies, credit, and fuel. This has been at the expense of traditional irrigation practices (qanats) which were employed by 80% of farmers up to the mid-1970s, and has led to excessive groundwater pumping and a decline in aquifer levels in some locations such as the Central Plateau.

3.35 Irrigation subsidies further distort agricultural land-use patterns and discourage efficient use of water. Estimated irrigation efficiency is only 30-35%, and the objective of the next five-year plan is to increase efficiency to 50%. It is estimated that improving irrigation efficiency by 10% would yield gross benefits of 210 Billion Rials per year (based on an economic value of 30 Rials per m3). This is roughly equivalent to 45,500 Rials/Hectare ($29 per hectare) of irrigated land or 5% of average gross farm output per irrigated hectare (assuming an average gross income per irrigated hectare of 932,000 Rials/Hectare, which is 2 times the average for all agricultural land).

3.36 In addition to these economic/efficiency costs of poor water use, excessive use of water also has led to environmental degradation in the form of increased salinization and waterlogging where there is poor drainage, and increased runoff and water erosion. There are now 2 million hectares of saline land in Iran (annual increase is 100,000 hectares per year), and 100,000 suffer from waterlogging. The costs of removing salinity are estimated at 100,000 Rials per hectare, which is roughly 10% of estimated gross output per irrigated hectare, and approximately 20% of the average annual rent per hectare of irrigated land. Thus, depending on the other costs of production, reclamation efforts on only the most productive agricultural land should be considered. Measures aimed at preventing future salinization are likely to be more cost-effective than reclaiming existing saline land, since the latter would only be economic for those lands on which net income would be at least 100,000 Rials per hectare in the absence of salinization.

Urban Water Use and Pollution

3.37 Since 1956 the country's population has grown from 19 million to 58 million in 1991. Urban population has grown six times in the same period from 6 to 33 million. The number of cities has grown from 186 to 606 (Table 22).

Table 22: Population Growth and Urbanization in Iran

Year	Total Population	City	Percent
1881	7,654,000	1,964,000	26
1921	9,707,000	---	---
1956	18,955,000	5,954,000	31
1966	25,889,000	9,794,000	38
1976	33,592,000	15,150,000	47
1986	49,440,000	26,844,000	54
1991	58,110,000	33,138,000	57

3.38 Urbanization and migration into cities are thus major features of Iran's demography. The urban increase has been particularly rapid in the 1986-91 period: out of the total increase of about 9 million in the country, nearly 7 occurred in the cities. Such spurts in urban population create considerable pressure on urban resources such as water supply, sanitation and transport. Tehran as the capital city and the largest population center has expanded its water supply significantly in the recent past, but without adequate provision for the treatment of the polluted waste water. Therefore the true cost of supplying water was not obvious, nor was it paid by water users. Consequently, little was done to conserve water, and now the city is faced with investments worth several billions of dollars to treat the waste water (Box 2).

Waste water Treatment Costs for Tehran

3.39 A comprehensive sewerage system for Tehran has been under study and scrutiny for over 20 years. The 1st phase, covering about a third of the population, itself may cost about $650 million or about $325 per capita. The 2 phases, together, may take about 25 years to complete. As the EIA report observes "for the project to be effective, every street in Tehran has to be dug up." It is important to note that even after the completion of the 2 phases, only 4.8 million people or about 60% of the present population will be covered. Discharge of industrial wastes into the surface drainage canals is another major environmental problem (para 3.43). Two canals which are the principal drainage arteries of the city carry these discharges as well as sewage, street sweepings and solid waste dumped along the canals in some parts of the city. At the tail end the canals are more like waste water than drainage canals with BOD exceeding 380 mg/l in summer. Under the proposed sewerage project it is proposed to receive a part of this flow at the sewage treatment plant since the plant is expected to be completed in 5 years whereas the conveyance and transmission system i.e. the sewers may take 5 years more. At present these canals are used for irrigating a variety of crops in the Varamin area. Limited studies carried out so far indicate cadmium in vegetables as a problem. The discharge of industrial wastes, apart from the pollution caused, may also adversely affect the biological treatment proposed for the sewage treatment plants. In view of, both the cost and complexity of the project, lower cost alternatives, including increased incentives for conservation of water and demand management, should be examined prior to investment. The issues of water and waste water treatment, including costs and benefits of alternative plans should be analyzed in a broader regional context, because of the considerable trans-boundary and inter sectoral issues involved.

Box 2. : Tehran - Cost of Water Pollution

Tehran is on the northwestern boundary of the Kavir desert and, on the southern slopes of the Alburz mountains. Until some 70 years ago Tehran depended mainly on 48 quanats and numerous wells for its water supply. City planning provided for abstraction from the canals for water supply and drains along most streets to carry the surplus and also water the neat rows of chinar trees. In the 1920's one of the first water supply projects was completed when a 53 km channel was built to bring water from the Karaj river in the west. Since then Tehran has been looking to water sources, beyond its boundaries. The Karaj Dam was completed in 1960. Another Dam on the Jaj-e-Rud river to the northeast was completed in 1968. In 1975 a third Dam across the Lar river, flowing towards the Caspian Sea was constructed to divert part of the flow into Jaj-e-Rud Dam. The Jaj-e-Rud however is used for irrigating the Varamin agricultural area to the south of Tehran as well. Conflict between agricultural and urban usages are developing.

Today 80% of Tehran's water supply comes from surface sources i.e. the Karaj and Jaj-e-Rud and 20% from ground water i.e. artesian or tubewell pumps. At 265 liters per capita per day the quantity is adequate. The quality of water is high, and Tehran residents speak of their water quality with justifiable pride. Unfortunately, in the absence of any central sewerage system, the sewage is disposed through sewage pits and drainage canals, which contaminate both the ground and surface water flowing south towards the poorer settlements and agricultural areas. Therefore, while the urban areas get better quality water, the poorer agricultural areas to the south suffer the effects of urban water pollution. This trans-boundary pollution issue is a source of conflict. The Government is now considering resolving this issue with large investments in sewage collection and treatment plants, which may cost several billion dollars. This would place a heavy fiscal burden. Incentives for conservation of water could ease the fiscal burden by moderating growth in demand and also by raising revenue to cover costs from those that pollute the water.

Water Quality Problems in Secondary Cities

3.40 Apart from the Tehran region, water quality problems have been identified in other urban areas and river basins as well, in the country. The 1978 Water Plan listed 25 major urban locations in 6 of the 8 hydrographic regions (Tehran, Tabriz, Bandar Abbas etc.) as having significant raw water quality problems. Schools of Public Health in Tehran and other universities supervised by the Ministry of Health have identified heavy metals pollution in ground water and endemic fluorosis as serious problems in many parts of the country. Isfahan, Shiraz, and Mashad as well as smaller cities like Kerman, Nehavand and Birjand are affected by water pollution. While untreated industrial discharges are considered to be a major source of pollution in some cities, contaminant migration in ground water is caused significantly by untreated sewage. Better planning, and monitoring of pollution sources in the secondary cities early on would help to minimize the heavy costs that Tehran now has to pay. In particular, industrial pollution of water would need to be attended to, particularly in cities such as Tabriz and Isfahan (para 3.43).

Industrial Sources

3.41 Iranian industry, mines, and energy sectors use about 2 to 4 bcm of fresh water per annum, which is about 2% of the total water use in Iran (para 3.31). Many of the major industries recirculate their wastewaters back to the process after treatment in order to reduce consumption but a majority of the medium and small scale industries discharge their wastewaters without treatment. At present less than 20% of industries have any kind of wastewater treatment plants, and this a cause for concern. More detailed information about water consumption and water discharges is provided in the Background Reports (Annex 1). However, comprehensive monitoring of water quality on a systematic basis is currently not carried out. Therefore most of the information about water quality is based on expert estimates rather than hard evidence.

3.42 The total amount of BOD discharged from industry is more than 35,000 tons per year. The sugar industry, textile industry, tanneries and slaughter houses are the main sectors responsible for the BOD discharge, though some pulp and paper industries are also major point sources. In comparison, the BOD load from cities in Iran with a population over 100,000 persons has been estimated to over 250,000 tons per year. The BOD load from industry in Iran seems not to have created any major environmental problems in Iran and only in a limited number of rivers is the dissolved oxygen depletion of concern.

3.43 Of greater concern is the discharge of heavy metals. The main sources for heavy metal discharges are tanneries and the electroplating industry. The discharge of chromium from the tanneries in Iran has been estimated to over 300 tons per year. No data on the electroplating industry exists but considering the amount of electroplaters in Iran (more than 600) and that only some handfuls have any kind of treatment, the discharge of metals probably is in the same order of magnitude as from tanneries. Water polluted with metals from tanneries and electroplaters is often used for irrigation in the agriculture of Teheran and Tabriz and this causes a direct health threat to the population. Only a very limited number of studies to detect metals in food has been performed, but the findings suggest that cadmium in vegetables is a problem in the Tehran area. Because of the very nature of heavy metals, (elements that do not degrade with time), continuing discharges will cause rising levels in the environment which will increase the damage done over time.

3.44 The tanneries in Tehran are planned to be relocated to a new industrial city where the discharges are connected to a central treatment plant for reduction of chromium and BOD in the wastewater. According to the present plan the relocation should start 1994. The construction work on the industrial city is in a very early stage and the blueprint on the treatment plant is not ready yet. A delay can therefore be foreseen. A number of the roughly 80 tanneries in Teheran that have not already closed down are likely to close down in connection with the relocation.

3.45 In Tabriz an advanced treatment plant is already under construction for the licensed 50 tanneries. The plant is planned to come into operation in spring 1994. Since the treatment plant was decided upon, an additional number of unlicensed tanneries have been built (on the order of 40). There is no possibility to expand the plant under construction because of the limited space at the present location. The tanneries discharge their waste into the river, which also provides water for human consumption and agriculture. This makes it a serious threat to human health and reduction of untreated tannery waste should be a priority investment.

3.46 Most of the 400 electroplating shops in Teheran dispose of their wastewater in injection wells or discharge directly into the drainage (i.e., jube) system without any treatment. The result of this practice is that the ground water in the southern part of Teheran, where most of the electroplaters are located, is severely polluted. This water causes elevated levels of cadmium in vegetables when it is used for irrigation. Concern has also been raised that the metal discharges from the electroplaters could disturb the treatment of municipal sewage water in the planned treatment plant. Initial discussions to relocate have started between city authorities and some of the electroplaters.

3.47 At present, three chlor-alkali plants based on the mercury process are in operation in Iran. A large new plant with a capacity of 240,000 tons of chlor-alkali production per year is under construction. The new plant is designed for a mercury concentration of less than 0,005 mg/l in the effluent. The old plants probably do not meet these standards and a mercury load of between 5-10 g/tons of chlor-alkali production could be suggested for these facilities. Even small loads of mercury are of concern, due to mercury's ability to form very toxic metalorganic compounds with a high tendency for biomagnification.

3.48 Most of the larger industries have an appropriate treatment plant and recirculate their water. One exception is the Abadan oil refinery which has a once-through water cooling system and a water consumption of 18 m3/tons of crude oil feed. The result is an oil discharge of ca 2,500 tons of oil per year. Many of the compounds in the oil are relatively stable in water and can cause long term disturbances, even after total elimination of the discharge. The Persian Gulf has suffered from severe oil pollution linked both to the wars in the region, chronic oil spills from tankers and land based discharges. If recovery is a part of the environmental agenda for the Gulf, actions to reduce the oil input from Abadan refinery should be emphasized.

Recommendations.

3.49 The following actions are recommended:

a. Reform of existing irrigation and urban water supply pricing policies will be necessary, and of other policies which distort technology choices. Such reforms would provide additional financing for rehabilitation and improvement of existing and planned irrigation and drainage systems, in addition to providing farmers with greater incentives for more economical use of water. In urban sector, this would create incentives for water conservation thereby reducing the need for investment in expensive water treatment plants;

b. Investment measures should focus on rehabilitation of the existing irrigation systems by improving construction and concrete lining of irrigation canals and drains, improving drainage, and of irrigation lift and pumping stations, while investments in new systems should receive lower priority until irrigation efficiency is improved (these measures are being addressed under the Bank supported Irrigation Improvement Project focussing on Behbehan, Moghan, Zarrineh Roud, and Tajan);

d. In the rural sector, farmers should be organized to actively participate in the management of irrigation schemes (e.g., through techniques for improved on-farm water application, irrigating on prearranged schedules, and improving the utilization of traditional irrigation systems (qanats)) should be explored since this could reduce the need to expand modern irrigation works in some areas;

e. A complete survey of soil salinization should be carried out, in order to better understand its seriousness and impacts on agricultural productivity before any reclamation efforts are undertaken;

f. In the urban sector water supply and sewerage utilities should be organized on an autonomous and commercial basis with ability to raise revenues to fully cover operations and maintenance costs and over time also the full investment costs. The Government would ofcourse need to regulate the utilities to ensure that the utilities to not engage in monopolistic pricing policies nor do they pass on the cost of any inefficiencies to the consumer;

g. In the industrial sector, reduction of industrial discharges at source by investments in treatment and pretreatment plants as well as water conservation and reuse should be a priority. Price of water use and waste water discharge would need to be raised to full cost levels to provide appropriate market signals and incentives for such actions by the industry; and

h. Institutional and legal/regulatory strengthening measures at the Ministry of Agriculture and the Ministry of Energy and Water should focus on improving basin wide planning and implementation capacity (specially to ensure sustainable extraction of ground water), and inter-sectoral coordination, specially in areas such as Tehran, where conflicts between urban and agricultural use are developing. These measures should focus on both water quantity as well as quality issues.

D. Marine and Fisheries Resources

The Marine Environment

3.50 For Iran the marine environment comprises two distinct bodies of water: the Caspian Sea to the north with an Iranian coastline of about 990 kilometers; and the Persian Gulf to the south with an Iranian coastline of about 1800 kilometers. Certain features of these ecosystems make pollution an especially important concern. Both water bodies are largely enclosed making concentration of pollution impacts much more likely. The Caspian is a fully enclosed water body connected to the open ocean only through the Volga River, while the Persian Gulf is largely closed since very little interchange takes place through the narrow Straits of Hormuz. The Caspian is home to some of the world's most valuable marine products such as caviar. The Persian Gulf is of course the location of intense oil exploration, production and transportation activity, in addition to containing important fisheries and other marine resources. The following paragraphs describe the marine resources of Iran, and highlight some of the key marine pollution impacts now being observed in the country's coastal areas.

Fisheries, Shrimping & Pearling

3.51 Fish production has expanded rapidly over the 1980's; in 1992 the fisheries output was 308 thousand tons compared with the total catch in 1981 of only 93 thousand tons. In terms of economic value, approximately 63% of the catch is from the Persian Gulf and Sea of Oman, 32% from the Caspian Sea, and 5% from inland waters (Table 23).

Table 23: Distribution of Fisheries Output in Iran

Groups of Fishes	Amount of Catch (000 Tons/Year)	Average Unit Value (Million Rials per Ton)	Total Value (Billion Rials)
Caspian Sea	33.00		265.13
Sturgeon Meat	2.25	9.00	20.25
Sturgeon Caviar	0.30	600.00	180.00
Pelagic Fishes	13.45	0.40	5.38
Carps, Rutilus, and Others	17.00	3.50	59.50
Persian Gulf and Sea of Oman	230.00		531.80
Edible Demersal	31.00	6.50	201.50
Small Edible Demersal	87.00	1.50	130.50
Shrimp	5.00	7.00	35.00
Tuna	15.00	4.00	60.00
Mackerels	6.00	4.00	24.00
Other Large Pelagic Fishes	18.00	3.50	63.00
Small Pelagic	21.00	0.40	8.40
Inedible Demersal	47.00	0.20	9.40
Inland Waters	45.00		43.80
Farmed Carp	29.00	1.00	29.00
Farmed Rainbow	2.00	2.50	5.00
Native Fishes	14.00	0.70	9.80
Grand Total	308.00		840.73

3.52 For most species the catch sizes appear to range between 20 percent and 50 percent of sustainable yield levels (Table 24), and plans call for expanding output of small bony fish (kilka) many-fold in the Caspian. Presently, there are an estimated 730 fishing vessels active in the Caspian, and around 6100 active in the Persian Gulf.

Table 24: Fish Catches and Sustainable Yields, 1992

Type of Fish	Sustainable Yield (Thousand Tons)	Size of Catch (Thousand Tons)	Ratio of Catch to Sustainable Yield
Shrimp	4	5	1.25
Edible Demersal	100	31	0.31
Inedible Demersal	85	47	0.55
Large Pelagic	85	26	0.31
Small Pelagic	100	21	0.21

Source: National Specialists' Report on Fisheries

3.53 Declining output of species such as sturgeon and shrimp are believed to be related to the destruction of natural spawning grounds and nurseries, in addition to overfishing of these species. Polluted rivers, building of obstructions in rivers used as migration routes, and illegal fishing during the spawning season are among the factors adversely influencing the fish population. Unlike fishing, shrimping is a very localized activity and most of the catch is from three main shrimping grounds: Bushire-Dayyer, Bandar Abbas - Kolahi, and Deylam - Mahshahr, all on the Persian Gulf and collocated with the main inter-tidal zones and seagrass areas. These areas are also in close proximity to major oil production/transportation activities (see Map- superimpose Figures 12, 13 and 18 of the report). Pearl oyster habitats are primarily the coral islands in the Persian Gulf, but their fishing is now restricted to Lavan, Qesh and Hendurabi Islands. Khark Island, which is Iran's main oil export terminal, was once a major producer of oysters, but today due to oil pollution in the area, there is no sign of oysters there.

Corals

3.54 Corals are one of the most important habitats in the Persian Gulf, and the coral complexes in Iranian waters consist of coral reefs and coral platforms. In addition to their role in supporting marine life, these corals are important for the fisheries and the pearl oyster industry. Oil industry activity, particularly the shipping and terminal activities around Khark Island and Lavan Island, have led to significant damage to corals. Coral reefs occur just beyond Iran's 12 mile territorial sea, separated from the mainland by a deep trench which parallels the Iranian coastline. Navigational channels for tanker traffic follow this trench, and the coral reefs have come under considerable pressure from the deposition of asphaltic residues of past oil spills. In some areas around Khark Island asphaltic deposits of upto 45 cm thickness have been found by NIOC staff. It is believed that prompt reporting of oil spills, actions to collect the oil, and the use of appropriate dispersants (though some studies show that dispersing increases toxicity, and therefore careful adaptive research would need to be done) could have prevented much of the damage to coral reefs. No research or surveys have been undertaken to study the condition of corals in the Persian Gulf in a systematic manner.

Mangrove Forests & Tidal Flats

3.55 There are about 20,000 hectares of mangrove forests along Iran's Persian Gulf coast, with the biggest concentrations occurring at Khamir and Laft between Qeshm Island and the mainland. These mangroves are important nursery grounds for many marine organisms, and any significant changes could have extensive impacts on marine life in the Persian Gulf. Qeshm Island has been designated for accelerated economic development as a free zone area (Qeshm Free Area), and care is needed to ensure that these economic development activities do not impact adversely on the mangrove areas to the north of the island. The main threat to the mangroves at present is use by locals as a source of fuel wood and as feed for cattle. A visit to the island and meetings with the agencies concerned with development activities there, indicated a very high degree of environmental awareness, and numerous initiatives were underway to ensure that the developments planned result in a net positive impact on the ecology of the area. Extensive tree planting, using innovative methods for this arid area, and creation of artificial inter-tidal zones were among the noteworthy environment enhancing activities taking place in the Qeshm Free Area.

3.56 The effects of environmental pollution on fish populations and spawning activities are not well-known in Iran, though based on experience elsewhere it is believed that the effects are likely to be greater in inland and semi-enclosed waters such as in Iran. Little investigation has been undertaken, even in the Persian Gulf after the huge oil spills during the Gulf War in 1990. Although the effects of the pollution on the fish population are likely to be much less than those of fishing, there is still a need to more closely examine the potential impact of pollution on fisheries (both quality and quantity) in Iran.

3.57 Trade restrictions on fish limit imports, and this undoubtedly inflates the domestic price. In the past, exchange controls and shortages also affected investments in the industry. These restrictions should be reexamined in light of their economic efficiency implications, and an assessment of the effects of lifting trade restrictions on the fishing industry should be carried out. However, a thorough economic analysis would need to be carried out to ascertain the extent to which fishing would remain viable.

Sources of Marine Pollution

3.58 Both the Caspian Sea and the Persian Gulf have come under increasing pressure from pollution. Oil pollution appears to be the main source of marine pollution, though industrial effluent, fertilizer and pesticide use and diversion of freshwater could also become major contributors. This section examines each of these four sources of marine pollution.

Oil Spills

3.59 Most of the oil pollution in Iranian waters is in the Persian Gulf, though recent increases in oil exploration by the Central Asian Republics on the continental shelf of the Caspian is likely to lead to oil pollution problems there as well. Data for the Persian Gulf indicates that the single biggest source of oil pollution is tanker operations which contribute about 60 percent of the total quantities discharged, offshore production is the second biggest contributor (about 22 percent), and natural seeps contribute another 10 percent. With these three sources accounting for 90 percent, the contribution of the other sources, such as runoffs and refinery effluent, may be considered to be of much smaller significance.

3.60 Iran produces and exports about 3-4 million bbls of crude oil per day from three main terminals in the Persian Gulf: Khark Island, Lavan Island, and Siri Island. This level of traffic would imply 2 to 4 super tanker movements a day, and probably requires somewhere in the region of 5 to 10 sailing of vessels of various sizes. Based on international statistics for small operational spills (under 1000 bbls), this level of exposure is estimated to cause about three or four small oil spills on average each day somewhere in the Gulf. No data on small chronic oil spillage was available. Large catastrophic oil spills from Iranian facilities in the recent past have all been the result of the Iran-Iraq war, during which around 250 tankers were attacked, and production platforms in the Nowruz Field were damaged.

3.61 Illegal discharges of oily ballast water by tankers prior to loading is also an area of serious concern for the Gulf. Iran maintains oily waste reception facilities at Siri Island, Masheh and Bandar Abbas; however, on Khark Island which is said to account for a large majority (upto 90%) of oil exports, no reception facility is available. Iran has not yet ratified the MARPOL 1973/78 international convention for the prevention of pollution from ships, preferring to reach regional accord with other Gulf oil producers on ratification of the convention which would i.a. require the provision of adequate waste reception facilities. Iran does, however, seek to enforce its own laws prohibiting dumping of oily wastes and other pollutants within its jurisdiction, and has on numerous occasions penalized vessels in this connection.

3.62 Studies conducted recently have found that the areas around Khark Island (loading terminal) are the most severely polluted with oil concentrations in the sediment on the order of several grams per kilogram near the jetties. Recent spillage caused by the tanker war in the Persian Gulf badly damaged the inter-tidal zone between Bandar Imam and Bushire, and though the area is recovering through natural processes, it is reported that several kilometers of beach are still contaminated. Among the larger oil spills during the 1980s, are the Nowruz Field spill which discharged about 1.5 million barrels of oil, the Larak Island spill which discharged over 100,000 bbls and the Sanandaj oil tanker which discharged between 200,000 and 300,000 bbls. It is estimated that the total oil spilled in these incidents over the period 1983-87 was around 3 million bbls. By comparison, the Torrey Canyon and Amoco Cadiz spills were of 700,000 bbls and 1.6 million bbls respectively. In addition, the oil discharged from Kuwaiti fields during the Gulf War has made this area the single most oil spill affected waterbody in the world.

3.63 Iran's situation with regard to oil pollution in the Gulf is believed to be somewhat fortunate in that most studies indicate that the circulation patterns in the Gulf cause oil spill trajectories to generally result in the oil moving towards the southern Gulf areas, ie. towards the Saudi and UAE coasts. Existing oil spill trajectory models are maintained by the Regional Organisation for Protection of the Marine Environment (ROPME in Kuwait), and are not very sophisticated. Iran does not possess a trajectory model. Development of a detailed trajectory model for Iran's coastal areas is necessary since such models are the basis for oil spill planning and response. Alternatively, the members of ROPME could collaborate in the development of a suitable trajectory model which could then be made available to all members for use by their individual spill response agencies.

Industrial and Urban Effluent

3.64 Both the Caspian Sea and Persian Gulf coastlines are heavily affected by urban and industrial effluent, though for different reasons. Along the Caspian coast, the higher population densities and lack of sewage treatment facilities cause large amounts of urban sewage to be discharged directly into the sea, and it is estimated that this amounts to about 70 to 80 million cubic meters of untreated sewage being discharged annually. The Persian Gulf coastline suffers from the same problem (about 100 million cubic meters of sewage per year), but in addition is also subjected to a high degree of pollution from the Abadan refinery which discharges 2500 tons of oil per year, and solid waste disposal. Around Bandar Abbas for instance, beaches have become waste dumps filled with all manner of scrap metal (including scrap automobiles), plastics (discarded packing materials from the ports), and other debris, indicating a complete lack of awareness of the impacts of these on the marine environment. Communities along the Caspian Sea coast in contrast appear to have a much better developed ecological sensitivity, possibly because of their tradition as a center of tourism and recreational activities.

Fertilizer & Pesticide Runoff

3.65 Consumption of fertilizers and pesticides have expanded rapidly over the last thirty years, and presently fertilizer consumption in Iran is about 2 million tons/year while the figure for pesticides was about 50,000 tons/year in 1991/92. The surface water basin draining into the Caspian covers eight provinces which account for about a third of total consumption. For the Persian Gulf, only Khuzistan province has a high rate of fertilizer use and this province accounts for about 10 percent of consumption. The impacts of fertilizer use is therefore much more likely to be of significance in the Caspian Sea than in the Persian Gulf. There is little systematic information concerning the transformation of nutrient runoffs in the Caspian, however the impact of high nutrient discharges has been observed in the Anzali Lagoon where the growth of weeds is steadily on the increase. There have however been no reports of red tides or algal blooms in the coastal waters of Iran.

Freshwater Diversion and Intervention

3.66 Since both the Persian Gulf and the Caspian are largely closed water bodies, the obstruction of inflows of freshwater and its diversion could potentially impact on the marine ecology in these water bodies. In the case of Iran, diversion of water could be more of an issue in the Persian Gulf, where Iran's Karun River contributes about 30 percent of total inflows, than in the Caspian where the majority of inflows are from northern rivers such as the Volga. A number of diversion dams have been constructed on many of the rivers in Iran, which in addition to diverting freshwater flows also interfere with fish migration to spawning areas. In the case of the Caspian, dams and reservoir structures have been built which affect approximately 25 percent of the total inflows, while in the case of the Persian Gulf almost all of the flows have structures. No information exists on any studies of the environmental impacts of these structures.

Regulatory Controls & Response Capacity

3.67 Regulatory control of Iran's coastal zone is now fragmented among a number of agencies:

- Organisation for Natural Resources;
- Department of Fisheries
- Ministry of Health
- Department of Environment
- Ministry of Interior
- Ports and Shipping Organisation

As a result, no coordinated regulatory framework has emerged for management of the coastal zone. Department of Environment has proposed a Coastal Zone Management Project, which could become the basis for development of a coordinated framework.

Pollution Response & Clean-up Capacity

3.68 Oil spill response capacity in Iran is fragmented. Atleast three agencies appear to have some capacity for oil spill clean-up: the Ports and Shipping Organisation, the Continental Shelf Co. and the Navy. A contingency plan for oil spill response is being developed by DOE, and should be available in about a year. Technical assistance in preparing this contingency plan would be useful since DOE could benefit from the experience in other countries of some of the problems of coordinating an effective response and avoiding actions which have exacerbated problems. In addition to contingency planning, there is a need to develop a strategic plan which assesses overall risk and specifies appropriate levels and locations for stockpiles of clean-up materials, ie. dispersants, booms, etc., taking into account the location of vulnerable resources and potential sources of oil spills.

Recommendations

3.69 Key recommendations emerging out of this review are the following:

a. Iran must take urgent action to ratify the MARPOL Convention, including investment in adequate oily waste reception facilities and enforcement of segregated ballast tank regulations for oil tankers operating out of Iranian oil facilities;

b. An oil spill response plan must be implemented, and adequate spill response equipment should be stockpiled at strategic locations along the Persian Gulf and Caspian Sea coasts to protect especially vulnerable resources;

c. The Coastal Zone Management Project should be initiated to prepare a comprehensive Coastal Zone Management Plan together with the regulatory framework necessary to control developments, in particular interventions on rivers flowing into the Caspian Sea and the Persian Gulf;

d. In the short-term, privatization of fisheries should continue, while at the same time ensuring that the government maintains adequate regulatory control over fisheries management;

e. Once trade restrictions and other regulations which govern fisheries in Iran have been modified, fisheries management should closely examine the economics of increasing fish catches up to sustainable yields in the Persian Gulf and Sea of Oman;

f. A survey should be carried out in order to assess the potential environmental/pollution problems in each of the three major fishing regions;

g. Regional/international cooperation in fisheries management must be enhanced to ensure that sustainable fisheries management is practiced in the Caspian Sea, Persian Gulf, and Sea of Oman, and financing under the Global Environment Facility (GEF) should be considered; and

h. Community participation in fisheries management, protection, development, and rehabilitation must be encouraged to ensure that measures such as privatization, changing regulations concerning equipment, and any restrictions on types and quantities of fish catches will be successfully implemented.

Chapter 4: PROTECTING NATIONAL AND GLOBAL HERITAGE

A. Overview

4.1 Iran has a rich natural and cultural heritage, which is of global significance. Iran's cultural heritage is well known. It was on the cross-roads between two of the four ancient river valley civilizations of Indus and Euphrates/Tigris, and has many ancient archaeological sites throughout the country, which show trade contacts with those civilizations. The ancient Iranian Empire extended to Greece and both influenced it and was influenced by Greece. In the middle ages, similarly Iran was on the silk route between the West and the Orient. This rich history has produced numerous archeological sites, which are both national and global heritage. Some of the sites are already well known such as the Susa hill, excavated by French between 1886 and 1979, and where the tablet depicting Hamurabi Code of Law was discovered, and Takht-e-Jamshid (Perespolis) near Shiraz. However, there are many other important archaeological sites, which are not yet excavated, but are destroyed when roads are built carelessly e.g. Tappeh Giyan dating back to 5th millenium BC. This chapter analyzes some of the threats to this rich cultural heritage and suggests some solutions.

4.2 Iran's biodiversity and natural heritage is similarly rich because it is at the junction of four major plant geo-ecological regions, namely the Irano-Turanian, Euro-Siberian, Saharo-Arabian, and Sudanian. Accordingly, Iran amongst the south-western Asian countries, possess the most diversified biological region. It supports some 7,000 plant species of which about 20% are endemic, 500 species of birds, and 148 species of mammals. Iran has been in the forefront of biodiversity conservation and the international convention for wetlands protection was formulated at Ramsar in Iran, and is accordingly named as the Ramsar Convention. The Wetlands of Iran are particularly important as they are the resting grounds for several important migratory birds such as the Siberian Crane, Flamingoes, and Pelicans, which are also global heritage. The several threats to this National and Global heritage include uncontrolled grazing, hunting, and other human activities. The chapter recommends a strategy for addressing these problems.

4.3 Iran borders two important international waters, Caspian Sea, which is the source of the World famous caviar, and the Persian Gulf, which has been the center of equally famous pearl fisheries since the antiquities. These waters are facing pollution from international sources as was discussed in the previous chapter. This along with Global Warming from the burning of fossil fuels will require international co-operation and aspects of this co-operation is also discussed in this chapter.

B. Biodiversity and Natural Heritage Protection

Background

4.4 Iran is considered the center of origin for many genetic resources of the world and many plant genera have their diversity in Iran. Like Turkey to the west, it contains many of the original strains of commercially important plant species (e.g. wheat), which are increasingly becoming scarce and more important in global terms. There is also a wide range of medicinal and aromatic species. The deciduous forest characteristic of central and western Europe reaches its most easterly limit between the Euro-Siberian and Irano-Turanian regions. The genetic resources at the limit of these Caspian forests are particularly important and the populations of all species are under environmental stress. With the possibility of global warming, the adaptive characteristics of such marginal populations could be of greater regional importance.

4.5 The diversity.of animals is also high with over 500 species of birds and 148 species of mammals (specially deers, leopard, cheetah). The wetlands of Iran are of particular significance and play a key role for many of the worlds migratory species including the endangered Siberian Crane. Many millions of waterbirds, notably grebes, cormorants, ducks, geese, swans, cranes, coots, shorebirds, gulls and terns which breed in Siberia, spend the winder at these wetlands or use these areas as refuelling areas on their way to and from over wintering areas in Africa or the Indian Sub-continent. The marshes of the south Caspian lowlands are particularly important for ducks and geese (over 20 species) while the mud flats of the Gulf coast are of critical importance for shorebirds, gulls and terns. The wetlands of the Orumiyeh basin, South Caspian lowlands, Khuzestan and Central Fars have long been recognized as internationally important wetlands. The Government is in the process of ratifying the Biodiversity Convention.

4.6 At present biodiversity protection of the country is basically confined to national and natural forest parks and protected areas. In the unprotected areas, the biodiversity is diminishing at a remarkable rate. For example during the last 30 years, 1.2 million hectares, or 40% of Iran's deciduous temperate forests have vanished. Irrational land use practices and poor management are the chief causes of biodiversity loss in Iran. Nonetheless there still remains a great variety of plan and animal species which need to be protected and maintained. Fary and Prosbot (1986) emphasize that "the degradation of the vegetation of Iran is still by no means as extensive as in other countries of south-west Asia."

Protected Areas

4.7 In Iran, protected areas cover some eight million ha (about 5%) of the land area (Table 25), and are classified under the following three categories.

Table 25: Distribution of Protected Areas in Iran

Type of Protected Area	Area in Hectares	Percentage of National Area
National Parks	1.1 Million	0.7%
Wildlife Refuges	1.9 Million	1.2%
Other Protected Areas	5.0 Million	3.0%
Total	8.0 Million	4.9%

Source: National Specialists' Report on Biodiversity Protection

4.8 **National Parks/ Nature Monuments.** These serve dual functions of conservation and nature tourism, and are typically selected as outstanding examples biodiversity/ ecology, and geological/ scenic resources that are of national and global importance. These are protected by law. In recognition of their dual function some park infrastructure is constructed, but under strict conservation and architectural control. Currently, there are seven National Parks (Table 26), and four National Nature Monuments (Khoskeh Saran, Dehloran, Sosan-e-Sefid, and Sero).

Table 26: National Parks in Iran

National Park	Status
Golestan	Minimal degradation
Urumieh	Minimal degradation
Tandureh	Minimal degradation
Bamou	Semi-degraded
Khojir	Semi-degraded
Sorkhe-Hessar	Degraded
Kavir	Degraded

4.9 From both an ecological and economic perspective, the most important national parks are Golestan and Urumieh (Box 2). Both have wider biological diversity than the other parks of Iran, and potential for increased tourism. Golestan is located in the Northeast of Iran along the Caspian Sea covering 92 thousand hectares, and is characterized by temperate to humid deciduous and hardwood forests, while Urumieh is located in Eastern Azerbaijan.

4.10 **Wild Life Refuge.** These are also protected areas which are representative ecosystems supporting wildlife significant to the nation, but which don't justify the intensity of management of full fledged national park. There are 24 Wild life refuges, which currently cover about 1.9 million ha. The main threat is from poaching.

4.11 **Other Protected Areas.** These cover eco-systems of important conservation values, but which don't fall within the first two categories. Generally, only 20% of such areas are fully protected and limited use is allowed in the remaining area. These cover about 5 million ha. There are 57 other protected areas including 15 forests.

Main threats

4.12 The most serious threats to the national parks and protected areas are from poaching and grazing, since there are only limited resources available for monitoring and enforcing regulations. There is no hard data available on the extent of the problem, but there is general agreement that poaching and grazing pose the most serious environmental threats to management of national parks and protected areas since these problems afflict 80-90% of all protected areas. The most seriously affected national parks are Kavir and Sorkhe Hessar.

4.13 Grazing is not allowed in national parks, but it is allowed on 80% of the land in protected areas. Consequently, there is tremendous potential for overgrazing within these areas since systematic monitoring of land-use patterns in the protected areas is not possible given the lack of resources available. Other pressures include cutting of shrubs and bushes for fuel by villagers living within protected areas, and the conversion of rangeland to agricultural uses which has exacerbated overgrazing in nearby protected areas.

4.14 Training for park officials and game guards in the country's national parks and about 200 protected areas is sorely needed since there are no prerequisites for these jobs despite the fact that nearly 50% of the Department of Environment's employees are engaged in these activities. Before the revolution six months training was required, but management of national parks and protected areas was seriously neglected during the Iraq-Iran war, with the management of protected areas suffering relatively more. It is estimated that during the Iran-Iraq war 80% of all wildlife was lost due to lack of management in wildlife refuges, and that 50% of the protected areas were seriously affected.

4.15 Community participation in management of protected areas and biodiversity is also lacking. This is especially important in the case of buffer zones where control and enforcement by the legal authorities is more limited than in restricted zones, and effective land management will require the cooperation of local communities.

4.16 Better zoning of protected areas to better take into account community interests and participation is also needed. A variety of zones will be needed to reflect the vulnerabilities of protected areas, by taking into account the biophysical characteristics of the land and its compatibility with different land-uses (e.g., restricted zones; protected zones; extensive and intensive use zones; buffer and transition zones; heritage zones; and research, education, and training zones). Surveys of communities living in and near protected areas will need to be carried out to ascertain their willingness to pay for alternative types of land-uses and conservation.

Recommendations

4.17 The following are the main recommended actions:

a. A full inventory and mapping of the nation's biodiversity, flora, and fauna is required first, so that more informed decisions concerning priorities, investment proposals, and institutional strengthening measures can be taken;

b. Once a through inventory of the nation's biodiversity is completed, it will be possible to better prioritized the types of associated institutional strengthening measures which would be required to implement a sound biodiversity and protected areas management program (e.g., training of park rangers, regional and national administration);

c. Zoning of land-uses will need to be developed in cooperation with local communities to ensure that land-use regulations balance the multiple objectives of protected areas, and that local communities participate in the management of the protected areas, along with the implementation, monitoring, and enforcement of programs aimed at improving the state of Iran's protected areas;

d. A strategy for biodiversity preservation and management of protected areas and national parks will need to be developed in parallel with financing proposals. The possibility of collecting revenues through visitor fees from national parks and protected areas must be explored given the budgetary constraints of the Department of Environment. To the extent that more self-financing is made available, this would facilitate co-financing from international organizations for technical assistance, institutional strengthening, and investments; and

e. The Government of Iran, with international guidance, should develop 2-3 proposals for possible biodiversity or protected areas management projects. Along with gene pool conservation in East Azerbaijan, the Urumieh and Golestan National Parks, and Shardigan and Harmoun wetlands would be the top priorities for any biodiversity management projects, which could also be considered for financing under the Global Environment Facility (GEF), following the ratification of the Biodiversity Convention, which is currently under active consideration.

C. Cultural Heritage

Background

4.18 In addition to the protection of natural heritage, historic preservation in Iran would also provide national and global benefits. Iran was on the cross-roads between two of the four ancient river valley civilizations of Indus and Euphrates/Tigris, and has many ancient archaeological sites throughout the country, which show trade contacts with those civilizations. The ancient Iranian Empire extended to Greece and both influenced it and was influenced by Greece. In the middle ages, similarly Iran was on the silk route between the West and the Orient. This rich history has produced numerous archeological sites, which are both national and global heritage. Some of the sites are already well known such as the Susa hill, excavated by French between 1886 and 1979, and where the tablet depicting Hamurabi Code of Law was discovered, and Takht-e-Jamshid (Perespolis) near Shiraz. However, there are many other important archaeological sites, which are not yet excavated, but are destroyed when roads are built carelessly e.g. Tappeh Giyan dating back to 5th millenium BC. Given Iran's rich and diverse history, there are literally thousands of sites which could be designated as historic. However, there will be a need to prioritized these, if any meaningful follow-up can be expected. Persepolis, Isfahan, and Shiraz are perhaps the most famous and historically significant locations, but little is known about many of the other sites. Consequently, an effort will need to be made to gather information on the classification and state of existing and proposed sites.

4.19 Iran is only just beginning to assess the effects of environmental degradation on cultural property. During the 1980s, little attention was paid to the issue of historic preservation because of the nation's preoccupation with the Iran-Iraq war. Consequently, little is known about the specific impacts of degradation of cultural property throughout the country. A top priority for cultural heritage during the 1990s will be to reverse this trend by evaluating the state of archaeological sites, historic monuments, native gardens and landscapes, and museums.

Main Threats

4.20 Air pollution, especially SO_2 and traffic exhaust, is clearly the most significant environmental threat to historic sites since most of the damage to the building material of cultural monuments and historic sites is pollution-related (one estimate suggests as much as 80% of the damages to buildings is air pollution-related). With local tourism of approximately 5-6 million people per year, the effects of tourism on cultural property is less significant, and limited in comparison to pollution, and in comparison to other countries.

4.21 Damages to cultural heritage in Iran are also the result of a number of other activities besides pollution, although no information on their quantitative effects is available. These include damages from earthquakes and floods, unlawful excavations, infrastructure development such as dams and transport and communication networks, agricultural activities (e.g., mechanization, overgrazing, soil erosion), and the Iran-Iraq war. The high rate of population growth has also contributed to existing pressures on historic property, especially in urban areas, where zoning and other regulations to protect historic property are not always adequate. Infrastructure construction has also lead to destruction of several of the historic sites, such as Tappeh Giyan which dates back to 5th millenium BC.

Recommendations

4.22 The most important issues to address for cultural heritage preservation in Iran are to:

a. Carry out a preliminary survey, followed by a complete inventory of historical and archaeological sites, which together identify (i) the most important sites, (ii) the primary causes and impacts of degradation (both nationally and at each site), and (iii) preliminary mitigation measures;

b. Improve building controls and zoning regulations to protect historic sites in urban areas (e.g., bazaars, qanats) which have come under increasing pressure due to rapid urban expansion over the past two decades;

c. Assess the effects of SO_2 and traffic exhaust on historical sites and associated damage costs, especially in cities such as Isfahan, Shiraz, and Tehran, in order to ascertain what pollution abatement measures would best serve the interests of protection of cultural heritage;

d. Develop a plan to ensure that important historical sites are protected from the effects of earthquakes in seismically active areas;

e. Begin to develop a national strategy, and cost-effective regional strategies, for protection and rehabilitation of cultural property based on clearly identified priorities from the preliminary survey and inventory;

f. Develop a strategy for institutional strengthening of the Ministry of Culture and Higher Education and the Iranian Cultural Heritage Organization focussing on their roles in the administration, financing (see paragraph below), and management of cultural property;

g. To affect any change in the existing framework for preservation of historic property and cultural property, however, it is imperative that the Government of Iran develop specific proposals for financing preservation measures, including proposals for international and government financing for specific projects and programs;

h. The Ministry of Culture and Higher Education will need to explore the possibility of increasing user fees for visitors to historic and archaeological sites and museums, as a mechanism for raising the additional internal funds which will be necessary to finance improved and comprehensive cultural and historic preservation; and

i. Carry out careful assesment of the impact of on any new construction, specially roads, on archeological site.

D. Other Issues

4.23 There is an international concern that an increase in CO_2 emissions will cause a change in global climate with negative impact on coastal communities, and on agricultural production. Iran is currently responsible for the third largest amount of gas flaring after Russia, and Nigeria, and this contributes about 12 million tons per annum in increased CO_2 emissions. The Government considers elimination of gas flaring a high priority objective and has accordingly prepared a project, estimated to cost about $ 1 billion for reducing the flaring. The project will have additional benefits through the reduction of SO_2 emissions and the use of cleaner natural gas. The economic rate of return has also been estimated at over 40% per annum. This proposed project should be given a high priority for funding. In addition, the options discussed in Chapter 2, regarding policies and actions for improving energy efficiency should also receive priority since they will help to meet the international goal of reducing CO_2 emissions, in addition to the national goals of improved economic growth and better local environment. The Government is also in the process of ratifying the Global Climate Change Convention.

4.24 The other issue of international significance is the pollution of international waters. Actions discussed earlier for reduced marine pollution (para 3.69) will help to reduce the pollution of international waters. For this, Iran should work with other littoral countries of the Caspian Sea to develop an action plan for improved management of this international waters. With regard to the Persian Gulf, Iran is already participating in the Regional Organization for the Protection of Marine Environment (ROPME), and this participation should be strengthened. An effort should be made to strengthen ROPME and to agree with all member countries to provide waste reception and treatment of oily waste from oil tankers plying through the Gulf.

Chapter 5: TOWARDS A PRIORITY ACTION PLAN

A. Overview

5.1 As discussed in Chapter 1 under the economic policy framework, macro-economic and pricing policies induce serious economic distortions which are on the balance detrimental to the environment. In particular the over valued exchange rates and low price of energy have lead to wasteful use of fossil fuels. As pointed out in Chapter 2, this has lead to low efficiency of energy use and consequently high emissions. The situation is serious in major cities. The monitoring data indicates that annual average ambient air concentrations in Tehran of SO2, NOx, TSP and lead by far exceed WHO and World Bank guidelines (40 to 340% over maximum allowable values). Even in other cities such as Mashad, Tabriz, Isfahan, and Ahwaz, the concentration of TSP is consistently in the range of 200-400 ug/m^3, which is 2 to 4 times World Bank recommended maximum value. Current projections show that the problem will become more serious in the future, and by year 2010, about 45,000 additional premature deaths will occur unless actions are taken now to reduce the pollution of air. Therefore preventing further deterioration of the air quality should receive priority attention. However, considering that per capita GDP of Iran is less than $2,000 per annum which is less than 10% of the income level in the industrialzed countries, this objective has to be met concurrently with other priority objective of improving the income of the population. Therefore, the highest priority must be given to those actions that both improve air quality and economic well being. Fortunately, there are several such actions, the so called "win-win" actions, and these are summarized in this chapter.

5.2 As mentioned in Chapter 3, while drinking water quality is generally good, some problems of sustainable use of land and water resources are emerging. Soil erosion is accelerating and this leads to irreversible loss of soil fertility, and siltation of irrigation channels and reservoirs for supply of water to cities and for agriculture. Annual losses are large and estimated to cost about $500 million per year. As with air pollution mitigation, the highest priority needs to be given to actions which reduce environmental degradation and these are discussed in the next few sections. Other priority actions include prevention of water pollution and its sustainable use, protection of national and global heritage.

B. Policy Actions

5.3 It is important that incentives for efficient utilization of investment are improved before large investments made to assure the Government that its scarce financial resources bring the highest return. The main policy actions are summarized below.

Price Subsidies for Polluting Substances

5.4 Implicit price subsidies of polluting substances, such as fossil fuels, need to be phased out. The rationale for this is that the burning of fossil fuels produce harmful emissions such as SO_2, NOx, and particulates. The level of these emissions in major urban areas of Iran is already much higher than maximum recommended levels, and improving incentives for conservation of energy would moderate increase of demand for these fuels. It will improve incentives for investments in more energy efficient vehicles, appliances, industrial processes, and thermostats, which have high economic rates of return, but would not be seen as advantageous by consumers unless price subsidies (currently about 90% of for the consumption of fossil) are reduced. Reduction of subsidies will have both environmental and economic benefits. It will reduce the projected premature deaths by about 13,000 per annum and will have net economic benefits (due to fuel savings, which can be exported) of about $4.7 billion per annum. Safety net arrangements should be in place to mitigate negative social impact. The safety net arrangements can be funded from increased revenues. Other polluting substances such as pesticides, which are also subsidized, should similarly have their price subsidies removed. This will give incentives to the farmers to switch to less polluting and more economic Integrated Pest Management (IPM) techniques. Following removal of price subsidies in the next three to four years, the Government should consider levying taxes on polluting substances. This will have two benefits. First, it will provide incentive to shift to less polluting substances, e.g. unleaded gasoline, and second, it will provide financial resources for mitigation and environmental investments.

<u>Use of Natural Gas</u>

5.5 The Government should progressively substitute more polluting fuels such as high sulfur oil, by natural gas (Ministry of Petroleum). First step should be to switch thermal power station in major urban areas such as Tehran, Tabriz, and Isfahan from fuel oil to natural gas by March 1996 (Ministry of Energy). The rationale for this is that Iran has the second largest reserve in the World of natural gas. Because of transportation difficulties for export markets (high investment costs for pipelines and LNG carriers), the opportunity cost of natural gas is amongst the lowest of all fossil fuels. It is also the cleanest burning. Therefore by switching from other fossil fuels, it is projected that by the year 2010 Iran can reduce annual premature deaths by 21,500 and at the same time get net economic benefits of about $2 billion per annum.

<u>Water Pricing</u>

5.6 Although urban drinking water quality is adequate in most cities, waste water treatment is not. This creates problems for rural agricultural sector as it affects quality of agricultural output. It also pollutes ground water. The problem is specially severe in Tehran, Mashad, and Tabriz as they lack central waste water treatment capacity. Charges for the service would need to be levied to assure that there is sufficient incentive for conservation and recycling (specially in the industrial sector) as well as to assure finances for adequate operation and maintenance. Safety net provision would be needed along with water price reform. Fuller cost recovery from irrigation schemes in the rural sector would also be needed to assure sustainable use of water, as well as to assure that sufficient financial resources are available for efficient operation and maintenance.

C. Institutional Strengthening

5.7 While pricing reforms will provide better incentives for conservation of resources and reduction of pollution, they will not be sufficient. It will take time to go to full price reform including pollution based charges, and in the interim greater reliance on careful monitoring and environmental assesment would be needed. Furthermore, environmental information monitoring would be needed to make pollution based charges work in the future. For this it is neccessary to strengthen the quality of environmental information collection as well as its analysis and use for policy formulation. In particular the Department Of Environment (DOE), should be strengthened through staff training, formulating and implementing regulations for environmental impact assessment, and establishing a high quality environmental information system which would provide the basis for environmental impact assessment and for creating greater environmental awareness. Local environmental training capacity should also be strengthened. Detailed project preparation should be done by DOE during 1994, with a view to start implementing a project in 1995. Financial assistance for project preparation could be requested from the UNDP.

5.8 For co-ordination on cross-jurisdictional air and water quality issues also DOE will need to play a greater role. While EHC has been established for this purpose, it is at a very high level and would need technical support from a strong secretariat in DOE. Furthermore, since water quality and quantity issues are closely related, the role of EHC would need to be extended. The Government has already expanded the mandate of EHC to cover sustainable development issues also, and DOE would need to provide technical support for this also.

5.9 Public utilities which play an important role in managing environmental investments, such as the water and sewerage companies, and also power companies need to be strengthened before investments are made to assure sustainable operation and maintenance of the investments. This can be done through corporatization or privatization so that these utilities can raise sufficient funds to cover their operation and maintenance costs, and also to assure that they can give salaries to staff to attract and motivate them to run these investments in an efficient manner. Publicly owned industrial corporations would also need to be restructured to improve incentives and training provided to staff. This is specially true for companies that can have a large impact on environment if they are not operated and maintained well. This includes major mining, metalurgical, and chemical industries and petroleum refineries.

D. Investments

5.10 In Iran, there are numerous opportunities to improve environmental management, while at the same time supporting growth of income, through truly "win-win" type of investment projects. The following are some of the high priority projects that should be considered for funding by GOI:

Natural Resource Management :

5.11 Watershed Conservation Project: Currently soil and agricultural productivity loss in watersheds is a major problem. A project which would reduce soil erosion in the watersheds while increasing the income of the poor rural population that are currently subsisting on it, would produce both environmental and poverty alleviation benefits.

5.12 Forestry Institutions and Conservation Project: Valuable forests in Iran have degraded rapidly (30% in last 30 years). By strengthening the management and conservation of the remaining forests, production from these forests could be maintained or even increased, while preventing further deforestation.

5.13 Rangeland Management: Poor rangeland management practices are leading to reduced soil cover and accelerated soil erosion. Improved practices could maintain better soil cover and reduce soil erosion while increasing income of poor herders.

5.14 Irrigation / Drainage Rehabilitation: Excessive water use is depleting ground water resources and in the absence of good drainage, it is also leading to salinization of good agricultural land. Improving irrigation and drainage system, accompanied by demand management policies, could bring important environmental and sustainable development benefits.

Industrial / Urban Pollution Control

5.15 Tehran Air Pollution Control Project: Currently several large industries including refineries and metallurgical industries near Tehran are polluting Tehran's environment creating health hazards for 20% of Iran's population. A project to control emissions by shifting to more efficient and less polluting technologies could bring substantial benefits. Emission reduction from transport sources could be considered as a parallel project to be funded by GEF. The project could be followed by similar projects for some other major cities such as Tabriz, where problems similar to Tehran's are developing.

5.16 Gas Flaring Reduction Project: Iran flares gas produced in association with crude oil at 13 bcmy, the third highest level in the World. A project to utilize the flared gas from both on-shore (2.2 bcmy) and off-shore (4.6 bcmy) locations should be implemented to utilize about half of the gas for productive purposes. A project has been prepared, but institutional arrangements and financing plan remains to be finalized.

5.17 Water Pollution Reduction Project: Urban water is polluted by several sources, including small industries (tanneries, electro-plating), workshops (motor oil), and households. Of the pollutants heavy metals are specially hazardous(Chromium, Nickel) as they concentrate in soils and food chain. Projects to reduce water pollution in major urban centers such as Tehran, Tabriz, Isfahan, and Mashad should be considered including both central systems and disaggregated waste water collection and treatment systems. The success of current and proposed investments in municipal waste water treatment and reuse is threatened by the failure to adequately deal with industrial discharges in urban areas, especially in Tehran.

5.18 Solid and Hazardous Waste Disposal Project: Solid and hazardous waste are not handled properly and consequently they end up polluting the water (see Annex IV). A project for improved collection and disposal of waste should be prepared initially for Tehran, and following that for other major urban areas in Iran.

Global and Transboundary Issues (GEF Projects):

5.19 Biodiversity Protection Projects: Iran has several bio-diversity sites of international importance. One of the most important is the Lake Ourimieh National Park, which is the habitat and breeding ground for several migratory birds, including Flamingoes and Pelicans. It is also designated as a Ramsar site (wetland of international importance). A GEF biodiversity conservation project could be prepared and proposed to GEF participants. Possible participation of other countries where the migratory birds visit could also be considered. Another protected area of international significance is the Gulistan National Park near Caspian Sea. The protection of the biodiversity of Shardigan and Harmoun wetlands also has a high priority. A biodiversity project in Azarbayejan Province could be considered for both in-situ and ex-situ gene pool conservation in an area which is considered as one of the six "centers of origin" of valuable commercial crops.

5.20 International Waters: Projects to protect the Caspian Sea and Persian Gulf should be considered within the regional framework for international waters. Effort should be made to bring the two seas under the MARPOL convention with adequate waste reception facilities at major ports.

5.21 Greenhouse Gas reduction Projects: Iran with substantial natural gas flaring offers opportunities for utilizing these gases to reduce CO2 emissions. In addition, increasing energy efficiency and fuel conversion to gas in transport and households could also be considered. Renewable energy projects may offer some opportunities in remote areas and should also be considered. Several of these projects would have substantial returns and if they become ineligible for GEF funds, consideration should be given to using other sources of funds.

ISLAMIC REPUBLIC OF IRAN **Annex I**

ENVIRONMENTAL STRATEGY STUDY

List of National Reports

1. Overview: Macro-Economic Perspectives (including environmental economics and financing)
2. (a) Sustainable Management of Natural Resources: Forest
   (b) Sustainable Management of Natural Resources: Range
   (c) Sustainable Management of Natural Resources: Fisheries
3. Sustainable Agriculture and Rural Development
4. Environmentally-Sustainable Industry and Mining
5. Sustainable Energy Development: Economics, Conservation and Renewable Resources
6. Sustainable Transport Policies
7. Human Settlements and the Environment
8. Air Quality and Pollution Control
9. Water Quality and Pollution Control
10. Soil Quality
11. Environmental Health and Sustainable Development
12. Marine Environment and Coastal Zone Management
13. Biodiversity Protection and the Management of National Parks, Wetlands and Protected Areas
14. Environmental Aspects of Refugees and Displaced Persons (including environmental impact of was and defence)
15. Preservation of Historic Property and Cultural Monuments
16. Women, Environment and Sustainable Development
17. Environmental Law
18. Sustainable Development Education and Public Awareness

ISLAMIC REPUBLIC OF IRAN

ENVIRONMENTAL STRATEGY STUDY

List of National Experts

Report No.	National Experts
1.	Ahmed Jalali-Naini, Central Bank of Iran Amir Houshang Amini, PBO Saeed Dehghan, MEAF Mohsen Jalali, MOA Mohammed Khosravi, DOE Mostafa Mohajerani, PBO
2.(a)	Karim Javanshir, University of Tehran Mostafa Abdollahpour, Forestry & Range Organisation Rasul Jalali, Plan & Budget Organisation Saeed Shafee'far, Forestry & Range Organisation Houshang Sobhani, University of Tehran
2.(b)	Mostafa Behbahani, FRO Changeez Eshraghee, FRO Rasul Jalali, PBO Mahmoud Jom'eh-pour, MOJ Hassan Moinoddin, FRO
2.(c)	Amin Keyvanfar, University of Tehran Marjaneh Bahamin, Kish Fisheries Corporation Mahmoud Jom'eh-pour, MOJ Moh. Ali Gharee-Saadati, DOE Moh. Sahgaree, DOE Abdolrahim Vosooghi, Iranian Fisheries Research & Train.Org.
3.	Hossein Heydary, Plant Pests and Diseases Research Inst. Abolghassem Alizadeh-Naini, PBO Mohammed Bybordi, PBO Habibollah Erfani, Agricultural Development Bank Morteza Esmaili, University of Tehran Ali Haj-Yousefi, PBO Hadi Hosseini-Araqi, Ministry of Agriculture Mahmoud Jom'eh-pour, Ministry of Rlural Reconstruction Mahmoud Shojaee, University of Tehran Parviz Vojdani, National Gene Bank
4.	Mehdi Borghei, Sharif University; and Ministry of Industry Nasser Keyvani, Department of the Environment Mojtaba Hirbod, Consultant Jaafar Noori, University of Tehran
5.	Ali-Mohammad Ahmadi, Atomic Energy Organisation Saadollah Larijani, Ministry of Energy Mojtaba Hirbod, Consultant Yadollah Saboohi, Sharif University
6.	Mohammed Javad Atrchian, Azad University Behrooz Gharavi, Ministry of Transport Mostafa Khademi, Department of the Environment

Hooshang Sobhani, University of Tehran

7. Hassan Zendeh-Del, Allameh Tabatabai University
Abbas Gerami, Tehran Metro Corporation
Hameed Majedi, Ministry of Housing & Urban Development
Masood Mo'tamedi, Plan & Budget Organisation
Hassan Rahimi-Farzan, Pars Vista Consultants
Masoud Safarian, Society for Industrial Research Centres
Esfandiar Kharrat-Zabardast, Min.of Housing & Urban Dev.

8. Taghi Ebtekar, University of Tehran
Hossein Atri, Department of the Environment
Javad Fuladi-Rad, Ministry of Health
Mansour Ghiaseddin, University of Tehran
Jaafar Noori, University of Tehran; and Azad University

9. Mahmoud Shari'at, University of Medical Sciences (UOM)
Karamatollah Imandel, UOM
Simin Nasseri, UOM
Hassan Salman-Manesh, Ministry of Health
Ali Torabian, University of Tehran

10. Abbas Ali Nasrollahi, Institute for Scientific & Industrial Research
Parvin Akbari, Department of the Environment
Alizadeh, Plant Protection Institute
Ramazan Rouin Tan, Ministry of Agriculture
Mohammed Reza Shari'ati, Soil & Water Research Institute
Mahnaz Vojdani, Department of the Environment

11. Hooshang Goodarzi, United Nations Evironment Programme
Kamiar Esmaili, Society for Social Medicine
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ISLAMIC REPUBLIC OF IRAN

ENVIRONMENTAL STRATEGY STUDY

ANNEX II: BENEFIT VALUATION OF AIR POLLUTION REDUCTION IN IRAN

It is recognized that air pollution often cause adverse health impacts and degradation of productive assets. Policy makers and the public are asking which pollutant should be reduced, from which sources and by how much. In order to provide some guidance in this respect, benefits of air pollution reductions must be estimated in addition to costs of reductions.

For policy purposes, benefits of air pollutant reductions should be expressed in terms of economic benefits per ton of each pollutant reduced for comparability with costs per ton of reductions. This requires the following three steps: (1) environmental impacts of changes in ambient air concentrations of the pollutant must be estimated; (2) the impacts must be quantified, and (3) changes in emissions must be related to the changes in the ambient air concentrations. It is often practically impossible to estimate all impacts of air pollution on health and the physical environment and to quantify such impacts in monetary terms. The focus here is limited to some of the health impacts of air pollution.

Suggestive estimates of benefits from reductions in emissions of total suspended particulates, sulphur dioxide and lead are presented. Although not conclusive, they indicate that benefits are significant. Benefits of carbon monoxide emission reductions are considered low in comparison to the former three pollutants, and is therefore not estimated. Benefits of NOx emission reductions are difficult to quantify because of a lack of empirical studies on the links between environmental concentrations and health effects.

A. BENEFIT-COST ANALYSIS VERSUS COST EFFICIENCY

1. Optimality

The most common approach to air pollution reduction is to establish a target in terms of ambient air quality or annual emissions. The cost of achieving the target depends on a set of variables such as flexibility in terms of fuel substitution, costs of abatement technology as well as choice of policy instruments. A cost efficient strategy to air pollution reduction would first exploit the least cost options. Although exploitation of least cost options is cost efficient and a necessary condition for optimality, it is not sufficient for optimality.

Optimality requires that emissions are reduced to the point where marginal costs equal marginal benefits. Thus the target for ambient air quality or annual emissions should ideally be based on a monetary quantification of the marginal benefits of pollution reductions in addition to costs of reductions. Benefits of air pollution reductions include reduced mortality and morbidity and their associated costs, increased utility from leisure, reduced corrosion of physical structures and reduced degradation of natural resources. In order to simplify comparisons between abatement costs and benefits, both need to be quantified in monetary terms.

2. Ethical Considerations

Benefit valuation of air pollution reduction is often controversial from ethical considerations. Such considerations arise primarily because a monetary value is placed on human life. One may argue that the value of a human life is infinite. By attaching a finite monetary value on a life we are in fact establishing the upper bound on what society is willing to pay to save a life. Perhaps more controversial, the upper bound is likely to be lower in lower income countries as a result of the valuation techniques commonly applied. This seems to contradict a common conviction that the value of life is independent of where he/she is born. The consequence of such valuation is also that the value of a life increases if he/she migrates from a lower to a higher income country.

Ignoring a benefit valuation of reduced air pollution by exclusively addressing cost efficiency does not resolve the dilemma of valuation of life. By specifying a target for emission reductions or ambient air quality policy makers sometimes establish an upper bound on society's willingness to pay for reducing risk of death, though other factors such as crop damages, impact on cultural heritage and the ecosystem, and public pressure also play a part. In fact, policy makers and individuals often implicitly value their own life and the life of others every day. Mortality rates or risk of mortality could be lower by further investments in, but not limited to, provision of safe water and sanitation, health education and services, transport and job safety, as well as environmental quality. Scarce investment resources are allocated to increase the stock of physical capital for future consumption versus to reduce mortality rates. Choices are also made between current consumption and overall investment levels. These choices implicitly place a value on human life in terms of society's willingness to forego consumption to save human lives. Since higher income countries have more resources available for consumption, they are willing to forego more to save a human life in absolute monetary terms although not necessarily as a proportion of their income. As much as we believe human life has an infinite value regardless of place of birth and income level, scarcity of resources forces the society to make choices that implicitly place an upper bound on willingness to pay to reduce risk of mortality.

3. Valuation Techniques

Several valuation techniques are commonly applied to estimate the benefits of air pollution reductions or other improvements in environmental quality. Cropper and Oats (1992) present a comprehensive survey of the two main categories of valuation techniques which are summarized here. The first category is indirect market methods and the second is direct questioning approaches.

Indirect market methods involve making valuation estimates from observing actual choices people make. Some choices that are observed in the market place reveal willingness to pay (WTP) for reduced exposure to pollution and reduced risk of morbidity and/or mortality. Similarly, willingness to accept compensation (WTA) for increased risk of morbidity or mortality and increased exposure to pollution can sometimes also be observed in the market place. There are several examples of indirect market methods. The averting behavior approach relies on the fact that inputs can sometimes be used to compensate for the effects on productivity or health of reduced environmental quality: farmers can sometimes increase the amount of other inputs to compensate for reduced soil productivity from pollution, individuals can sometimes use medication to compensate for the health impacts of pollution, or households can avoid exposure to pollution by purchasing bottled water. The value of improving environmental quality or reducing exposure to pollution is measured as the cost of these additional inputs. The weak complementarity approach relies on how much more people are paying to take advantage of improved environmental quality, such as increased travel costs associated with increased demand for a recreational site that has improved in quality. The hedonic market approach relies on decomposing the price of a good into the prices of its attributes. Housing attributes are for instance air quality and noise level. Job attributes can be risk of death or injury. Thus the value of improved air quality can be measured as the marginal price differential in property values due to differences in air quality. The value of mortality risks can be measured as the wage differential due to different risk levels.

Direct questioning approaches, also called contingent valuation methods, rely on respondents stated willingness to pay for improved environmental quality or reduced risk of mortality and/or morbidity, or respondents stated minimum compensation they are willing to accept for a reduction in environmental quality or increased risk of mortality and/or morbidity. These approaches can be useful (1) when no appropriate averting or mitigating choices exist or (2) to quantify non-use values, which refer to the benefits received from knowing that a good exists even though the individual may never experience the good directly, such as preserving endangered species or a scenic location.

4. Transferability of Existing Estimates

Air pollution impacts are very point specific and depends for instance on geographic and climatic conditions, age distribution and health characteristics of the population, degree of human exposure to the pollutants, and location of pollution sources relative to natural resources such as agricultural land, forests and waters. Thus estimates of air pollution impacts should ideally be carried out at the localities of concern. But estimates of health and non-health impacts of air pollution and monetary valuation of such impacts are almost exclusively limited to OECD countries. No such studies have been carried out in Iran, but policy makers need information to address questions as from what sources should air pollution be reduced, how much should pollution be reduced, and which pollutants should receive priority. The government of Iran should make sure that studies are carried out in order to better answer these questions. In the meantime, studies from OECD countries can provide some information. However, an application of these studies to Iran involves making a set of assumptions. Thus estimates of benefits of reducing air pollution presented here should by no means be considered conclusive.

B. HEALTH IMPACTS OF SUSPENDED PARTICULATES

1. Health Impacts of a Change in Ambient Air Concentrations

The health impacts of TSP depends on for instance the size distribution of particles. Smaller particles penetrate deeper than larger ones and can therefore have more severe health impacts. Dust from a cement factory may have a larger portion of large particles than particulates from diesel combustion. The size distribution of TSP from natural sources can be quite different than TSP from combustion of oil derivatives. Thus the health impacts of a change in annual air concentration depends not only on the magnitude of change in TSP but also on the change in size distribution. Health impacts of TSP are also often associated with peak levels of concentration. Studies of the impacts of TSP on mortality and morbidity rely often on changes in daily peak concentration levels. A reduction in annual average concentration levels may not translate into an equivalent reduction in peak levels. Data are simply not available to take account of the above considerations, and the following dose-response function is applied to approximately estimate the health impacts:

$$d\ H_i = b_i * d\ TSP_c \qquad (1)$$

where H_i is health impact i (i = mortality and morbidity 1,...,n), b_i is the estimated regression coefficient associated with health impact i, and TSP_c is the annual average air concentration of TSP (ug/m^3). The change in H_i can be stated as the change in probability of mortality or morbidity.

To arrive at total number of annual expected incidences from a change in TSP_c, change in H_i is multiplied by the population exposed to TSP_c,

$$d\ H^T_i = b_i * d\ TSP_c * POP^e \qquad (2)$$

where H^T_i is the total health impact, i, for the whole exposed population, POP^e.

No studies exist for Iran that provide estimates of a dose-response function. Most studies are from OECD countries and are summarized in Ostro (1992). The health impacts are measured in terms of the impact of changes in concentration of TSP on mortality, respiratory hospital admissions, emergency room visits, restricted activity days, lower respiratory illnesses (here bronchitis) in children, asthma attacks, and minor respiratory symptoms. Health impacts will depend on variables such as smoking habits, age distribution and general health status, and the rates of hospital admissions and emergency room visits will depend on access to health services and the extent to which the patients pay for the services. Thus health impacts as measured by these "indicators" are likely to be different in Iran, and thus estimates from OECD countries can only serve as an approximation.

Ostro (1992) presents estimates of the coefficient, b, in (2) for a set of health impacts from studies in OECD countries. The central estimates are presented in Table 1. The estimated coefficients or health responses associated with a unit change in ambient air concentration of TSP are likely to depend on the base concentration of TSP. The magnitudes of the coefficients are likely to be larger at higher concentration levels. Thus it is important to know the base levels observed in the localities for which coefficients are estimated. The annual average concentration levels in the largest cities in Iran are in the range of concentration levels associated with the studies on mortality impacts of TSP, and the central estimate presented above is therefore applied to Iran. The concentration levels in the localities on which estimates are based for morbidity impacts are not generally reported in Ostro (1992), but are likely no higher than in the largest cities in Iran. If health impacts are larger at higher concentration levels, estimated impacts in Iran are not overstated, ceteris paribus, by applying the coefficient estimates presented above.

Table 1

Estimates of Coefficients for Annual Health Impacts of TSP[1]

	Central Estimate
Mortality[2]	$6.13 * 10^{-6}$
Respiratory Hospital Admissions	$5.59 * 10^{-5}$
Emergency Room Visits	$12.95 * 10^{-5}$
Restricted Activity Days for Adults	$3.20 * 10^{-2}$
Lower Respiratory Illnesses in Children[3]	$8.60 * 10^{-4}$
Asthma Attacks	$5.30 * 10^{-3}$
Minor Respiratory Symptoms in Adults	$1.48 * 10^{-1}$

[1] The coefficients, b_i, for health impact, i, are from the following equation:

$d\ H^T_i = b_i * d\ TSP_c * POP^e$

[2] The coefficient is adjusted for the crude death rate differential between US (0.007) and Iran (0.009).
[3] Limited to bronchitis only of the exposed population under 15 years.

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2. Monetary Value of Health Impacts

The valuation techniques presented above can be applied to estimate the monetary value of health impacts from air pollution. However, valuation estimates are not available for Iran. Until such estimates exist, one is limited to rely on estimates from OECD countries. No consensus prevails regarding which valuation technique is most appropriate and to some extent it depends on the type of benefits to estimate. Estimates of willingness to pay (WTP) for a reduction in morbidity or risk of mortality, derived either from observed choices people make (indirect market methods) or direct questioning approaches, better reflect the value people place on improved health and safety relative to consumption than simply the financial cost of illness (cost of medical treatment and lost income from illness). In fact, estimates of WTP are often two to four times higher than the cost of illness, which suggest the relatively large value people place on utility from leisure, absence of pain and other non-financial dimensions of health. Ostro (1992) presents estimates of WTP to the extent available and costs of illness in OECD countries for a set of health impacts associated with air pollution. An application of these estimates to Iran must at least recognize the following factors. First, the average income level in Iran is substantially lower than in most OECD countries. Thus, the maximum amount the average individual in Iran is willing to give up to reduce adverse health impacts is therefore expected to be significantly lower. Second, the economic cost of medical treatment is substantially lower in Iran implying that cost of illness, which is one component of WTP, is lower. In an attempt to account for these differences, WTP and cost of illness are adjusted for the difference in per capita income.

2.1. Mortality:

WTP is used for valuation of reducing the risk of death. Studies from OECD countries present a mean estimate of WTP of US $200-300 for a risk reduction of 0.0001, which translates to value of US $2-3 million per statistical life. These estimates are based on observed wage premiums in higher risk jobs and direct questioning regarding fatal accidents at work or in traffic. However, an application of this estimate to risk of mortality from air pollution is not straight forward. It is likely that deaths from increases in TSP are among the most vulnerable in the population, i.e. young children and elderly people. However, the WTP estimate presented above is for people in their prime adult life. These people have a longer expected remaining life than elderly people, but shorter than young children. People in their prime adult life have accumulated significant amounts of training, skills and experience of high economic value to society that make them far more irreplaceable than young children in which society has not yet invested substantial resources. Thus from a strictly economic perspective the value of reducing risk of mortality for children and elderly would be less than the above estimate. But WTP for reducing risk of mortality is not only based on economic considerations, and the value applied here is therefore US $2-3 million per statistical life as estimated for people in their prime adult life, adjusted for the income differential between Iran and high income OECD countries.

2.2. Morbidity:

Cost of illness will primarily be used for valuation purposes of morbidity. The measure includes medical costs and lost income, but excludes value of reduced leisure, increased discomfort, and defensive or averting expenditures. Figures presented here are US cost figures (Ostro 1992), which will be adjusted for the income differential between Iran and high income OECD countries.

1. Respiratory Hospital Admissions: US $28,000 per admission, which includes medical costs and lost wages for an average stay of 10 days.

2. Emergency Room Visit: US $250 per visit, which includes medical costs and lost wages for 1 day.

3. Restricted Activity Days: US $60 per day, which assumes a wage loss of 20% of restricted activity days and one-third of wages for the remaining days.

4. Lower Respiratory Illness in Children: US $325 per illness, which assumes two week duration at $ 15 per day and two restrictions by a parent for day care.

5. Asthma Attacks: US $100 per attack, which includes medical costs, restrictions in activity, work or leisure.

6. Respiratory Symptoms: US $15 per day, which is based on an average of WTP estimates for eliminating symptoms such as a day of coughing or sinus or throat congestion.

3. An Application to Iran:

Three cases will be considered in terms of health impacts of TSP emissions. Case I presents the estimated health impacts of a marginal change in the concentration level of TSP for the year 1991. Case II presents the estimated annual increase in health impacts from 1991 to 2010. Case III presents the estimated annual decrease in health impacts in year 2010 from alternative emissions reductions strategies.

Case I: The estimated health impacts of changes in TSP ambient air concentrations, and the monetary valuations of health impacts are applied to derive an estimate of expected annual benefits of a one unit (ug/m^3) reduction in ambient air concentrations of TSP. Key parameters are specified for this purpose:

- A total population of 16 million is estimated to be affected by excessive levels of TSP air concentrations, of which almost 9 million are children of age 0-14 years and more than 7 million are of age 15 years and above. Outdoor air pollution is primarily a concern in larger urban areas. The total urban population of Iran is about 33 million. There are six cities with more than one million people. Including Greater Tehran the total population in these cities are in the order of 15-17 million, which is the base for the estimated exposed population.

- The monetary valuations are adjusted by the difference in per capita income level between high income OECD countries and Iran. Based on the World Bank atlas methodology, per capita income in Iran is about US $2,200. However, GDP in local currency was Rl 67.8 trillion in 1992/93[2]. This implies a per capita income of about US $800 at the floating exchange rate of Rl 1,400 per dollar as of May 1992. The purpose of estimating benefits is to facilitate a comparison to costs of emission reductions. These costs are to a large extent in terms of capital investments, which often must be imported at an exchange rate of more than Rl 1,700 per dollar as of November 1993. Thus one may argue that the floating exchange rate of Rl 1,400 per dollar should be applied to convert

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[2]March 1992 to March 1993.

to per capita income in units of US dollars for 1992/93. The income differential is about 11 if a per capita income of US $2,200 is applied, and about 30 if the floating exchange rate is used for conversion. An income differential of 20 is applied here.

The estimated annual impacts of a one unit reduction in TSP ambient air concentration (1 ug/m^3) are presented in Table 2, both in terms of expected reduction in number of cases of each health impact and monetary benefits associated with reductions as a percentage of total benefits. The "high case" and "low case" of monetary benefits is for a mortality valuation of US $3 million and US $2 million (US $150,000 and US $100,000 after adjusting for income level), while morbidity valuation is the same under both cases. The monetary benefits associated with expected reduction in mortality are 83.1% and 76.7% of total benefits in the "high case" and the "low case" respectively.

Table 2.

Annual Health Benefits from Reductions in TSP Air Concentrations

Reduction in annual Health Impacts	Cases Per Unit Reduction (ug/m^3)
Mortality (premature deaths avoided)	100
Respiratory Hospital Admissions	925
Emergency Room Visits	2,150
Restricted Activity Days	240,000
Lower Respiratory Illnesses in Children	8,000
Asthma Attacks	17,500
Minor Respiratory Symptoms in Adults	1,100,000

Reduction in annual Health Impacts	Percent of Total Monetary Benefits	
	Low case	High case
Mortality (premature deaths avoided)	76.6%	81.1%
Respiratory Hospital Admissions	9.8%	7.1%
Emergency Room Visits	0.2%	0.1%
Restricted Activity Days	5.4%	3.9%
Lower Respiratory Illnesses in Children	1.0%	0.7%
Asthma Attacks	0.7%	0.5%
Minor Respiratory Symptoms in Adults	6.3%	4.6%
Total	100.0%	100.0%

Case II: The mortality and morbidity impacts of changes in ambient air concentrations of TSP will change over time. Since estimates presented in Case I suggest that the mortality component by far outweighs the morbidity component for the valuations applied, only changes in mortality impacts are presented here. Baseline emissions of TSP from energy consumption and industry are projected to increase by 150% from 1991 to 2010, and the urban population is projected to increase by 110%. It is assumed that the exposed population will increase by the same percentage as urban population, while the geographical area over which the population is distributed will only increase by 50%.

In order to estimate the increase in mortality impacts, an estimate of the change in the TSP concentration level must be derived. The following equation is applied for this purpose:

$$TSP^c_{2010}=TSP^c_{1991}*[(TSP^e_{2010}+TSP^N_{2010})/(1+A)]/(TSP^e_{1991}+TSP^N_{1991})$$

where superscript c refers to ambient air concentrations (ug/m^3), superscript e refers to annual emissions (000 tons) from energy consumption and industry, superscript N refers to annual emissions (000 tons) from natural sources, and A is the increase in the geographical area of the exposed population and emission sources. With an estimate of the baseline concentration level for 2010 at 240 ug/m^3, the annual difference in mortality in 2010 and 1991 is calculated based on the coefficient presented in Table 1 and the following equation:

$$d\ M = 6.13*[POP^e_{2010}(TSP^c_{2010}-90)\ -\ POP^e_{1991}(TSP^c_{1991}-90)]/1{,}000{,}000 \qquad (3)$$

where POP^e is the exposed population. The first product on the right hand side of the equation is the number of premature deaths in 2010 from excessive levels of TSP concentrations, i.e. above 90 ug/m^3. The second product is premature deaths in 1991 from excessive levels of TSP concentrations. The upper bound of the annual average WHO standard (90 ug/m^3) is chosen as the base level, above which TSP concentrations are considered excessive. If a lower base level is chosen, the estimated increase in annual premature deaths from 1991 to 2010 would be higher. The estimated annual increase from 1991 to 2010 is presented in Table 3.

Case III. Estimates of reductions in annual premature deaths in 2010 from reductions in TSP emissions resulting from efficient energy pricing, active natural gas expansion and low-cost process and abatement technology are based on the following equation and presented in Table 3:

$$d\ M = 6.13 * d\ TSP^c_{2010} * POP^e_{2010} / 1{,}000{,}000 \qquad (4)$$

which is the same equation as (2), or a difference equation of (3).

Table 3.

Incremental Changes in Mortality Cases
(annual)

(0) Baseline from 1991 to 2010	+22,900
(1) Efficient energy pricing in 2010	- 5,200
(2) Efficient energy pricing and active natural gas expansion in 2010	- 8,400
(3) Low-cost process and abatement technology and (2)	- 8,100

C. HEALTH IMPACTS OF SULPHUR DIOXIDE

1. Health Impacts of a Change in Ambient Air Concentrations

Emissions of SO2 often have adverse health as well as non-health impacts. The focus here is limited to some of the health impacts. Health impacts of SO2 are often associated with peak levels of concentration. Studies of the impacts of SO2 on mortality and morbidity rely often on changes in daily peak concentration levels. A reduction in annual average concentration levels may not translate into an equivalent reduction in peak levels, but data are simply not available to take account of the above considerations. No studies exist for Iran that provide estimates of health impacts of SO2. Most studies are from OECD countries and are summarized in Ostro (1992). The health impacts are measured in terms of the impact of changes in concentration of SO2 on mortality and minor respiratory symptoms.
The following dose-response function is applied to approximately estimate annual the health impacts (Ostro 1992):

$$d\ H^T_i = b_i * d\ SO2_c * POP^e \qquad (5)$$

where H^T_i is the total health impact, i, for the whole exposed population, POP^e, b_i is the estimated coefficient, and $SO2_c$ is the ambient air concentration (ug/m^3) of SO2. The central estimate of the coefficients are presented in Table 4. The annual average concentration levels of SO2 in the largest cities in Iran are in the range of concentration levels associated with the studies on mortality and morbidity impacts, and the central estimate presented above is therefore applied to Iran. The central estimate is derived to the extent possible from studies which controlled for other pollutants, in particular TSP since movements in air concentration levels of TSP and SO2 are often correlated.

Table 4.
Estimates of Coefficients for Annual Health Impacts of SO2

	Central Estimate
Mortality[1]	$4.32 * 10^{-6}$
Minor Respiratory Symptoms in Children[2]	$1.81 * 10^{-5}$
Minor Respiratory Symptoms in Adults[3]	$1.02 * 10^{-2}$

[1] coefficient is adjusted for the crude death rate differential between US (0.007) and Iran (0.009).
[2] Measured as cough only in exposed population under 15 years.
[3] Measured as chest discomfort in exposed population 15 years and above.

2. Monetary Value of Health Impacts

The same approach and monetary unit values are applied as in the case of TSP, i.e US $2-3 million per statistical life and US $15 per case of respiratory symptoms adjusted for income differential between high income OECD countries and Iran.

3. An Application to Iran

Three cases will be considered in terms of health impacts of TSP emissions. Case I presents the estimated health impacts of a marginal change in the concentration level of TSP for the year 1991. Case II presents the estimated annual increase in health impacts from 1991 to 2010. Case III presents the estimated annual decrease in health impacts in year 2010 from alternative emissions reductions strategies.

Case I: The estimated health impacts of changes in SO2 ambient air concentrations, and the monetary valuations of health impacts are applied to derive an estimate of expected annual benefits from a one unit (ug/m^3) reduction in SO2 air concentrations. Key parameters are specified for this purpose:

- Excessive levels of SO2 are prevalent in Greater Tehran, but in fewer of the other large cities than is the case for TSP. Thus an estimated 13 million people are assumed to be affected by excessive levels of SO2 air concentrations, of which 7 million are children of age 0-14 years and more than 6 million are of age 15 years and above.

- The monetary valuations are adjusted by the difference in per capita income level between high income OECD countries and Iran, i.e. by a factor of 20.

The estimated impacts of a one unit reduction in SO2 ambient air concentration (1 ug/m^3) are presented in Table 5, both in terms of expected reduction in number of cases of each health impact and monetary benefits associated with reductions as a percentage of total benefits. The "high case" and "low case" of monetary benefits is for a mortality valuation of US $3 million and US $2 million (US $150,000 and US $100,000 after adjusting for income level), while morbidity valuation is the same under both cases.

The monetary benefits associated with expected reduction in mortality and minor respiratory symptoms are more than 99% and less than 1% of total benefits respectively in the "high case" and the "low case".

Table 5.
Annual Health Benefits from Reductions in SO2 Air Concentrations

Reduction in annual Health Impacts	Cases Per Unit Reduction (ug/m^3)
Mortality (premature deaths avoided)	70
Minor Respiratory Symptoms in Children	165
Minor Respiratory Symptoms in Adults	75,000

Reduction in annual Health Impacts	Percent of Total Monetary Benefits	
	Low case	High case
Mortality (premature deaths avoided)	99.2%	99.5%
Minor Respiratory Symptoms in Children	0.0%	0.0%
Minor Respiratory Symptoms in Adults	0.8%	0.5%
Total	100.0%	100.0%

Case II: The mortality and morbidity impacts of changes in ambient air concentrations of SO2 will change over time. Since estimates presented in Case I suggest that the mortality component by far outweighs the morbidity component for the valuations applied, only changes in mortality impacts are presented here. Baseline emissions of SO2 from energy consumption and industry are projected to increase by 160% from 1991 to 2010, and the urban population is projected to increase by 110%. It is assumed that the exposed population will increase by the same percentage as urban population, while the geographical area over which the population is distributed will only increase by 50%.

In order to estimate the increase in mortality impacts, an estimate of the change in the SO2 concentration level must be derived. The following equation is applied for this purpose:

$$SO2^{c}_{2010} = SO2^{c}_{1991} * [(SO2^{e}_{2010}/(1+A)]/SO2^{e}_{1991}$$

where superscript c refers to ambient air concentrations (ug/m^3), superscript e refers to annual emissions (000 tons) from energy consumption and industry, and A is the increase in the geographical area of the exposed population and emission sources. With an estimate of the baseline concentration level for 2010 at 239 ug/m^3, the annual difference in mortality in 2010 and 1991 is calculated based on the coefficient presented in Table 4 and the following equation:

$$d\ M = 4.32*[POP^{e}_{2010}(SO2^{c}_{2010}-90) - POP^{e}_{1991}(SO2^{c}_{1991}-90)]/1{,}000{,}000 \qquad (6)$$

where POP^{e} is the exposed population. The first product on the right hand side of the equation is the number of premature deaths in 2010 from excessive levels of SO2 concentrations, i.e. above 90 ug/m^3. The second product is premature deaths in 1991 from excessive levels of SO2 concentrations. The same level as for TSP (90 ug/m^3) is chosen as the base level, above which SO2 concentrations are considered excessive. This level is above the upper bound of the WHO standard, but below the World Bank standard of 100 ug/m^3. The estimated coefficient for mortality of SO2 is lower than of TSP. Thus the upper bound (60 ug/m^3) of the WHO standard is not chosen as base level since the upper bound for TSP is 90 ug/m^3. If a lower base level is chosen, the estimated increase in annual premature deaths from 1991 to 2010 would be higher. The estimated annual increase from 1991 to 2010 is presented in Table 6.

Case III. Estimates of reductions in annual premature deaths in 2010 from reductions in SO2 emissions resulting from efficient energy pricing, active natural gas expansion and low-cost process and abatement technology are based on the following equation and presented in Table 6:

$$d\ M = 6.13 * d\ SO2^{c}_{2010} * POP^{e}_{2010} / 1{,}000{,}000 \qquad (7)$$

which is the same equation as (5), or a difference equation of (6).

Table 6.

Incremental Changes in Mortality Cases
(annual)

(0) Baseline from 1991 to 2010	+18,800
(1) Efficient energy pricing in 2010	- 6,500
(2) Efficient energy pricing and active natural gas expansion in 2010	-13,100
(3) Low-cost process and abatement technology and (2)	- 6,600

D. HEALTH IMPACTS OF LEAD EMISSIONS

1. Health Impacts of a Change in Ambient Air Concentrations

Lead emissions are primarily from consumption of leaded gasoline, but also from stationary sources such as lead smelters. The largest health impacts are neurodevelopmental effects in children that impair their intelligence, but impacts include also hypertension and related cardiovascular conditions in adults.

No studies exist for Iran that provide estimates of health impacts of lead emissions. Most studies are from OECD countries and are summarized in Ostro (1992). The health impacts are measured in terms of the impact of changes in concentration of lead on mortality associated with cardiovascular effects, hypertension, and IQ loss in children from impairment of neurodevelopment.

Ostro (1992) presents estimates from studies on health impacts of lead emissions. A 0.5 ug/m^3 reduction in ambient air concentration of lead is associated with annual:

Reduction in mortality	14 per 100,000 adult men;
Reduction in hypertension	2,860 cases per 100,000 adults;
IQ loss (points) in children	48,750 per 100,000 children.

2. Monetary Value of Health Impacts

The same approach and monetary unit values are applied for mortality as in the case of TSP and SO2. The cost per case of hypertension is US $220 in terms of medical costs and lost income. The cost of neurodevelopmental impacts is approximated by estimated loss of lifetime earnings associated with a reduction in IQ. The estimate is US $4,500 per IQ point (Ostro 1992). For consistency with the other estimates, this estimate is annualized to US $450. All estimates are adjusted for the income differential between high income OECD countries and Iran.

3. An Application to Iran:

Three cases will be considered in terms of health impacts of lead emissions. Case I presents the estimated health impacts of a marginal change in the concentration level of lead for the year 1991. Case II presents the estimated annual increase in health impacts from 1991 to 2010. Case III presents the estimated annual decrease in health impacts in year 2010 from efficient energy pricing and removal of leaded gasoline.

Case I: The estimated health impacts of changes in ambient air concentrations of lead, and the monetary valuations of health impacts are applied to derive an estimate of expected annual benefits from a one unit (0.1 ug/m^3) reduction in air concentration of lead. Key parameters are specified for this purpose:

- Excessive levels of lead are prevalent in Greater Tehran, and likely in a few of the other large cities in Iran. An estimated 16 million people, of which 9 million are children of age 0-14 years, are assumed to be affected by excessive levels of lead air concentrations from leaded gasoline consumption.

- The monetary valuations are adjusted by the difference in per capita income level between high income OECD countries and Iran, i.e. by a factor of 20.

The estimated impacts of a one unit reduction in lead ambient air concentration (0.1 ug/m^3) are presented in Table 7, both in terms of expected reduction in number of cases of each health impact and monetary benefits associated with reductions as a percentage of total benefits. The "high case" and "low case" of monetary benefits is for a mortality valuation of US $3 million and US $2 million (US $150,000 and US $100,000 after adjusting for income level) respectively, while morbidity valuation is the same under both cases.

Table 7.

Health Benefits from Reductions in Lead Emissions

Reduction in Health Impacts	Cases Per Unit Reduction (ug/m^3)
Mortality (premature deaths avoided)	105
Hypertension	42,600
IQ (points) loss in children	890,000

Reduction in Health Impacts	Percent of Total Monetary Benefits	
	Low cse	High case
Mortality (premature deaths avoided)	33.9%	43.5%
Hypertension	1.5%	1.3%
IQ (points) loss in children	64.6%	55.2%
Total	100.0%	100.0%

Case II: The mortality and morbidity impacts of changes in ambient air concentrations of lead will change over time. Only changes in mortality impacts are presented here, although morbidity impacts are substantial (Table 7).

Baseline emissions of lead from traffic are projected to increase by 110% from 1991 to 2010, and the urban population is projected to increase by 110%. It is assumed that the exposed population will increase by the same percentage as urban population, while the geographical area over which the population is distributed will only increase by 50%.

In order to estimate the increase in mortality impacts from 1991 to 2010, equations similar to the case of TSP and SO2 are applied. The estimate is presented in Table 8.

Case III: Estimates of reductions in annual premature deaths in 2010 from reductions in lead emissions resulting from efficient gasoline pricing and removal of leaded gasoline are based on the coefficients in D.1. and presented in Table 8.

Table 8.

Incremental Changes in Mortality Cases (annual)

(0) Baseline from 1991 to 2010	+3,350
(1) Efficient energy pricing in 2010	-1,550
(2) Removal of leaded gasoline	-3,050

V. MONETARY BENEFITS PER TON OF POLLUTANT

For policy purposes, benefits of air pollutant reductions should be expressed in terms of monetized benefits per ton of each pollutant reduced for comparability with costs per ton of reductions. This requires the following three steps: (1) health impacts of changes in ambient air concentrations of the pollutant must be estimated; (2) the impacts must be monetized, and (3) changes in emissions must be related to the changes in the ambient air concentrations of the pollutant. The first and second step were presented in preceding sections, while the third step is discussed in this section.

1. Impact of Changes in TSP Emissions on Ambient Air Concentrations

Ambient air concentration of TSP differs across locations within a metropolitan area or in the neighborhood of a power plant, a cement factory or a steel plant. The impact on ambient concentration of emission reductions from any particular source depends on for instance the location of the emission source, wind characteristics, and the level of TSP from natural sources such as air born particulates from deserts. Monitoring of TSP concentrations is also limited to relatively few points within the region of concern and concentration levels differ substantially during the day and across months. These factors complicate an accurate specification of the relationship between changes in TSP emissions and the ambient air concentration of TSP. Given the immense information requirement for an accurate specification, one is limited to operate with broad averages in terms of ambient air concentration and impacts of changes in emissions. Thus the following relationship is used here to estimate the average impact of changes in emissions:

$$d\ \ln(TSP_c) = a * d\ \ln(TSP_e) \qquad (4)$$

where d is the marginal change, TSP_c is annual average air concentration of TSP (ug/m^3), TSP_e is tons of TSP emissions per year from energy use and industrial activities, and a is the ratio of TSP_e to total TSP emissions including from natural sources. This relationship states that a percentage change in TSP_e results in the same percentage change in TSP_c adjusted for emissions from natural sources.

2. Impact of Changes in SO2 Emissions on Ambient Air Concentrations

Practically no SO2 emissions are from natural sources in Iran. It is therefore postulated that a one percent change in SO2 emissions results in a one percent average change in the ambient air concentration of SO2, recognizing that most of the factors relevant for TSP pertain to SO2 as well in terms of complicating an accurate specification of the relationship between emissions and concentration levels. Thus the following relationship is used here to estimate the average impact of changes in emissions:

$$d\ \ln(SO2_c) = d\ \ln(SO2_e) \qquad (8)$$

where d is the marginal change, $SO2_c$ is annual average air concentration of so2 (ug/m^3), $so2_e$ is tons of TSP emissions per year from energy use and industrial activities.

3. A Comparison of TSP and SO2 Emissions and Concentrations

Total annual emissions of TSP from energy and industrial activities in 1991 are estimated at about 220,000 tons, and emissions of SO2 at about 860,000 tons. Monitoring data from the Environmental Health Department show a consistently higher average concentration level of TSP in all major cities. The lifetime of SO2 in the air is normally longer than of TSP, suggesting at first that concentration levels of SO2 should be higher than of TSP, contrary to what monitoring data indicate. However, there are at least two factors to consider in this respect. First, TSP from natural sources are expected to be high, given that Iran is to a large extent located in a semi-arid region. Unfortunately, no reliable estimate is available to determine the ratio of particulates from natural sources to particulates from energy and industrial activities. Second, monitoring stations may not capture a large part of SO2 emissions due to their locations. For instance, SO2 emissions from refineries are estimated at about 210,000 tons. If most of the monitoring stations in for instance Tehran are located in areas of heavy traffic and proportionately less in areas affected by SO2 emissions from the refinery, average monitored concentrations of SO2 will be an underestimate of actual levels.

4. Benefits Per Ton of TSP and SO2

Total annual emissions of TSP in 1991 are about 220,000 tons from energy use and industrial activities. It is assumed that an equivalent amount of TSP is from natural sources. Thus a one percent change in TSP emissions translates to a one-half percent change in TSP ambient air concentration. For an annual average TSP ambient air concentration of 180 ug/m^3, a one unit (1 ug/m^3) reduction in the average annual concentrations requires a 2,440 tons reduction in annual TSP emissions. This translates to US $5,400 benefits per ton of TSP in the low case of mortality valuation. Expressed in terms of lives rather than monetary units, in order to avoid controversy of valuing life, the benefits per 1000 tons of TSP reductions are 42 premature deaths avoided. However, the benefits per 1000 tons of TSP reductions in 2010 are 58 premature deaths avoided because the exposed population to excess levels of TSP has increased.

Total annual emissions of SO2 in 1991 are about 860,000 tons from energy use and industrial activities. A one percent change in SO2 emissions translates to a one percent change in SO2 ambient air concentration. Thus a one unit (1 ug/m^3) reduction in the average annual SO2 ambient air concentration requires a 6,140 tons reduction in annual SO2 emissions for an average SO2 concentration of 140 ug/m^3. If a one percent change in lead emissions translates to a one percent change in lead ambient air concentration. This translates to almost US $1,200 benefits per ton of SO2 in the low case of mortality valuation. Expressed in terms of lives rather than monetary units, in order to avoid controversy of valuing life, the benefits per 1000 tons of SO2 reductions are 12 premature deaths avoided. However, the benefits per 1000 tons of SO2 reductions in 2010 are 16 premature deaths avoided because the exposed population to excess levels of SO2 has increased.

1. Changes in Lead Emissions and Benefits Per Ton

Most of lead emissions in Iran are from consumption of leaded gasoline. It is therefore postulated that a one percent change in lead emissions from a one percent change in leaded gasoline consumption results in a one percent change in the average ambient air concentration of lead, recognizing that most of the factors relevant for TSP and SO2 pertain to lead as well in terms of complicating an accurate specification of the relationship between emissions and concentration levels.

Total annual emissions of lead is about 4,300 tons from leaded gasoline consumption. A one unit (0.1 ug/m^3) reduction in the average annual lead ambient air concentration requires a 190 tons reduction in annual lead emissions for an average lead concentration of 2.2 ug/m^3. This translates to about US $0.1 per liter of gasoline in mortality and morbidity benefits of reducing consumption of leaded gasoline. A measurement only in terms of premature deaths avoided would substantially understate benefits of reductions because a large component of benefits is morbidity.

VI. CONCLUSIONS

Estimated benefits of reductions in emissions of total suspended particulates, sulphur dioxide and lead are substantial. One the one hand, if the estimated health impacts considered are reasonably correct, health benefits are likely to be understated for several reasons. First, non-health benefits are not included although likely to be minor relative to health benefits. Second, health impacts of TSP and SO2 are short term effects. Long term effects could be significant. Third, average health conditions in Iran are likely to be worse than in high income OECD countries, and pollution impacts could therefore be larger in Iran than estimates from OECD countries suggest. On the other hand, monetary valuations for the given estimated health impacts are to a large extent determined by the valuation of mortality for TSP and SO2. If discounted present value of future income is used for valuation of mortality, monetary benefits would be lower. Nevertheless, estimated monetary benefits suggest that actions should be taken immediately to reduce air pollution. The benefit estimates along with estimated costs of reducing pollutants can help determine a reasonable target for reductions.

Emissions Coefficients
(kg/ton of energy)

Sector	Emission	Diesel	Fuel Oil	Kerosene	Gasoline	Natural Gas	LPG
Residential/comm							
	SO_2	9	30	2		0.045	0.04
	NOx	2.3	3	2		2.4	1.0
	TSP	3	5	1		0.15	0.2
	CO	0.6	0.6	0.6		0.5	0.6
	HC	0.3	0.4	0.3		0.2	0.1
Industry							
	SO_2	9	30			0.045	
	NOx	8.6	8.6			3.6	
	TSP	3	5			0.15	
	CO	0.7	0.7			0.9	
	HC	0.3	0.4			0.8	
Agriculture							
	SO_2	9	30				
	NOx	8.6	8.6				
	TSP	3	5				
	CO	0.7	0.7				
	HC	0.3	0.4				
Road Transport							
	SO_2	9			1.6		
	NOx	35			15		
	TSP	6			0.4		
	CO	30			550		
	HC	20			90		
Power							
	SO_2	9	54			0.045	
	NOx	13	16			13*	
	TSP	3	8			0.15	
	CO	2	2			2.2	
	HC	0.7	0.8			0.8	

*This coefficient is reduced to 7.5 for low-NOx burners in all future gas-fired power plants.

ISLAMIC REPUBLIC OF IRAN

ENVIRONMENTAL STRATEGY STUDY

ANNEX III: AIR POLLUTION FROM INDUSTRIAL SOURCES

The major air polluting industrial sectors are the metallurgical industry, refineries, petrochemical industry, and the cement industry. The metallurgical industry emits metals, sulfur dioxide, volatile hydrocarbons, PAHs, nitrogen oxides, particulates, and fluorides. The emissions from refineries and petrochemical industry includes SO_2, volatile hydrocarbons (VOCs), and nitrogen oxides. The emissions from cement plants is mainly particulates and nitrogen oxide, but also heavy metals such as mercury could be present in the exhaust gases depending on the raw material. A closer evaluation of the emissions based on information collected in Iran and also on the team's general knowledge of industrial pollution follows below.

The copper smelter in Sar Cheshme could be considered to be one of the major "hot spots" in Iran. Only limited data on the air emissions from the smelter have been made available to the team in the report "Environmentally Sustainable Industry and Mining" prepared by consultants. Based on this data, production figures and a general knowledge of the process technology used, estimates can be made. Data on production of copper per year differs between different sources. The most reliable production information gives a production of 125,700 tons per year in 1991. Knowing that there is no sulfur emission control, the sulfur dioxide emission can be estimated to 1000 kg/per ton of copper produced or on the order of 125,000 tons per year. The copper emission could be judged to be approximately 500 tons per year based on the present production and the NOx emission 150 tons per year.

The smelter uses what is today considered to be an outdated production technology based on reverbatory furnaces and Pierce-Smith converters. The normal way to reduce SO_2 emissions from this type of smelter is to produce sulfuric acid from the SO_2 in the furnace gases. The resulting SO_2 emission will be roughly 100 kg/ton. Modern processes are more energy efficient and use only half of the energy amount per ton of produced copper as compared with the reverbatory route of production. The process gases from a modern method such as the flash process are also higher in SO_2 concentration which increases the recovery rate of sulfur. The emissions consequently drop to about
30 kg/ton of produced copper. The most advanced processes used world-wide, have a sulfur dioxide emission rate of less than 5 kg ton.

The trend in the copper industry today is to close down older reverbatory furnaces and replace them with more energy efficient options.
Copper smelters producing copper, from ordinary ores, based on the reverbatory technology will hardly survive on the market without subsidies. A reduction in the SO^2 emissions from the Sar Cheshme smelter should therefore primarily build on a shift of process technology. Several new process options are available for the production of copper. All will result in a considerable reduction of sulfur dioxide emissions.

According to Iranian government plans, the production of copper will be increased to 250,000-365,000 tons per year. In order to avoid a very severe environmental situation as a result, the related environmental issues need to be addressed. The Iranian government should be encouraged to look for modern process options for the expansion. The result will be a more competitive smelter and minimal emissions. The copper emission is likely to be reduced by more than 90% with such a shift.

Another metal smelter with potentially dangerous air emissions is the National Lead & Zinc Co's lead smelter in Zanjan. The smelter is not yet in full operation because of problems with the process. The process equipment is very advanced from an environmental point of view. Correctly operated, the smelter should release only small amounts of heavy metals into the atmosphere. The converter is equipped with a hood to collect dust from the operation. The process gases trapped in the hood are transferred to a wet scrubber for cleaning. In addition, the whole converter is encapsulated in a so-called "dog house" evacuated to a filter. The converter building also has an evacuation and dust removal system. The only major air release when properly operated is an SO_2 emission of 2,200 tons per year at a scheduled production capacity of 75,800 tons per year.

The problems in the lead smelter with the process operation results in an overload of the wet scrubber for dust control and the cooling towers for mercury reduction. The process gases are therefore frequently bypassed and released without any cleaning. The untreated raw gas from the converter is estimated to contain on the order of 10% of the ore feed or 1,500 kg of dust per hour containing As, Sn, Cd, Zn, and Pb. Also emissions of vaporized Hg are released. If the situation is not corrected soon, a very severe health problem can be foreseen in the area. A training program for the process operators seems to be urgently needed to improve their capabilities.

Two secondary lead smelters are located in Tehran. The smelters base their production on scraped batteries and are considered to be strategic industries headed by the Ministry of Defence. No information has therefore been made available to the team. The impression after a visit to the area where one of the smelters is located, however, is that environmental control at the plant is of low standard or does not exist at all. The lead emission from an uncontrolled secondary smelter is normally in the order of 50 kg per ton of production. A production capacity of 10,000 tons per year is a reasonable estimate indicating that emissions could be on the magnitude of 500 tons per year. With proper control, an emission of less than 0.2 kg per ton or 2 tons per year is possible.

Another major source of pollution is the aluminum smelter in Arak with an annual production of 113,000 tons in 1991. It was not possible for the mission to visit the smelter, but according to information from Iranian sources, the smelter uses so-called Soderberg furnaces. This technology is a polluting technology with high energy demand. All aluminum plants that have been built in the last ten years use furnaces with prebaked anodes. The advantage of prebaked technology is that the energy demand is reduced from 16,5-18,5 MWh per ton of produced aluminum to 13,0-15,0 MWh per ton. The prebaked technology is also easier to control from an environmental point of view. The key factor is the degree that the furnace gases can be collected and transferred for treatment. The prebaked technology has a gas capturing degree of 97-98% while the Soderberg furnaces with horizontal studs normally have a collection degree of 65-90%. Soderberg furnaces with horizontal stud cells admit a somewhat better collection than furnaces with vertical studs. The major emissions from aluminum smelters are particulates, sulfur dioxide, and gaseous fluoride. Part of the particulate emissions consist of carcinogenic polyaromatic hydrocarbons and a part particulate fluoride.

One source provided information that the aluminum smelter had no air emission arrestment equipment at all. Considering the information given in the report <u>Environmentally-Sustainable Industry and Mining</u>, given the concentrations of sulfur dioxide, particulates, and fluorides in the process gases, that information seems unlikely. Also, considering that the plant is situated close to a larger city indicates that some sort of control is used. Estimating that the Arak smelter has normal fugitive emissions and an air cleaning system below average gives the resulting emissions of 1,400 tons of particulates per year, 1,900 tons of gaseous fluorides, 1,300 tons of sulfur dioxide, and 280 tons of PAH. Without control, the smelter would emit about 5,000 tons of particulates and 9,000 tons of HF. The SO_2 emission would probably not change significantly.

The best option to reducing emissions from the aluminum plant is by converting to pre-baked furnaces. A HF emission of less than 0.5 kg per ton and a particulate emission of less than 2 kg per ton is achievable if the furnaces are combined with dry absorption on alumina combined with a fabric filter. The investment cost for a transfer to prebaked technology is at least 200 million dollars. Considering the location of the present plant, such an investment is questionable. A sea location is favorable from a logistic viewpoint. Raw materials are imported from abroad. Through better operation, it is likely that estimated emissions could be reduced by half. A training program for the operators seems to be a reasonable first step in reducing emissions.

The steel industry is also a major polluter. Iran has three ore based steel works, one located in Ahvaz with a capacity of 1.5 million tons and two outside Isfahan with a capacity of 2.9 and 1.9 million tons respectively. The Ahvaz works and Mobarakeh steel complex use direct reduction methods while the Isfahan Steel Mill uses the old traditional production method with coke oven, sintering plant, blast furnace and steel furnace. The production in Isfahan Steel Mill will be expanded to 4 million tons. A new steel plant based on direct reduction is planned at Keshm Island. In addition, at least one scrap-based steel plant is in operation in Ahvaz and some are planned or under construction in Azerbaijan, Khorasan, and Yazd. After the expansion, production capacity will reach 16 million tons.

The most polluting steel works in Iran is the Isfahan Steel Mill (ISM). The traditional process produces higher emissions than direct reduction. ISM has provided the following information to the mission: the blast furnaces have an emission of 6,400 tons of dust per year and the steel furnaces 10,100 tons. Dust emissions from the coke oven is probably about 1.5 kg per ton or 1,600 tons. The sintering plant produces 2.5 million tons of sinter. Estimated dust emission factor is 1 kg per ton, with the knowledge that the sintering plant is equipped with cyclones, ESP, and wet scrubbers. Resulting emission are 2,500 tons. Total dust emission is in the order of 25,000 tons per year if other sources such as desulfurization, scarfing and cutting are included.

The sulfur emission from ISM is of a notable magnitude. No figures have been provided by the company, but knowing that the coke oven has a capacity of 1.135 million tons and that coking coals normally have a sulfur content close to 1%, the sulfur dioxide emissions can be estimated. ISM has a $NaCO_3$ scrubber for desulfurization, so a part of the sulfur in the coal will be captured. Emissions through door leakages, under-firing in the coke oven and in other parts of the steel plant will probably result in an emission of 4,000 tons per year. Together with sulfur emissions from other parts of the plant, such as the sintering plant and blast, furnace the total emission could be estimated at 5,000 tons per year. The CO emissions have been estimated at 200,000 tons per year. Mercury and other heavy metals are also present in the coal. Mercury, which is very volatile is released into the environment during the process. A rough estimate is that an emission of 50 kg is likely. A qualified guess is that also some 1,000 tons of NOx mainly from the sintering plant is emitted.

Mobarakeh Steel Complex has 5 direct reduction furnaces (DRF) and 8 electric arc furnaces (EAF). Ahvaz has 3 DRFs and 6 EAFs. No information has been provided by the companies on the dust emissions. Direct reduction furnaces normally have a specific emission of less than 0.5 kg/ton. The emissions from EAFs could be up to over 15 kg/ton. Both plants are equipped with so-called "fourth hole" dust evacuation from the furnaces, hoods to prevent dust from charging and tapping, and total building evacuation, which properly managed, should give an emission of less than 0.3 kg/ton. Mobarakeh has a pellet plant in operation with a capacity of 4.1 million tons. Estimating that Ahvaz has a pellet plant on 2.3 million tons and an emission of 0.5 kg/ton, it is possible to calculate the total dust emission from those plants. Adding some emissions for disturbances in the process and for minor sources such as cutting and scarfing, an emission of 8,000 tons per year is likely.

No information has been made available to the team on the amounts of fuel used in the direct reduction plants. The main fuel is however gas with low sulfur content. The sulfur content of the ores are also unknown to the team. No estimate on the sulfur emission has therefore been possible. The NOx emissions from the pellet plants are estimated at 5,000 tons per year.

The control equipment used in Isfahan Steel Mill should, with proper maintenance and operation, result in no more than 10,000 tons of dust emissions and it is likely to be below 5,000 tons per year. The mission was also informed that

Mobarakeh Steel had operational problems and when the team visited Isfahan no steel was processed. Training for personnel in the steel industry would probably be an efficient way to reduce emissions. Spare parts are also a scarce resource in need of upgrading.

Besides the metallurgical industry, the chemical and petrochemical industries are major air polluters. Rich in oil resources, the refinery sector is large. Iran has 7 major refineries in operation with a present capacity of 58 million tons of processed crude. Before the war with Iraq, the refinery in Abadan was the largest refinery in the world with a capacity of 630,000 barrels of oil per day. The present production is 255,000 barrels. Both the refineries in Tehran and Isfahan are presently at a higher level of production. The new refinery in Arak is the most modern one constructed to produce lead free gasoline. When the refinery in Bandara Bas is rebuilt, the capacity will be well above 60 million tons. There are also a number of small refineries in the country. These have been neglected in pollution load calculations due to their limited overall contribution to sector emissions.

The Isfahan refinery has provided direct information to the team on fuels used and their sulfur content. Calculations based on that information give a sulfur dioxide emission of 44,000 tons per year. The team also visited the Refinery Research Institute and asked about emissions from the refineries. The institute was reluctant (or unable) to provide such information, but an emission figure of 100 tons per day of SO_2 from the Tehran refinery has been estimated. Based on those two primary emission figures, an emission factor has been calculated and used for all of the refineries in Iran. The result is a sulfur dioxide emission close to 120,000 tons per year. It should be noted, however, that this calculation is built upon on the assumption that all refineries are equipped with sulfur recovery plants. It has not been possible to verify if this assumption is correct.

No information on other pollutants was made available to the team. Emission factors from US EPA 42 have therefor been used to calculate the emissions of VOCs and NOx. The result indicates that the NOx emission is about 10,000 tons per year and VOCs on the order of 70,000 tons. Refineries are significant sources of pollution. For instance the Tehran Refinery releases 5 times more SO_2 than all of the vehicular traffic in the city. After the Sar Cheshme copper smelter and some power plants refineries are the major SO_2 source in Iran.

The petrochemical industry is under expansion and a new complex is under construction. The largest chemical/petrochemical complexes in Iran are the Razi Chemical Complex in Khuzistan which produces inorganic acids, phosphate, ammonia, and urea; Shiraz Chemical Complex which produces soda ash, urea, nitric acid, and methanol; Khark Chemical Complex, producing Sulfur, propane, neptan, and butane; Abadan Chemical Complex producing of chlorine, NaOH, DDB and PVC and the Arak Chemical Complex, which is under construction.

Very limited information is available on emissions from the chemical/petrochemical sector. The following figures are given in the report Environmentally-Sustainable Industry and Mining for the emissions in Khuzistan Province: SO_2 24,000 tons, NOx 10,000 tons, hydrocarbons 20,000 tons CO 120,000 tons, and ammonia 30,000 tons per year (rounded figures as compared to the report).

The most environmentally threatening emission from the chemical sector is mercury. The mission has therefore made an attempt to calculate mercury emissions based on information collected by the team during its time in Iran. Three chlor-alkali plants based on the amalgam process are at present operating in Iran, one in Shiraz and two in Abadan with the following capacities: 20,000, 10,000, and 33,000 tons respectively. One plant is under construction by the Bandar IMAM Petro-chemical Company, with a capacity of 240,000 tons per year. The likely mercury emission from these plants is on the order of 3,000 kg per year.

One sector that often causes strong reactions because of large visible dust emissions is the cement industry. Iran has 19 cement plants with a total production capacity of 18 million tons per year. The largest plants are located in Tehran and Isfahan. Emissions from cement plants differ depending on their design and air control equipment. Primary emission data has been provided from 5 of the cement plants in Iran. Dust emissions vary from 230 to 780 g/tons and the NOx emission from 620 to 1570 g/tons. A NOx concentration of 300 mg/Nm^3 has been estimated for calculation of the above NOx emissions. US EPA 42 gives 1400 g/tons for NOx and about 200 to 400 g/tons of dust for plants equipped with the control equipment on which the calculation is based. Considering that 3 of the five plants are close to 400 g/tons, calculation of the total dust load from Iranian cement plants is based on that. For NOx EPA's factor has been used, resulting is a total dust emission of 7,200 tons per year and 25,200 tons for NOx.

The figures above indicate that dust emissions from the cement industry are not a major problem. Considering that the dust is of an inert character, the cement industry has low priority. This is only partly true, however. Disturbances in the dust arrestment system can lead to large emissions. Untreated kiln gas can contain up to 50 g dust per m^3 compared with 50 to 150 mg after the passage of a functioning ESP. Most of the problems with cement plants in Iran are probably linked to disturbances in the process. During start-ups and shut-downs, when CO and O_2 monitoring instruments are out of operation, and when mechanical problems occur in the filter, episodes of high dust emission are common. Proper maintenance, availability of spare parts and proper training are the main actions needed to overcome these type of disturbances.

ISLAMIC REPUBLIC OF IRAN

ENVIRONMENTAL STRATEGY STUDY

ANNEX IV: SOLID AND HAZARDOUS WASTE MANAGEMENT

A. SOLID WASTE MANAGEMENT IN TEHRAN

Nature of the Problem

1. The city of Tehran today has a relatively clean appearance thanks primarily to recent efforts to improve municipal collection services. Similar gains, however, have not yet been made in the areas of disposal, recycling, operational management, institutional arrangements, financing, and regulation -- especially of special and hazardous wastes. Tehran would benefit from adopting a comprehensive approach to solid and hazardous waste management starting with the preparation of an integrated management strategy and action plan. The Tehran Municipality (TM) is cognizant of this need and has requested Bank technical support for such a strategic planning exercise.

Institutions

2. Overall municipal solid and hazardous waste management services for Tehran are the responsibility of the Organization of Waste Recycling and Composting (OWRC), established by the TM a few years ago. The name is misleading and is soon to be changed to better reflect the organization's scope of activity. The OWRC is responsible for metropolitan-wide system planning, disposal and recycling operations, collection and disposal of special wastes, research and development, training, and technical assistance to municipal districts.

3. Residential solid waste collection and transport are the direct responsibility of the 20 municipal districts (*mantagheh*) which make up the TM. Services are provided through some 130 subdistricts (*nahieh*). the districts are also charged with collection of market and park wastes, street cleaning, and cleaning of drains (*jubes*) and canals. The districts also have their own workshops for vehicle maintenance.

4. There are limited experiences with privatization of solid waste collection services. Some four subdistricts have contracted with private sector operators (but the subdistricts have provided the collection vehicles). Impediments to expanding the private sector role include lack of: government regulations for tendering, experience in writing and supervising contracts, appropriate conditions of contract, means of sanctioning poor performance, and private sector capacity to offer such services. Labor relations also appear to be a sticking point to expanded involvement of the private sector.

5. A third actor is the Motor Vehicle Organization (MVO) which procures the basic collection vehicles (Nissan pickups) and contracts for local manufacture and installation of beds and tipping mechanisms. The districts purchase finished vehicles from the MVO. The MVO also operates several of the transfer stations, although most are operated by the districts.

6. Finally, although they have no active role in the solid waste system, the head of TM's Urban Renewal Organization (URO) is a member of the board of OWRC. The URO also conducts environmental studies for greater Tehran and acts as principal liaison between the Mayor's office, the OWRC, and the Bank.

Recent Improvements

7. Over the past three years, the TM has succeeded in mechanizing residential collection services in Tehran. From a manual cart system with about 1,200

transfer points, the system today is based on a unique and relatively efficient system utilizing some 1,250 Nissan pickup trucks for primary collection and 34 transfer stations located throughout the city. The pickups are 2 ton nominal capacity equipped with 2.2 m^3 tipping body. Transfer vehicles and stations are of varied design, with some of fairly high capacity utilizing 30 m^3 semi-trailers. The OWRC has done a recent evaluation of this collection system and concluded that it is much more efficient than the previous traditional system. In most of the city, service is daily and approximately 6,000 tons per day (2.2 million tons per year) of municipal solid wastes are handled by this system. The total workforce of the districts is about 6,000 collection workers and street sweepers, including 1 driver and 2 workers per Nissan. A ratio of one supervisor for five Nissans is also maintained.

8. Disposal operations by the OWRC presently are concentrated at the Kahrizak landfill, a 420 ha site that is located 58 KM southeast of the city center. A prior landfill at Abeli was recently closed after leachate pollution caused fishkills in a nearby river -- the site has been covered and planted with trees although it does continue to receive some demolition and construction debris. The Kahrizak landfill was formerly an open dump. It utilizes the trench landfill method, with trenches varying from 15 to 30 m deep, depending on depth of groundwater, and 30 m wide. Recent improvements in operations include the application of soil cover (about 60 cm) and final cover after settling with inert and dry industrial waste and soil. However, wastes are not compacted, there is no bottom preparation, and no control of leachate or gas. The remaining capacity of Kahrizak is estimated at 10 years, possibly longer with the introduction of recycling. A new landfill site of 250 ha has been identified and reserved at Dowtouye, some 14 km east of Kahrizak.

9. Another improvement is the introduction of a special OWRC service to collect hospital wastes. About 60 tons per day of hospital wastes are collected from 136 hospitals and 277 clinics. The wastes are disposed in a dedicated trench at the Kahrizak landfill and receive immediate limestone and soil cover. This service needs to be extended in the future to another 9,000 medical and health care centers.

10. The OWRC has also embarked on R&D activities to evaluate composting and other recycling technologies, and incineration. It also is about to begin a training course for district solid waste supervisors and for higher-level municipal staff. Currently, supervisors do not have high school diplomas and many are illiterate. District solid waste managers are expected to have a diploma, but some do not. In general, considerable staff upgrading is needed. As part of its training activities, the OWRC has already produced training materials for district and municipal staff as well as text books for university courses.

Financing System

11. There is no solid waste service fee in Tehran. The 20 municipal districts finance solid waste services through general revenues that they collect (eg, property taxes, building construction permit fees). Poorer districts may receive transfers from the TM; districts with excess revenues surrender the surplus to the TM who in turn redistribute. All districts pay a tipping fee of 4,000 Rl. per ton to the OWRC for use of the landfill. Large commercial and industrial waste generators are expected to contract with private haulers, who in turn must pay the OWRC the same tipping fee. A weigh scale is in operation at Kahrizak for control; districts are billed monthly, private haulers generally prepay while occasional users pay in cash. Hospitals also pay the OWRC for special collection and disposal services.

12. A rough estimate by the OWRC of the average cost of municipal solid waste services using the present system is US$ 15 per ton, broken down as follows:

Collection:	US$ 10 per ton
Transfer:	US$ 2 per ton
Disposal:	US$ 3 per ton

Transfer costs vary by location, of course, and so northern districts may pay as much as US$ 18 per ton in total as they are furthest from the landfill. This rough estimate does not include some cost items such as worker benefits or equipment depreciation (or debt servicing).

13. Although householders do not pay a direct solid waste service fee, many do apparently pay substantial tips to the district collection crews.

Unresolved Issues

14. While the recent improvements in collection services are impressive, there are still a number of problems to be resolved. Among them in no particular order are:

a. There are no Iranian laws or regulations for municipal and hazardous solid waste management, nor municipal regulations and bylaws governing solid waste services.

b. Solid waste services are not considered as cost centers in the municipal district accounting systems, so that there is no systematic information about expenditures.

c. Some scattered communities in the south and urban peripheries of Tehran only receive sporadic collection services, particularly where access by truck is difficult.

d. As progress is made in water and air pollution in the TM, additional solid wastes may be generated (such as treatment plant sludges) and provision for their management should be anticipated.

e. The educational and preparation levels of solid waste managers, supervisors, and workers is low and in need of substantial upgrading.

f. The municipal districts are reluctant to have OWRC interfere in their operations, but must gradually improve their solid waste management practices and require technical assistance and training for this purpose.

g. Looking beyond the immediate limits of the TM to the Greater Tehran Region that is rapidly growing and contains several new towns and industrial estates, there is presently no comprehensive regional plan to deal with the municipal and industrial wastes of this area in the future.

h. District maintenance operations are in need of improvement also, as is evidenced by vehicle downtime which is estimated to be between 20-25 percent.

i. There is a need for better management information, and in particular the financial and accounting systems used in the TM and the districts are in need of considerable improvement.

j. For greater participation of the private sector in delivery of solid waste services, there is a need both for municipal districts to gain experience in tendering and contract supervision and to help establish private sector capacity in this field.

k. Hazardous wastes continue to be problematic, especially those of small generators, and greater capacity is needed at the municipal and district levels for safely collecting and handling such wastes. Also, close coordination is needed with industrial and hazardous waste management programs at the national level.

l. The OWRC is under constant pressure (from suppliers, government officials, environmental groups) to introduce sophisticated recycling methods such as mechanized composting and incineration, but it lacks information and research to evaluate such proposals adequately.

m. There is a perceived need for greater public involvement in solid waste improvement if improvements such as source separation of wet and dry wastes or storage are to be achieved, but this requires a greater public relations and education efforts.

Recommended Actions

15. To address all of the above issues, a systematic approach is needed. While there does not appear to be a lack of facilities nor financial resources, greater integration, operational management, and efficiency in the use of existing resources is needed. The starting point should be the preparation of a comprehensive strategy and action plan for solid waste management covering generation, storage, collection, transfer, disposal and resource recovery and recycling alternatives of domestic and industrial wastes, as well as a coordinated hazardous waste management strategy.

16. The URO and the OWRC recognize the importance of preparing a strategic plan, and are seeking technical assistance to prepare final terms of reference for the needed set of studies and substudies, leading to the formulation of a sector strategy and preparation of an action plan that identifies needed investments and institutional reforms. The Bank should be ready to assist in this effort.

17. Particular attention should be given to opportunities for efficiency improvements and cost control through involvement of the private sector, such as private delivery of collection services, private management of operations, or concessions for private ownership and operation of treatment and disposal facilities. Municipal districts should be provided assistance in tendering and contract supervision which is critical to successful privatization of collection. Where vehicles continue to be owned and operated by municipal districts, significant improvements in vehicle maintenance can be achieved by contracting with the private sector. Recycling facilities in particular should be considered as candidates for BOT/BOO type arrangements since it provides a good test of their financial viability and whether subsidies in the form of tipping fees are needed.

18. Cost recovery and cost accounting for solid waste management should receive urgent attention to ensure the sustainability of recent improvements. The basis for cost recovery should be a service charge (benefit) tax levied on all households given the public goods nature of this service. This may appear as a separate line item on property tax bills, or can be added to other utility bills such as water or electricity. The amount of the service charge should be set to balance recurrent costs, including operations, maintenance and debt servicing. Poorer households can be cross-subsidized by increasing the service charge to richer households. Large commercial and industrial solid waste generators should continue to contract collection with private haulers and should be required to pay on a volumetric or tonnage basis including provision for tipping fees. The introduction of refuse service charges should be accompanied by a public education campaign to raise citizen awareness and get their cooperation.

19. Priority should be given to staff training and upgrading. The OWRC has already begun to address this priority and should be fully supported to intensify and expand training activities for TM municipal district staff as well as staff from other urban areas in Iran.

B. SOLID WASTE MANAGEMENT IN THE REST OF IRAN

20. In other Iranian cities, both basic collection services and environmentally sound disposal continue to be problematic for local authorities. The problems are more acute in larger cities, especially the 34 large and intermediate cities of over 100,000 population that hold one-quarter of the total population of Iran. Seven of these cities have over a half million inhabitants (Mashad, Isfahan, Tabriz, Shiraz, Ahvaz, Kermanshah and Qom). Of these, the waste management system in Isfahan is the best developed, and some composting of municipal solid waste is being done. A second group of concern are some 586 small cities and towns of 5,000 to 100,000 inhabitants that hold about one-fifth of the total population. In these urban areas only the most basic services are provided and there is little capacity for environmental management.

21. Surveys conducted by the Ministry of Health in 1990 and 1992 in five large cities in each of the 24 provinces showed that solid waste generation in the large cities in 1992 was estimated to be 0.66 kg per capita per day, and the rate of generation appears to be increasing in recent years at about 6.5 percent per year. With regards to characteristics, the average density is 617 kg per m^3 and the composition is approximately 70 percent putrescible, 8 percent paper and carton, 5 percent plastics, 3 percent metals, 3 percent glass, and 11 percent other. Data on moisture content was not available, but given the high putrescible content and density the moisture content must be high.

22. Collection services in many cities are still by non-motorized carts. Several cities are now considering mechanizing collection as was done in Tehran using pickup trucks with tipping bodies. However, an economic and financial analysis should be carried out before making a decision of this magnitude. Manual primary collection systems may still be appropriate, especially for low-income communities.

23. The 1992 survey showed that only 30 percent of collected waste is taken to sanitary landfills for disposal; the rest goes to open dumps, although this share has been increasing in recent years. Industrial and hospital wastes in most cities are collected and transported together with domestic solid wastes and taken to the same disposal sites. Leachates spilled during transport and flowing from disposal sites have been observed to have BOD concentrations of 12,000 mg/l and COD of 41,000 mg/l.

24. Material recovery, recycling and reuse appears to be organized haphazardly and in some cases is unsafe with the use of raw refuse in farms and the uncontrolled recovery and paper and plastics in many dump sites. Given the high compostable fraction in the waste stream and widespread arid lands where compost could be beneficially applied for soil conditioning, the introduction of composting technology together with well organized materials recovery could be a viable recycling option. However, even this option should be studied with care. Successful composting would depend on the use of simple cost-effective composting technologies such as open-air windrows, the production of high-quality compost, and the development of agricultural marketing networks within a reasonable distance of the urban area. Concession arrangements with the private sector may be the best way of expanding such recycling options.

25. To manage the solid waste problems of urban areas in Iran, it is important to distinguish between groups of cities:

a. *Large cities:* The seven urban areas of over 500,000 population should be dealt with on a city-specific basis, developing a strategic plan for each one and creating a solid waste management disposal authority responsible for both municipal and industrial wastes. For these cities, the recommendation made for Tehran may be equally relevant. The TM, through the OWRC, should be encouraged to provide technical assistance and training.

b. *Intermediate cities:* Each of these cities should have a strengthened municipal solid waste management department. The national and provincial governments should have technical and financial assistance programs needed to help organize and build the capacity of these departments. In those cases where there is significant industrial concentration, specialized technical assistance will be needed from the national environmental, public health and local government authorities. Cost recovery and cost accounting should be a priority.

c. *Small cities and towns:* A national solid waste program for small cities and towns should be initiated. Both technical and financial assistance will be needed, and should be easily accessible. It may be desirable to strengthen provincial centers to provide this support. Particular attention should be given to low-cost technologies for basic collection and disposal services. Cities with industrial waste problems can be assisted from the national level.

26. Private sector delivery of solid waste services in intermediate and small cities may offer the best hope of expanding services rapidly. To assist cities in privatizing in an effective and cost-controlled manner, guidelines and model contracts should be prepared by the national government.

C. INDUSTRIAL SOLID AND HAZARDOUS WASTE MANAGEMENT

Overview

27. The information on industial waste is sporadic, as described below. However the description shows that based on the nature of the industry and the available information, substantial risks exist that hazardous waste could affect agriculture and human health. In view of this, the Government needs to carry out a more systematic survey to identify risks and to take mitigative actions.

Mine waste

28. To feed the Sar Chasme copper smelter, a copper mine in the same area is operated. The production of ore in 1991 was 9.2 million ton. Only 1.2 % of the ore is copper. This implies that more than 9 million tons of waste is produced per year. No information has been made available to the team on the rest concentration of copper in the waste. A normal rest concentration is in the order of 0.05 %. If that is true also for the tailings from the Shar Chasme mine, the annual amount of copper disposed off is 4500 tons based on the production in 1991. If the copper production is increased, the amount will be close to 10000 ton per year.

29. In many other countries there are major problems linked to old mine waste because of leakages of metals from the waste. In the USA about half of the investments made by the Super Fond have been allocated to solve mine waste problems. The extent of the mine waste problem depends on the concentration of pyrite and buffering substances. The pyrite trigger formation of acid waste drainage. The acid drainage could be more or less neutralized by buffering substances. No data is available for the team to make a closer evaluation of the risk for serious copper leakages in Shar Sasme, but there is a high probability for future problems.

Copper smelter

30. No information is available on the amount of waste formed at the Shar Chasme copper smelter. It is however known from general information that the reverbator - converter route used at the smelter produce in the order of 40 kg per ton of dust escaping from the process. If the earlier estimate on control efficiency of air pollutants is correct it implies that in the order of 25 kg dust per ton of copper production is collected in the air control equipment. Nothing is known about how much if any of that dust is reused in the process. Estimating that all of it is deposited, the amount is in the order of 3000 ton per year. The copper concentration is probably 20 - 25 %. If not properly

handled, the dust could create environmental problems. Except for copper the dust is likely to contain lead, zinc, cadmium and other heavy metals.

Aluminum smelter waste

31. The waste from the aluminum smelter would consist of anode and cathode residues containing fluorine, cyanide and polyaromatic hydrocarbons. Also, dust collected in air control equipment, if any, would contain the same hazardous substances. No data has been made available to the mission. However, the amounts of such waste is likely to exceed 5000 tons per year.

Iron and Steel Industry waste

32. The waste from the steel industry would contain metal sludges and dusts, mill scale, slag, metal hydroxide from pickling and tar from coke ovens. Only limited data is available on the amount of such wastes but for instance, the amount of tar from Isfahan Steel and the amount of mill scale from Mobarakeh Steel Complex has been provided to the mission. As mentioned above, the amount of tar from Isfahan Steel is 50,000 tons per. The amount of mill scale from Mobarakeh is in the order of 110,000 ton per year.

33. The formation of dust in different kind of furnaces in the steel industry can be predicted with a quite good accuracy. Electric arc furnaces normally produce between 10 - 15 kg of dust per ton of steel, a sintering plant in the order of 5 - 10 kg/ton, a basic oxygen furnace in the order of 15 kg/ton and blast furnaces some kg. Based on those figures and the production of steel in Iran the formation of heavy metal containing dust can be estimated. If also some other minor sources are included the dust formation is in the order of 150 - 200,000 tons. Of that amount 25,000 ton is estimated to escape as air pollutants. The rest should be considered as waste if no reuse takes place. Isfahan Steel recycle sludges and dusts so also at least in the order of 50,000 ton need to be withdrawn from the above figure.

34. The figures on waste in the steel industry is calculated on the present production. The planned expansion will increase the amount of waste to at least twice as much if no action is taken to recirculate or reuse it.

Chlor - alkali industry

35. Mercury containing waste is formed in the chlor-alkali industry. Waste is produced in the salt dissolving step of the process and in the waste water treatment process if mercury is precipitated. The major amount comes from the salt dissolving. The amount of waste and the concentration of mercury in the waste differs depending on the quality of the salt and the process design. Mercury concentrations of 20 - 200 ppm and a waste amount of 100 kg per ton of produced chlorine can be used to indicate the composition and magnitude of waste formation.

Miscellaneous

36. Isfahan refinery produces solid waste in a amount of 500 tons ieach year. The concentration of oil in the waste is 10 %, and the water content 20 %. The rest is solids. The waste is disposed of in the desert 50 km from the plant and covered by soil. Metal hydroxide sludge from the 20 electroplaters in Teheran is disposed of with urban solid waste. Chromium waste from the new treatment plant for tanneries in Tabriz is planed to be dried and disposed of in remote areas. Import of PCB's has been banned only since the spring of 1993, and it may exist in the country from old stock. Foundry sand is reused to 80 %. Iran has two producers of asbestos cement. The authorities are in a stage to decide how to take care of the hazardous waste from the production.

Recommendation

37. The information on industial waste described above shows that substantial risks for human health and agricultural production exist from such waste. In view of this, the Government needs to carry out a more systematic survey to identify risks and to take mitigative actions.

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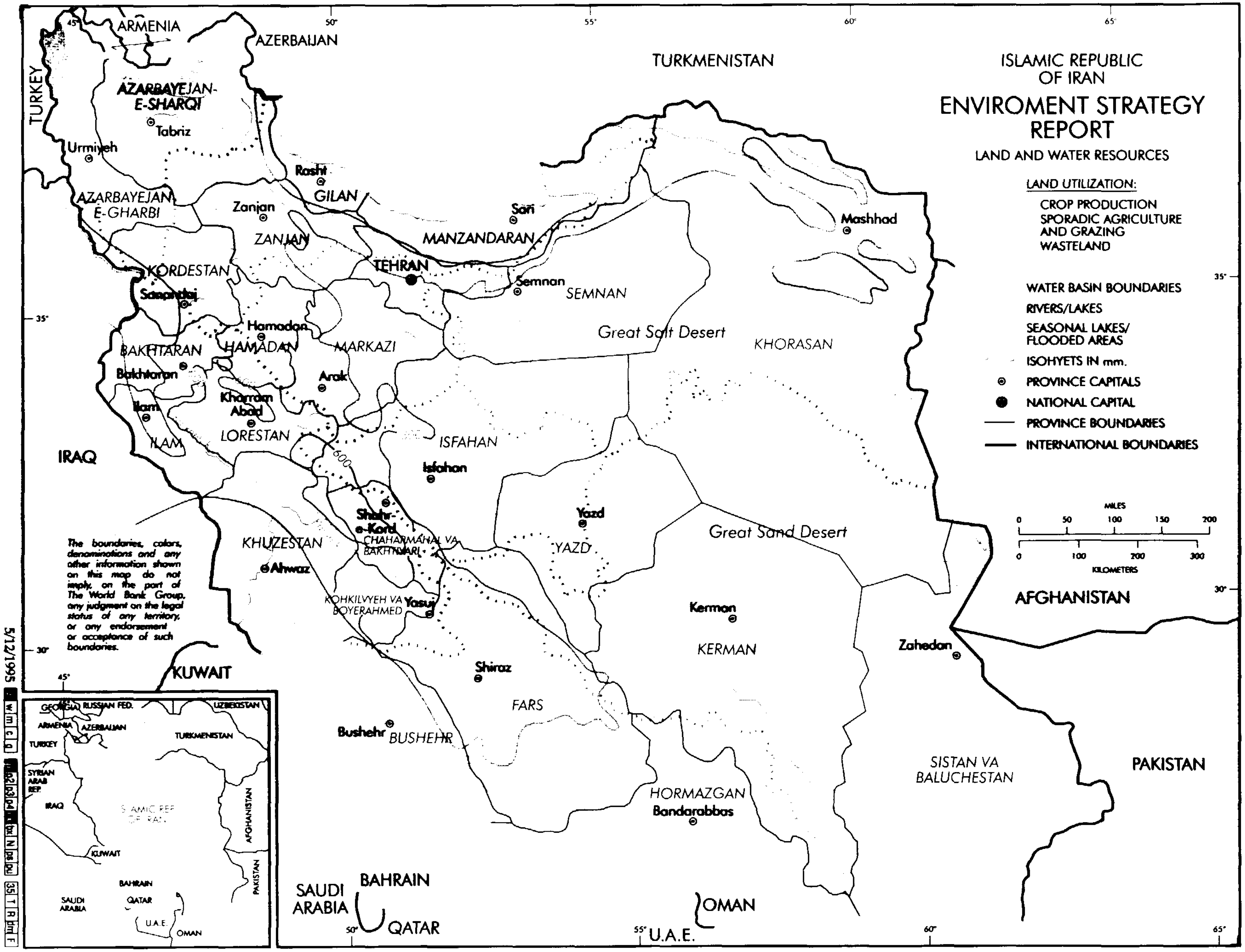

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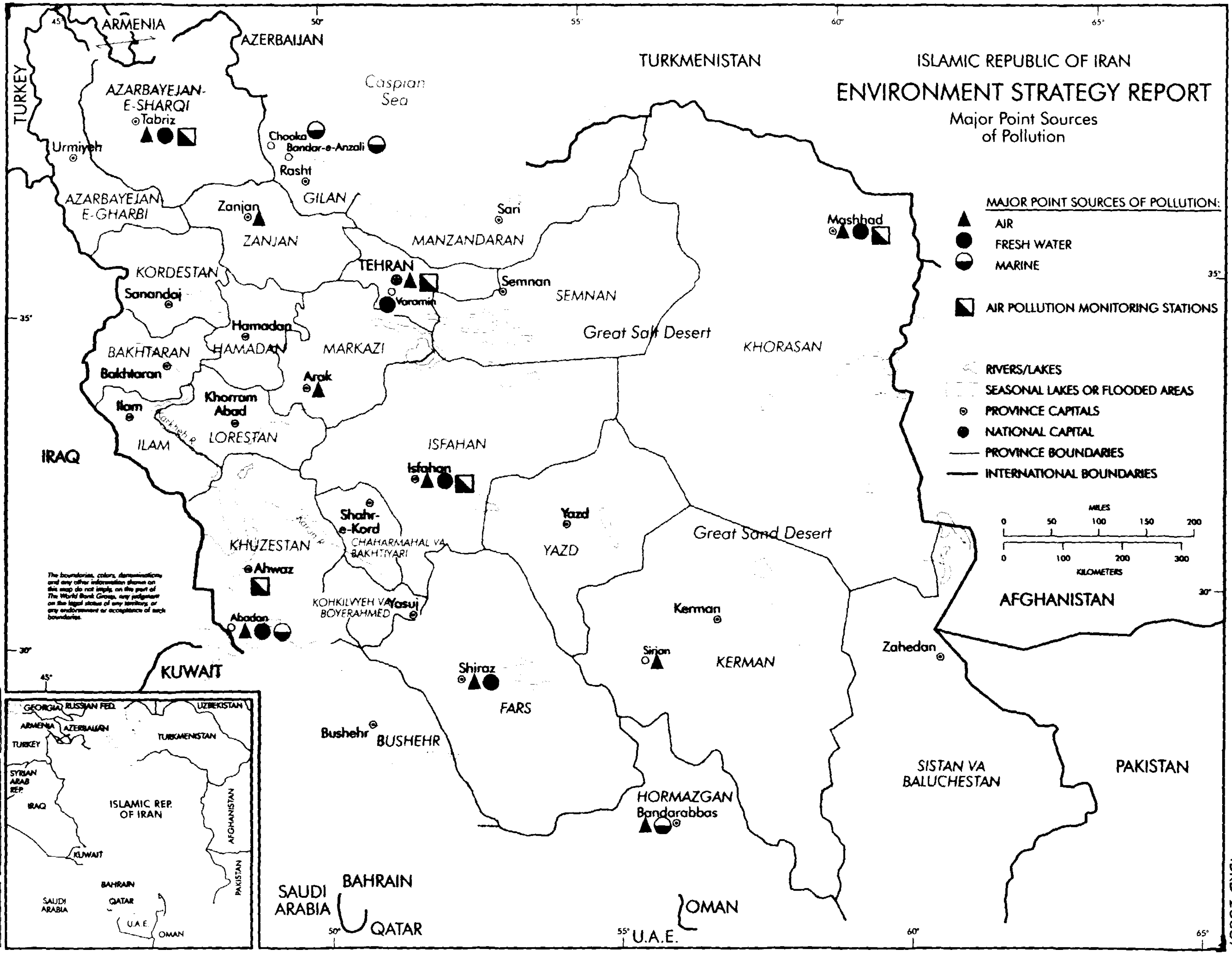

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