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Environment Data Compendium

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FOREWORD

By the Central Bureau of Statistics

The environmental indicators compendium was initiated as the concluding output of the MED-ENV II project. The publication is aimed to provide a minimal data set for the general public interested in the environment. The staff of the Environment Statistics Division at the Israeli Central Bureau of Statistics prepared the compendium, despite problems of understaffing and a strict and short timetable.

The data presented in the compendium reflect current environmental conditions in Israel, as well as core trends wherever supporting reliable data were available. The compendium consists of six chapters: General (including geography, demography and public expenditure on the environment), Land and Land Conservation (including land cover and biodiversity), Air Quality (including pollutant emissions, pollutant concentrations and greenhouse gas emissions), Water, Waste and Sustainable Development Indicators.

Greenhouse gases emissions (GHG), biodiversity and sustainable development indicators are new subjects that were developed under the MED-ENV II project in the Central Bureau of Statistics. Inventories of GHG emissions are currently calculated on an annual basis and are reported to international organizations. Sustainable Development Indicators (SDI) were developed in collaboration with the Ministry of Environment and the Jerusalem Institute for Israel Studies. The chapter mainly concentrates on SDI concerned with environmental indicators. These include indicators related to land cover and population density, water, air and the impact of economic activity on the environment, in terms of motorization rates and energy consumption.. Also included is the human development index which is a complex, indirect environmental index of SDI. It presents a comprehensive development indicator for the country's economy and population.

The data included were obtained from organizations collecting or accumulating data on the listed subjects for research or administrative purposes. A full list of the contributing parties appears under "Acknowledgments."

The compendium is the second environment specific publication published by the Central Bureau of Statistics. Annual data on environmental statistics were also published in previous years in a dedicated chapter within the “Statistical Abstract of Israel.” We hope this publication will serve as an additional trigger to improve data quality and expand the volume of the collected data, hence improving data reliability and availability.

The compendium, along with other MED-ENV I and MED-ENV II training sessions, has revealed the versatility of definitions and methodologies used in different countries and among different organizations within countries. The project advances the steps taken toward unification of data collection standards and definitions. Furthermore, efforts to present a comprehensive picture, based on integrated data, have uncovered gaps and limitations in the existing data.

The compendium is the second endeavor to accumulate data from a variety of available sources, including governmental and non-governmental organizations, which differ in their orientation and targets. Nevertheless, it is still at its early stages and constructive comments will be highly appreciated in order to assist in future publications.

Many thanks to all the parties who helped compile the publication. Special thanks, to the Blue Plan, for their instruction and comments, to EUROPEAID Cooperation Office for their financial support and EUROSTAT for their tecnical support of the project and the publication.

Warm thanks to Jean Koch (PhD) for his assistance in launching the GHG project. His patient and enthusiastic training of the staff of the Environment Statistics Division of the Central Bureau of Statistics enabled the planning of the annual calculation of GHG emissions for Israel.

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FOREWORD

By EUROSTAT

The European Union's policy with regard to the Mediterranean region is governed by the Euro-Mediterranean partnership (referred to as the Barcelona Process) launched after the 1995 Barcelona Conference. The Euro-Mediterranean summit of November 2005 which celebrated the 10th anniversary of the Barcelona Process restated the commitment to the principles and objectives of the Declaration of Barcelona and reiterated the importance of regional understanding and cooperation.

The member states of the European Union and the Mediterranean Partner countries[1] have intensified their relationship in the field of statistics thanks to MEDSTAT, the regional statistics cooperation programme, This programme is funded by the European Commission (MEDA fund) under the contractual responsibility of the Directorate General of EuropeAid Cooperation Office. Eurostat, the European Community's statistics office, is in charge of the technical monitoring of the programme. MEDSTAT confirms the importance of supplying complete, reliable, relevant and comparable statistics for decision-makers and for a sustainable economic development of the Mediterranean region.

As of the launching of the programme in 1996, the environment was proposed to be fully dealt with; the sub-programme MEDSTAT-Environment was put in place, the latter forming one of the ten MEDSTAT sub-programmes.

This second phase of the MEDSTAT-Environment project (MED-Env II), implemented by Plan Bleu, regional activity centre of the Mediterranean Action Plan, covers the period 2003-2006 and is a continuation of the actions carried out in the first phase of the programme (1999-2003) while emphasizing efforts for three new topics: air pollutant emission, biodiversity and the calculation of environmental indicators for sustainable development. MED-Env II is based on the experience and progress made by each country since the start of the programme.

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[1] Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestinian Authority, Syria, Tunisia, Turkey and, for the continuation of the programme, Cyprus and Malta, which have been Member States since 1st May 2004.

The main objective of MED-Env II is to strengthen the sustainable capacity of the twelve Mediterranean partner countries to produce and publish complete, reliable, relevant environmental statistics and indicators while taking into account the users' needs. This information should be in conformity with international standards, more especially with the European ones, in order to be comparable in time and space.

The results targeted in this second phase are:

- To contribute to the institutional and inter-institutional strengthening of national statistics systems with regard to the production of environmental statistics;
- To adapt the regional strategy so as to take into consideration the specific situation of each national statistics system;
- To promote the harmonisation of national statistics with the international and European standards underway;
- To ensure data exchange between the Mediterranean countries and the European Union, and among the Mediterranean partners themselves;
- To ensure more visibility concerning the results from the Euro-Mediterranean partnership in terms of environmental statistics;
- To take into consideration the users' needs at national, regional and international levels.

This national statistics compendium of Israel is co-financed by Central Bureau of Statistics and the MEDSTAT-Environment programme. This compendium, as visibility tool, reflects the progress made by Central Bureau of Statistics in the production of environmental information since the launching of the MEDSTAT-Environment programme.

The efforts deployed by the Central Bureau of Statistics throughout this second phase of MEDSTAT-Environment have helped not only to enrich and widen the collection of environmental data, but also to produce this first and major publication on environmental statistics. This publication reflects the results achieved so far by the Central Bureau of Statistics in data collection of environmental statistical information.

1. General Introduction

Source: Photo Archive KKL-JNF

INTRODUCTION

Modernization and progress have brought about major benefits to human health and well-being, but, at the same time, they have also been responsible for drawbacks in terms of the environment. It is well recognized that human activities are largely responsible for adverse environmental impacts. However, only in recent decades has awareness of potential environmental hazards led to public actions on behalf of the environment. This growing awareness has catalyzed international and national political movements, first by non-governmental organizations and later by governmental agencies. Public awareness has prompted governments to recognize the need to allocate resources to identify global and local potential hazards. The political recognition of the necessity to monitor environmental indicators over time has encouraged many governments to appoint ministers and to establish offices responsible for environmental protection and to develop alternatives to harmful human activities.

Israel joined the global effort and established a designated Ministry of the Environment in December 1988. The ministry drew together various divisions that were previously spread in different ministries, such as the Ministry of the Interior, Ministry of Health and Ministry of Agriculture. Nevertheless, the recognition that environmental monitoring should be accompanied by reliable information systems came about much later. Although bits and pieces of information existed over the years, these were not collected in a systematically and methodologically established process. There were no guidelines as to what data should be collected, who is responsible, or how it should be collected, analyzed and presented in order to enable appropriate monitoring. Continuous monitoring of changes in environmental parameters is needed in order to plan intervention and modification of behavior patterns, and to evaluate protection measures and their progress over time.

The need for reliable information to support evidence based decision processes initiated the establishment of a specific unit at the Israeli Central Bureau of Statistics (CBS) to collect data related to environmental issues. The terms of reference for the unit were to establish reliable statistical series over time and space (geography) for ecological, chemical and physical variables that would enable reasonable monitoring of the main indicators of the environment.

1.1. GEOPHYSICAL CHARACTERISTICS

Israel's location on the eastern shore of the Mediterranean Sea, between 29°-33° north of the equator, makes it a subtropical region. Israel, therefore, is on a "climatic crossroad": its southern and eastern parts are arid land, whereas its northern and western parts are characterized by Mediterranean climate.

The Mediterranean coast is the western border of the country. The Red Sea at the southern end of the country is the passage to the Indian Ocean. The total area of the country is about 22 thousand km^2, of which 21.6 thousand are land areas. About half of the land area is desert land with less than 200 mm of rain per year (multi-annual average). There is only one freshwater lake - the "Sea of Galilee" (Lake Kinneret) which covers 164 km^2 and is the country's main surface water source. The northern part of the country consists of two East-West mountain chains. The total shore length is 194 km at the Mediterranean Sea coast, and 11 km at the Red Sea coast. The total lakeshore area is 175 km. The lowest point in Israel – the Dead Sea - is 417 meters Below Sea Level (BSL).

1.1.1. Methods

1.1.1.1. Definitions

Area: refers to June 4, 1967

Temperature, Multi-Annual Monthly Average: The data are based on daily averages for each month from the year 1981 up to the year 2000.

Global Radiation: Short-wave radiation of the sun, both direct and dispersed, on a horizontal plane from a spatial angle of 2π radians.

Duration of Sunshine: The amount of time (in hours and minutes) that the sun shines in a given location.

1.1.1.2. Data Sources

Data on temperature, radiation and sunshine were obtained from the Israel Meteorological Service.

1.1.1.3. Data Limitations

The monthly averages for duration of sunshine were calculated on the basis of daily data rather than hourly data. Missing data on measurements due to mechanical or other failures are imputed or omitted. There is no documentation on the magnitude of missing data; it is believed to be rather small.

Multi-annual averages are calculated only once in each decade, with a different number of years for each parameter.

1.1.2. Results

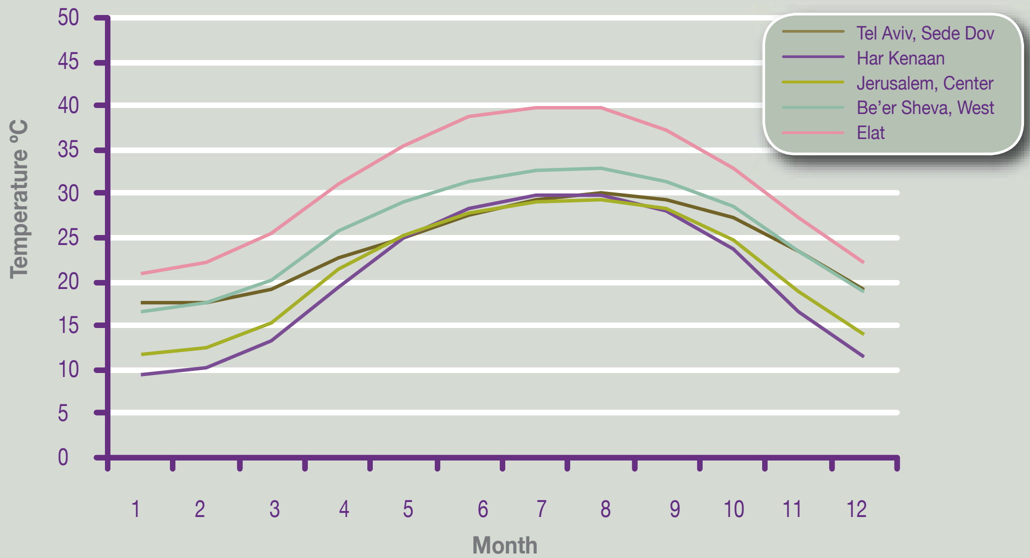
Table 1.1: Geophysical Characteristics of Israel

Area	(1000 km²)
Total area	20,700
Surface area	20,271
Lakes area	429
Sea of Galilee (Lake Kinneret)	164
Dead Sea	265
Coast line	**(km)**
Total	**205**
Mediterranean Sea	194
Red Sea	11
Total lakes coast line	**175**
Lake Kinneret	54
Dead Sea	121
Altitude	**(m) above/below MSL[1]**
Lowest point in the world - The Dead Sea	-417
Length of streams	**(km)**
Jordan river	172
Soreq stream	92
Qishon stream	49
Yarqon stream	25

Mean Sea Level[1]

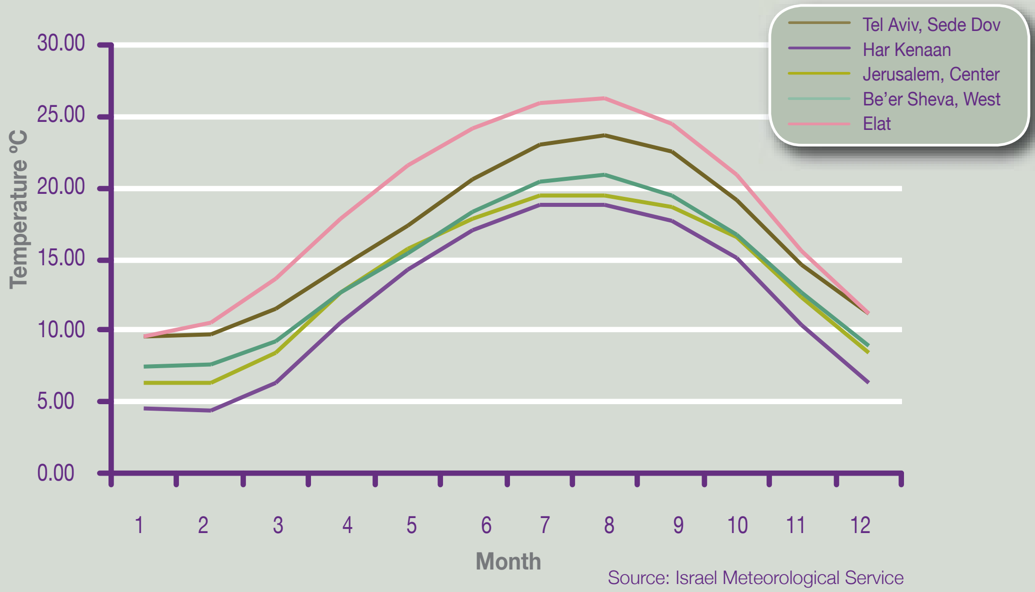
Source: CBS

Chart 1.1: Daily Average Maximum Temperature
(Multi Annual Averages) 1981-2000



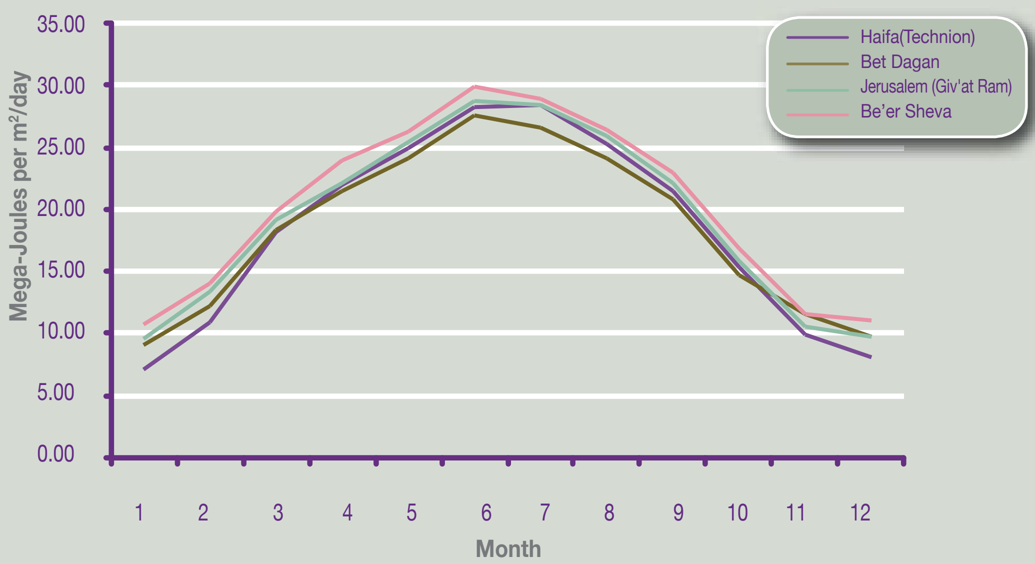
Source: Israel Meteorological Service

Chart 1.2: Daily Average Minimum Temperature
(Multi-Annual Averages) 1981-2000



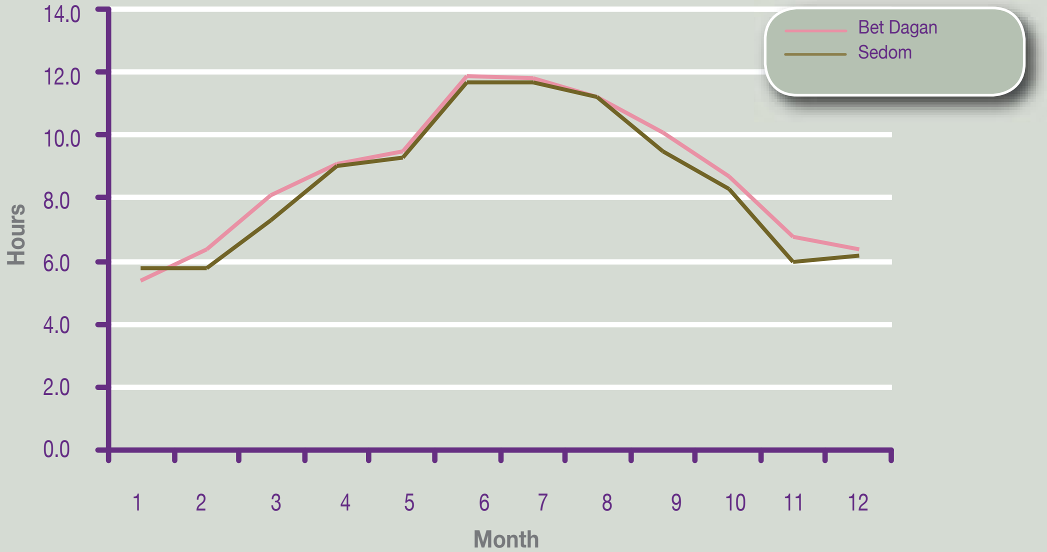
Source: Israel Meteorological Service

Chart 1.3: Monthly Average of Daily Global Radiation (2004)



Source: Israel Meteorological Service

Chart 1.4: Monthly Average of Daily Sunshine (2004)



Source: Israel Meteorological Service

1.2 POPULATION - DEMOGRAPHICS AND URBANIZATION PROCESSES

1.2.1. Introduction

Interactions between the human population and the physical environment affect the natural balance in the environment and its capacity, as a life supporting system. Environmental carrying capacity reflects the potential of the environment to provide basic life needs: on the one hand to provide food, energy and physical living space, and on the other, to be able to absorb products and wastes generated by human activity. Population growth places stress on the environment and may cause degradation of natural resources such as soil, air and water, thereby reducing environmental carrying capacity. Population size, population growth rate and population spatial dispersion characteristics are core issues in the planning of national long-term programs. Such programs are derived from the anticipated needs of the population, the demands of the population and its desire for better standards of living in every aspect: housing, education and culture, health and well being, transportation means, leisure activities, etc.

In its early years, authorities in Israel were mainly concerned with means of defense and physical security. These concerns led to policies, which encouraged population dispersion and other human activities across the country rather than concentrating them. These dispersion policies resulted in the misuse of the already limited, available land. Another consequence of these policies was irreversible damage to open space continuity and harm to the local biodiversity.

Over time, dispersion policies proved unsuccessful, with the final outcome that the southern and northern parts of the country are currently less populated, while the central part of the country is densely populated. Population growth, as a result of immigration waves, a relatively high rate of natural growth, and changes in employment and social trends contributed to population density patterns. The demand for housing encouraged the private and public sectors to initiate real estate development programs that changed land designation from open space to build-up area. This process has been especially intense in the center of the country.

1.2.2. Methods

1.2.2.1. Definitions

Population (*De Jure* Population): Permanent residents with or without Israeli citizenship, potential immigrants residing in Israel, temporary residents residing in Israel for more than one year.

District (six): Defined according to the official administrative division of the State of Israel.

Natural Region: Within the framework of the official division of the 16 sub-districts, a more detailed sub-division into 50 regions named "Natural Regions" was updated in 1995. Defined as a continuous area, as homogeneous as possible, in terms of the physical characteristics of the area, and demographic, economic and cultural characteristics of the population.

Urban Locality: A locality with 2000 inhabitants or more.

Rural (Non-Urban) Locality: A locality with less than 2000 inhabitants.

Metropolitan Area: A large cluster of authorities whose territories are contiguous and are socio-economically and culturally integrated.

Internal Migration Balance: Net difference between the number of persons immigrating to a locality and the number of persons emigrating from a locality based on address changes in the Population Register.

Migration Balance: The difference between the number of persons immigrating (entering) to Israel from abroad and acquiring residence status or staying in Israel over 12 months, and the number of persons emigrating (leaving) from Israel and those absent from Israel for over 12 months, during a given year.

Natural Growth: The difference between the number of live births and the number of deaths, occurring in a given year.

Growth Rate (Percent): Immigration balance + natural growth in a given year, divided by the average population in this year, multiplied by 100.

1.2.2.2. Data Sources

Population and Localities - Data are processed by the CBS and are based on the "1995 Population Census" updated by vital events and migration updates according to registration in the Population Register, which is administered by the Ministry of the Interior.

1.2.2.3. Data Limitations

Population estimates are based on census results updated by the changes recorded in the Population Register. Data related to Israelis residing abroad over 12 months are based on border crossings.

1.2.3. Results

The following tables present some main demographic characteristics of Israel over time. The number of localities is presented in Table 1.2.

The figures show that while the number of the smallest and largest localities has increased, a major increase occurred in the number of middle-sized localities.

Table 1.2: Number of Localities by Size of Localities

Year	Total Number of Localities	Number of Residents in Locality						
		200,000+	100,000-199,999	50,000-99,999	20,000-49,999	10,000-19,999	2,000-9,999	-1999
1961	873	3		2	15	14	70	769
1972	905	3	2	6	15	24	75	780
1983	1,091	3	7	5	22	25	88	941
1995	1,185	3	9	9	31	32	108	993
2000	1,193	4	8	9	39	36	118	979
2004	1,194	4	10	9	46	39	111	975

Source: CBS

Table 1.3 presents the number of households and the average number of persons per household. It can be seen that the number of households in Israel has increased more than 2.5 fold over the last three decades. At the same time, the average number of persons per household has decreased, although at a much slower pace.

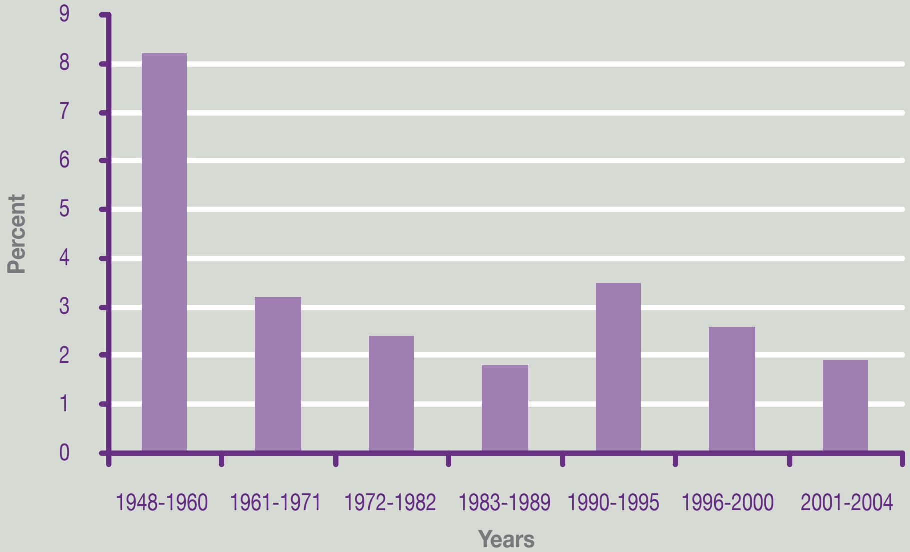
Table 1.3: Number of Households and Average Number of Persons per Household

Year	Number of Households (1000)	Persons per Household (Average)
1970	756.8	3.80
1980	1025.8	3.66
1990	1227.5	3.64
2000	1752.3	3.40
2004	1926.4	3.36

Source: CBS

The following tables and graphs present population growth trends in Israel. Chart 1.5 shows the average annual population growth from 1948 onwards. In general, the growth rate has decreased since the establishment of Israel, except for an increase in the 1990s due to an immigration wave from the former Soviet Union (see Table 1.4).

Chart 1.5: Average Annual Population Growth Rate



Source: CBS

Table 1.4: Sources of Population Growth

Years	Population at Beginning of Period (1000)	Natural Increase (1000)	Migration Balance (1000)	% Average Annual Growth²	% Migration out of Total Growth
1948-1960	806	475	869	8.2	65%
1961-1971	2,150	562	340	3.2	38%
1972-1982	3,116	753	184	2.4	20%
1983-1989	4,034	495	31	1.8	6%
1990-1995	4,560	466	594	3.5	56%
1996-2000	5,612	461	296	2.6	39%
2001-2004	6,369	414	86	1.9	17%

Geometric average of annual growth in each year of the given period[2]

Source: CBS

As to the regional picture, over the last decade most of the districts have experienced negative migration balance, except for the Central District. This trend has been slightly reversed recently, in relation to some large and medium size cities. The former trend was a reflection of the desire to live in a "detached house with a private yard", which led to emigration from large urban localities to semi-rural areas.

Israel is one of the most densely populated countries in the world. Population density has increased by 20% over the last decade and has reached an average of 299 persons per km2 in the year 2004. The districts in the center of the country are much more densely populated than in the peripheral regions (See Table 1.5). Along the years, the Tel-Aviv District has far exceeded the average density and has had the highest average density of all districts. It has risen from 1834 persons per km^2 in 1948 to 6881 in 2004.

Table 1.5: Population Density by District

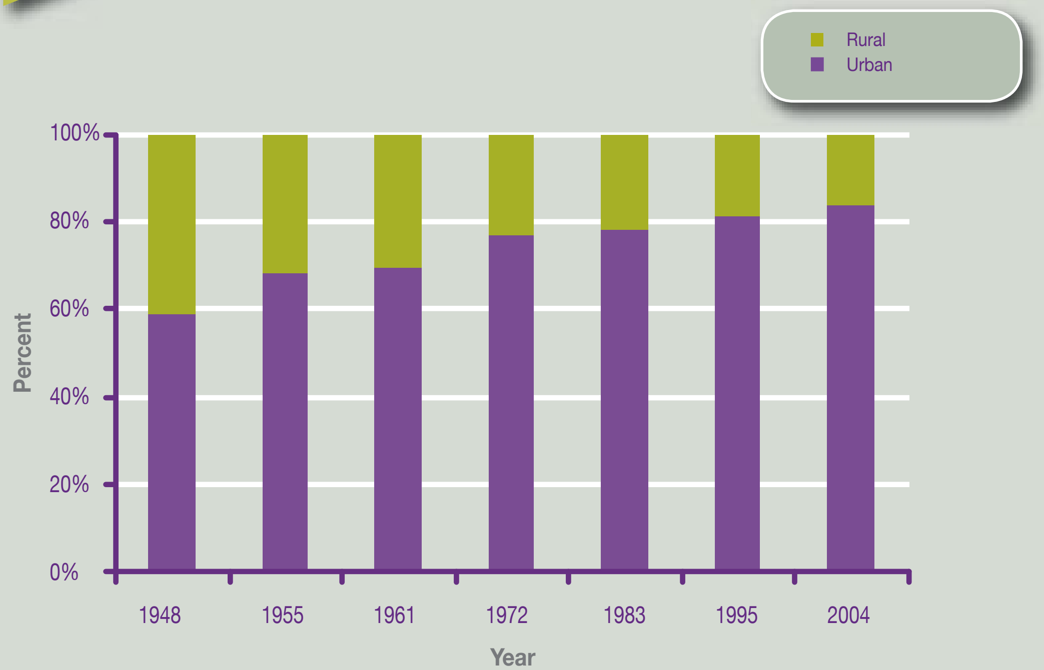
	1948	1961	1972	1983	1990	1995	2000	2003	2004
Southern District	2	12	25	34	41	53	63	68	69
Northern District	44	101	142	146	179	211	242	257	261
Haifa District	209	434	567	674	768	861	948	980	987
Central District	100	328	467	669	831	953	1,142	1,236	1,265
Jerusalem District[1]	160	345	554	754	922	1,036	1,163	1,246	1,276
Tel Aviv District	1,834	4,114	5,337	5,884	6,439	6,679	6,747	6,809	6,881

Source: CBS

[1]The data of the population of east Jerusalem can not be disaggregated from the population of Israel

The results show that the national average density does not well represent the entire density picture. About 10% of the country's land is densely populated (over 1000 persons per km^2) while the rest of the land is much less densely populated. About 65% of the population is concentrated on about 14% of the land. About 91.5% of the population in Israel resides in urban localities, a little less than half in cities with more than 100,000 residents (Chart 1.6).

Chart 1.6: Urban-Rural Population Distribution (Urban= 2000+)



Source: CBS

1.2.4. Discussion

Demographic changes in population size and distribution, high population growth rates and increasing population density, combined with improved services quality and changes in environmental quality have occurred in the fifty-seven years since the establishment of the State of Israel. These trends have intensified in the last decade.

One of the key indicators for industrialization is the urbanization rate. Urbanization rates have constantly increased since the establishment of the State of Israel in 1948. Currently, less than 10% of the population lives in a rural setting. Only 2% of the labor force works in the agricultural sector, which accounts for less than 2% of the GDP. Educational levels are rising constantly, and entry into the labor force is delayed. Over 30% of Israel's labor force consists of professionals engaged in the liberal occupations. These trends along with increased standards of living contribute to the growing pressure on environmental resources.

Urbanization in Israel depicts a typical phenomenon in industrialized countries. Global trends as well as local modifications have resulted in the convergence of the population toward the central coastal region of the country where most of the main economic centers are located. The localities in this area have grown both in total number as well as in population. Currently two-thirds of the Israeli population resides in the central coastal area.

Assuming that these trends will prevail in coming decades, the potential hazards to the environment will increase accordingly. To reduce hazardous effects on the environment, action plans and policies should be implemented. Incentives and sanctions should be used to decrease the pressure on the environment, especially in the densely populated regions. Recent trends of modifying and transforming open spaces into constructed areas should be reduced and policies that maintain natural open spaces and ecological corridors should be adopted.

Unwavering action, accompanied by supporting legislation and policy, is needed to slow down current trends and preserve the environment for future generations.

1.3. PUBLIC EXPENDITURE ON THE ENVIRONMENT

1.3.1. Introduction

Industrial development, technological progress and economic growth generate many negative impacts on the environment and severely harm certain natural resources, which in turn pose hazards to human health and well-being. For example, air pollution affects urban centers, and freshwater resources and seawater are contaminated as well. Prevention or reduction of these hazards requires the allocation of financial resources in order to develop measures and technologies to treat man-made environmental problems. Given the importance of this issue and the need to design sound environmental policy, it is necessary to collect statistical data that provide information over time on environmental expenditure. The data currently collected by the CBS only cover public sector expenditure.

1.3.2. Methods

1.3.2.1. Definitions

Expenditure for public environmental services is classified according to the implementing

sector - government, governmental companies, local authorities, and non-profit institutions.
The collected data include five types of public services for environmental protection:

Treatment of sewage: planning, maintenance, and development of sewage and drainage systems, construction and operation of pumping and treatment plants, and treatment of rainwater.

Treatment of waste: collection, disposal, and incineration of domestic and industrial waste, treatment of solid waste and hazardous materials, street sweeping, and cleaning of marketplaces.

Protection of the biosphere: landscape, and atmosphere, construction, maintenance, and beautification of parks, preservation of forests and forestation, fire fighting, maintenance of beaches and nature reserves, maintenance and reclamation of land, and prevention of air and water pollution.

General administration: general management as well as planning and supervision related to environmental protection in government ministries, local authorities, and conurbations.

Other services, activities that do not fall within the categories of services specified above. For example: urban planning and construction, and the activities of environmental protection units in local authorities.

Expenditure for public environmental services is classified into the following categories:

Current expenditure: labor expenses and current purchases of commodities and other services in addition to a calculated estimate of expenditures for depreciation of buildings and equipment.

Investment in fixed capital: expenses for constructing installations, buildings, other construction projects, and purchase of machinery and equipment for environmental protection.

1.3.2.2. Data Sources and Collection

The data were collected by the Macro Economics Statistics Department in the CBS.

Government consumption expenditure was estimated based on an analysis of the Accountant General's budget execution reports as well as the budget provisions, and on complementary data received from other ministries, such as the Ministry of Finance and Ministry of Environment. Consumption expenditure of local authorities and non-profit institutions was estimated on the basis of data obtained from analyzing their financial and budgetary reports.

1.3.2.3. Classifications

Environmental services are generally defined according to the guidelines of the statistical offices of the UN and the European Union (EUROSTAT) for classification of activities aimed at protecting the environment. Based on this classification, expenditure for environmental protection in the public sector includes the following items:

1. Protection of air quality and climate.
2. Sewage and waste treatment.
3. Protection of soil and groundwater.
4. Extreme noise and vibration abatement.
5. Biosphere and landscape protection.
6. Protection against radioactive radiation.

1.3.2.4. Data Limitations

- The data do not include the environmental expenditure of the commercial and industrial sectors.
- The data do not include the expenditure of organizations in the public sector whose primary purpose is not environmental protection. For example, the expenditure of the Israel National Road Company for landscape restoration and IEC (Isreali Electric Company) expenditure for a scrubber implemented in a power station, in order to reduce SO_2 emissions.

1.3.3. Results

Table 1.6: Expenditure on Environmental Public Services by Operating Sector and Type of Expenditure

OPERATING SECTOR	1995	2000	2001	2002
% of Gross Domestic Product	1.6	1.4	1.5	1.5
% of general government expenditure	2.9	2.9	2.8	2.8
	MILLION NIS AT CURRENT PRICES			
GRAND TOTAL	4,237	6,799	7,191	7,451
Government	403	722	772	770
Local authorities	3,501	5,606	5,954	6,237
Non-Profit Institutions	333	471	465	443
	CURRENT EXPENDITURE			
TOTAL	2,817	4,697	5,141	5,253
Government	124	302	349	384
Local authorities	2,445	3,990	4,396	4,479
Non-Profit Institutions	248	405	396	390
	FIXED CAPITAL FORMATION			
TOTAL	1,420	2,102	2,050	2,197
Government	279	420	423	386
Local authorities	1,056	1,616	1,558	1,758
Non-Profit Institutions	85	66	69	53
Average annual exchange rate NIS/€	3.8934[1]	3.7679	3.7644	4.4780

Source: CBS

[1]The Exchange rate for 1995 is expressed in terms of NIS/ECU

1.3.4. Discussion

In the period spanning 1995 to 2002, public environmental expenditure, at current prices, increased by about 75%. However, its proportion out of the national GDP remained nearly identical. As mentioned previously, environmental hazards are inflicted by the scope of economic activities. Since the GDP during this period increased at a similar rate (83%), it may be that the public sector needed proportional resources to treat burgeoning environmental problems. Out of the total expenditure in 2002, 83% were spent by local authorities, 10% were spent by the government, and the share of non-profit institutions was 6%. Between the years 1995 and 2002, environmental investments by non-profit institutions decreased by 38%, and their share in the total environmental expenditure decreased from 8% to 6%. These figures may reflect a trend of declining participation by the community in addressing environmental problems or transfer of maintenance expenses from NGO to governmental non-environmental branches (such as Ministry of Infrastructure) or to local authorities. However, it should be noted that these figures are incomplete and may, therefore, be biased.

2. Land and Biodiversity

Source: Photo Archive KKL-JNF

2.1. LAND USE

2.1.1. *Introduction*

Land use describes how a surface area of land is used by humans according to different categories. Land use data present quantitative and qualitative distributions according to accepted and feasible categories over time. Some of the presented categories are constant over time, such as total land or lakes, but others are the results of political, social and economic processes, such as built up areas, industrial areas, open spaces, etc. This section summarizes existing land use data from all available sources within the CBS and from external sources. Follow-up over time on land use facilitates analysis of development processes and their environmental impacts. Examples include changes in built up areas versus open spaces, changes in declared nature reserves and changes in agricultural land.

2.1.2. *Methods*

The presented data are a result of a project carried out by the GIS Sector in the CBS. Within the framework of this project, several GIS layers from different sources were collected and integrated into 13 basic layers. The process of identifying the main use of each area was based on a set of assumptions and priorities in order to resolve conflicts among different uses for the same area.

2.1.2.1. Definitions

Land use is defined as the different ways that humans utilize land for activities, such as construction, industry, agriculture, commerce, forestation, etc. Land use categorization portrays a snapshot of current uses on the surface of the land, as opposed to land allocation which refers to future plans for the land.

Classification hierarchies refer to the order in which the main land use was determined, when more than one land use were suitable.

2.1.2.2. Data Sources and Collection

The final data are based on the processing and integration of a variety of sources that were received from government offices, non-governmental organizations and private companies:

- Data on the jurisdiction area of local authorities were obtained from the Ministry of the Interior. The GIS Sector at the CBS created the corresponding layer. The layer is based on Ortho-Photos and updates provided by the Ministry of the Interior.
- Data on agricultural uses were obtained from a layer jointly produced by the Hebrew University of Jerusalem and the Ministry of the Interior.
- Data on road areas were collected by the Construction Division at the CBS.
- Data on forest areas were obtained from the Jewish National Fund (JNF) and the MAPA Company.
- Data on nature reserves were obtained from the Israel Nature and Parks Authority.

Data were also obtained from the National Agency for Geodesy, Cadastre, Mapping and Geographic Information, the Ministry of the Environment, the Geological Survey of Israel, the Geophysical Institute of Israel, the Israel Meteorological Service, the Ministry of Construction and Housing, the Ministry of Health, the Ministry of Education and the Ministry of National Infrastructure.

2.1.2.3. Classifications

The different land use categories are classified as follows:

1. Education - areas used for schools, universities, kindergartens and community culture centers.
2. Health and Welfare - Areas used for health or welfare purposes, such as hospitals, medical clinics and old-age homes.
3. Public Service - Areas used for emergency and rescue services, public administration and religious services.
4. Culture, Leisure, Recreation and Sport -
   - Areas used for cultural purposes, such as theaters, museums, public libraries, zoos and archeological sites.
   - Areas used for tourism and recreation, such as hotels, restaurants and amusement parks.
   - Areas used for sport such as stadiums and swimming pools.
5. Commerce - Areas used for commerce, such as shopping malls and commercial centers.
6. Industry and Infrastructure -
   - Industrial areas, mines and quarries;
   - Infrastructure sites, such as airports, harbors, sewage treatment plants and landfills.
7. Transportation - Areas used for parking lots, gas stations, train and central bus stations.

8. Agricultural Building - Areas used for agricultural buildings, such as greenhouses and fishponds.

9. Residence - Areas used for housing and built up areas not classified for other uses.

10. Public Open Space – Areas used for public parks and swimming beaches.

11. Forest – Areas used for natural and planted forests and unspecified forests.

12. Orchards - Areas covered by various kinds of orchards.

13. Cultivated Fields- Areas of cultivated fields.

14. Other Open Space - Areas not classified for any other uses.

2.1.2.1. Data Limitations

1. Homogeneity of data - The data were collected from 13 different layers that were integrated within the CBS. These layers were created on different years and have different spatial and time resolutions. Therefore, there may be some discrepancies between the different layers.

2. Different shapes of entities- Some of the layers refer to polygons and others to points in space. Therefore, some adjustments were made in order to coordinate between the different shapes. These adjustments do not necessarily represent the exact boundaries of the land use categories in practice.

3. Roads were not identified separately, and were categorized according to the land use surrounding them.

4. Conflicts between data sources - Due to discrepancies between the different data sources, overlaps occurred between layers. As a result, in some cases, certain areas could be identified with more than one land use category. In order to resolve these conflicts, a hierarchy was assigned to the different land use categories (see Section 2.1.2.3 for the list of categories in their hierarchical order). Areas that had more than one possible land use category were uniquely identified according to the highest relevant category in the hierarchy.

2.1.1. Results

Table 2.1 Land Use in Israel by District (2002)

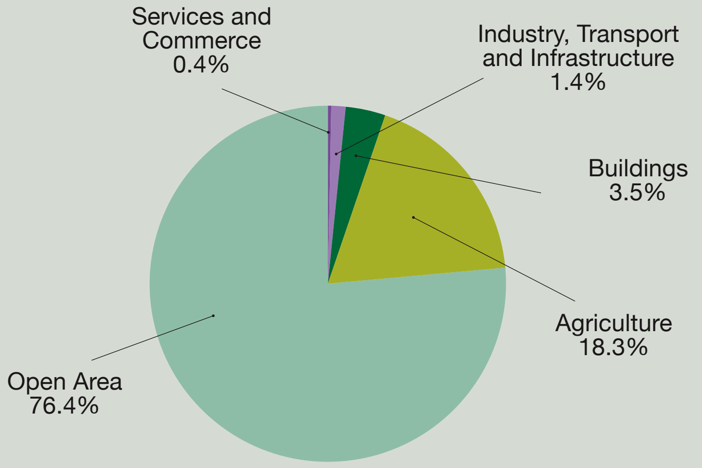
District	Jerusalem	North	Haifa	Center	Tel-Aviv	South	Total Israel
Education	2.9	4.2	3.7	6.6	4.6	4.5	27
Health and Welfare	0.5	1.2	0.9	1.7	1.3	0.9	7
Public Service	3.2	4.6	3.0	4.6	4.4	3.2	23
Culture, Leisure, Recreation and Sport	1.1	3.9	1.9	3.3	2.0	3.9	16
Commerce	0.4	1.9	2.5	3.3	3.0	1.4	13
Industry and Infrastructure	9.5	89.9	34.7	55.2	11.9	93.5	295
Transportation	0.5	0.4	0.7	0.9	1.3	0.6	4
Agricultural Building	5.1	37.0	12.8	43.7	0.4	58.5	158
Residence	46.0	136.6	87.8	161.1	68.8	100.0	600
Public Open Space	4.8	19.9	5.7	9.2	10.1	27.7	77
Forest[1]	361.2	1207.4	352.5	151.1	6.4	464.3	2,543
Thereof: Planted Forest	191.6	306.1	70.5	57.2	0.2	277.9	904
Thereof: Natural Forest	142.9	523.2	243.2	11.6	0.0	61.2	982
Orchards	24.9	316.6	81.4	209.2	3.1	162.2	797
Cultivated Fields	72.6	945.3	126.6	313.4	16.6	1,698.6	3,173
Other Open Space	120.3	1,704.1	151.9	330.7	38.1	11,565.8	13,911
Total Area	653	4,473	866	1,294	172	14,185	21,643

The data for forest refer to 2003[1]

Source: CBS

Table 2.1 presents the distribution of the land use categories in Israel and in its six districts. Overall, the table shows that the land use categories are not uniformly distributed among the districts. For example, 74% of the industrial and infrastructure areas are located in the peripheral districts in the north and south of the country (including the Haifa, North and South Districts). Together these districts host 54% of the residential areas and 69% of the agricultural building areas. As to open space, 83% of the category labeled "other open space" is located in the South District, which is also the largest district (66% of the total land area). The table also shows that although the Tel Aviv and Central Districts take up only 6% of the country's total area, they host 36% of its residential area. The Tel Aviv and Central Districts also have the smallest portion of open spaces within their districts (32% and 38% respectively). From the three districts that include the three major cities in the country, the Jerusalem District has the highest portion of open space within the district (74%), almost twice the share of open space in the Tel Aviv District.

Chart 2.1 General Land Use in Israel (2002)



Source: CBS

Chart 2.1 presents an aggregated picture of Table 2.1. From the chart we can see that 18% of the country area is used for agriculture, and 77% is open space (forests, public and other open space). The different kinds of built-up areas total about 5% of the total area of Israel.

Table 2.2 Protected Areas in Israel (2002)

Total	Terrestrial	Coastal	Marine	Total
Number	390	29	8	427
Area km 2	4,071.7	19.7	8.3	4,099.7
National Parks				
Number	180	23	-	203
Area km 2	263.0	18.3	-	281.3
Nature Reserves				
Number	210	6	8	224
Area km 2	3,808.7	1.4	8.3	3,818.4

Source: Israel Nature and Parks Authority

Table 2.2 presents selected figures on Israel's protected areas. These protected areas total some 19% of the land in the country. About 99% of the reserves are terrestrial and the rest are located in coastal and marine regions. With regard to type of protected area, 52% are nature reserves and 48% are national parks.

2.1.2. Discussion

Land uses in Israel's six districts vary significantly. In the south, the vast majority of the land is open space, whereas in the Tel Aviv area less than a third of the land is open space. Most of the built-up areas and the different services are concentrated in the Tel Aviv and Central Districts.

In recent years the trend of converting open space and agricultural land into built-up areas appears to be rapidly increasing. However, current figures cannot support or defy this claim. They only provide a present snapshot of the situation, and do not allow for the backtracking of land use changes over time. While a previous attempt to describe the land cover in Israel took place in 1995, the categories and the classification methodology at the time were entirely different and therefore do not allow for comparisons with current figures.

Systematic updates of the current data over time will be required to track land use changes in the future and help policy makers and planners progress towards a sustainable development strategy.

With regard to protected areas, about a fifth of Israel's land is protected. Most of the protected areas are located in the south, with the largest amount of open space and the smallest population in the country. Protected areas in the central and coastal regions are much smaller and constitute about three percent of the total area of these regions. In addition, these areas are scattered and fragmented and do not create terrestrial continuity, which is necessary for biodiversity conservation. Recently, the concept of ecological corridors that connect between protected areas has been proposed in order to address this problem.

Although Israel has a long coastline, there are only a very few small protected areas along its coast and in the sea. Since most of the country's population is concentrated in the coastal zone, the conservation of the marine and coastal areas is a difficult task, and should be prioritized.

2.2. BIODIVERSITY

2.2.1. Introduction

Israel is a country with a small land area, located at the crossroads of three continents and includes a variety of different landscapes and climatic conditions. These conditions contribute to the high species diversity in the country. However, intensive human activity, including massive exploitation of natural resources, development and subsequent destruction of natural habitats, alteration and pollution of ecosystems and hunting, has caused harm to many of the country's animal and plant species. harm is manifested at varying levels of severity, ranging from reduced geographic distribution to total extinction. The World Conservation Union (IUCN) has defined a set of criteria for evaluating the threat of extinction for plant and animal species, based on the population size of the species and their distribution area.

2.2.2. Methods

2.2.2.1. Definitions

Number of Species: The number of species in Israel since the beginning of the 20th century (including extinct species).

Taxonomic Group: Animal or plant group having natural relations, such as birds, mammals, reptiles, insects, etc.

Risk categories for species, according to the international categorization scheme, were grouped to allow comparison at different points in time. The risk categories are:

- No risk of extinction: Species that are not exposed to severe danger of extinction. This category includes the following risk categories: 1) vulnerable; 2) near threatened; and 3) least concern (IUCN 1996).
- At risk of extinction: Species that are exposed to severe or very severe risk of extinction. This category includes the following risk categories: 1. endangered; 2. critically endangered (IUCN 1996). According to these risk categories, the population of the species is expected to decline by 50% to 80% within the next ten years.
- Extinct: The cumulative number of extinct species since the beginning of the 20th century. Data on extinction relate to the local level. Thus, there may be cases in which there is a decline in the number of extinct species due to reintroduction by humans or natural reintroduction from other areas.
- Not estimated: Species for which there is not enough information or no available information to evaluate the extent to which they are endangered. This category includes the following risk categories: 1. data deficient; and 2. not evaluated (IUCN 1996).

2.2.2.2. Data Sources and Collection

Data on vascular plants were received from Prof. Avi Shmida of the Alexander Silberman Institute of Life Sciences at the Hebrew University of Jerusalem.

Data on vertebrates were received from the Nature and Parks Authority and from the Institute for Nature Conservation in Tel Aviv University. The data were gathered from research reports at three points of time, whereas the risk categories and some of the species names were not identical. In order to compare the different time points, the risk categories were merged into new risk categories (see definitions). Species names, for comparison purposes, were determined according to the latest available taxonomic data.

- The 2002 data were obtained from the book "Endangered Species in Israel, Red List of Threatened Animals – Vertebrates," published by the Nature and Parks Authority and the Society for Protection of Nature in Israel.
- The 1987 data were obtained from the publication "The Names of Vertebrates in Israel," published by the Nature and Parks Authority.
- The 1975 data were obtained from the "Survey of Extinct and About to Become Extinct Plants and Animals in Israel," published by the Environmental Protection Service.
- The 1975 research included the area of the Sinai Peninsula, although the data referred only to Israel territories.

2.2.2.3. Classifications

Classifications for the risk categories for vertebrates and vascular plants are based on the IUCN (1996) criteria for evaluating the threat of extinction. However, in both cases, criteria were partially adapted to suit local conservation needs.

2.2.2.4. Data Limitations

- The data only relate to wild species of vertebrates that currently live or have lived in Israel in the past. Species brought to Israel by humans are not included in the risk assessments.
- The data are mainly based on the subjective estimates of different experts, and do not necessarily follow the same categorization guidelines.
- Data on fish only include freshwater fish.
- Data on birds only relate to birds that currently nest or have nested in Israel in the past.

2.2.3. Results

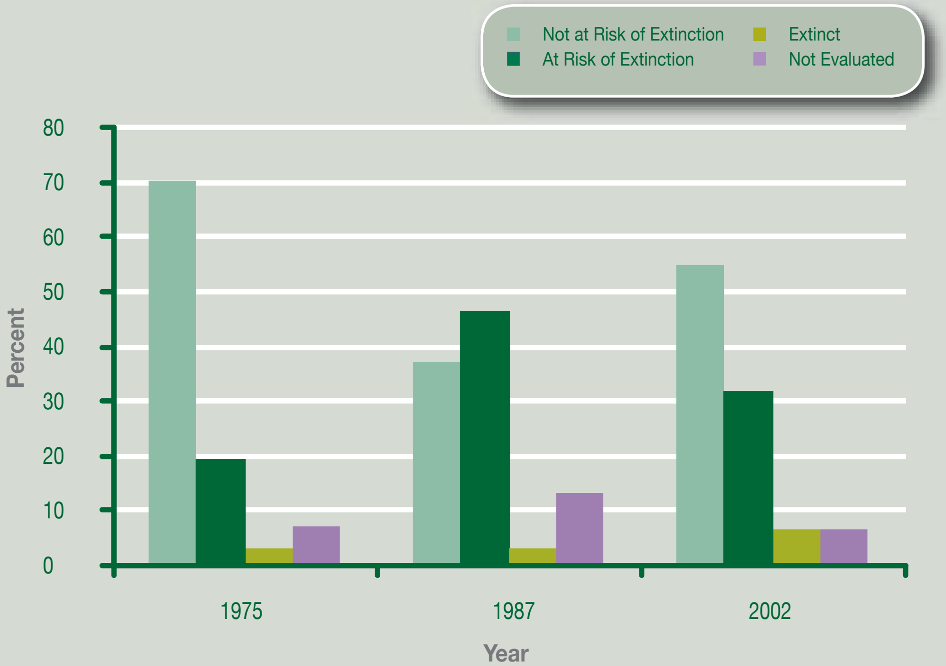
Table 2.3 Vascular Plants by Risk of Extinction (2002)

Risk Level	Number of Species	% of the Local Species
Extinct	33	1%
Critically Endangered	51	2%
Endangered	111	5%
Vulnerable	176	8%
Data Deficient	1,867	83%
Total (Local Species)	2,238	100%
Invading species	135	

Source: Hebrew University of Jerusalem

Table 2.3 presents the distribution of vascular plants by their risk categories as estimated in 2002. The table shows that 1% of the local vascular plants are extinct and 7% are at high risk of extinction (endangered and critically endangered). Most of the plant species were not evaluated, and therefore the number of species at risk may be higher. The table also presents the number of invading vascular plant species, which is higher than the total number of both extinct and critically endangered vascular plant species.

Chart 2.2 Vertebrate Species by Risk of Extinction



Sources: Nature and Parks Authority, Tel Aviv University, the Society for Nature Protection

Chart 2.2 summarizes the findings on the percentage of vertebrate species which are at risk of extinction. The figure shows that the percentage of extinct vertebrate species has increased during the observed period. There is a sharp increase in the percentage of species at risk between 1975 and 1987, but there is a decrease between 1987 and 2002.

Table 2.4 presents a summary of research in Israel on the threat of extinction of vertebrate species by taxonomic group. The table shows that from the beginning of the 20th century to 2002, 30 vertebrate species became extinct in Israel. In addition, by 2002, 146 species were at risk of extinction.

With regard to birds, four species were extinct by 2002, 50 species were at risk in 1975 and 2002, and 92 species were at risk in the interim period in 1987. In 1987, 27 species were not evaluated, almost twice the number in 2002 and nine fold the number of unevaluated bird species in 1975.

For reptiles, there was no change in the number of extinct species along the reviewed period. The number of reptile species at risk of extinction significantly increased from five species in1975 to 41 in 1987, although it slightly decreased to 35 in 2002.

As to amphibians, only seven species are native to Israel, of which one was recorded as extinct along the entire reviewed period. Out of the six remaining species, the number of species in danger of extinction rose from two species in 1975 to five species in 1987, with no change in 2002.

With regard to freshwater fish, six species were extinct by 2002. This represents a dramatic six-fold increase from 1975 and 1987. The number of species found to be in danger of extinction increased from four in 1975 to 17 in 1987 and decreased to six species in 2002.

The number of extinct mammals increased from seven in 1975 to nine in 1987, but decreased to five species in 2002. The number of species in danger of extinction rose continually throughout the reviewed period, although not at a constant rate. In 1975, there were 28 mammal species in danger of extinction in comparison to 58 in 1987 and 61 in 2002.

Table 2.4 Threat of Extinction to Vertebrate Species

	2002		1987		1975	
	%	No. of species	%	No. of species	%	No. of species
Total Evaluated Vertebrates	**100**	**459**	**100**	**459**	**100**	**459**
In no danger of extinction	55	252	37	171	70	322
In danger of extinction	32	146	46	213	20	90
Extinct	7	30	3	15	3	15
Not estimated	7	31	13	60	7	32
BIRDS						
Total	**100**	**210**	**100**	**210**	**100**	**210**
In no danger of extinction	68	142	43	90	73	154
In danger of extinction	24	50	44	92	24	50
Extinct	2	4	0	1	1	3
Not estimated	7	14	13	27	1	3
REPTILES						
Total	**100**	**105**	**100**	**105**	**100**	**105**
In no danger of extinction	51	54	45	47	82	86
In danger of extinction	33	35	39	41	5	5
Extinct	3	3	3	3	3	3
Not estimated	12	13	13	14	10	11
AMPHIBIANS						
Total	**100**	**7**	**100**	**7**	**100**	**7**
In no danger of extinction	14	1	14	1	43	3
In danger of extinction	71	5	71	5	43	3
Extinct	14	1	14	1	14	1
Not estimated	0	0	0	0	0	0
FRESHWATER FISH						
Total	**100**	**32**	**100**	**32**	**100**	**32**
In no danger of extinction	56	18	28	9	69	22
In danger of extinction	19	6	53	17	13	4
Extinct	19	6	3	1	3	1
Not estimated	6	2	16	5	16	5
MAMMALS						
Total	**100**	**105**	**100**	**105**	**100**	**105**
In no danger of extinction	35	37	23	24	54	57
In danger of extinction	58	61	55	58	27	28
Extinct	5	5	9	9	7	7
Not estimated	2	2	13	14	12	13

Source: Nature and Parks Authority, Tel Aviv University, the Society for Nature Protection

2.2.4. Discussion

The results for vertebrate biodiversity seem unstable along the studied years. For most of the taxonomic groups, there is a sharp increase in the number of species in danger of extinction between 1975 and 1987, and a considerable decrease from 1987 to 2002. These changes in species status are not reasonable for such a short time period. It may well be that the studies in the three points of time used inconsistent criteria and scales for determining risk of extinction. In addition, there were changes in the area under study.

Although some of the vertebrate data are not robust, and should be treated with great caution, there are certain trends that seem to emerge from the analysis:

- Extinct species doubled in number between1975 to 2002. The greatest increase in extinct species occurred in the freshwater fish group.

- The results indicate that different taxonomic groups encounter different levels of extinction risk. The differences may depend on land use changes in Israel and on differing human pressure levels on their habitats.

- On the one hand, a considerable increase in the number of endangered species is observed for amphibians and reptiles. On the other hand, the bird group shows a slight improvement in risk level.

- The status of freshwater fish and amphibians may be affected by the intense use and pollution of surface water in Israel. Although efforts have been invested to restore water quality in some streams, most of the main streams in Israel's Mediterranean region are heavily polluted. In addition, the massive human pressure on wetland habitats has heavily affected these taxonomic groups.

- The increase in the number of endangered reptiles may be related to the loss of natural habitats for these species across the country, especially due to accelerated building and development in the coastal region in recent years and the disappearance of the coastal sand dunes.

- The continual increase in the number of endangered mammals may be linked to the loss and fragmentation of their natural habitats. The decrease in the number of extinct mammals is clearly a result of the reintroduction of locally extinct species and of continuous conservation efforts for these species.

- Fragmentation of habitats may play a smaller role in the case of birds, which show a slight trend of improvement in recent years. Conservation efforts may also be a contributing factor for this trend

Although, the data for vascular plants only refer to one point in time, and therefore a time trend cannot be drawn, the high number of invading species relative to the extinct and endangered local plant species may be indicative of the impact of human intervention on plant biodiversity in Israel.

The above results suggest that future research should use the IUCN methodology in a systematic manner in order to facilitate comparison over time and across borders. Reliable time series data are required for additional taxonomic groups, especially non-vertebrate species. For instance, there are no available data on non-vascular plants, insects and marine species. Further research is highly needed in order to evaluate the risk of extinction of Israel's fauna and flora and to assess the effects of human pressure on biodiversity in Israel.

3. Air Quality

Source: Photo Archive KKL-JNF

3.1 INTRODUCTION

Air pollution in Israel is highly influenced by the country's unique features. Most of Israel's economic activities and half of its population are concentrated on the coastal plain, in a strip spanning 171 kilometers from north to south and 10 kilometers from west to east. Israel's principal power plants operate in this area and about 70% of its motor vehicles fleet is located there. However, air pollutants are not concentrated within a limited radius of power plants and industries. They are found in areas located tens of kilometers away from pollution sources. Some air pollutants, especially sub-micron particles containing sulfur ions, are even known to reach Israel from sources in eastern and southern Europe. The main sources of air pollution in Israel are transportation, energy generation, and industry. Since 1990, both the motor vehicle fleet and electricity consumption have doubled.

Information on air quality is presented in two modes:

- Calculated estimate of air pollutant emissions from fuel combustion.
- Concentrations of air pollutants, as measured at monitoring stations throughout Israel.

3.1.1 General Definitions

Primary Pollutant: A pollutant emitted directly from the source of pollution into the atmosphere.

Secondary Pollutant: A pollutant derived from a chemical or photochemical reaction between primary pollutants in the atmosphere.

Inversion: An atmospheric condition in which air temperature rises with increasing altitude, instead of dropping as would be expected. A light and warm layer of air lies above a cold and heavy layer. The heavy layer, adjacent to the ground, serves as a pollutant trap as long as it does not mix with the layer above, thus preventing dispersion of pollutants.

CO_2 (Carbon Dioxide): A gas originating from complete combustion of fuel materials. CO_2 is a greenhouse gas. The main source of CO_2 emissions is fuel combustion in power plants, industry and transportation. An additional source of CO_2 is the cement industry where gas is emitted during the decomposition of limestone ($CaCO_3$) in the incinerators.

CO (Carbon Monoxide): A gas produced by incomplete combustion of hydrocarbon fuels, deriving mainly from motor vehicle emissions. This gas is a precursor of greenhouse gases.

HC (Hydrocarbon): Compounds of hydrogen and carbon emitted during the combustion and evaporation of fuel. These gases are mainly produced by emissions from vehicles and refineries.

CH_4 (Methane): A greenhouse gas produced in landfills and sewage purification plants following the breakdown of organic waste in anaerobic conditions (without oxygen), from animal digestion processes, mainly from chewing cud, and from anaerobic decomposition of animal secretions. Methane is also produced from natural sources such as plant decomposition.

NMVOCs (Non-Methane Volatile Organic Compounds): Gases produced during hydrocarbon fuel combustion or during the vaporization of liquid fuels, solvents, paints and intermediate products for chemical production. These gases are precursors of greenhouse gases.

NO_x (Total Nitrogen Oxides): Acidic gases and precursors of greenhouse gases. This group of gases includes nitrogen dioxide (NO_2) and nitric oxide (NO). NO_x emissions are produced by fuel combustion. The coefficient of emission is determined by the combustion temperature and the air-fuel ratio. In nature, the oxides are produced as a result of volcanic activities and lightning storms. When oxides combine with water vapors they produce "acid rain" (a phenomenon that does not exist in Israel), and the photochemical reaction of NOx with VOCs creates ozone. The combination of the oxides with air particulates produces smog. NO_2 is the most hazardous of the NOx in terms of health and environmental effects.

N_2O (Nitrous Oxide): A greenhouse gas naturally emitted from soils and oceans. Human activity contributes to the release of N_2O through various agricultural processes such as soil cultivation and production and use of nitrogen fertilizers. In addition, N_2O emissions are released from the combustion of fossil fuels and burning of organic matter.

SOx (Sulfur Oxides): Sulfur is a natural component of fuel, so that there is a direct ratio between the sulfur content in fuel and the emission quantities of this pollutant. The main sources of SOx emissions are power stations, oil refineries and industrial plants that require high-sulfur fuels. SOx are emitted from elevated stacks and thus dispersion and dilution of this pollutant occurs before the plume reaches ground level. Depending on the height of the stacks, the pollution emitted affects areas tens or even hundreds of kilometers downwind of the plants. SO_2 (Sulfur Dioxide), which constitutes the majority of SOx emissions from fuel combustion, is a heavy, pungent, colorless gas. Like NOx, SOx create strong acidic water vapors that are a main source of "acid rain." SO_2 is an aerosol precursor, which mitigates the greenhouse effect.

SPM (Suspended Particulate Matter): A series of atmospheric materials based on carbon, produced by natural resources (sand, pollen, etc.) and by human activity (fires, fuel combustion, construction, quarrying, etc.). The most hazardous particles are those that are 10 microns or less in their diameter, Respirable Suspended Particulate Matter - PM10. These particles can penetrate the respiratory system. They derive mainly from natural sources and include fractions of small particles that are smaller than 2.5 microns, Fine Particulate Matter - PM2.5, usually emitted by industries, transportation, and space heating.

O_3 (Ozone): A secondary pollutant produced by photochemical reactions between HCs and NOx. There is a clear connection between O_3 concentrations and radiation intensity, as the production of O_3, as a photochemical pollutant, is limited to light hours. This pollutant is produced in the lower layers of the atmosphere (the troposphere), and is considered a greenhouse gas. Another type of O_3 is produced in the upper layers of the atmosphere (the stratosphere), and plays an important role in protecting the biosphere, because it prevents the penetration of harmful ultraviolet solar radiation.

Fuel Combustion: A process in which fuel is burned in order to produce energy within the following sectors: energy industries (electricity generation and oil refining), manufacturing and construction industries, transportation, etc.

3.2 EMISSIONS OF AIR POLLUTANTS FROM FUEL COMBUSTION

3.2.1 Introduction

Israel's anthropogenic sources of air pollution include stationary and mobile sources. The main air pollutants are attributed to the following main sources:

Air Pollutant	Anthropogenic Sources
CO_2	Power stations, industry and transportation
SOx	Power stations, oil refineries and industry
NOx	Power stations, industry and transportation (mainly from diesel-powered engines)
CO	Gasoline-powered vehicles
SPM	Industry, power stations, oil refineries, diesel-powered vehicles, quarries and cement plants

3.2.2 Methods

3.2.2.1 Definitions

Sulfur Content in Fuels: Sulfur is a product of crude oil from which various fuel products derive. The quantity of sulfur in distillations can be reduced according to the treatment level of the fuel and the consumer or standard requirements. The percentage of sulfur in the fuel determines the quantity of SOx emitted and affects the formation of particulate matter.

Catalytic Converter: A device installed on the exhaust system of unleaded gasoline-powered vehicles. The catalytic converter helps to complete the combustion process through the oxidation of CO, HC and NOx to CO_2, water and nitrogen. The converter reduces the amount of CO emitted by almost 80%. In Israel, cars manufactured since 1994 are required by law to install catalytic converters.

Diesel Oxidation Catalyst: A device installed on the exhaust system of diesel-powered vehicles. This converter changes HC, CO and organic compounds in particulates into CO_2, water and other neutral elements. The converter reduces CO and HC emissions from diesel-powered vehicles by up to 95% and SPM emissions by up to 50%.

Particulate Trap: A filter made from ceramic materials that traps the particulates found in emission gases. With the accumulation of particulates on the filter, a process of increasing resistance and temperature begins, which leads to the combustion of the particulates. The particulate trap has the potential to reduce particulates by 50%-95%.

Gasoline: Refined petroleum distillate, combined with certain additives. Gasoline is used as fuel for spark-ignition engines.

Gas/Diesel Oil: A fuel composed of distillates obtained in petroleum refining or blends of such distillates with residual oil used in motor vehicles. Several grades are available depending on use: diesel oil for diesel compression ignition (cars, trucks, vessels, etc.), gas oil for industrial and commercial uses.

Liquefied Petroleum Gas (LPG): A group of hydrocarbon-based gases derived from crude oil refining or natural gas fractionation. They include ethane, ethylene, propane, propylene, normal butane, butylene, isobutane, and isobutylene. For convenience of transportation, these gases are liquefied through pressurization.

Natural Gas: Comprises gases, occurring in underground deposits, whether liquefied or gaseous, consisting mainly of methane (CH_4). Production is measured after purification and extraction of natural gas liquids and sulfur, and excludes re-injected gas and quantities vented or flared. Natural gas is one of the cleanest combustible fuels from an environmental perspective.

Heavy Residual Fuel Oil: Heavy fuel oils produced from the non-volatile residue from the fractional distillation process, which constitute the "leftovers" of various refining processes. Heavy fuel oil comprises all residual fuel oils, including those obtained by blending.

Heating: Includes cooking, space heating and water heating in the commercial, industrial and residential sectors.

Bus: A motor vehicle designed to transport 16 or more persons in addition to the driver and described in its license as a bus.

Minibus: A motor vehicle, up to 4 tons gross weight, designed to transport up to 15 persons in addition to the driver and described in its license as a minibus.

Public Vehicles: Motor vehicles used to transport passengers that include the following types: buses, minibuses and taxis.

Private Vehicles: Non-public motor vehicles that include the following types: private cars and motorcycles

3.2.2.2 Classifications

According to the Israeli standard, residual fuel oil is categorized according to its sulfur content:

- Low-sulfur residual fuel oil - contains up to 1% sulfur.
- Low-low sulfur residual fuel oil - contains up to 0.5% sulfur.

3.2.2.3 Data Sources and Collection

- Data on annual quantities of various types of fuel consumed by the manufacturing sector and by motor vehicles were obtained from the Energy Division of the CBS.
- Data on annual kilometers traveled for the various types of vehicles, by age of vehicle, are based on an annual sample survey of cars registered in Israel, conducted by the CBS.
- Data on percentages of sulfur in coal used to generate electricity were obtained from the Israeli Coal Company.
- Since 2004, Israel also uses natural gas for electricity generation. Calculations of emissions from natural gas are based on coefficients of the Intergovernmental Panel on Climate Change (IPCC). In cases where appropriate coefficients were not found, coefficients provided by the Israel Electric Corporation were used.
- Emission factors of air pollutants from stationary sources (e.g., manufacturing) are based on factors developed by the United States Environmental Protection Agency (USEPA), and modified by the Ministry of Environment in order to suit conditions in Israel in 1997. The emission factors were obtained from the Air Quality Division (stationary sources) of the Ministry of the Environment.
- Emission factors of NO_x from coal consumption in electricity production are based on IPCC coefficients (1996) adapted to existing reduction technology.
- Emission factors of air pollutants (except for CO_2) from different types of mobile sources (vehicles) are based on studies conducted at the Technion – Israel Institute of Technology on the "Evaluation of Pollutant Emission Factors from Motor Vehicles in Israel" (L. Tartakovski et al., June 1997), "Evaluation of Pollutant Emission Factors from Diesel Vehicles in Israel (stage 1 - buses)" (L. Tartakovski et al., May 2000) and "Evaluation of Emission Factors from Motorcycles in Israel (L. Tartakovski et al., 2001). To date, these emission factors have only been developed for private gasoline-powered vehicles, motorcycles and buses. Emission factors for other types of vehicles and other fuel types are based on data from the United Kingdom and are adapted to conditions in Israel. The adapted emission factors were obtained from the Air Quality Division (mobile sources) of the Ministry of the Environment.
- Emission factors of air pollutants for CO_2 from different types of mobile sources (vehicles) are based on IPCC coefficients (1996).

3.2.2.4 Data Limitations

- The data do not refer to all air pollutants emitted into the atmosphere, and include only those that are emitted due to fuel combustion.

- Some of the emission factors are derived from Europe and are not completely adapted to conditions in Israel.
- The emissions resulting from fuel combustion are measured indirectly, according to the quantity of fuels (or kilometers traveled) and selected mean emission coefficients.
- The emissions derived from kilometers traveled are calculated from an estimate of annual kilometers traveled.

3.2.2.5 Models and Calculations

There are two sets of models for the calculation of air pollutant emissions. The first set refers to the type and combination of fuels used. In this model, annual quantities of air pollution emissions are calculated by multiplying emission coefficients by annual quantities of fuels consumed. This model includes all emissions from the manufacturing sector (including energy production), heating in various sectors and emissions of SOx, lead and CO_2 from motor vehicles. Emissions of SOx, NOx, and particles from electricity production originating from coal are calculated based on emission coefficients, taking into account the existing pollution reduction technology and the concentration of sulfur in the imported coal.

The second set of models refers to motor vehicles and is based on kilometers traveled by the various types of vehicles. This set of models covers CO, NOx, and HC and SPM. The emission coefficients of these air pollutants are calculated according to vehicle type and year of production.

3.2.3 Results

Table 3.1 presents emissions of the main pollutants from fuel combustion by energy consumer type:

- CO_2: The main contributor to CO_2 emissions is the manufacturing (mainly electricity production sector), which accounts for about 75% of the total emissions. From the 1980s to the end of the 1990s, CO_2 emissions for all type of consumers increased sharply. However, since the onset of the millennium the level of emissions has stabilized.
- CO: Emissions of CO increased sharply from the 1980s to the end of the 1990s, but since the 2000s the trend has changed and emissions have decreased. About 95% of the CO emissions derive from gasoline vehicles. In the last decade, these vehicles have undergone engine improvement processes and installation of catalytic converters that have contributed to reducing their emissions significantly.
- SOx : Since 1995 a decrease in SOx emissions was noted for all types of consumers. This trend is mainly due to an improvement in fuel quality and the introduction of pollution reduction technology in electricity production. Approximately 97% of the total SO_x emissions come from the manufacturing sector, mainly from electricity production.
- NOx : From 1995, there are mixed trends for the different types of consumers. On the one hand, emissions from the manufacturing sector have increased. On the other hand, emissions from motor vehicles have decreased. From 1980 to 2000, total emissions of NOx increased, and since the year of 2000, emissions have decreased. About 60% of the total emissions derive from the manufacturing sector, mainly from electricity production.
- HC: The major contribution to HC emissions is from gasoline vehicles. Since 1995, total HC emissions have

decreased due to the introduction of catalytic converters.

- SPM: In general, since 1995 SPM emissions from motor vehicles and the manufacturing sector have decreased. The manufacturing sector contributes about 90% of total SPM emissions.

- Pb: Emissions of lead (Pb) from gasoline vehicles have drastically decreased. This decrease is due to an improvement in gasoline quality consumed by vehicles, due to the unleaded gasoline requirement for catalytic converters.

Table 3.1 Emissions from Fuel Combustion, By Type of Consumer (Tons, unless otherwise stated)

Type of consumer	1980	1985	1990	1995	2000	2001	2002	2003	2004
CARBON DIOXIDE (CO_2)	**22,300**	**26,549**	**34,170**	**50,555**	**63,007**	**63,005**	**64,719**	**66,050**	**65,641**
(1,000 TONS)									
Space heating[1]	-	-	-	-	2,652	2,756	2,823	2,640	2,412
Motor vehicles	-	-	-	-	13,076	13,290	13,803	13,672	13,419
Thereof: Gasoline vehicles	-	-	-	-	6,297	6,025	6,159	6,162	6,245
Manufacturing	-	-	-	-	47,279	46,959	48,093	49,739	49,811
Thereof: Electricity production	-	-	-	-	36,978	37,334	38,595	40,151	40,713
CARBON MONOXIDE (CO)	**284,166**	**371,008**	**490,141**	**741,163**	**358,763**	**341,466**	**306,634**	**292,845**	**278,704**
Space heating[1]	406	370	479	614	567	591	605	565	513
Motor vehicles	280,929	367,778	485,698	716,906	349,976	333,583	298,402	284,367	270,284
Thereof: Gasoline vehicles	260,966	342,448	452,316	681,683	338,476	322,889	287,907	274,091	260,429
Manufacturing	2,831	2,860	3,964	23,643	8,219	7,292	7,626	7,913	7,908
Thereof: Electricity production	1,985	1,931	2,903	4,159	6,007	5,275	5,635	5,892	6,009
SULFUR OXIDES (SOx)	**308,129**	**251,081**	**272,288**	**286,472**	**273,263**	**238,753**	**223,802**	**226,249**	**207,320**
Space heating[1]	3,836	3,488	4,532	6,498	3,183	3,211	3,192	2,336	2,086
Motor vehicles	6,976	7,340	10,252	14,078	2,620	2,189	2,285	1,547	835
Thereof: Gasoline vehicles	2,976	3,748	5,564	7,880	615	588	601	601	610
Manufacturing	297,317	240,253	257,504	265,896	267,460	233,354	218,325	222,367	204,398
Thereof: Electricity production	203,242	145,817	169,220	205,740	180,728	150,859	142,108	148,506	132,412

Table 3.1 Emissions from Fuel Combustion, By Type of Consumer (Tons, unless otherwise stated) continuance

Type of consumer	1980	1985	1990	1995	2000	2001	2002	2003	2004
NITROGEN OXIDES (NOx)	**78,888**	**111,199**	**145,644**	**224,261**	**217,009**	**210,368**	**208,077**	**209,707**	**202,007**
Space heating[1]	1,551	1,420	1,839	2,495	2,229	2,320	2,381	2,234	2,032
Motor vehicles	41,983	53,991	71,216	98,009	87,096	79,888	74,293	71,704	66,863
Thereof: Gasoline vehicles	16,591	21,771	28,755	44,380	32,354	29,743	25,957	24,483	22,864
Manufacturing	35,354	55,788	72,589	123,757	127,684	128,160	131,403	135,769	133,111
Thereof: Electricity production	24,823	44,450	59,722	90,751	106,690	108,304	112,335	116,911	114,724
HYDROCARBON (HC)	**34,383**	**45,118**	**59,594**	**90,887**	**54,949**	**53,013**	**48,490**	**46,967**	**45,142**
Thereof: Gasoline vehicles	-	-	-	-	46,721	45,521	41,351	40,046	38,820
SUSPENDED PARTICULATE	**26,773**	**21,682**	**24,688**	**32,141**	**22,178**	**19,498**	**19,064**	**19,547**	**18,385**
MATTER (SPM)									
Space heating[1]	149	131	170	221	207	219	224	217	181
Motor vehicles	4,797	5,882	8,019	13,081	1,975	1,777	1,653	1,574	1,453
Thereof: Gasoline vehicles	377	494	653	972	485	469	427	416	412
Manufacturing	21,827	15,669	16,499	18,839	19,996	17,501	17,187	17,756	16,752
Thereof: Electricity production	14,383	8,571	9,759	9,299	11,137	9,163	9,295	10,026	9,130
LEAD (Pb) (from gasoline vehicles)	**432**	**543**	**292**	**287**	**127**	**98**	**23**	**21**	**10**
Thereof: Unleaded	-	-	-	-	121	7	7	8	8

[1] Space heating in residential, commercial and industrial buildings

Source: CBS

Table 3.2 presents NOx emissions by different types of vehicles and fuels.

- Total emissions from gasoline vehicles decreased from 2000 to 2004 by about 30%. This decrease is mainly attributed to the introduction of catalytic converters in private vehicles. Private gasoline vehicles emit about 80% of the total emissions from gasoline vehicles.

- On the one hand, NOx emissions from vehicles produced prior to 1993 decreased from 2000 to 2004.This decrease is explained by the decline of these vehicles in the vehicle fleet. On the other hand, emissions from vehicles, which were produced from 1994 and on, are on the increase due to the increase in their number. However, their emissions are increasing at a slower rate due to the impact of catalytic converters.

- Emissions from gasoline trucks have decreased due to the decline in their number and kilometers traveled in the observed years. Their share of emissions from the total gasoline vehicle emissions is about 20%.

- Emissions from motorcycles and gasoline minibuses and taxis are almost negligible due to their small share in the total gasoline vehicle fleet.
- Total emissions from diesel vehicles decreased from 2000 to 2004 by 20%. This decrease is explained by technological improvements of the various diesel engines.
- The major contributors to diesel oil emissions are trucks (70%), buses (25%) and taxis and minibuses (10%).

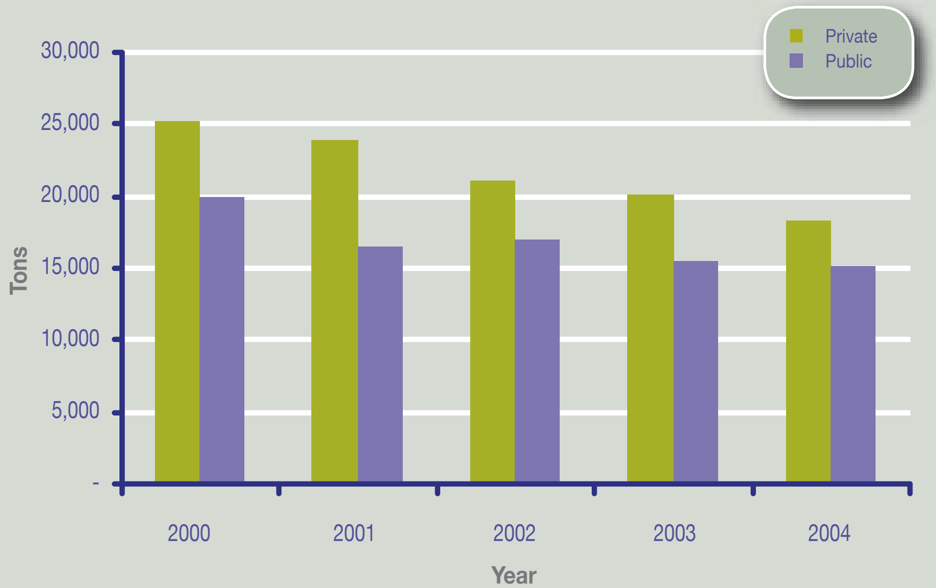
Table 3.2 **NOx Emissions from Vehicles by Fuel and Vehicle Type (Tons) and Number of Vehicles**

	2000	2001	2002	2003	2004
Gasoline					
Total	**32,354**	**29,743**	**25,957**	**24,483**	**22,864**
Private cars by model year					
Before 1993	19,869	17,864	14,794	13,306	11,027
1994-2004	4,999	5,635	5,960	6,348	6,858
Motorcycles	119	129	127	137	149
Trucks	7,303	6,074	5,033	4,660	4,804
Minibuses & taxis	62	40	42	32	25
Diesel					
Total	**54,743**	**50,146**	**48,336**	**47,221**	**43,999**
Private	173	221	247	262	273
Trucks	34,702	33,516	31,208	31,461	28,665
Buses	14,586	11,963	11,239	10,686	10,308
Taxis & minibuses	5,283	4,445	5,642	4,811	4,752
Number of vehicles					
Private (000)	1,474	1,540	1,576	1,597	1,644
Public (000)	357	374	384	386	394

Source: CBS

Chart 3.1 presents NOx emissions from public and private vehicles (excluding trucks, see section definitions). The chart shows that NOx emissions from private vehicles are about 30% higher than emissions from public vehicles. There is a similar decrease in emissions for both private and public vehicles within the reviewed period due to technological improvements in these vehicles.

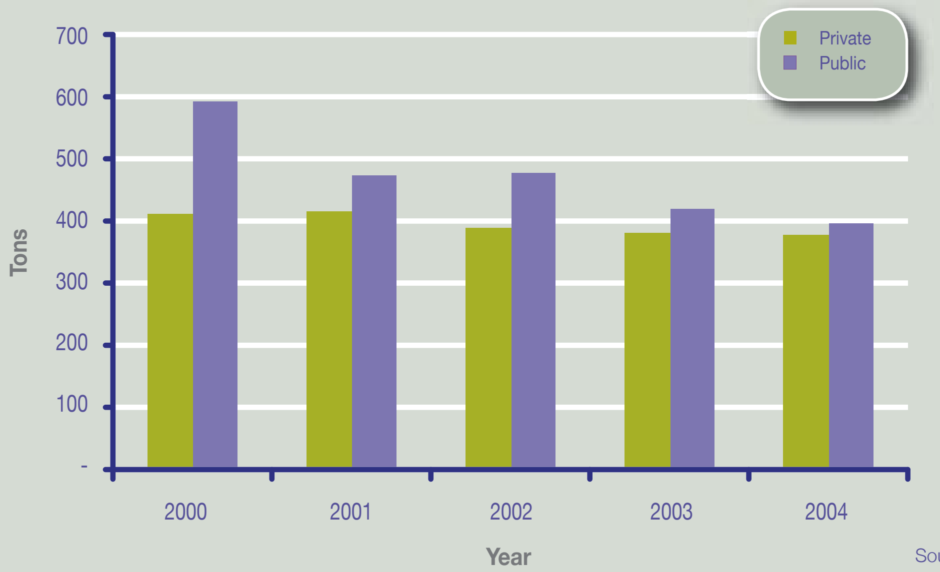
Chart 3.1 NOx Emissions from Public and Private Vehicles



Source: CBS

Chart 3.2 presents SPM emissions from public and private vehicles. The chart shows that SPM emissions from public vehicles were about 40% higher than emissions from private vehicles in 2000.The gap between public and private vehicles has since shrunk and reached 5% in 2004. There is a decrease in emissions within the reviewed period for both private and public vehicles, but the decrease in emissions from public vehicles is much sharper, possibly due to technological differences between the two groups of vehicles.

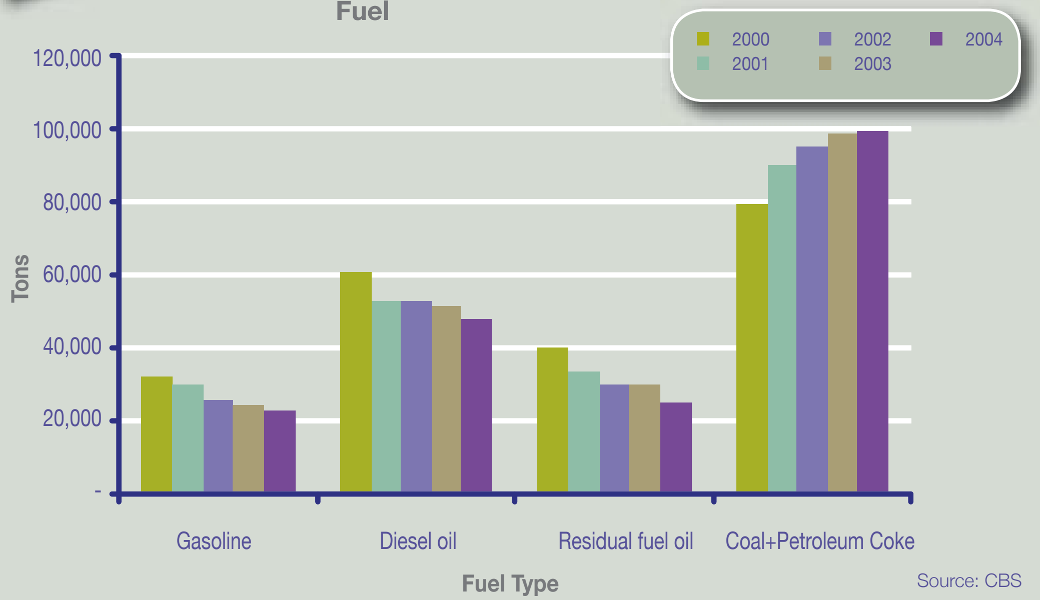
Chart 3.2 SPM Emissions from Public and Private Vehicles



Source: CBS

Chart 3.3 presents NOx emissions by major types of fuels. The major contributor to NOx emissions is coal, which accounts for 45% of the total emissions from fuel combustion. An increase in coal emissions has occurred from 2000 to 2004, due to an increase in coal consumption for energy. Decreases in NOx emissions were noted for the other presented fuel types. In the case of diesel and gasoline, the decrease is largely attributed to technological improvements in the transportation sector. In the case of residual fuel oil, the decrease is largely attributed to a decline in consumption, mainly by the energy sector.

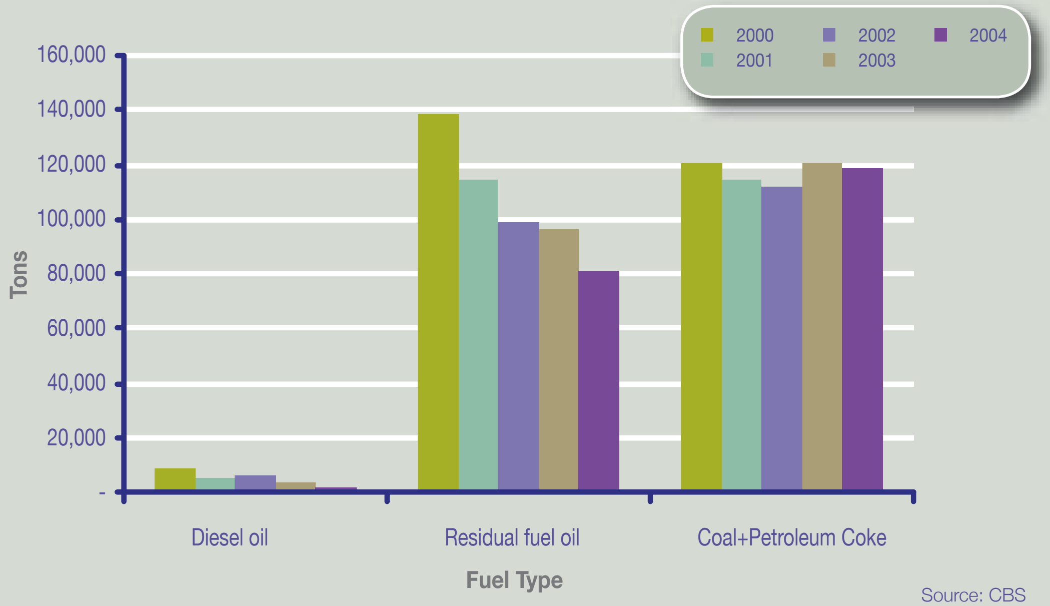
Chart 3.3 NOx Emissions from Fuel Combustion, by Type of Fuel



Source: CBS

Chart 3.4 presents SOx emissions by fuel types. The main contributors to SOx emissions are coal and residual fuel oil, which together account for 95% of the total emissions from fuel combustion. From the presented fuels, diesel oil and residual fuel oil show a decrease in SOx emissions from 2000 to 2004. This decrease is explained by a series of improvements in the sulfur content in these fuels that occurred in the presented years. The reduction in emissions from residual oil is also explained by the decline in its consumption within these years. As to coal, there are only minor changes in the reviewed period. This stability is largely explained by the technological progress in SOx reduction in electricity production, despite the increase in the quantities of coal consumed in these years.

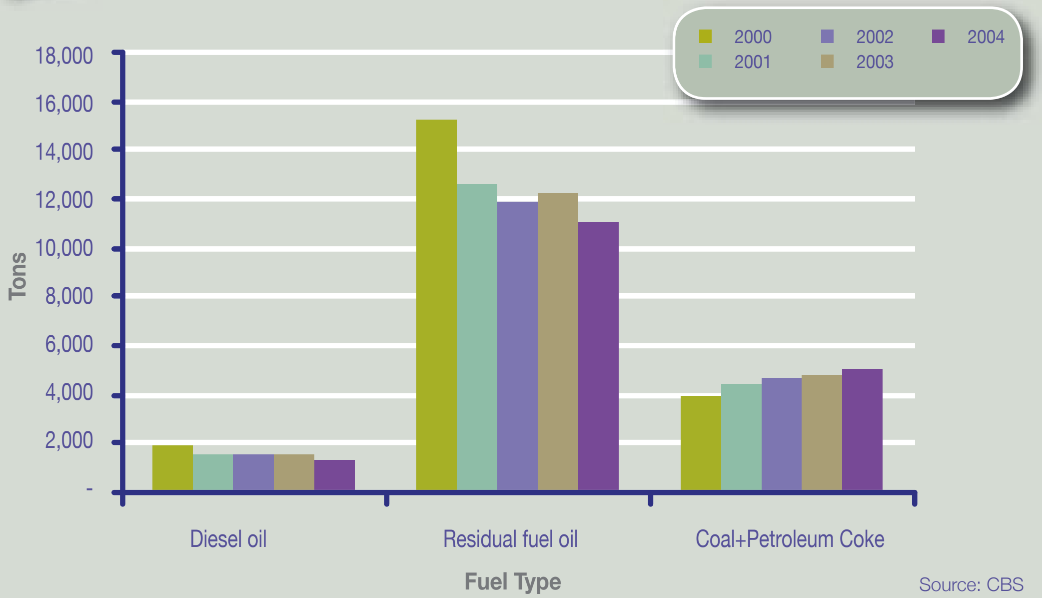
Chart 3.4 SOx Emissions from Fuel Combustion, by Fuel Type



Source: CBS

Chart 3.5 presents SPM emissions by types of fuel. The main contributor to SPM emissions is residual fuel oil, which accounts for 60% of the total emissions from fuel combustion. There was a significant decrease in SPM emissions for residual fuel oil between 2000 and 2004. This decrease is mainly due to a decline in its consumption mainly by the energy sector. There is also a decrease, although more moderate, in emissions from diesel oil. This decrease may be explained by technological progress in transportation. In emissions from coal, however, there is a moderate increase, which can be explained by an increase in coal consumption on the one hand, moderated by technological developments in the energy sector, on the other hand.

Chart 3.5 SPM Emissions from Fuel Combustion, by Fuel Type



Source: CBS

3.2.4 *Discussion*

Emissions for most of the reviewed air pollutants[1] decreased due to improvements in technology, fuel quality and consumption patterns.

Emissions from transportation account for 97% of the total CO emissions. The introduction of catalytic converters in gasoline-powered vehicles has significantly reduced CO emissions. This decrease occurred despite the continuous increase in the number of gasoline vehicles and their kilometers traveled. Although CO emissions from diesel-powered vehicles are significantly lower, they are the second source of CO emissions in Israel.

In 2004, emissions from transportation accounted for 28% of the total NOx emissions. Diesel-powered vehicles contributed about 65% of these emissions. There is a declining trend in NOx emissions from both gasoline and diesel vehicles. However, the decrease in emissions for gasoline vehicles is greater due to the introduction of catalytic converters.

Although transportation contributes only 8% to the total SPM emissions, these emissions have a major impact in urban centers because they are emitted at pedestrian level. Most of the SPM emissions in transportation originate from diesel vehicles, especially diesel trucks. In recent years a decrease in SPM emissions from vehicles has been observed due to the introduction of improved technology in new cars.

In recent years, SOx emissions from transportation significantly decreased as a result of a continuous reduction in the fuel

[1] CO_2 emissions will be discussed in depth in the indicator "Carbon Dioxide Emissions per Capita" in the SDI chapter.

sulfur content. Today, SOx emissions from transportation account for less than 1% of the total SOx emissions.

Emissions of HC from transportation have decreased in recent years due to the operation of catalytic converters in gasoline vehicles and technological improvements in diesel vehicles. About 85% of HC emissions originate from gasoline vehicles.

Pb emissions from transportation dramatically decreased due to the reduction in gasoline lead content and the switch to unleaded gasoline consumption.

Emissions of SOx from the manufacturing sector account for 98% of the total SO_x emissions. Most of these emissions originate from electricity production. In recent years, a SOx reduction technology was introduced into coal power plants. In addition, improved fuels with low sulfur content are being used in the manufacturing, commercial and residential sectors.

Emissions of NOx from electricity production, mainly from coal, have increased in recent years. Emissions from other types of fuels in manufacturing and electricity production have decreased, mainly as a result of a decline in their consumption.

SPM emissions have decreased in recent years. Around 90% of SPM emissions originate from the manufacturing sector. The decline in the consumption of residual fuel oil accounts for most of the decrease in emissions.

In order to further reduce emissions from gasoline-powered vehicles, catalytic converters should be maintained to ensure proper operation since their efficiency decreases over time. The efficiency of operation of catalytic converters can be checked within the framework of the annual car registration test. In addition, suitable maintenance and operation of vehicles are also required in order to reduce emissions.

In order to ensure that the trend of decreases in SOx, lead and HC emissions continues, measures should be taken to further improve fuel quality.

Since NOx emissions from private vehicles are higher than emissions from public vehicles, a transfer to public transportation should be encouraged in order to further decrease NOx emissions. In addition, diesel oxidation catalysts should be installed in diesel-powered public vehicles.

The installation of diesel oxidation catalysts and particulate traps in diesel-powered vehicles, mainly in trucks, will significantly decrease emissions of CO, HC and particulate matter.

Implementation of traffic reduction policies in city centers is highly required. High-polluting vehicles should be prohibited from entering these areas during busy hours in order to reduce the health risks posed by emitted pollutants such as PM2.5.

Recently, LPG-powered vehicles began entering the Israeli market. These vehicles have cleaner emissions and therefore can further reduce pollutant emissions.

As to the manufacturing sector, recently there has been a shift toward the use of natural gas in power plants. Expansion of natural gas use in power plants and elsewhere and reduction in the use of residual fuel oil and coal would significantly reduce emissions from this sector. In addition, it is recommended that combustion efficiency should be improved and pollution reduction technologies should be introduced, such as scrubbers and electrostatic precipitators.

In summary, despite the achievements in emission reductions on several fronts, additional measures are still necessary, since maximum reductions in pollutant emissions can only be achieved through the simultaneous implementation of a variety of methods. Furthermore, measures to reduce pollutant emissions should be complemented by sustainable energy consumption and production practices, including improved energy efficiency and conservation and introduction of renewable energy.

3.3 CONCENTRATIONS OF AIR POLLUTANTS FROM MONITORING STATIONS

3.3.1 Introduction

Availability of accurate nationwide data on air quality is a prerequisite for air quality management. Pollutant concentrations are measured at air quality monitoring stations located at various sites throughout Israel. There are two types of stations: "general" and "traffic" stations. Each station has a data-storage system that, since 1997, transmits information to the National Air Monitoring Network ("MANA") of the Ministry of the Environment. From the 1980s until today, some local authorities have measured air pollution concentrations in their jurisdiction area. While concentration levels measured by general stations reflect air quality in the vicinity of these stations at roof height, concentration levels around traffic monitoring stations actually reflect the concentration levels inhaled by passers-by and pedestrians, adjacent to main traffic routes. Some pollutants affect areas adjacent to the emission sources while other pollutants affect regions kilometers downwind from the pollution source. Certain pollutants are not directly emitted but are formed later as a result of a series of photochemical reactions. These secondary pollutants can pollute regions tens of kilometers downwind from the precursor origins (ozone) or even thousands of kilometers away (SO_2). The pollutants SO_2, NOx, O_3, CO, and SPM are known as "criteria pollutants" and are used as indicators for additional pollutants in the atmosphere.

3.3.2 Methods

3.3.2.1 Definitions

General Monitoring Station: Used for air quality monitoring in a wide and general area, with a population of over 150,000 people. The station is located in a representative area, at roof height, and not adjacent to any specific emission sources. In addition to pollutant monitoring, a meteorological mast at a height of eleven meters enables the measurement of meteorological parameters, which affect pollutant dispersion in the atmosphere. Air pollutants measured at the general stations include: O_3, NOx, SO_2, SPM and CO. Some of today's SO_2 monitoring stations are situated in the vicinity of power plants in order to monitor the effects of these plants on the surroundings.

Traffic Monitoring Station: A station used for monitoring pollutants deriving from vehicles. The station is located near major transportation routes, at vehicle level. Traffic stations have only been operational since 1998. They measure NOx, SPM and CO.

Ambient Air Quality Standards: Define the maximum concentration of a pollutant permitted at specified time durations, without considering the specific source of pollution. The standards were set based on the recommendations of such organizations as the World Health Organization (WHO). A distinction is made between two types of environmental standards:

A. **Statistical Standard (a standard of 99.75%)**: Applies to SO_2. It defines the maximum permitted concentration of SO_2 99.75% of the time. For the maximal half-hour value, the statistical standard can exceed the maximum concentration level up to 44 times during a year at each monitoring station.

B. **Absolute standard (a standard of 100%)**: Applies to all pollutants. It defines the maximum concentration of a pollutant permitted at all times.

Uptime of Monitoring Station: The percent of time in which the station was active during a year. Uptime rates below 100% can be attributed to daily scaling time, instrument failure or disruption of work at the station. Data from stations whose uptime is less than 75% may be biased and not reliable.

Maximal Value for Half-Hour/ 8-Hours/ 24-Hours: Data are based on records taken at the monitoring stations every five minutes. From these records, means are calculated for half-hour intervals, 8-hours, 24-hours and for the year. The maximum half-hour, 8-hour, and daily values (respectively) represent the maximum recorded values in these time intervals during the year.

Intermittent Control System (ICS): A system for the prevention of exceedances in air quality standards, due to the operation of large polluting establishments, such as the oil refineries in Haifa and Ashdod and the power plants in Haifa, Hadera and Ashdod. The control system determines a regiment for fuel use. Use of fuel oil is determined by seasons, measurements of the monitoring stations, and weather forecasts of the Israel Meteorological Service. The system has two warning positions: "yellow ICS regulation" - transition to use of low-sulfur fuel; and "red ICS regulation" - transition to use of low-low sulfur fuel.

3.3.2.2 Data Sources and Collection

Data were obtained from "MANA", operated by the Air Quality Division of the Ministry of the Environment. Prior to 1998, data were directly obtained from municipal associations for the environment, local authorities, and the Israel Electric Corporation. Today, these entities operate the stations, take the measurements and transfer them to "MANA", which gathers and analyzes the received data. The data are based on records taken at the monitoring stations every five minutes. From these records, means are calculated for half-hour intervals, 8-hours, 24-hours and the year.

3.3.2.3 Classifications

Ambient standards for measured pollutants were published in Israel in 1992. The following table presents the ambient air quality standards that were set in Israel.

Ambient Air Quality Standards for Israel [Micrograms per m^3 atmosphere]

Standard	SO2	NOx	O3	PM10	CO
Half-Hour	(absolute) 1,000 (statistical) 500	940	230	-	60
8-Hour	-	-	160	-	11
Daily (24 hours)	280	560	-	150	-
Annual	60	-	-	60	-

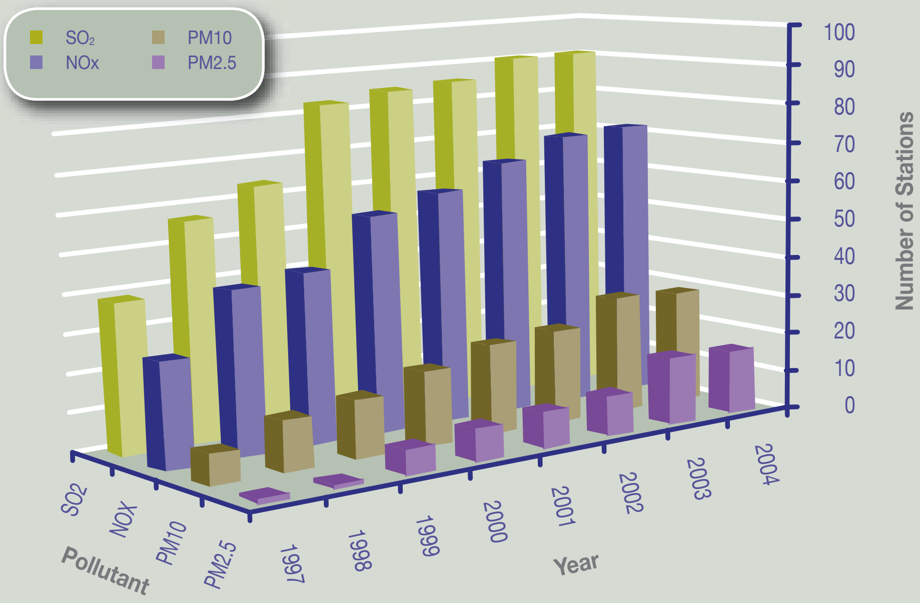
- No Israeli annual standard has yet been defined for NO_x. While NO_x are important as precursors of ozone formation, only NO_2 is associated with adverse effects on human health. According to a recommendation by the WHO, most countries around the world have determined such a standard.
- There is no Israeli standard for PM2.5. The daily standard of the United States Environmental Protection Agency (USEPA) is 65 micrograms per cubic meter[3]. This standard has been adopted in Israel. Both the WHO and the USEPA have defined the emission of particulate matter from diesel-powered vehicles as dangerous and possibly carcinogenic.
- The statistical standard for SO_2 is the standard used in Israel.
- The concentrations are reported in units of micrograms (one millionth of a gram) per cubic meter (m^3) atmosphere.

3.3.2.4 Data Limitations

The reported stations represent residential, commercial and industrial types of regions. Difficulty arises in comparing air quality between different types of regions for the following reasons:

- The data do not refer to all air pollutants.
- Not all pollutants are monitored in each station.
- The displayed data refer to concentrations of pollutants from only a few selected stations in Israel.
- The number and density of monitoring devices in a specific area can vary between different regions.
- The up-time of monitoring stations is not uniform.
- In order to accurately characterize the anthropogenic contribution of SPM, the sampled particulates must be analyzed.
- Since MANA was established, the number of air quality monitoring stations has constantly increased. From 1998 to 2004, the number of stations has more than doubled. Dozens of monitoring stations measure NOx and SO_2 throughout Israel, particularly in the densely populated areas in the center and north of the country. As to SPM monitoring, although the number of stations has increased, it remains fairly low.

Chart 3.6 The Evolution of Monitoring Stations in Israel



Source: Air Quality Division, Ministry of the Environment

3.3.3 Results

3.3.3.1 SO_2 (Sulfur Dioxide)

Chart 3.7 Maximal Half-Hour Concentrations of Sulfur Dioxide (SO_2)

Source: Air Quality Division, Ministry of the Environment

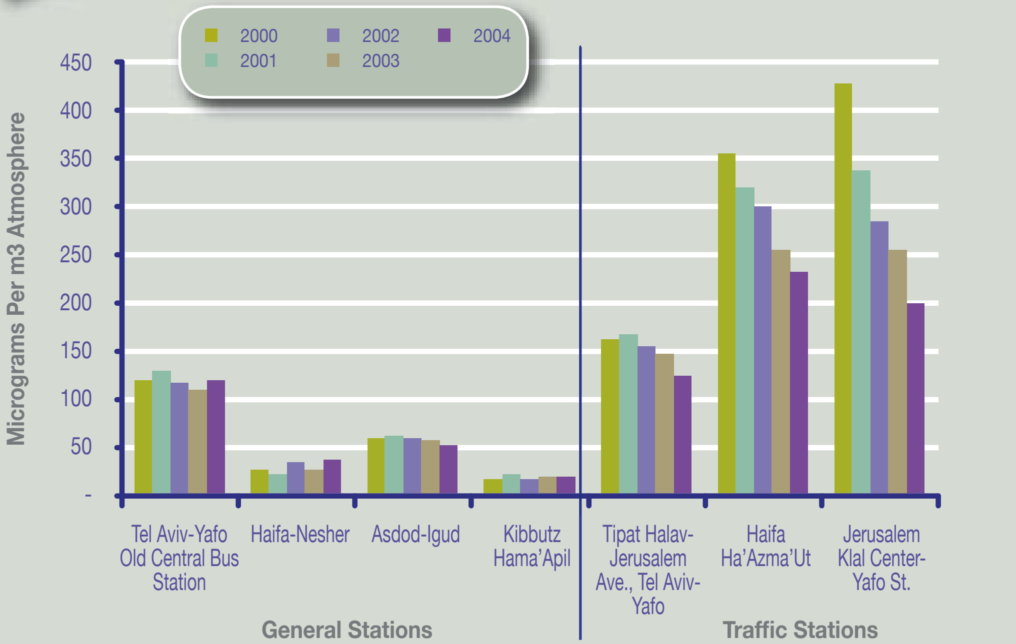
No exceedances of the annual standard for SO_2 were observed during this period at all monitoring stations. The annual average concentration at the various monitoring stations ranged between 4%-30% of the annual standard. The highest annual concentration levels were registered in recent years in Ashdod, due to failures at the sulfur recovery facility at the oil refineries.

In the last five years, only a few exceedances of the statistical half-hour standard were noted as presented in chart 3.7. In the late 1990s, the Ashdod station was the only general station to register exceedances for SO_2. During the 1980s, many exceedances were registered at the stations located in Ashdod and Haifa.

Between 2000 and 2004, maximum daily concentration levels of SO_2 ranged between 3 and 170 micrograms per m^3, which are below the daily standard. During these years, no exceedances of the daily standard were registered at any of the stations.

3.3.3.2 NOx (Total Nitrogen Oxides)

Chart 3.8 Annual Average Concentrations of Total Nitrogen Oxides (NOx)



Source: Air Quality Division, Ministry of the Environment

As shown in Chart 3.8, there was no major change in the annual average concentrations of NO_x in the general stations during the years 2000 to 2004. Annual averages in these stations ranged between 2 and 121 micrograms per m^3. Out of the general stations, the old central bus station in Tel Aviv showed the highest annual average concentrations during these years. As to the traffic stations, annual averages in all traffic stations were higher than those recorded in the general stations, and showed a sharp decrease in average concentrations during that period. Annual average concentrations ranged between 119 and 427 micrograms per m^3.

In the years 2000 to 2004, the general stations measured more than 100 exceedances of the half-hour standard for NO_x, and almost no exceedances of the daily standard. Most of the exceedances occurred in the Tel Aviv metropolitan area. The traffic monitoring stations measured thousands of exceedances of the half-hour standard in 2000-2002, decreasing to several hundreds in the years 2003-2004. These exceedances mainly occurred in the three major cities of Israel. A similar trend was noted for exceedances of the daily standard for the traffic stations, whereas the number of exceedances decreased from more than a hundred to few dozens between 2000 and 2004.

3.3.3.3 O_3 (Ozone)

Dozens of exceedances of the half-hour standard and 8-hour standard for O_3 have been registered in monitoring stations throughout Israel, mainly in the central regions, in the years 2000 to 2004. There is no apparent trend in the annual concentrations of O_3 at the various monitoring stations.

Annual average concentrations of O_3 at monitoring stations, which were mainly influenced by traffic emissions, are lower than in the others. The highest levels of O_3 are found during the summer months when radiation is at its highest at all monitoring stations without exception.

3.3.3.4 PM10 and PM2.5 (Respirable and Suspended Particulate Matter)

In recent years, hundreds of exceedances of the daily standard for PM10 were registered in various monitoring stations throughout the country. There is no clear trend in the annual average concentrations as measured by these monitoring stations. High concentrations, including exceedances of the daily standard, have been registered in the autumn and spring, seasons that are characterized by sand storms.

Currently only three stations in Israel monitor PM2.5 and PM10 simultaneously. The rate of fine suspended particulate matter (PM2.5) out of PM10, provides an estimate of the proportion of particulates originating from human activity compared to natural activity. For example, the Haifa District Municipal Association for the Environment reported a ratio of 30% to 70% PM2.5 out of PM10 in 2004. During autumn and spring, levels were at the lower border of this range.

3.3.4 Discussion

The low values of SO_2 in all the monitoring stations can be attributed to the shift to consumption of low-content sulfur fuels in recent years. In addition, other means such as intermittent control systems (ICS) and technological measures for reducing large-scale emissions in refineries, power stations, cement enterprises and phosphate terminals have also contributed to the decrease in large-scale SO_2 emissions. The relatively high values in the Ashdod, Hadera and Haifa areas can be explained by the proximity to the refineries and power stations that operate in these regions. Relatively high concentrations were also recorded at some rural sites, far from the sources of pollution, due to the greater distance traveled by the plume to those sites. However, in the Haifa region SO_2 concentrations have decreased due to a decline in the consumption of high-content sulfur fuels in power plants and various industries. An additional improvement in SO_2 concentrations is expected with the introduction of natural gas for energy generation.

In the general monitoring stations, there was no major change in NOx concentrations. This lack of change can be explained by two contradicting trends: On the one hand, increasing use of fuels in the manufacturing sectors, which contribute to NOx emissions, and on the other hand, use of catalytic converters in new vehicles, which reduces the emissions. The NOx concentration serves as an indicator of air pollution in transportation, and therefore may help identify other air pollutants from vehicles. NO_2 emissions are more harmful to humans in high concentrations and for long periods of time. High concentrations of NOx and NO_2 in particular for different time intervals were registered in all traffic stations in Israel. Since the traffic stations are situated at the level of the vehicles in densely populated urban areas, they present high risk levels for passers by in these areas.

High levels of O_3 were mostly recorded in the central parts of Israel, while relatively low levels were registered in urban and industrial areas. This phenomenon can be explained by ozone production patterns. Once O_3 has been produced, it may persist up to a limited number of days. In consequence, O_3 measured at a particular location may have arisen from VOC and NOx emissions hundreds of kilometers away, and may then travel further for similar distances. Maximum concentrations, therefore, generally occur downwind from the source areas of the precursor pollutant emissions. Because of the chemical reaction with the nitrogen oxides: $NO + O_3 = NO_2 + O_2$, ozone that was produced in urban areas with intensive traffic movement is "destroyed" at a faster pace than at other locations.

High values of SPM were recorded in various stations in Israel, especially in the southern region. In addition, during natural dust episodes, which reach Israel from North Africa, exceedances of the daily standards were recorded throughout the country.

Currently only one traffic station in Israel monitors PM2.5. This pollutant should also be monitored in other traffic stations in order to learn more about the contribution of anthropogenic sources to SPM pollution.
The increase in the number of monitoring stations has improved the reliability of data. Further improvement can be achieved through enhancing consistency with regard to location, type of pollutants measured and measuring practices.

In order to derive conclusions about policies and practical steps from the data generated by the monitoring stations, models should be developed for understanding modes of dispersion and convection of pollutants. Such models will also be used to forecast air quality in places where monitoring is not conducted.

3.4 EMISSIONS OF GREENHOUSE GASES

3.4.1 Introduction

The earth is surrounded by an atmosphere, which consists of various gases. Certain gases (e.g., water vapor and CO_2) trap the heat within the atmosphere and maintain suitable temperatures that enable the existence of life on earth. This phenomenon is known as the greenhouse effect. Technological and industrial development has caused intensification of the greenhouse effect due to the continuous rise in the emissions of greenhouse gases. Many experts have warned that an increase in greenhouse gas concentrations in the atmosphere leads to global warming and global climate changes, which may be destructive for humans and biodiversity in the future.

3.4.2 Methods

3.4.2.1 Definitions

Greenhouse Gases (GHG): Gases in the atmosphere that can be penetrated by ultraviolet solar radiation. These gases absorb infra-red radiation emitted by the earth. The infra-red radiation that is absorbed by greenhouse gases turns into heat, which causes global warming.

Global Warming Potential (GWP): A measure of the radiation effects of greenhouse gases in relation to carbon dioxide (CO_2). In the calculation of total emissions of direct greenhouse gases, methane (CH_4) and nitrous oxide (N_2O) emissions are converted into measures whose value is equivalent to that of CO_2. In the calculation, the following conversion factors were used:

- CH_4 - 21
- N_2O -310

Direct Greenhouse Gases: A group of gases comprising six main gases with a direct greenhouse effect: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

Indirect Greenhouse Gases: Gases that are precursors of greenhouse gases, and that are involved in the production of ozone (O_3), which is also a greenhouse gas: carbon monoxide (CO), nitrogen oxide (NO_x), and non-methane volatile organic compounds (NMVOCs). Also included is sulfur dioxide (SO_2), which is the precursor of aerosols and acts to cool the climate.

3.4.3 Data Sources and Collection

- Emission data for 1996 and 2000 were obtained from the Air Quality Division of the Ministry of the Environment. Data for 1996 were obtained from the publication "Inventory of Emissions and Removals of Greenhouse Gases in Israel" (Abraham Mey-Marom, Uri Dayan, and Jean Koch, August 2001). Data for 2000 were obtained from the publication "Greenhouse Gases in Israel, Inventory Update of Emissions and Removals for 2000" (Jean Koch and Shlomo Shafat, December 2002).

- The emissions for 2003 were calculated at the CBS, using data from the following sources:
  - The data for fuel combustion were obtained from the Ministry of Infrastructure and the CBS.
  - The data for waste and sewage were obtained from the Ministry of the Environment and the CBS.
  - The data for industrial processes were obtained from various sources in the manufacturing industry.
  - The data for agriculture were obtained from the CBS.
  - The data for changes in land use and forestry were obtained from the Jewish National Fund and the CBS.

3.4.4 Data Limitations

- As a result of differences in emission coefficients and data sources, the calculated inventory of greenhouse gases emissions from fuel combustion does not equal the quantities of emissions presented in the tables related to the combustion of fuels.

- In calculating the inventory of emissions from industrial processes, estimates were derived for some of the emissions on the basis of data from previous years.

- The greenhouse gases HFCs, PFCs and SF_6 were not included due to lack of data.
- The report does not include international bunkers emissions (from international aviation and marine transport).

3.4.5 Models and Calculation

The calculations were based on data on the inputs for GHG emission processes, such as fuels and waste quantities, forest area, etc. These data were multiplied by sets of coefficients for each emission process in order to calculate the total emissions for each gas.

Data for 2003 were calculated at the CBS according to the 1997 revised guidelines of IPCC (Intergovernmental Panel on Climate Change). According to these guidelines, two levels of details ere used:

- Tier 1, in which the calculations were based on international coefficients, adapted to local conditions. This method was used for calculations, where local detailed data were not available.
- Tier 2, in which the calculations were based on detailed available data from various sources in the country.

3.4.6 Results

Table 3.3 - Emissions of Greenhouse Gases, By Source (Tons, unless otherwise stated)

Source	1996	2000	2003
DIRECT GREENHOUSE GASES			
TOTAL (1,000 tons)[1]	**62,705**	**72,438**	**71,282**
CARBON DIOXIDE (CO_2) (1000 tons)	51,862	61,007	63,729
From fuel combustion	50,344	58,917	62,015
Thereof:			
Energy industries	28,466	36,412	40,099
Manufacturing industries and construction	6,720	6,912	6,126
Transportation	11,031	14,018	14,626
From other sources[2]	1,518	2,090	1,715
METHANE (CH_4)(tons)	**425,970**	**439,311**	**256,248**
From fuel combustion	3,551	3,466	3,366
Thereof:			
Energy industries	570	728	720
Manufacturing industries and construction	229	253	158
Transportation	2,177	2,255	2,315
From other sources[2]	422,419	435,845	252,882
Thereof: Disposal of solid waste	370,000	381,830	202,538

Table 3.3 - Emissions of Greenhouse Gases, By Source continuance (Tons, unless otherwise stated)

Source	1996	2000	2003
NITROUS OXIDE (N_2O)(tons)	**6,120**	**7,114**	**7,005**
From fuel combustion	580	693	731
Thereof:			
Energy industries	363	465	531
Manufacturing industries and construction	68	75	47
Transportation	115	139	142
From other sources[2]	5,540	6,421	6,274
Thereof: Agriculture	3,805	4,192	4,476
GREENHOUSE GASES PRECURSORS			
CARBON MONOXIDE (CO)(tons)	**478,177**	**362,138**	**295,726**
From fuel combustion	477,693	362,138	295,726
Thereof:			
Energy industries	5,960	7,638	8,439
Manufacturing industries and construction	1,145	1,268	790
Transportation	469,437	352,773	285,765
From other sources[2]	484	-	-
NITROGEN OXIDES (NOx)(tons)	**219,898**	**236,643**	**219,483**
From fuel combustion	214,737	231,773	216,488
Thereof:			
Energy industries	86,381	110,719	123,262
Manufacturing industries and construction	22,681	25,189	15,656
Transportation	99,919	93,571	75,821
From other sources[2]	5,161	4,870	2,995
NON-METHANE VOLATILE	**247,421**	**239,200**	**246,971**
ORGANIC COMPOUNDS (NMVOCs)(tons)			
From fuel combustion	157,981	155,695	158,672
Thereof:			
Energy industries	1,641	2,102	2,275
Manufacturing industries and construction	568	630	392
Transportation	155,484	152,848	155,841
From other sources[2]	89,440	83,505	88,299
SULFUR DIOXIDE (SO_2)(tons)	**279,532**	**298,011**	**235,883**
From fuel combustion	260,393	278,516	216,549
Thereof:			
Energy industries	190,705	210,674	173,306
Manufacturing industries and construction	45,572	46,391	39,212
Transportation	11,002	17,308	1,821
From other sources[2]	19,139	19,495	19,335

[1] CO_2 equivalent total
[2] Other sources Include industrial processes not related to energy, treatment of solid waste and sewage, agriculture and changes in land use, and forestry (also including CO2 absorption by forests).
Source: CBS and Soreq Nuclear Research Center

Direct GHG equivalent CO_2 emissions increased by 15% between 1996 and 2000 and remained nearly stable between 2000 and 2003.

CO_2 is the main GHG emission, with a share of 85% of the total emissions. Between 1996 and 2003 there was a 24% increase in CO_2 emissions, largely originating from fuel combustion, particularly from the energy industries and transportation sector.

CH_4 contributed about 12% of direct GHG emissions. 84% of the CH_4 emissions

originate from solid waste disposal. There was a sharp decrease (42%) in CH_4 emissions between 2000 and 2003 due to a new program of CH_4 collection in landfills. This decrease was the main factor in the decline of CH_4 emissions in these years.
N_2O was the lowest contributor to GHG emissions, with only 3% of the total direct GHG emissions. About two thirds of N_2O emissions originate from agricultural activity. There was a 16% increase in N_2O emissions between 1996 and 2000 and a 2% decrease between 2000 and 2003.

There is no clear pattern in the changes of indirect GHG emissions for the period covered (1996 to 2003).

There was a continuous decrease in CO emissions. Most of the emissions originate from fuel combustion in transportation. CO emissions decreased by about 40% between 1996 and 2003. This decrease was largely due to the compulsory introduction of catalytic converters in cars and trucks imported since 1994 and 1996 respectively.

No clear trend was discernible in NOx emission due to contradicting trends in emissions from the energy industry and transportation sector.

SO_2, emissions decreased between 1996 and 2003. Data for 2000 are based on previous coefficients (which differ from those presented in table 3.1 and affect the change of the trends).

NMVOCs emissions were relatively stable between 1996 and 2003. About 63% of the NMVOCs originate from transportation. About one third originate from non-fuel combustion sources.

3.4.7 Discussion

Overall, there is a trend of stabilization in direct GHG emissions since 2000, which discontinues the trend of continuous increases during the previous period.

The main contributor to direct and indirect GHG emissions is fuel combustion (see indicator "Carbon Dioxide Emissions per Capita" and "Energy Consumption per Capita" in the SDI chapter).

The second contributor to direct GHG emissions is solid waste management. In Israel, most of the solid waste is buried in landfills that emit substantial quantities of CH_4. In recent years these quantities were significantly reduced due to a CH_4 collection project in landfills.

Other contributors are industrial processes and agriculture. However, their contribution is fairly small and derives from many different sources.

In order to reduce greenhouse gases, emissions from fuel combustion should be reduced. Possible solutions include utilization of renewable energy sources for energy production and applying energy efficiency and power-saving technologies and practices.

In addition waste generation quantities should be reduced through recycling and reuse and through the adoption of environment-friendly consumption patterns as well as expanded collection of CH_4 from landfills.

Effort should be made to collect unavailable data, especially data on HFC, PFC and SF_6 emissions. Systematic collection of data will enable better coverage of GHG emissions in Israel.

4. Water

Source: Photo Archive KKL-JNF

4.1 INTRODUCTION

A short rainy season and vast arid areas with very limited rain characterize Israel, which is located on the southeastern shore of the Mediterranean. Israel's water sources are limited by the country's climate, geography and hydrology.

Water flow in the region does not recognize national boundaries. One country's main water source may often originate in a neighboring country. Thus, regional water shortages also affect political conditions in the region. As an example, the Israel-Jordan Peace Treaty (1994) includes a water-sharing section.

Israel is very sensitive to changes in annual rainfall volumes. Consecutive years with below average rainfall accompanied by increased water consumption due to population growth and increased living standards can escalate the water shortage problem. In such periods water reservoirs are not refilled to their full capacity during the rainy season.

There are three main drinking water sources in Israel: two major aquifers (coastal aquifer and mountain aquifer), dozens of surface storage reservoirs and one freshwater lake – the Sea of Galilee (Lake Kinneret). In addition to the total water shortage, water sources are unevenly distributed throughout the country. Rainfall in the northern area is much higher than in the central and arid southern parts of the country. In order to supply freshwater to its water impoverished areas, Israel initiated a national water project in 1963, known as “The National Water Carrier" (*Ha’Movil Ha’Artzi*). The carrier transfers water from the northern basin (Lake Kinneret) to the arid south. In addition, "man-made" reservoirs that capture rainwater runoff were introduced during the last decade to reduce water loss. Today, several such reservoirs operate in Israel.

In addition to problems related to water quantity, Israel is also concerned with water quality, and intensive consumption has caused a decline in water quality as well. Water quality is reflected by chloride concentration (salinity) rates and by other chemical, physical and biological indicators.

Israel is a world leader in recycling wastewater - recovering more than 75% of its treated effluents for agricultural usage. Reused water is obtained from two different sources: from modern wastewater treatment plants and from special drillings in aquifers that have been recharged with "recharged effluents," left in the aquifer for about a year and then pumped out ("reclaimed water") and used for irrigation in agriculture, industrial uses (heat recovery, process metering and pressure reduction), rehabilitation of streams, etc. The latter technology, known as Soil Aquifer Treatment (SAT) was developed in Israel. Quality tests have shown that recharged effluents meet potable water standards. In addition, there are several projects aimed at capturing rainwater runoff in aquifers.

The concentration of total dissolved salts in Israel's sewage limits the possibilities of effluent reuse in agriculture. Therefore, legislation has been introduced to prohibit the discharge of brines to water sources and municipal sewage systems.

Israel is also a leader in the development of desalination techniques and these techniques are used in several countries. Over the past few years, resources have been allocated toward the expansion and establishment of desalination plants that will supply the increasing demands for water in the country and in the region.

In addition to the extensive research and management of Israel’s freshwater resources, rehabilitation programs are being implemented to improve the quality of the country's stream water, which has deteriorated largely as a result of the discharge of municipal and industrial wastewater to the streams.

The 194-kilometer long Mediterranean coast is continually monitored to determine water quality, pollution levels discharged to the sea from streams and rivers and conditions of aquatic fauna. Israel monitors seawater quality in all of its public beaches, according to the MEDPOL Accords for Preservation of the Mediterranean Sea.

This section presents data on precipitation, freshwater sources, water balance, stream water quality and sewage and effluents.

4.2 PRECIPITATION

4.2.1 Introduction

The presented data estimate the total annual rainfall in the entire area of the country (16 years of data) and multi-annual averages of precipitation, which show variations between the country's different climatic regions.

4.2.2 Methods

4.2.2.1 Definitions

Hydrological Year: From 1 October to 30 September of the following year (used for the presentation of annual precipitation in selected stations).

Annual Rainfall Volumes: Estimation of accumulated rain each year from the beginning of August until the end of the following July. Measured in billion cubic meters (BCM).

Precipitation, Multi-Annual Monthly Average: Based on average accumulated daily precipitation quantities for each month, adjusted to the normal standard precipitation period - August to July (1971-2000).

Number of Rainy Days, Multi-Annual Monthly Average (1971-2000): Including days with any duration of precipitation of more than 1 mm.

4.2.2.2 Data Sources

All data were obtained from the Israel Meteorological Service (IMS).

4.2.2.3 Data Limitations

Multi-annual averages are calculated only once each decade, with a different number of years for each indicator, and are therefore not fully updated and synchronized.

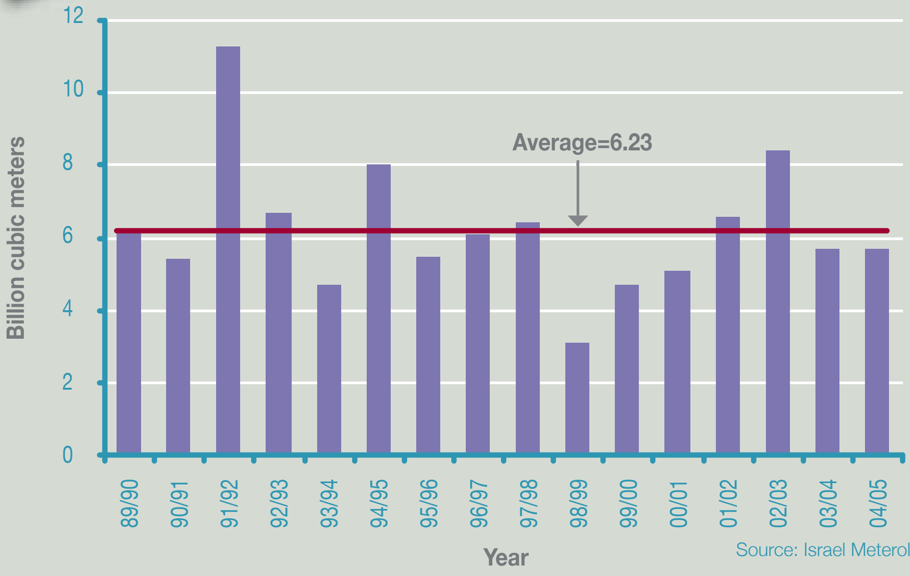
4.2.2.4 Models and Calculations

Annual Rainfall Volumes: Data on daily rainfall from the IMS archives were used as a basis for the analysis. Geographical Information System ("GIS") computer software was used in the analysis. Specifically, seasonal totals from several hundred stations (ranging from 358 to 505 stations) were interpolated to grid-points with a resolution of 1km by 1km. Four methods were used to estimate the accuracy of the analysis. The model was used to infer values at the grid points, and then totaled over the entire country.

Multi-Annual Monthly Averages of Precipitation: The data present precipitation in selected stations that represent different climatic regions in the country. Tel-Aviv – central coast (Mediterranean), Jerusalem – central mountains, Zefat – northern mountains, Be'er Sheva – south (Negev) and Elat – south (Arava).

4.2.3 Results

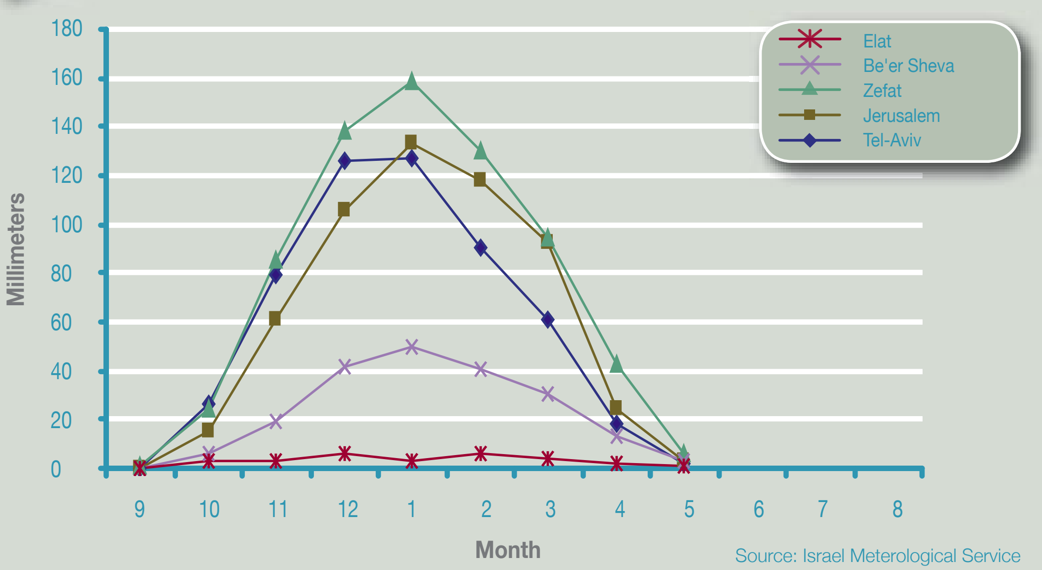
Chart 4.1-Annual Volumes of Rainfall in Israel (August-July)



Source: Israel Meterological Service

Values ranged from 3.1 billion cubic meters (BCM) in the 1998/99 season to 11.3 BCM in the 1992/92 season. The average for the 16 years beginning in the 1989/90 season was 6.23 BCM with a standard error of 0.46 BCM. Based on the discrepancies between the four methods employed, rainfall volumes are estimated to be in error of less than 2%, ranging from 51 million cubic meters (MCM) to 181 MCM in the 1998/99 and 1991/92 seasons respectively.

Chart 4.2-Precipitation by Month (multi-annual averages) 1971-2000

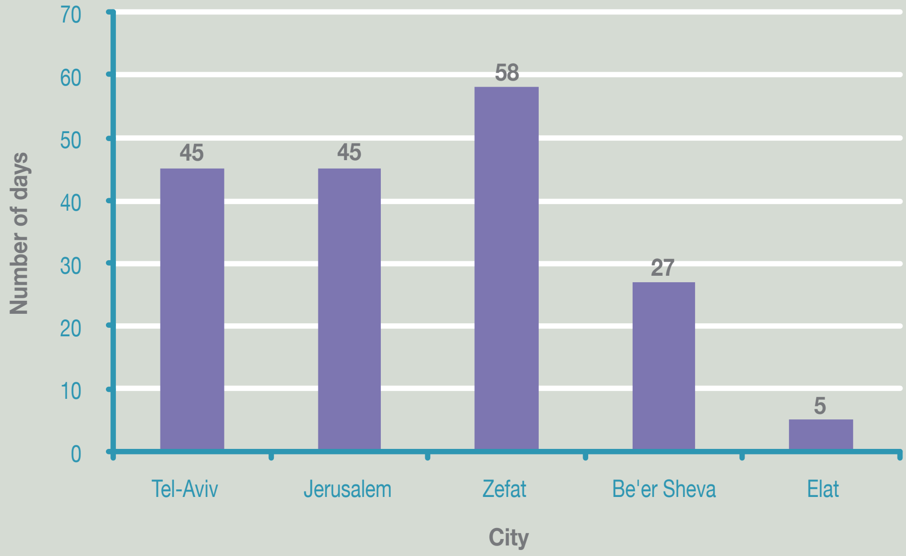


Source: Israel Meterological Service

Chart 4.3 Annual Precipitation in Selected Stations (multi-annual averages) 1971-2000

Source: Israel Meterological Service

Chart 4.4 Number of Rainy Days (multi-annual average) 1971-2000



Source: Israel Meterological Service

4.2.4 Discussion

Israel is located in a transition area between a desert climate and a temperate climate. Israel's northern area is influenced by a Mediterranean temperate climate and its southern and eastern areas are influenced by a desert climate. This transition area is referred to as a semi-arid climate. The data reflect the characteristics of this climatic zone. One of the main characteristics of such a climate (as presented in the data) is the fluctuation in weather patterns as a result of the random influences of the two different climates. The semi-arid climate is characterized by a high frequency of consecutive rainy years and consecutive dry years. Moreover, it should also be noted that in a semi-arid climate, in contrast to the classic temperate climate, major losses of water occur due to evaporation back to the atmosphere.

4.3 FRESHWATER RESOURCES

4.3.1 Surface Water

4.3.1.1 Introduction

There are two relatively large lakes in Israel, the Sea of Galilee (Lake Kinneret) and the Dead Sea. The first is the only freshwater lake in the country, while the Dead Sea is salty, and therefore is not included in Israel's water balance. Lake Kinneret is located at the northern end of the Afro-Syrian Rift Valley in northern Israel. It serves as the major reservoir for Israel's National Water Carrier and supplies approximately one third of the country's annual water requirements. However, because it is a surface water body, the Kinneret is particularly threatened by pollution. Fertilizers and pesticides are extensively used in the agricultural area surrounding the lake. These products are washed into the Jordan River and surrounding rivulets, eventually finding their way into the Kinneret. In addition, household sewage occasionally leaks into the lake. The Kinneret's water contains pathogenic microorganisms as well as nutrients, such as nitrogen and phosphorus which accelerate the development of algae in the lake. The Kinneret is unable to store water beyond its capacity (water above the designated upper red line overflows and floods its shores), and hence it cannot serve as a perennial freshwater reservoir. Therefore, during rainy years, excess water is pumped from the Kinneret and recharged into the groundwater for storage.

4.3.1.2 Methods

4.3.1.2.1 Definitions

Water Balance of Lake Kinneret: Total inflow of water minus total outflow. Measured in million cubic meters (MCM).

Water Salinity: Concentration of chlorides in milligrams per liter (mg/liter). The standard concentrations used in Israel are:

Drinking water,	< 400 mg/liter
Brackish water	400-4000 mg/liter
Effluent water,	> 4000 mg/liter

Total Suspended Solids (TSS): Solids suspended in water including a wide variety of material such as silt, decaying plant matter, industrial wastes and sewage. Measured in milligrams per liter.

Turbidity: A measure of the dispersion of light in a column of water due to suspended matter. The higher the turbidity, the cloudier the appearance of the water. If water becomes too turbid, it loses the ability to support a wide variety of plants and other aquatic organisms. Measured in Nephelometric Turbidity Units or NTU, which represent the average volume scattering over a defined angular range.

Total Phosphorus: The total concentration of phosphorus found in the water. Phosphorus is a nutrient and acts as a fertilizer, increasing the growth of plant life forms such as algae. Measured in micrograms per liter.

Total Nitrogen: A measure of all forms of nitrogen (for example, nitrate, nitrite, ammonia-N, and organic forms) that are found in a water sample. Measured in milligrams per liter.

Chlorophyll: A green pigment, present in algae and higher plants that absorb light energy and thus play a vital role in photosynthesis. Measured in micrograms per liter.

Cyanobacteria: Prokaryotic organisms without organized chloroplasts but with chlorophyll a and oxygen-evolving photosynthesis; capable of fixing nitrogen in heterocysts; occurring in lichens both as primary photobionts and as internal or external cephalodia. Commonly called blue-green algae.

Faecal Coliforms: A group of bacteria that are normally abundant in the intestinal tracts of humans and warm-blooded animals and are used as indicators (measured as the number of individuals per milliliter of water) when testing the sanitary quality of water.

4.3.1.2.2 Data Sources

Water Level and Average Salinity in Lake Kinneret: Hydrological Service.

Water Balance of Lake Kinneret: Hydrological Service.

Water Quality of Lake Kinneret: Kinneret Limnological Laboratory.

4.3.1.2.3 Models and Calculations

Water Level of Lake Kinneret: Relative to mean sea level (MSL).

Water Balance of Lake Kinneret: The amount of available water is equal to the total inflow of water from streams, from underground springs surrounding the Kinneret and within it, and from direct rainfall, deducting water used and evaporated from the lake.

Water Quality of Lake Kinneret: Lake Kinneret is a warm monomictic lake. During the winter it undergoes a complete period of mixing and during the summer there is a period of thermal stratification. Therefore, water quality data are presented separately for these two periods of the year. For each quality indicator there is a defined normal range, which varies from the winter period to the summer period. The data presented are an average of monthly figures.

4.3.1.3 Results

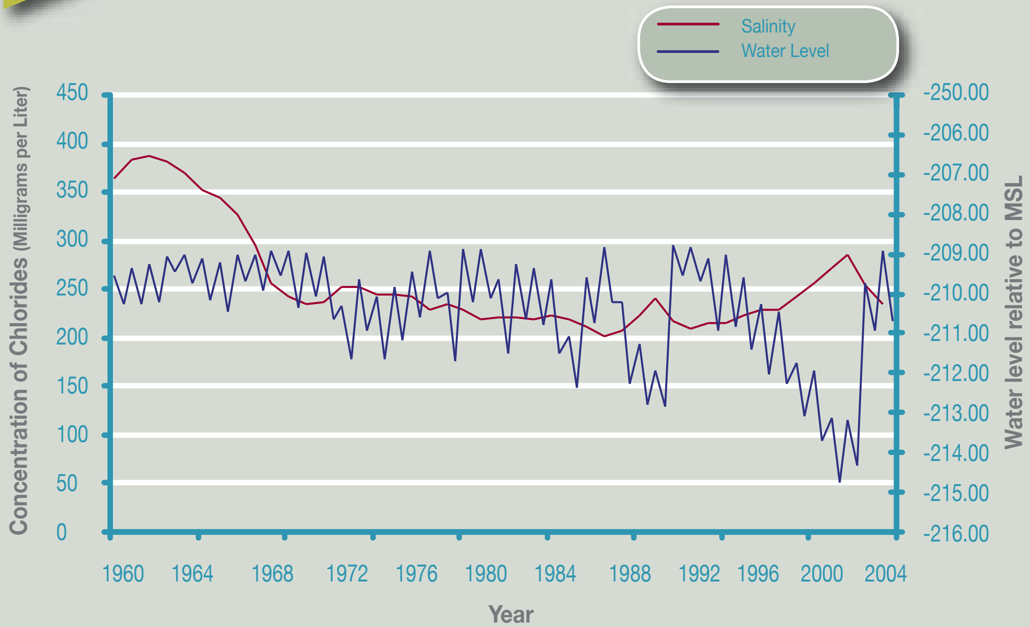
Table 4.1 Water Balance of Lake Kinneret (MCM)

Origin	2003/2004	Multi-Annual Average
Total Balance	46	14
Inflow	892	691
Streams	761	515
Rain	68	70
Springs	32	70
Other entries	31	36
Outflow	846	677
Evaporation	219	250
Drawing by the National Water Carrier	521	303
Local usage	95	70
Outlet to south (Lower Jordan)	10	54

Source: Hydrological Service

Most of the water flows into Lake Kinneret through the Jordan River (619 MCM in 2003/2004). The main outflows of water result from pumping by the National Water Carrier and evaporation losses. The water balance for the year 2003/2004 is positive due to above average annual rain volumes in the preceding couple of years.

Chart 4.5 Water Level and Average Salinity in Lake Kinneret



Source: Hydrological Service

Salinity in Lake Kinneret has been alleviated by diverting several major saline inputs at the northwest shore of the lake into a salty water diversion canal leading to the southern Jordan River. The canal, built in 1965, removes about 70,000 tons of salt (and 20 MCM water) from the lake each year. Water level decline has caused a rise in the salinity level (chloride concentration). After a series of dry years that resulted in a decline in water levels and an increase in salinity, the year 2003 marked a change in the trend following a winter with above average rainfall.

Table 4.2 Water Quality of Lake Kinneret (2004)

	January - June		July - December	
	Value	Standard range	Value	Standard range
Total suspended solids, mg/L	6.3	0.8 - 8.3	4.0	4.9 - 0.3
Turbidity, NTU	4.0	1.4 - 5.3	2.5	3.6 - 0.8
Total phosphorus, µg/L	33.8	8.0 - 37.0	14.3	27.0 - 4.0
Total nitrogen, mg/L	0.9	0.4 - 1.2	0.5	1.0 - 0.3
Chlorophyll, µg/L	**38.1**	5.0 - 38.0	9.4	1.1 - 10.2
Cyanobacteria, % Total biomass	2.3	0.0 - 7.0	**36.0**	0.0 - 13.0
Faecal coliforms, No./100mL	53.9	0.0 -100.0	18.2	0.0 - 60.0

Source: Kinneret Limnological Laboratory
Numbers in bold represent averages beyond the standard range.

Overall, the quality of the water is good, although in the summer, water quality was impaired due to high rates of cyanobacteria out of the total biomass, a phenomenon that has become more frequent in the past few years.

4.2.1.4 Discussion

In order to cope with the growing demand for water and, at the same time, to preserve the quality of lake water, a delicate balance must constantly be maintained. The data reveal that several consecutive dry years (not an uncommon phenomenon in Israel) can have dramatic effects on water salinity levels. Lowered water levels have an immediate effect on salinity levels. Therefore decision makers in Israel, responsible for the pumping of water from the lake, are constantly faced with the challenge of responding to today's needs without damaging this valuable resource for years to come.

4.3.2 Groundwater

4.3.2.1 Introduction

The aquifers are Israel's largest water reservoirs. They receive water through precipitation, penetration of runoff and irrigation water, effluent recharge, and leakages from water consumption systems. The average amount of rainfall in Israel is approximately 6.2 BCM per year. Most of this quantity evaporates from the soil and plants; approximately 5% flows into riverbeds and out to the Mediterranean Sea (westward) and to the Dead Sea (eastward); and only 2-3.5 billion cubic meters seep into the soil, are collected in aquifers, and are available for use in Israel. Seven aquifers are spread over Israel and supply about 70% of the total freshwater consumed annually, for drinking, domestic, agricultural and industrial uses. The two main sources of groundwater are the coastal (HaHof) aquifer and the mountain aquifer (Yarqon-Taninim). Groundwater is pumped from the sands and sandstone of the coastal plain, and from the limestone rock in the hilly areas of Israel. About 70% of the amount abstracted is pumped from the two major aquifers. The annual quantity (perennial average) of water pumped from the mountain aquifer is approximately 358 MCM. About 420 MCM are pumped annually from the coastal aquifer. Greater quantities were pumped from the coastal aquifer in the past; however excessive pumping caused the level of the aquifer to drop, leading to contamination by ingress of seawater, i.e., salination.

The coastal aquifer is situated in the most densely populated area in the country, and is therefore particularly vulnerable to pollutants from urban, industrial and agricultural sources. The mountain aquifer currently enjoys the highest quality of freshwater used in Israel. The greatest threat to the mountain aquifer is untreated sewage from urban centers such as Jerusalem, Nablus, and communities in the Judean Hills, Samaria and the Galilee.

4.3.2.2 Methods

4.3.2.2.1 Definitions

Aquifer: An underground geological formation (or group of formations) of permeable rock, sand or gravel which bears water. The water is obtained through filtration and percolation.

Water Salinity: See Definition Surface Water

4.3.2.2.2 Data Sources

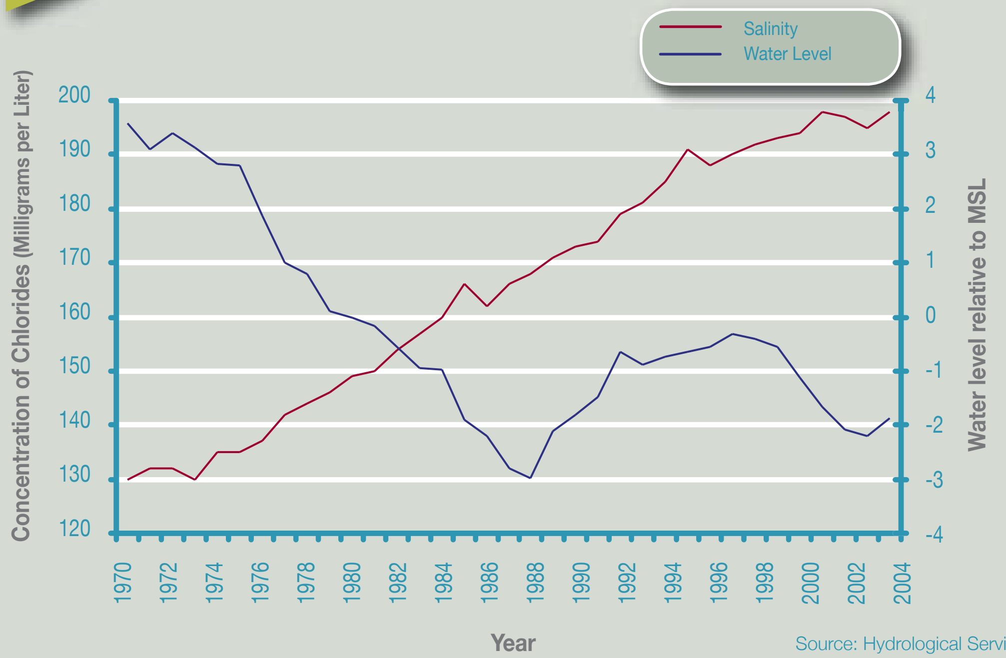
All data were obtained from the Hydrological Service.

4.3.2.2.3 Data Limitations

Aquifer levels are based on measurements of one drilling in each aquifer. In these drillings water is not pumped, and therefore the measured levels are more reliable than those delivered from active drillings.

4.3.2.3 Results

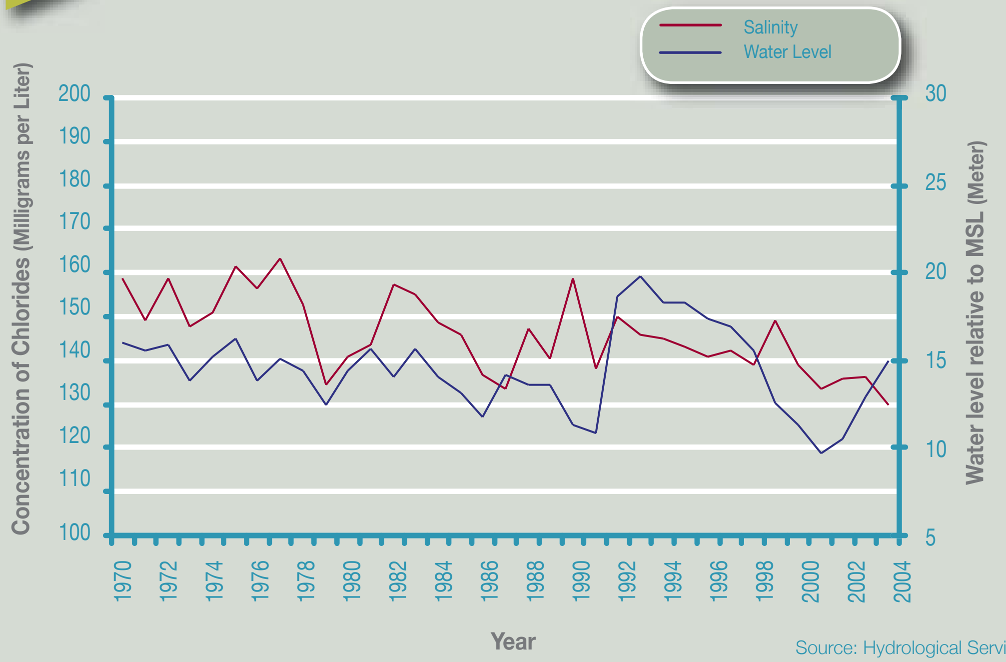
Chart 4.6 Water Level and Salinity in the Coastal Aquifer



Source: Hydrological Service

The decline in the aquifer's water level is linked to the increase in salinity. However, the rise of the water level in the late 1980s did not stop the continuing increase of salinity.

Chart 4.7 Water Level and Salinity in the Mountain Aquifer



Source: Hydrological Service

While salinity levels in the coastal aquifer show a clear trend of increase in chloride concentrations (from 130 to 198 mg/liter), salinity levels in the mountain aquifer have largely remained constant throughout the years and range between 130-160 mg/liter.

4.3.2.4 Discussion

Increased salinity levels in the coastal aquifer are caused by several factors:

- Infiltration of seawater - Overpumping of water causes the infiltration of seawater from the west to the aquifer. As the data show, this process is not necessarily reversible.

- Leakage from beneath the aquifer - Overpumping and lowering the water level causes an infiltration of salty water from the clay layer beneath the aquifer.

- Infiltration of salty water from irrigation – Two types of irrigation water are common in the coastal area: Kinneret water (230 to 290 mg chlorides/liter) and effluents (190 to 330 mg/liter). The excess irrigation water that infiltrates to the aquifer is ten times saltier than its initial salinity level. Fertilizer use in irrigation increases the salination process even further.

- Recharge of water from Lake Kinneret – Excess pumped water from the lake is recharged into the aquifer so it can subsequently be pumped. This also contributes to the increase in the aquifer's salinity level.

It is predicted that these processes will continue even if drastic measures are taken today because the effects of past damages are still being manifested. It remains to be seen whether the coastal aquifer’s water will only be used for irrigation and industry in the future.

4.3.3 Abstraction and Use

4.3.3.1 Introduction

This section presents the water balance for the past three years as well as a separate water balance for the aquifers. The distribution of consumption by different purposes is also presented.

4.3.3.2 Methods

4.3.3.2.1 Definitions

Water Balance: Annual national difference between water levels at the end of the previous hydrological year and water additions during the current hydrological year minus the usage quantities during the year.

Natural Inflow: Includes inflow from rain and, in the case of surface water, also from streams.

Inflow from Other Sources: Includes re-charged effluents, recharged Lake Kinneret water and recharge from irrigation.

Other Flows: Includes other outflows from the aquifers, mainly to the sea.

4.3.3.2.2 Data Sources

Water Balance – Hydrological Service.

Water Consumption by Purpose – Israel Water Commission.

4.3.3.3 Results

Table 4.3 Water Balance

	Inflow			Outflow				
	Natural inflow	Inflow from other sources	Total inflow	Abstraction	Flow from springs	Other flows	Total outflow	Total water balance
2001/2002	1,806	235	**2,041**	1,671	235	64	**1,970**	**71**
2002/2003	2,792	245	**3,037**	1,648	338	57	**2,043**	**994**
2003/2004	1,861	224	**2,085**	1,723	346	77	**2,146**	**-61**

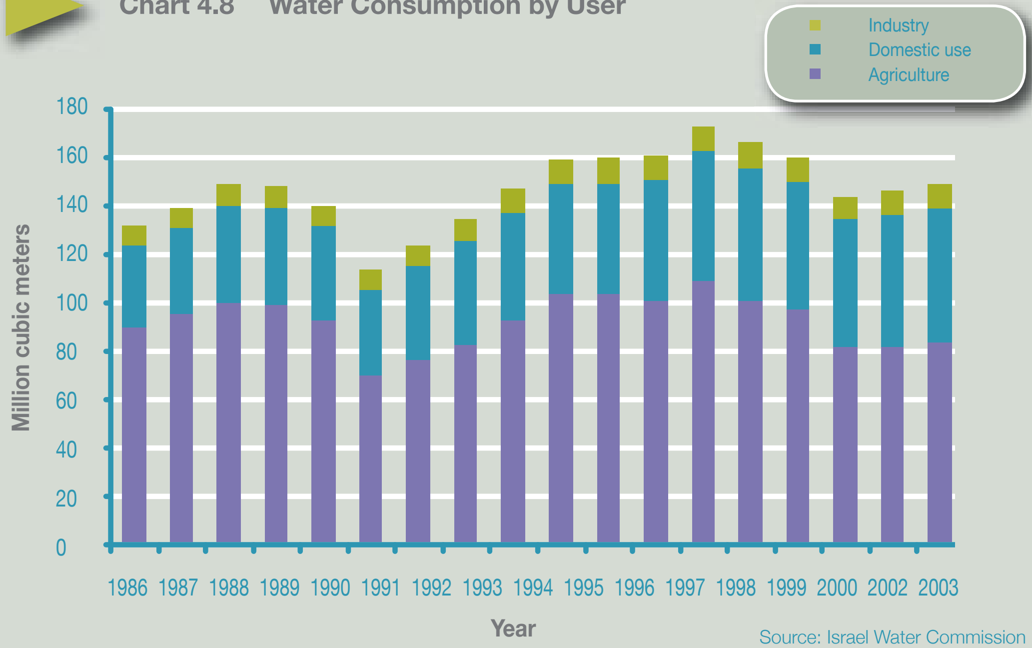
Source: Hydrological Service

Table 4.4 Recharge and Production from Aquifers

Year	Recharge	Production	Balance
1998/1999	877	1,835	-958
1999/2000	1,407	1,776	-369
2000/2001	1,390	1,778	-388
2001/2002	1,534	1,302	232
2002/2003	1,844	1,447	397
2003/2004	1,254	1,350	-96

Source: Hydrological Service

Chart 4.8 Water Consumption by User



Source: Israel Water Commission

The main changes in consumption trends over the years are an increase in water use for domestic purposes (from 25% in 1986 to 37 % in 2003) and a decrease in consumption for agriculture (from 68% in 1986 to 56% in 2003).

4.3.3.4 Discussion

Based on water balance and precipitation data (see Section Precipitation), the effect that consecutive dry years have on Israel's water economy is clearly understood. Water scarcity in the country accompanied by growing demands for freshwater by the domestic sector lead to a negative balance in dry years. In view of the characteristics of the Israeli climate, it is reasonable to assume that such dry periods are unavoidable. This explains the growing use of effluents for agricultural irrigation and the close monitoring of water quantities allocated to the agricultural sector (1045 MCM in 2003 compared to 1364 MCM in 1998). Israel will have to continue to promote and develop desalination facilities and encourage sustainable water consumption patterns in order to meet water demands and preserve natural water sources.

4.4 STREAMS

4.2.1 Introduction

Some twenty streams flow through Israel's coastal plain, where three-quarters of the country's population resides. Yet few rivers are sufficiently safe to permit swimming, boating or fishing. As a result of pollution, nearly all of Israel's coastal streams, including wadis, have been transformed into open sewage carriers. Responsibility for Israel's rivers is loosely shared by multiple agencies at the national, regional and local levels. Most of Israel's streams are aligned east-west, of which 14 flow to the Mediterranean, draining an area of 11,335 km2. Moreover, most of the streams only flow during the winter and early spring seasons and dry out in the summer. Some streams are polluted by Industrial wastes. A prominent example is the Qishon River, which runs through the largest industrial center in Israel into the Mediterranean Sea.

4.4.2 Methods

4.4.2.1 Definitions

COD (Chemical Oxygen Demand): An index of water pollution measuring the mass concentration of oxygen consumed by the chemical breakdown of organic and inorganic matters.

BOD (Biochemical Oxygen Demand): Dissolved oxygen required by organisms for the aerobic decomposition of organic matter present in water. (The standard measurement is at 20ºC and for 5 days).

TSS (Total Suspended Solids): See Definitions Surface Water

Salinity: See Definitions Surface Water

The Ministry of the Environment proposed a set of standards regarding the maximal concentration values of the parameters above in effluents discharged into streams in Israel. These values are noted bellow the following tables.

4.4.2.2 Data Sources

- Data on the Yarqon Stream were obtained from the Yarqon River Authority. Data on the Qishon Stream were obtained from the Qishon River Authority.
- Data on other streams were obtained from the Nature and Parks Authority.

- Data on water quantities in the streams were obtained from the Hydrological Service.
- The data as presented in all of the tables do not cover all of the existing monitoring stations along the streams.

4.4.2.3 Data Limitations

- Water quality parameters are monitored in most of the streams only twice a year, in the spring and in the autumn. Some of the stations along the stream were sampled only once a year.

4.4.2.4 Models and Calculations

In all of the following tables the parameters were calculated based on an average of all measurements at each existing monitoring station.

4.4.3 Results

Table 4.5 COD - Chemical Oxygen Demand [mg/liter]

Stream Name	2000		2001		2002		2003		2004	
	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Harod	151	85	606	172	592	161	294	149	132	88
Dalia	146	96	136	84	260	104	48	32	72	55
Hadera	356	140	226	130	774	184	245	165	604	202
Taninim	74	48	104	66	112	62	95	47	90	59
Qishon	215	149	170	93	178	106	78	55	96	62
Lower Jordan	88	51	176	73	144	69	532	228	132	69
Na'aman	232	108	291	151	370	105	159	91	220	82
Soreq	478	130	276	109	511	104	230	106	590	142
Alexander	254	127	904	204	426	139	760	111	118	67
Lakhish	162	127	160	114	218	117	760	195	804	148
Yarqon	143	57	260	68	198	68	131	72	164	79

*Recommended maximal value in discharged effluents: 100
Source: Nature and Parks Authority, Qishon River Authority, Yarqon River Authority

in similarity to past years, data are inconsistent and do not present a clear trend, but some improvement is evident in the Qishon Stream.

Table 4.6 - BOD - Biochemical Oxygen Demand [mg/liter]

Stream Name	2000		2001		2002		2003		2004	
	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Harod	165	29	370	51	252	42	42	15	39	20
Dalia	15	7	26	13	26	14	11	5	19	7
Hadera	153	42	45	18	452	82	62	28	297	63
Taninim	5	3	12	6	8	4	7	3	10	4
Qishon	96	39	38	13	34	10	16	12	31	10
Lower Jordan	13	4	14	6	31	10	180	52	16	8
Na'aman	135	20	42	18	110	26	28	9	153	17
Soreq	353	79	120	36	292	42	42	15	253	40
Alexander	84	28	440	66	165	61	433	19	24	8
Lakhish	27	12	136	30	120	32	433	77	380	47
Yarqon	34	12	114	13	55	16	28	12	84	17

*Recommended maximal value in discharged effluents: 15
Source: Nature and Parks Authority, Qishon River Authority, Yarqon River Authority

Table 4.7 – Salinity (Chloride Concentrations) in Streams [mg/liter]

Stream Name	2000		2001		2002		2003		2004	
	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Harod	3,615	1,932	3,814	1,979	2,045	1,402	2,524	1,552	2,340	1,632
Dalia	2,084	881	2,230	1,005	1,992	726	1,978	685	2,074	844
Hadera	581	439	798	483	950	443	535	328	652	460
Taninim	1,659	1,319	1,932	1,555	3,045	1,371	1,684	1,301	1,843	1,504
Qishon	7,178	1,680	3,417	2,591	23,716	11,121	20,527	7,131	23,290	9,943
Lower Jordan	2,446	1,591	2,651	1,560	2,630	1,568	1,808	608	3,510	1,503
Na'aman	5,282	1,481	2,389	1,324	1,921	998	2,148	1,061	2,091	1,120
Soreq	406	320	404	322	479	326	514	399	447	392
Alexander	1,886	498	4,608	843	3,797	639	6,665	1,163	10,936	1,631
Lakhish	542	375	2,099	897	5,069	919	6,665	1,648	4,786	1,550
Yarqon	362	214	255	120	11,805	1,020	271	217	13,648	1,080

*Recommended maximal value in discharged effluents: 400
Source: Nature and Parks Authority, Qishon River Authority, Yarqon River Authority

The Soreq River is the only river with salinity levels within the standard of freshwater. The other rivers are brackish and the Qishon is saline.

Table 4.8 TSS Total Suspended Solids [mg/liter]

Stream Name	2000		2001		2002		2003		2004	
	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Harod	802	253	272	149	662	206	272	97	186	90
Dalia	117	41	296	99	1,346	211	95	37	78	35
Hadera	490	89	86	46	120	64	122	48	429	102
Taninim	32	16	150	59	130	35	80	36	82	31
Qishon	95	57	454	142	352	81	508	135	177	76
Lower Jordan	269	67	203	51	316	90	276	100	296	71
Na'aman	173	92	172	102	844	125	101	61	103	44
Soreq	168	51	160	38	1,013	156	87	27	238	47
Alexander	111	50	1,500	176	210	62	319	58	120	46
Lakhish	1,360	360	68	23	80	39	183	60	310	73
Yarqon	63	24	95	34	112	29	114	29	104	37

*Recommended maximal value in discharged effluents: 15
Source: Nature and Parks Authority, Qishon River Authority, Yarqon River Authority

Table 4.9 Annual Quantity of Water (Flow) in Streams [MCM/year]

Stream Name	2000/2001	2001/2002	2002/2003	2003/2004
Kziv	-	0.4	5.7	5.7
Ga'aton	0.6	1.1	3.1	2.5
Beit-Ha'emek	0.9	2.7	8.8	6.1
Qishon	4.1	23.1	78.9	47.0
Dalia	1.5	11.4	12.4	13.1
Taninim	1.1	9.8	17.9	10.4
Hadera	13.4	23.4	35.7	20.5
Alexander	4.3	16.8	24.2	14.1
Yarqon	9.0	31.3	43.0	30.5
Ayalon	6.0	22.9	62.9	19.3
Soreq	8.7	22.1	46.9	6.9
Lakhish	8.4	26.2	20.0	0.9
Shikma	2.9	2.9	9.1	0.3
Habsor	3.8	-	13.0	0.4
Upper Jordan	199.0	326.0	807.0	619.0
Meshushim	8.2	17.3	54.5	41.9
Faran	1.9	-	1.3	-

Source: Hydrological Service

4.4.4 Discussion

The data summarize the state of the streams in Israel. When regulations on the protection and maintenance of water resources did not exist, many streams were contaminated by untreated municipal as well as industrial sewage, making them inadequate for any human use and permanently destroying their natural habitats. These streams largely served as drainage streams for sewage.

4.5 SEWAGE AND EFFLUENTS

4.5.1 Introduction

Sewage quantities have risen significantly over the years, endangering groundwater, streams, seas and beaches. The combination of severe water shortage, contamination of water resources, densely populated urban areas and highly intensive irrigated agriculture, makes it essential that Israel put wastewater treatment and reuse high on its list of national priorities. Effluents are the most readily available and cheapest source of additional water and provide a partial solution to the water scarcity problem. Only highly treated effluents, after chlorination, are used for irrigation of orchards and other edible crops, but effluents are never used for irrigation of vegetables or other crops which may be consumed directly without cooking. Out of a total of 440 MCM of sewage produced in Israel, about 96% are collected in central sewage systems and 64% of the effluents are reclaimed (290 MCM). Local authorities are responsible for the treatment of municipal sewage. In recent years new or upgraded intensive treatment plants were set up in municipalities throughout the country. The ultimate objective is to treat 100% of Israel's wastewater to a level enabling unrestricted irrigation in accordance with soil sensitivity and without risk to soil and water sources.

Until the 1960s sewage flowed freely in the stream channels, and even into the Mediterranean Sea. The flow of urban sewage into streams and sea can result in microbial contamination (by pathogens), closing of public beaches, and potential damage to marine agricultural sites. Urban sewage may contain high concentrations of salts, detergents, and various toxic synthetic substances. It also contains acids, minerals and heavy metals, which are highly toxic to animals and plants even in low concentrations.

About a quarter of Israel's total wastewater (about 120 MCM) undergoes treatment in the Dan Region Reclamation Project, which produces high-quality effluents. The system consists of facilities for collection, treatment, groundwater recharge and reuse of municipal wastewater from the Dan metropolitan area, which comprises the city of Tel Aviv and neighboring municipalities (e.g., Rishon-Le-Zion, Holon, Bat Yam, Jaffa, Petah Tikva, Ramat Gan, Givatayim, Bene Brak, Rehovot and nine small communities). It is based on a modern biological-mechanical activated sludge plant with nitrogen removal. Following treatment, the effluents are recharged into the regional aquifer by means of spreading basins. A separate zone is created within the regional aquifer, which is centered beneath the recharge basins and is dedicated to treatment and seasonal storage of the effluents (SAT – Soil Aquifer Treatment). After recharge, the reclaimed water is supplied for agricultural irrigation to the arid southern part of the country, through the Third Line to the Negev. The high quality of the treated water after recharge conforms to drinking water standards, but is not used for this purpose.

Regulations promulgated by the Ministry of Health in 1992 require secondary treatment to a minimum baseline level of 20 mg/liter BOD and 30 mg/liter TSS in every settlement with a population exceeding 10,000 people.

Freshwater in Israel has a high average hardness and water softening is performed routinely in factories for steam production, cooling towers, laundries, textile dye works and other industries. As a result of the release of sodium salts (mainly NaCl), sewage effluents have a higher salt content and a higher sodium absorption ratio (SAR) than the urban water supply.

It is estimated that industry contributes some 50% of the total chloride addition to municipal sewage, of which some 30% is derived from industrial water softening processes.

Wastewater treatment plants, which use the activated sludge method, generate large quantities of sludge, at a scope of hundreds of tons of dry matter per day. Sludge quantities already exceed 100,000 tons per year (dry weight) of which the Dan Region Reclamation Project (DRRP) produces nearly half, currently discharged into the sea. It is anticipated that by 2020, when many more intensive treatment plants will be in operation, sludge quantities will double and the faction produced by the DRRP will drop to about a quarter of the total. The Ministry of the Environment regards sludge as a valuable resource for fertilization and soil improvement, but only following appropriate treatment to reduce pathogens and to control and reduce heavy metal concentrations.

4.5.2 Methods

4.5.2.1 Definitions

SAT (Soil Aquifer Treatment): Recharging effluents into groundwater. The mixture of effluents and groundwater remains in the aquifer for about a year and is then pumped through special drills for agricultural irrigation.

Effluents: Sewage that was treated to reduce the organic load.

Reclaimed Water: The water that is pumped from drills originating in an aquifer that was recharged in the previous year by effluents (after treatment by activated sludge and tertiary/advanced treatment techniques).

Sludge: Muddy, semi-solids deposits remaining after most liquids have been removed from wastewater.

Activated Sludge: Sludge containing a high degree of active bacterial mass that is mixed with primary effluent or raw sewage and kept in suspension by aeration and/or agitation to eliminate organic material from the wastewater.

Secondary Treatment: Second step in most waste treatment plants during which bacteria consume the organic parts of wastes. This is accomplished by bringing the sewage, bacteria and oxygen together in trickling filters or within an activated sludge process. Secondary treatment removes all floating and settled solids and about 90% of the oxygen-demanding substances and suspended solids. Disinfection by chlorination is the final stage of the secondary treatment process.

DRRP (Dan Region Reclamation Project): A modern treatment plant operated by the

Meqorot Company. It provides for biological treatment of wastewater including nutrient removal. The secondary effluent is then recharged into the groundwater aquifer by means of spreading sand basins for additional polishing and long-term storage. The water is eventually pumped and transported to Israel's arid Negev desert for unrestricted irrigation through the Third Negev Pipeline.

TSS (**T**otal **S**uspended **S**olids): See Definitions Surface Water

Salinity: See Definitions Surface Water

BOD: See Definitions Streams

COD: See Definitions Streams

4.5.2.2 Data Sources

Raw Sewage that flows to the Treatment Plant - Ministry of the Environment.

Quantity of Sewage and Effluents in the DRRP - "Meqorot" National Water Company - Dan Region Reclamation Project.

Quality of Sewage in the Dan Region Reclamation Project - "Meqorot" National Water Company - Dan Region Reclamation Project.

4.5.2.3 Data Limitations

In table 4.10 only plants that treated more than 4 MCM of sewage in 2001 are listed. The total includes treatment plants that treated 95% of the sewage.

4.5.3 Results

The largest treatment plant in Israel is the Dan Region Reclamation Project (DRRP), which conducts and treats sewage from localities in the center of Israel. The DRRP treats about 30% of the sewage in Israel, while smaller treatment plants drain and treat about 50% of the sewage. The residual, about 20%, is currently not treated, and is mostly disposed to streams or directly to the Mediterranean Sea.

Table 4.10 Annual Amounts of Sewage from Treatment Plants (MCM)

Treatment Plant	2000	2001	2002	2003	2004
TOTAL	**381**	**389**	**399**	**402**	**403**
Thereof:					
DRRP	122	127	127	123	121
Haifa	37	37	38	38	35
Jerusalem (Soreq)	22	24	27	28	27
Netanya	12	12	13	13	13
Ayalon (Ramlod Nesher)	14	15	15	15	12
Ashdod	9	9	9	11	11
Be'er Sheva (West)	7	7	7	7	10
Hadera	9	9	9	9	9
Kefar Sava - Hod HaSharon	8	8	8	8	9
Qiryat Gat	4	5	5	5	8
Karmi'el	6	7	7	7	8
Elat	6	7	7	7	7
Herzliyya	7	7	7	7	7
Ashqelon	7	8	8	8	7
Jerusalem (Ogg)	5	6	7	7	7
Yavne	2	2	2	3	6
Are HaEmeq - Tel Adashim	4	5	5	5	5
Ra'annana	5	5	5	5	5
Bet Shemesh	4	4	4	4	4
Dimona	3	3	3	3	4
Timmorim (Be'er Toviyya)	3	3	3	3	4

Source: Ministry of the Environment

Table 4.11 Annual Amounts of Raw Sewage, Recharged Effluents, Losses of Effluents and Reclaimed Water from the DRRP 1987-2004 (MCM)

	Raw Sewage	Recharged Effluents	Losses of Effluents		Reclaimed Water
Year	Total	Total	Total	Thereof: discharge to the sea	Total
1987	38.5	36.5	9.2	3.2	19.3
1988	81.3	68.0	8.8	1.4	25.8
1989	95.7	67.1	23.8	15.3	21.3
1990	91.3	76.6	8.3	0.5	74.5
1991	88.8	78.8	5.2	1.1	85.0
1992	84.0	75.2	8.7	4.4	76.1
1993	86.3	73.3	8.3	5.8	81.0
1994	91.7	78.9	8.0	5.3	93.5
1995	92.6	72.7	15.9	12.0	96.6
1996	102.3	89.6	7.4	5.4	109.5
1997	111.5	102.8	3.5	1.5	112.1
1998	112.3	103.3	3.4	0.9	112.3
1999	115.4	108.7	1.4	0.2	133.6
2000	122.0	116.0	0.6	0.6	123.4
2001	126.6	115.1	5.6	5.6	118.0
2002	127.0	114.1	6.4	6.4	134.3
2003	122.9	107.5	11.9	11.9	127.9
2004	121.1	112.3	2.8	2.8	138.3

Source: "Meqorot" National Water Company - Dan Region Reclamation Project

Table 4.12 Quality of Sewage in the Dan Region Reclamation Project (DRRP) 2003-2004

	2003			2004		
	Raw Sewage	Recharged Effluents	Reclaimed Water	Raw Sewage	Recharged Effluents	Reclaimed Water
BOD (mg/l)	370	12	1<	351	10	1<
COD (mg/l)	852	51	-	868	47	-
TSS (mg/l)	376	12	0.78	371	9	0.73
CL (mg/l)	320	319	196	316	315	218

Source: "Meqorot" National Water Company - Dan Region Reclamation Project

4.5.4 Discussion

The effluents recharged from the DRRP are of very high standard with salinity levels of about 300 mg chlorides per liter. The amount of treated raw sewage has rapidly increased in the last few years, reaching 95 % in 2004.

The organic load in Israel's municipal wastewater is much higher than that in the western world. Furthermore, due to the high rate of effluent reuse for irrigation purposes, environmental sensitivity to the salt content of sewage is especially high.

According to the Ministry of the Environment, the adverse environmental impacts of domestic sewage may be reduced through the following activities:

1. Reduction of salt emissions to the sewage system through discharge of industrial brines to sea, changes in the composition of cleaning materials in domestic use and changes in dishwasher salt use.

2. Changes in the chemical composition of detergents to environment-friendly materials.

3. Legislation to prevent expanded use of domestic garbage grinders. In Israel, each person generates some 0.5 kg of organic waste per day. Discharge of this quantity to the sewage system through garbage grinders would increase the organic load in wastewater treatment plants by 10.

4. Measures to assure that industrial sewage discharged to municipal treatment systems will undergo pretreatment to remove toxic or harmful materials.

5. Waste

Source: Photo Archive KKL-JNF

5.1. INTRODUCTION

Waste disposal is a continuous challenge in Israel. Until the 1990s, local authorities operated tens of unauthorized dumps. These dumps created a potential environmental and health hazard by contaminating surface and groundwater, deteriorating soil quality, emitting air pollutants and causing health hazards. Disposal of hazardous waste was conducted without environmental protection safeguards. The waste accumulated at inappropriate sites, piled up in the backyards of factories, or was just dumped anywhere. The problem escalated with the rapid increase in the weight and volume of the waste and the change in waste substances as a result of population and density growth. Improvements in living conditions and changes in consumption habits, followed by accelerated building and industrial activity, intensified the waste dump problem.

Increasing public awareness drove the relevant authorities to introduce a national program for waste treatment, under the responsibility of the National Planning and Building Board. The program was initiated in 1993. As a result of this program, hundreds of illegal dumps were shut down and replaced by environmentally oriented regional landfills.

However, allocating land for landfills has become a major problem. There are several reasons for this phenomenon:

- Most of the waste in Israel is buried in landfills.
- Land is a very scarce and expensive resource.
- Landfills create public resistance due to their negative environmental impacts.

In order to reduce the quantity of buried waste, efforts have been made to find alternatives to landfilling. These alternatives include: waste generation reduction, reuse, recycling, anaerobic fermentation, composting, curbside recycling programs and waste-to-energy plants.

For this purpose two legal tools were established:

- The Collection and Disposal of Waste for Recycling Law was enacted in 1993. Regulations promulgated under the law in the same year set recycling targets for local authorities according to the following timetable: 10% by 1998, 15% by 2000 and 25% by 2007.

- The Deposit Law on Beverage Containers came into effect in 2001. The law set up a refund, bottle collection and recycling system. The system was designed to encompass over 910 million beverage containers, allowing for the reduction of about 8% of the volume and 4% of the weight of the country's solid waste.

In the year 1997 the Ministry of the Environment began a five-year program of financial support to local authorities in order to encourage the transfer of waste to legal landfills and initiate various recycling projects. The government subsidized the transportation costs to the legal landfills according to the weight of the waste that was disposed at the legal sites. As a byproduct, the Ministry of the Environment obtained some data on waste quantities and content. However, many local authorities waived the subsidies and continued to discard their waste without using the designated legal landfills and reporting to the Ministry of the Environment.

In 2003, the CBS began conducting a survey on the quantities of domestic, commercial and yard waste collected by local authorities. The information collected by the CBS and the Ministry of the Environment has improved the available waste data.

Information regarding the quantities and composition of domestic, commercial and industrial waste that is generated in municipalities is very important for decision makers. It enables the estimation of the actual area needed for landfills and indicates the financial potential and possibilities for developing the recycling industry by identifying reusable/recyclable waste quantities.

Israel has only one national site that is qualified and authorized to treat and store hazardous waste. This site is called "Ramat Hovav" and is situated in the south of Israel. According to Business Licensing Regulations which were promulgated in 1990, hazardous residuals, which are not reused, recycled or treated in the manufacturing industry (by special permit), must be transferred to this site. The site is equipped to treat various hazardous and toxic materials used in Israel, excluding radioactive waste, explosives and pathogenic waste. In addition to the routine transfer of hazardous waste to Ramat Hovav, special evacuation operations of old hazardous waste have been carried out since 1990.

5.2. Methods

5.2.1. Definitions

Waste: Residuals of organic or inorganic origin, generated by human activity. These materials that are not prime products (that is, products produced for the market), and the generator has no further use for them. Waste may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products and other human activities.

Municipal Waste: Waste collected by or on behalf of municipalities. In Israel this waste includes domestic, commercial and garden waste (yard waste). Separation of waste is as yet not very developed in Israel, and hence the municipal waste is a mixture of organic and inorganic compounds, although it does not include hazardous waste.

Hazardous Waste: Waste that contains hazardous materials in any concentration and in any phase. Hazardous materials are all registered and marked by a unique U.N. code.

Domestic Waste: Waste materials usually generated in the residential environment (sometimes referred to as household waste).

Industrial Waste: Waste originating from the manufacturing of products in the industrial sector.

Construction and Demolition Waste: Waste generated during the processes of construction. Its content and quantities are affected by the method and type of construction, such as, prefabricated construction or regular building, and by the materials in use (wooded house, stone building, etc.). This kind of waste may contain hazardous waste.

Solid Waste: Useless materials with low liquid content. Solid waste includes municipal, industrial and commercial waste, sewage sludge, and waste resulting from agricultural activity.

Dump: A site without environmental controls used to dispose solid waste.

Landfill: Final placement of waste underground or on the ground surface, in a controlled mode, according to different sanitary, environmental protection means. These means include: treating wastewater and collecting gases that are generated by the accumulated waste and other safety requirements.

Reuse: Use of materials or products more than once, such as bottle refilling.

Recycling: Waste used as a raw material for producing new products. Recycling factories receive waste materials from the following sources:

- Municipalities, which sort their waste (separating paper, cardboard, plastic and yard waste).
- Waste transfer stations, which sort waste and also separate organic compounds for compost manufacturing.
- Industrial factories.

Waste Data Presentation: It is customary to present quantities of waste generated in a geographically defined area (country, region, district, locality, etc.), by the average weight of waste produced per capita per day. Such an indicator enables comparisons between countries or between localities within a country.

Socio-Economic Cluster: Cities, municipal authorities, and rural authorities were aggregated into ten clusters. The clusters are as homogeneous as possible within the cluster and heterogeneous between clusters with regard to basic social and economic characteristics. These characteristics include demographic variables, life standard, education, employment and income. Cluster 1 indicates the lowest socio-economic status, while cluster 10 indicates the highest status. This variable (socio-economic cluster - from one to ten) was used for imputation of the missing municipal waste quantities, according to local authorities within a similar cluster. (See description of the imputation method in the Models and Calculations section below).

Hazardous Waste Treatment Methods: In order to lower the potential environmental hazard from hazardous waste, various methods of treatment are taken at the Ramat Hovav site:

- **Secured Landfill**: Burying non-volatile and inorganic solids.
- **Incineration**: Thermal decomposition of hazardous organic waste.
- **Neutralization**: Treatment process based on neutralization of acids and alkalines.
- **Detoxification**: Chemical treatment that

includes neutralization of cyanides and thionyl chloride, reduction of chromates, and sedimentation of heavy metals. Some materials undergo several types of treatment. For instance, oxidizers undergo a process of detoxification followed by neutralization.

In both detoxification and neutralization, the generated waste after treatment flows into evaporation ponds. Today the ponds are in the process of being shut-down and no further waste is directed to them.

- Biological Treatment: Treatment using bacteria on soils polluted by organic materials, or sludge containing biodegradable materials.

- Other Treatments: Until 2002, this category included solidification. Since 2002, this category includes storage and export, and in 2003 recycling was added as well.

5.2.2. Data Sources and Collection

1. Ministry of the Environment:

- Solid waste composition, according to surveys from 1975, 1983, 1995 and estimations for later years.

- Quantities and types of solid waste treated in recycling factories.

- Quantities and types of hazardous waste treated outside of Ramat Hovav and main treatment methods.

- Complementary data in addition to the CBS municipal waste survey.

2. Environmental Services Company Ltd.:

- Quantities and types of hazardous waste arriving at the Ramat Hovav site, main treatment methods and quantities treated by each method.

3. Central Bureau of Statistics (CBS):

- Population of local authorities.

- Data on annual quantities of waste recycling (collected from recycling factories by a special survey since 2004).

- Data on annual quantities of municipal waste (collected from local authorities by a special survey since 2003).

5.2.3. Data Limitations

1. There are two different types of sources for municipal waste. The first type includes data collected by the CBS from local authorities. The second includes data collected by the Ministry of the Environment from landfills and transfer stations. Differences between the data sources may lead to data discrepancies.

2. Until 1998, large cities such as Haifa and Jerusalem did not weigh their waste, and their waste quantities were estimated by their municipal sanitation departments based on the volume of waste. These estimations were often inaccurate. Since 1999, the number of cities that weigh their waste has increased, and the municipal waste data series is considered more reliable.

3. The total quantity of solid waste is based on municipal waste reports and on industrial waste estimations by the Ministry of the Environment.

4. Waste quantities per capita for the latest year are calculated according to population size at the end of the previous year, as average population data for the actual year are not yet available.

5. Recycling data are not complete and their reliability is low, since not all recycling activities are properly reported or weighed by the factories.

6. Data for waste quantities generated by agriculture and forestry are not available

7. Construction and demolition waste data are not yet collected and therefore are currently unavailable. Dumping of construction and demolition waste in illegal sites is a widespread phenomenon in Israel. The Ministry of the Environment estimates the quantity of construction and demolition waste which is generated in Israel as 7.5 million tons per year. This is only a partial approximation of construction waste, which is only based on data of new construction projects from the CBS and a solid waste survey (Ministry of the Environment, 1995).

8. Data on waste generation are not available. Data refer only to collected waste.

9. Data on waste composition after 1995 are based on estimates by experts and not on actual measurements.

5.2.4. Models and Calculations

Quantities of waste per capita per day for local authorities that did not report to the CBS or through the landfills administrations were calculated through a model of statistical imputation designed at the CBS, based on the Hot-Deck method. Imputation takes the "nearest neighbor" to the missing value, according to the type of locality (e.g., large city, small town, village, Jewish, non-Jewish, etc.), socio-economic cluster, population size and district.

5.3. Results

5.3.1. Solid Waste Composition

The last survey of solid waste composition was conducted in 1995. The survey was conducted in landfills and did not include construction waste. The survey results are presented in Table 5.1. Organic materials are the main component of waste by weight (42%), but plastics constitute most of the waste's volume (35%). In general the waste in Israel includes a high proportion of wet (organic) materials and small quantities of dry materials.

Table 5.1: Solid Waste Composition (1995)

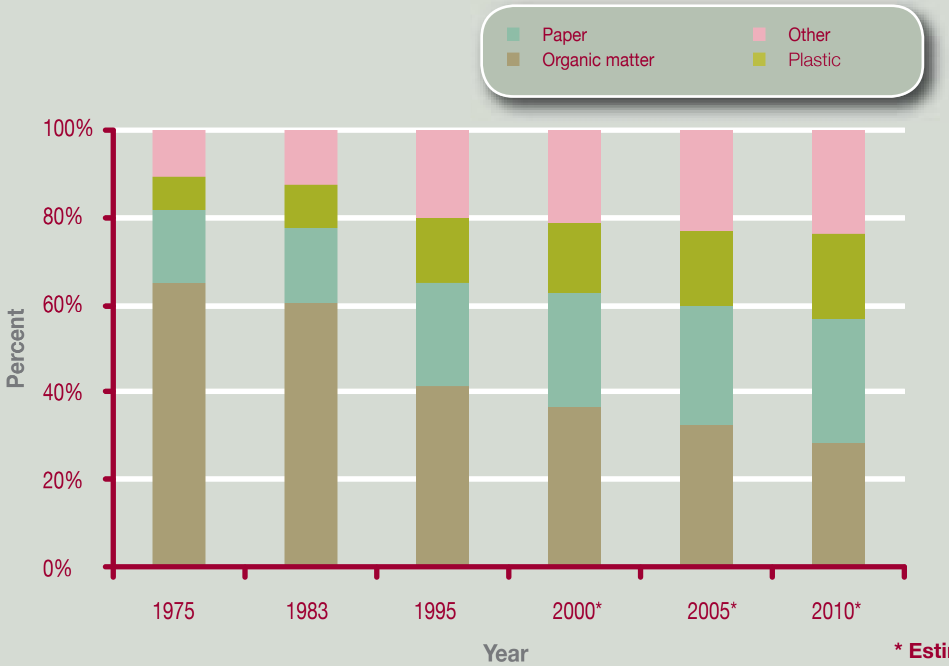
Components	Average Volume (% of total waste)	Average Weight (% of total waste)
White paper	4	2
Other paper	13	12
Cardboard	12	8
Metals	4	3
Textile	4	3
Plastic	35	14
Glass	2	3
Diapers	4	4
Trimmings and organic materials	19	42
Other (wood, rocks, rubber, leather)	5	8
Total	**100**	**100**

Source: Ministry of the Environment

As shown in Chart 5.1, there was a continuous growth of the paper and plastic fraction of the total waste from 1975 to 1995. At the same time, the fraction of organic matter decreased.

For the years 2000 to 2010, the composition of waste was estimated based on past trends and population growth estimates.

Chart 5.1 - Weight Composition of Collected Waste by Type of Material



*** Estimation**

Source: Ministry of the Environment

5.3.2. Municipal Waste Quantities

The average quantity of municipal waste collected in Israel was 1.59 kg of waste per capita per day (PCPD) in the year 2004. The PCPD figure is highly correlated with the type of locality (urban or rural) and the level of income. Table 5.2 presents the quantity of waste PCPD in different districts of Israel.

The table shows that the average PCPD in Israel fluctuated during the reviewed period, and has no coherent trend. High volumes of missing data and low-quality data from local authorities may be largely responsible for this incoherence.

The average quantity of waste for the years 1999-2004 in the Tel Aviv District, which is urban, was above 2 kg PCPD, while the North District, which is mostly agricultural, had about 1.5 kg PCPD.

The high waste figures PCPD in the Tel Aviv District coincide with the well-known phenomenon of a positive relationship between high waste volumes and high income. The Tel Aviv District includes high-income localities (socio-economic cluster above 8)

Table 5.2: Municipal Solid Waste (Domestic, Commercial and Yard Waste) by District, Kilograms Waste per Capita per Day

	1996	1997	1998	1999	2000	2001	2002	2003	2004
TOTAL	1.94	1.97	1.86	1.69	1.74	1.55	1.62	1.58	1.59
Jerusalem District	2.07	2.73	2.39	1.33	1.44	1.23	1.30	1.35	1.31
North District	1.62	1.91	1.64	1.98	1.64	1.50	1.49	1.54	1.53
Haifa District	1.56	1.91	1.65	1.29	1.39	1.15	1.47	1.46	1.48
Central District	2.11	1.45	1.39	1.63	1.90	1.63	1.64	1.55	1.55
Tel Aviv District	2.35	2.40	3.02	2.32	2.35	2.08	2.13	2.00	2.04
South District	1.70	1.53	1.08	1.41	1.51	1.55	1.58	1.61	1.64

Source: CBS and Ministry of the Environment

5.3.3. Solid Waste Recycling

Table 5.3 presents the quantity of recycling in Israel out of the total solid waste. The quantity of recycling and its percentage out of the total solid waste have continually increased along the reviewed period. In 2004, the recycling quantity reached 21% of the total solid waste.

Table 5.3: Quantities of Recycled Waste out of the Total Waste[1]

	1998	1999	2000	2001	2002	2003
Total solid waste (tons)	5,662,089	5,310,175	5,863,318	5,494,000	5,732,000	5,527,119
Total quantity recycled (tons)	717,422	746,732	983,450	1,018,591	1,085,000	1,160,695
Percentage of recycling (%)	13%	14%	17%	19%	19%	21%

[1] Includes only municipal and industrial waste
Source: Ministry of the Environment

The percentage of materials out of the total recycled waste and the types of materials extracted from the waste for recycling are presented in Table 5.4. As shown in this table, organic matter and metals are the main recycled materials in the examined period.

Table 5.4: Weight Distribution of Recycled Materials

Type of material	2000	2001	2002	2003	2004
Total Recycled Materials	100%	100%	100%	100%	100%
Organic waste	14%	30%	28%	27%	32%
Paper and newspaper	21%	21%	13%	15%	13%
Yard waste and wood	18%	17%	11%	14%	12%
Metals [1]	42%	26%	24%	25%	27%
Plastics	2%	3%	3%	4%	5%
Other [2]	2%	4%	21%	15%	12%

[1] Metals and electronic waste.
[2] Batteries, construction waste, tires, glass, used oil, textile and toners.
Source: CBS and Ministry of the Environment

5.3.4. Quantities and Treatment Methods of Hazardous Waste

The quantities of hazardous waste and the different ways of treatment are presented in Table 5.5.

Table 5.5: Hazardous Waste Quantities by Handling Processes, Tons

	1997	1998	1999	2000	2001	2002	2003
Waste-to-Energy	-	-	-	-	-	5,423	8,571
Imported hazardous waste	6,607	5,726	7,556	9,030	10,587	14,356	11,826
Recycling	39,353	38,644	39,100	51,780	56,678	46,918	25,285
Reuse	51,825	37,442	175,415	136,949	148,055	106,007	35,727
Treatment at factories outside of Ramat Hovav	35,735	78,320	46,468	14,629	28,727	65,456	107,680
Treatment at Ramat Hovav	48,644	49,954	63,529	68,211	80,383	74,260	107,995
Total quantity handled	**182,164**	**210,086**	**332,068**	**280,599**	**324,430**	**312,420**	**297,084**

Source: Environmental Services Company and Ministry of the Environment

In general, the total quantity of treated hazardous waste has increased in the reviewed years. However, the quantities do not present an even trend because treatment methods frequently changed along the years, largely due to technological and business considerations. In addition, special evacuation operations such as the evacuation of contaminated soil to Ramat Hovav in 2001 and 2003, took place, further and contributing to this uneven trend.

The total quantities of reused and recycled hazardous waste did not increase during the reviewed period. From 1999 to 2000 the quantity of reused or recycled hazardous waste constituted about 65% of the total hazardous waste produced. In 2003 only 40% of the hazardous waste produced was reused or recycled.

In the years 1997 to 2003, about 25% of the hazardous waste was sent to Ramat Hovav.

The quantity of hazardous waste that was transferred to Ramat Hovav has increased during the reviewed period.

The quantity of imported hazardous waste has increased by around 80% during the reviewed period.

In addition, the quantities treated outside of Ramat Hovav have increased along the entire period. However, there are many fluctuations along the years due to the frequent changes in handling procedures.

5.3.5. Quantities and Treatment Methods in Ramat Hovav

Hazardous waste is transported to Ramat Hovav and treated there in order to lower its potential hazard to the environment. The treatment methods are explained in the Definitions section above. The quantities of hazardous materials treated in Ramat Hovav are shown in Table 5.6

Table 5.6: Hazardous Waste Delivered to Ramat Hovav, by Types of Materials (Tons)

	1995	1998	1999	2000	2001	2002	2003	2004
TOTAL	**43,655**	**49,954**	**63,529**	**68,211**	**80,383**	**74,260**	**107,995**	**102,905**
Type Of Material								
Sediments	10,480	24,183	27,812	34,799	49,123	31,908	58,250	40,339
Organic material	12,216	15,700	12,489	14,244	13,768	23,390	30,159	38,934
Acids	8,560	3,888	7,242	7,754	7,136	7,534	8,751	8,164
Waste water and alkalines	7,050	3,552	13,213	7,937	6,357	8,422	7,673	13,034
Chromates	242	226	438	494	1,061	1,168	1,412	1,305
Hydrazide and cotnion	1,318	648	314	1,041	853	314	-	-
Medicinal waste	509	468	438	486	501	635	666	470
Cyanides	129	209	252	378	472	289	207	195
Laboratory waste	22	19	13	53	364	39	27	19
Copper-ammonia complex	369	261	267	420	214	111	41	1
Batteries and car batteries	369	279	212	274	143	195	186	210
Thionyl chloride	82	103	31	30	28	25	16	24
Gas tubes	23	16	12	10	53	40	22	5
PCB and PCB oil	867	53	95	-	6	79	12	15
Cytotoxic waste	192	193	243	284	287	108	432	186
Other materials [1]	1,227	157	456	5	15	4	139	4

[1] Includes acidic sludge, materials for safekeeping, magnetic tapes, magnesium, light metals, unidentified materials, etc.

Source: Environmental Services Company

The data show that the quantities and types of materials treated in Ramat Hovav have changed over time. The main types of materials are sediments and organic material. These materials comprise 77% of the total quantity treated in 2004. There is a constant increase in the quantity of organic material that is received in Ramat Hovav. There are various treatment methods for hazardous waste in Ramat Hovav. For the period shown in Table 5.7, the two dominating treatment methods were secured landfill and incineration, which constitute between 70 to 80% of the total quantity. New treatments are added from time to time. Biological treatment was established in 2001 and has increased since then, and in 2004 evaporation treatment was added.

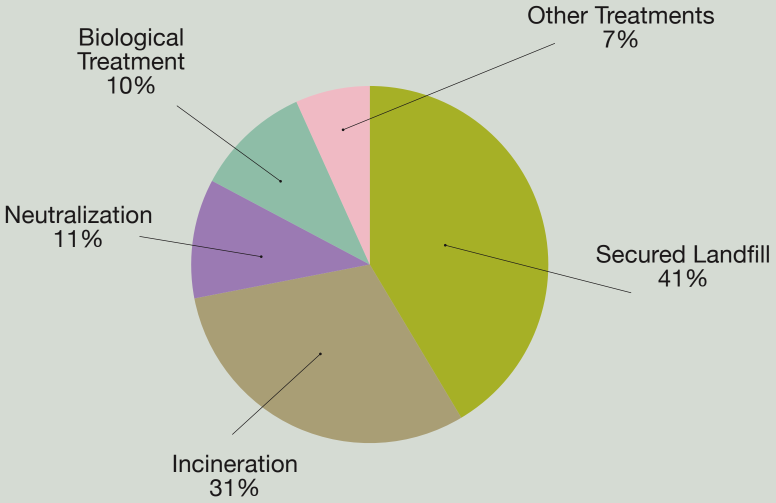
Table 5.7: Hazardous Waste Delivered to Ramat Hovav, by Methods of Treatment (Tons)

	1995	1998	1999	2000	2001	2002	2003	2004
TOTAL	**43,655**	**49,954**	**63,529**	**68,211**	**80,383**	**74,260**	**107,995**	**102,905**
Method Of Treatment								
Secured Landfill	17,595	24,953	28,671	35,576	49,866	32,638	59,197	42,697
Incineration	12,473	15,895	12,659	16,170	15,128	20,259	23,505	31,480
Neutralization	10,239	7,512	20,439	14,327	12,350	14,743	14,133	11,144
Detoxification	2,174	1,436	1,294	2,136	1,448	1,442	1,725	1,486
Biological Treatment					1,558	2,096	3,061	10,730
Evaporation								1,352
Other Treatments [1]	1,174	158	465	*1	33	3,083	6,373	4,016

[1] Other Treatments: Until 2002, the treatment used was "solidification". Since 2002, this category includes storage and export, and in 2003, recycling was added.
* Unreliable data
Source: Environmental Services Company

Despite the variety of treatment methods, most of the waste is still buried. As shown in Chart 5.2, in 2004 over 40% of the hazardous waste was buried in secured landfills. The next common method of treatment was incineration, which constituted about 30% of the hazardous waste in that year.

Chart 5.2 Distribution of Treatment Methods in Ramat Hovav (2004)



Source: Environmental Services Company Ltd.,

5.4. *Discussion*

According to the working assumptions of the Ministry of the Environment, solid waste quantities are expected to increase at a rate of about 5% per year in the coming years. These predictions are based on estimates of population growth and economic development. At the same time, the availability of open spaces that can be used for landfills is decreasing. Consequently, a general strategy of solid waste management was established. This strategy includes three main levels of actions:

1. Reducing the generated quantities as much as possible.
2. Reusing existing waste.
3. Recycling the waste.

In recent years, however, the total quantity of collected waste has remained stable with only small fluctuations. These findings may reflect economic conditions and consumption patterns in Israel during these years, as well as increases in reuse and recycling in households.

The data regarding the quantity of solid waste collected by municipal authorities are inaccurate due to incomplete cooperation with some municipal authorities and discrepancies between data sources. Data for industrial and construction waste are not available and are only roughly estimated.

Besides the limited availability of waste collection data, there are no current data regarding the generation and composition of solid waste in Israel. Based on the findings of the waste survey conducted in 1995, it is estimated that Israel's solid waste is composed mainly of trimmings, organic matter, and various types of paper and plastic. These materials have a high recycling potential. Although recycling quantities in Israel are growing each year, there is still a great potential that remains unused.

Recently, the Ministry of the Environment initiated a project for the collection and incineration of methane from landfills. Collecting methane prevents the release of methane, which is a potent greenhouse gas, to the atmosphere. In addition, the collected methane can be used for energy production. The CBS plans to start collecting methane data on an annual basis in the coming years.

Relative to solid waste, the data for hazardous waste seem more accurate due to the small size and the concentrated nature of this industry. Hazardous waste data that are forwarded from the Ramat Hovav treatment site and the Ministry of Environment to the CBS are of high quality and cover most of the generated hazardous waste. However, there is still room for improvement in order to complete the data coverage regarding all hazardous materials in Israel.

The reported quantities of hazardous waste are constantly growing as a result of industrial development, especially in the chemistry and pharmaceutics sectors. Another reason for this increase is the improved inspection of the industrial sector by the Ministry of the Environment.

Along the studied years, there are major fluctuations in the quantities of hazardous waste in each treatment category (e.g., recycling). The reasons for these fluctuations include special operations for the collection of hazardous waste (e.g., evacuation of contaminated soil), changes in industrial processes and changes in the number of businesses that transport hazardous waste for treatment.

In summary, the data regarding waste in Israel are far from complete. Although data for collected and treated waste are improving, there are currently no available data regarding generated municipal waste and its composition, agricultural waste and construction waste. The existing waste data are partial, often come from multiple sources and generate data discrepancies. Some of the existing data are of low quality and inconsistent.

In order to improve the existing data, new comprehensive waste surveys, better waste data collection and improved estimation methods are required. Globally, waste is a growing environmental problem, and further research is highly needed in order to better manage waste in Israel and leave a cleaner country for future generations.

6. Sustainable Development Indicators (SDI)

Source: Dr. Moshe Yanai

6.1. LAND COVER

6.1.1. Population Density in Coastal Regions

6.1.1.1. Introduction

a. Population density – This indicator measures the concentration of the human population in reference to space. On the national level, higher or growing population density can threaten the sustainability of protected forest areas and ecologically fragile or marginal land. High concentration of population also means more local demand for employment, housing, amenities, social security and services, and for environmental infrastructure for sanitation and waste management. Areas with a high demographic density tend to rely on resources from less populous regions and thus increase the risk of exceeding regional carrying capacities[1].

b. Population density in coastal regions – This indicator enables the assessment of demographic pressures, which are exerted on the coastal areas, some of which are ecologically fragile or at risk. By comparing this indicator to the national population density, the territorial imbalances and the attraction of the coastline are clarified[2].

In the future this indicator must be linked to other demographic indicators in addition to indicators on tourism, ecosystems, urban problems and arable land at coastal area level.

1 Indicators of Sustainable Development, EUROSTAT, 1997.
2 Indicators for Sustainable Development in the Mediterranean Region, Blue Plan, 1999.

c. **Population density in the Israeli coastal region** – This indicator is very much relevant to Israel due to the country's high population density (294 persons per km^2 in 2003). Population density in Israel has been continuously increasing as a result of the large waves of immigration combined with a high natural growth rate in a relatively small area.

This indicator supplies important information about the geographical distribution of population density, which separates the coastal region of Israel from the rest of the country. In order to reap the highest benefit from this indicator it is necessary to define the Israeli coastal region in accordance with criteria set on the national level and with national needs in mind (will be discussed in the methods section).

6.1.1.2. Methods

a. **Definition** – The ratio of the permanent population in the coastal area to its surface area.

The Mediterranean Action Plan defines a national coastal area as an area made up of all the administrative coastal regions around the Mediterranean outline, which are the equivalent of level 3 in the Nomenclature of Territorial Units for Statistics (NUTS 3). In the case of Israel, this definition includes almost the entire area of the country in the coastal area thus making the indicator irrelevant at the sub-national level. Therefore, a smaller littoral zone was chosen to represent the Israeli coastal zone, which is comprised of all the localities whose jurisdiction area borders with the coastline (more equivalent to NUTS 5).

b. **Unit of measurement** – Number of inhabitants per km^2.

c. **Data sources** –

1. Population data - The central population register.
2. Localities area data (2002) - Ministry of the Interior (jurisdiction area of localities) and Ministry of Agriculture (area of agricultural settlements).

d. **Data limitations** – Several coastal localities with small population are not included due to lack of data regarding the area of these localities (Caesarea, Arsuf, Shoshanat Haamakim, Tsukey Yam).

6.1.1.3. Results

The total area of Israel is 22,145 km^2, with a population of 6.75 million inhabitants in the year 2003. The total coastal area as defined for Israel is 458.1 km^2 (2% of the total area of the country) and the total population in the coastal area is 1.775 million in the year 2003, about 26% of the total population.

Table 6.1 Population Density in Israel

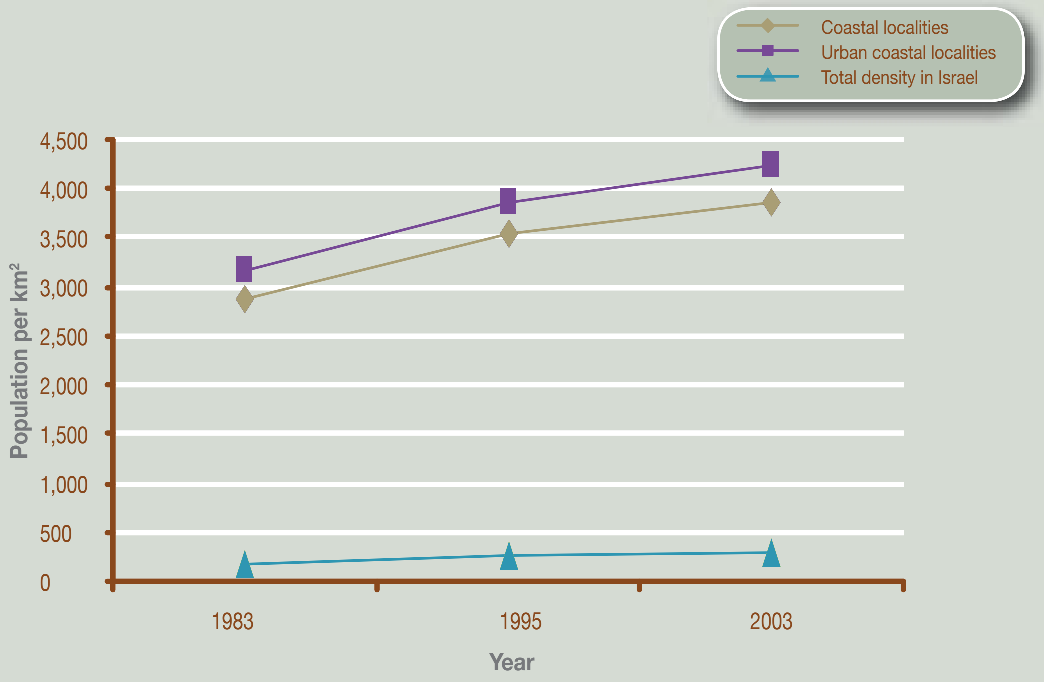
Year	1983	1995	2003
Coastal localities	2,880.9	3,537.7	3,875.2
Urban coastal localities	3,157.6	3,871.4	4,224.7
Total density in Israel	186.7	252.8	294.3

Source: CBS

In 2003, population density in the selected coastal localities was 3875.2 inhabitants per km². This represents a 35% increase in population density in the past 20 years; almost 13 fold the average density in the country in 2003.

The population density in the urban coastal localities (those with over 5,000 inhabitants) is even higher and reached 4,225 inhabitants per km² in 2003. The total area of these localities was 418.4 km², 91% of the total coastal area with a population of 1.767 million, which is about 99.6% of the total coastal area population.

Chart 6.1 Changes in Population Density in Israel



Source: CBS

The chart shows the large and increasing difference in population density between the defined coastal area and the whole area of the country.

Table 6.2 and Chart 6.2 show the population density in each of the coastal urban localities in the years 1983,1995 and 2003.

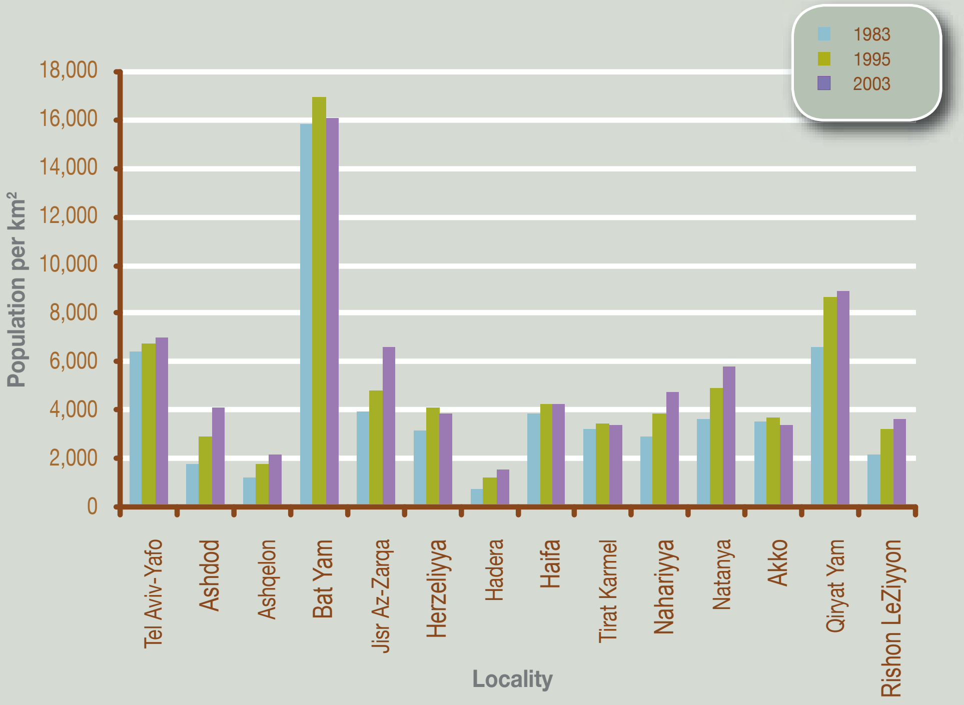
Table 6.2 Population and Population Density in Urban Coastal Localities

	Density 1983	Population 1983 (Thousands)	Density 1995	Population 1995 (Thousands)	Density 2003	Population 2003 (Thousands)
Tel Aviv-Yafo	6,400.3	327.3	6,768.7	348.2	7,015.2	363.4
Ashdod	1,729.5	65.7	2,860.6	125.8	4,068.6	192.0
Ashqelon	1,184.9	52.9	1,793.0	80.9	2,185.8	104.5
Bat Yam	15,836.7	128.7	16,971.4	136.4	16,087.4	131.9
Jisr Az-Zarqa	3,942.1	5.0	4,860.4	7.8	6,551.9	10.5
Herzeliyya	3,162.2	63.2	4,129.1	82.8	3,872.4	83.6
Hadera	741.0	38.7	1,210.1	60.4	1,516.6	74.9
Haifa	3,852.5	225.8	4,294.8	255.9	4,229.3	269.4
Tirat Karmel	3,223.1	15.5	3,452.6	17.3	3,362.3	18.8
Nahariyya	2,915.8	27.8	3,871.8	36.3	4,744.9	48.4
Natanya	3,593.6	102.3	4,935.2	143.4	5,760.3	167.1
Akko	3,539.6	36.4	3,680.2	44.2	3,380.7	45.6
Qiryat Yam	6,623.0	29.7	8,669.6	38.3	8,923.5	38.4
Rishon LeZiyyon	2,199.6	104.4	3,185.3	163.2	3,656.1	214.6

Source: CBS

An example of a rapid increase in population density is the city of Ashdod, which has more than doubled its population density in two decades from 1729.5 inhabitants per km^2 in 1983 to 4,068.6 inhabitants per km^2 in 2003. This was mostly due to the large immigration wave that started in the beginning of the nineties and had a significant effect on this city: 68.7% of the population in Ashdod consists of immigrants who arrived in Israel after 1990.

Chart 6.2 Population Density in Urban Coastal Localities



Source: CBS

Also worth mentioning is the city of Bat-Yam which has an extremely high population density of 16,087.4 inhabitants per km^2.

International comparisons are not presented in the case of this indicator because of the territorial definition given in this paper to the Israeli coastal region. Although this definition provides for a good distinction between coastal and non-coastal regions in Israel, it is not compatible with the definition for other Mediterranean countries formulated by the Blue Plan.

As mentioned earlier, Israel is characterized by high population growth as a result of a high natural growth rate combined with a large immigration wave (more than a million immigrants) that started in the early 1990s. Furthermore, the total area of the country is relatively small (half of which is desert) and the Mediterranean coastal region is a small fraction of the total area.

These factors, in addition to the natural tendency of a coastal region of a country to be denser than other regions, contribute to the high population density in the coastal region of the country.

6.1.1.4. Discussion

The main purpose of this indicator is to measure the demographic pressures, which are exerted on the coastal region. The data show that these pressures are extremely high in the coastal localities in Israel.

a. **Pressures on the coastal area** - The indicator of population density is regarded mostly as a state indicator, which means that the analysis of its data, must be considered in a wider context, and must take into account several other indicators of sustainable development.

Nevertheless it is possible, solely on the basis of this indicator, to point to the effects that such a high population density could have in terms of sustainable development:

- Loss of coastal open space – The high population density on such a small area leads to loss of scenic landscape, nature and agricultural land. The loss of coastal open space means that opportunities for recreation and leisure for the public and for nature protection are considerably diminished.

- Pollution of the sea and coast – 75% of the pollution that reaches the sea comes from the land (industry and sewage)[3]. In light of this, it is obvious that without appropriate infrastructure the pressures of high population density in the coastal localities could have an immense effect on the state of the sea and coast.

- Urban development - Nearly 100% of the population in the coastal region is an urban population. For this reason this indicator could be a very important instrument in active urban development. The definition chosen for the coastal region of Israel assists in the process. The indicator, in this form, allows for evaluating pressures at city level and planning ahead adequately when faced with the growing needs in the dense coastal localities for employment, infrastructure and residential areas.

b. Legal situation - The Law for the Protection of the Coastal Environment (2004) prohibits building along the coastal strip so that the coast may stay open for the public. This law, and similar environmental laws, could affect future trends of population growth and density in the coastal region, but it is as yet unclear whether the effects would be in the direction of an increase or decrease in population density.

c. Future trends in population density - Future trends could go either way as a factor of policy decisions. It is more likely that there will be an increase in density as a result of the growing population's demand for housing solutions in the coastal cities. Additions of tall multi-story apartment buildings in the coastal cities could be made in an attempt to comply with these demands. This in itself may be considered a sustainable solution because it helps protect the remaining open spaces.

Another way of coping with the high population density in the coastal region could be through more referrals of the growing population to less dense regions of the country, thus reducing the pressures on the small Israeli coastal region.

d. Recommendations for future research - As mentioned before, it is essential to combine this indicator with other indicators in order to correctly and accurately analyze the implications of the high population density of Israel's coastal region.

Indicators on the coastal level and on the national level should be taken into account.

[3] Israel Ministry of the Environment – Management of Coastal Zone in Israel, 1999.

The indicators should cover the fields of education, transport, tourism, waste treatment, open spaces and more.

The issue of international comparisons should also be considered. In addition to the definition that was given for the indicator in this paper, which was to assess the indicator within the framework of local needs, Israel should examine the possibility of defining an indicator, which would be relevant both for national purposes and for international databases as well.

6.1.2. *Forested Area*

6.1.2.1. Introduction

a. Forested area – Forested areas and natural groves have positive effects on sustainable development on several levels. These include ecological advantages (natural ecosystems, ecological corridors and wide habitats for flora and fauna), climatic benefits (production of oxygen and absorption of carbon dioxide and pollutants), prevention of desertification and stabilization of the land, and social and visual (landscape) benefits. The greater the area of forests, the greater its contribution.

b. Forested areas in Israel - The majority of planted forested areas in Israel are dominated by species of coniferous or mixed coniferous-deciduous trees. In some areas, primarily in the northern Negev, plantations of eucalyptus may be found. This trend of planting coniferous and eucalyptus trees, neither of which is native to the region, has recently changed. Today emphasis is placed on the need to promote, as much as possible, the planting of locally adapted species in addition to conifers and eucalyptuses. This new approach is compatible with the development of the concept that fostering and rehabilitating the land with native species, creating local forests, which are sustainable and composed of mixed species, and contributing to the biological and geographical diversity of the country, is of high importance.

The role of forests as contributors to the environment and to society worldwide and in Israel specifically may be viewed from different perspectives as follows:

1. Recreational use – Recreational areas located in a natural environment with unlimited public access offer a significant contribution from a social perspective. They function as sites for picnics, relaxation, recreation, organized games and sport. Millions of visitors, from every socio-economic sector, flock to forested areas on an annual basis.

2. Links between ecosystems – Forests are at the center of ecological corridors, providing a passage for different plant and animal species and thus forming a vital link between various ecosystems.

3. Biological diversity – Forests contribute to biological diversity as well as to protecting the flora and fauna within them and in surrounding areas. Rehabilitation and renewal of natural habitats, such as forests (natural wooded areas and native species), plays an important part in the conservation of biological diversity.

4. Preservation of open spaces – The need for housing facilities due to population growth, rises in living standards and limited land resources, poses a constant threat to open spaces in Israel. Forested areas serve to curb or restrain building plans both from a statutory (forests are protected by the National Master Plan for Forests and Forestation, known as National Master Plan 22) and physical viewpoint.

5. Protection against erosion – Natural plant life, including treed areas, protects the land from surface run-off, erosion and the destruction they wreak, particularly in gorges, creeks, and areas with loess soil. The planting of forests reduces the amount of pastureland, which has expanded significantly during the past centuries. Forestation prevents erosion and rehabilitates the land, as well as avoiding the salination of water reservoirs and waterways, and increasing the permeability of the land, allowing more water to reach the aquifers and raising the level of the water table.

6. Protection against desertification – Desertification is the loss of inhabitable, agricultural and forested lands and their transformation into barren regions, a phenomenon affecting countries world-wide. It is aggravated by unrestrained development, heavy pressure on the land and climate changes. In Israel, 60% of the land is already arid or semi-arid, thus increasing the risks of desertification. Forestation assists in halting the process of desertification and has been proven to convert desert border areas that have little economic value into areas with high environmental value and the potential for pastoral, agricultural or tourist development.

   Actions against desertification have mainly concentrated on the Negev. The first forest in semi-arid conditions was planted in 1964 south of Mount Hebron and was followed by many others in the following years in the western Negev and Beer Sheva region. These forests have been effective in altering the landscape and creating green belts around villages and towns. Nevertheless, from the nature conservation point of view, planting forests in the desert area poses threats to local biodiversity, which relies on arid open spaces.

   In the northern Negev, gorges, creeks and areas of loess soil are at high risk of erosion and damage, causing land loss and agricultural damage. In this area, forests have been planted with the specific aim of preserving the land. As a result a new landscape has been created, featuring forests running alongside the creeks between agricultural areas. More recently, there has been a marked increase in forest planting in the Negev as a result of a combination of factors, including the reduction of planting in the north and center of the country, the scarcity of land and the recognition of the high significance of forested areas for the south. Planting systems have been developed, which are based on ancient practices of run-off harvesting, with the addition of agro-technical approaches: the land is divided into areas producing run-off and those receiving it where water is collected and forests are planted.

7. Economic value –

   - Forests constitute one of the bases of Israel's recreational and tourist infrastructure: many tourist sites are located in the hearts of forests or close by and this is one of their most appealing qualities. However, there is no clear method of measuring the economic contribution of forests. It should be noted that a tourism industry has developed in and around forests, which has provided for employment as well as the potential for new initiatives based on existing infrastructures.

   - Forests raise land value in the surrounding area and, as a result, housing prices. Residential homes near forests and parks, in urban and rural villages, have a high value, at times substantially higher than homes in comparison with other locations. The preservation of forested areas – as green landscapes and buffer regions, especially in an urban setting – is of national interest since it will maintain high property values and standards of living.

- A byproduct of Israel's forestation is the production of wood that results from the thinning of forests to maintain their health. In recent times this production has reached approximately 30 thousand tons per year – supplying about 5% of the total national consumption.

- Forests create employment in a number of areas, both professional and non-professional: planning, land preparation, planting, and maintenance.

- Forests and thinned out forests fulfill the aims of pasture improvement, especially in exposed areas, and provide shade and food for farm animals.

c. **Relation to international conventions and treaties** - There are a number of international conventions and treaties related to forestation. These include the 1997 Kyoto Protocol, in which forests function as carbon sinks, aiding countries in the reduction of carbon dioxide levels. As such, the Protocol encourages forestation and sustainable development of existing forests. Likewise, the 1992 Rio Earth Summit issued a "non-legally binding authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests". The statement is aimed to encourage the examination of forests in a "holistic and balanced manner within the overall context of environment and development, taking into consideration the multiple functions and uses of forests including traditional uses, and the likely economic and social stress when these uses are constrained or restricted, as well as the potential for development that sustainable forest management can offer".[4]

The UNFF (United Nations Forests Forum), of which all countries of the UN are members, was established in the year 2000 in order to combat deforestation and forest degradation, review progress and consider future actions as well as to develop and adopt a plan for conservation and protection of unique types of forests and fragile ecosystems.[5] Likewise, the World Bank and World Wildlife Fund (WWF) formed an alliance for Forest Conservation and Sustainable Use in 1998.[6]

6.1.2.2. Methods

a. **Definition** - Based on the Food and Agriculture Organization of the United Nations, a forest is defined as an area with at least 20% tree coverage. Forests in Israel include forests planted by the Jewish National Fund and natural forests.

b. **Unit of measurement** – Km^2.

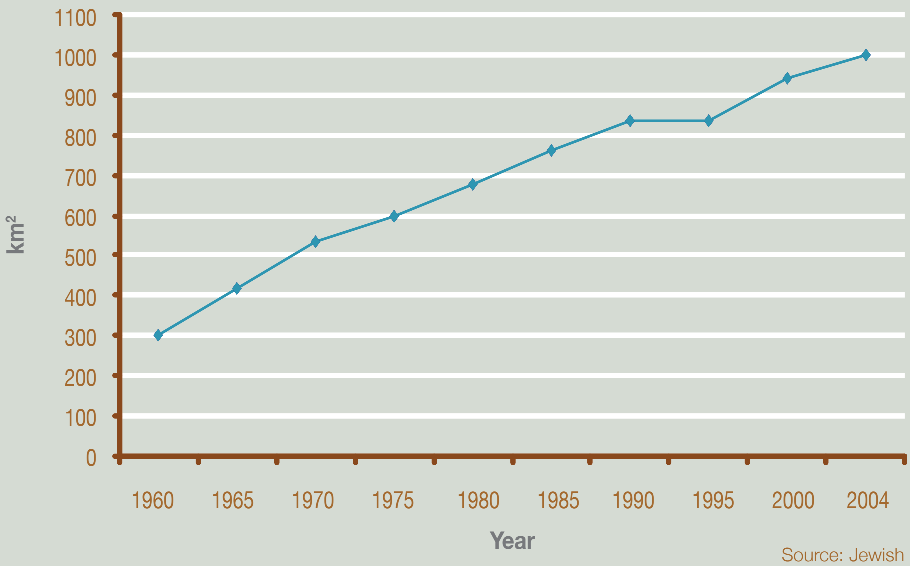
c. **Data sources** - Data provided by the Jewish National Fund.

d. **Data limitations** - The data include only forested areas administered by the Jewish National Fund and exclude natural forests that are under the jurisdiction of the Israel Nature and Parks Authority. There may be some discrepancies among data sources.

4 1992 Rio Earth Summit http://www.un.org/documents/ga/conf151/aconf15126-3annex3.htm
5 United Nations Forum on Forests Report on the organizational and first sessions 2001, http://www.un.org/esa/forests/documents-unff.html
6 Organization for Economic Co-operation and Development (OECD) Environmental Outlook, 2001, p. 129.

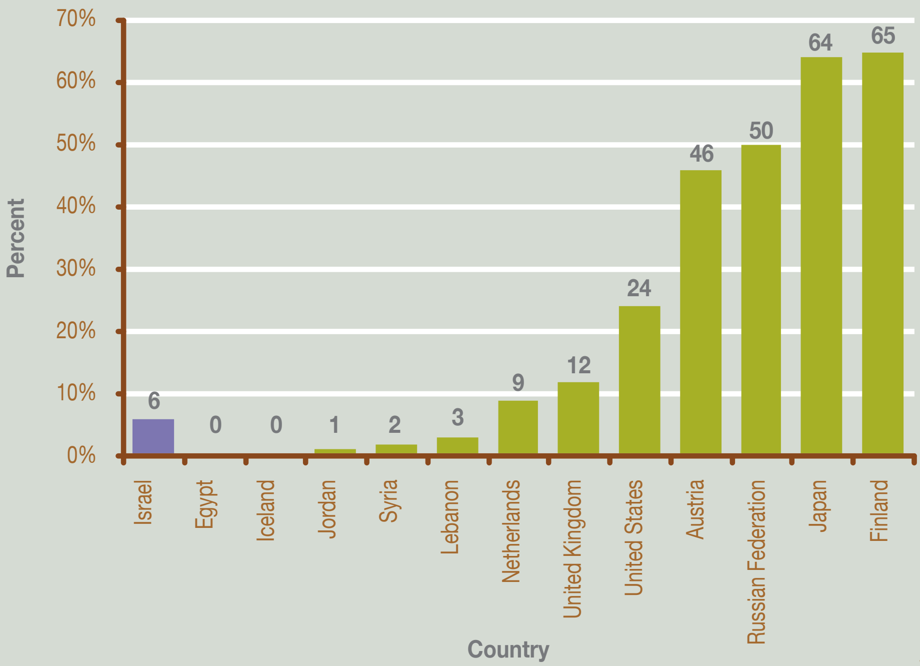
6.1.1.3. Results

Chart 6.3 Planted Forest Area



Source: Jewish National Fund

Chart 6.4 Percentage of Forested Area - International Comparison (2000)



Source: FAO

Israel's forested area totals 0.2 km^2 per capita (similar to the rates in the Netherlands, Jordan and Syria). In comparison, the rates in Canada and Australia are almost 80 km^2 per capita whilst the rate in Egypt is less than 0.005 km^2 per capita.

6.1.2.4. Discussion

a. **Status and trends in Israel** - Initial forestation activity in Israel took place in the 19th century. The motivations behind this included the draining of swamps and prevention of erosion on the coastal plain. At this time the German Templars, who came to pre-state Israel, also planted pine trees. The British Mandate enacted laws to protect the existing forests, covering nearly 830 km^2. Following these protection measures, logging was discontinued and forestation activities began in order to prevent the movement of sand dunes and rehabilitate the national landscape. As a result, by the time the State of Israel was established in 1948, nearly 100 km^2 of additional forest had been planted. In the past fifty years, over 650 km^2 of forest have been planted. In more recent years the rate of planting has slowed, limited by the availability and suitability of land for forests and the allocation of resources for the care of existing forests and the rehabilitation and renewal of natural forests.

b. **Sources of pressure on the forested areas** - In Israel the constant need to build and develop in open spaces has not spared the forests. Whilst annual planting continues, every year planted areas are further diminished (as are those intended for plantation). Sources of pressure stem from the necessity for additional land to build housing due to population growth and the increasing amount of space demanded by households, the need for additional industrial and business areas, and the paving of roads which results in a dissection of the forests.

c. **Legal situation** - In November 1995, the Israeli government enacted the National Master Plan on Forests and Forestation (National Master Plan 22). The Plan covers the majority of the existing forested areas and, additionally, natural wooded areas, thinned forests, sand dunes, and river banks that are to be protected and rehabilitated: a total of 6.2 thousands km^2 of land. This national master plan requires the amendment of local master plans. There are currently around seventy such plans in force that specifically include forest borders, planned forestry activities, forest tracks, accessibility, forest size, location, and more. National Master Plan 22 has also been assimilated into the regional plans. Therefore, existing and proposed forested areas will benefit from this legal protection.

d. **Israel in an international perspective**- Israel ratified the Kyoto Protocol in 2004. In addition, as a participant in the Rio Earth Summit of 1992, Israel agreed to the "Statement of Principles on Forests" described above. In 1996 Israel ratified the UN Convention to Combat Desertification and has participated in programs to combat this phenomenon within different frameworks.[7]

7. United Nations Convention for Combating Desertification, http://www.unccd.int/php/countryinfo.php?country=ISR,United Nations Department of Economic and Social Affairs http://www.un.org/esa/agenda21/natlinfo/countr/israel/natur.htm#desert

e. Future expectations: regulation, pressure, trends

- **Regulation**

  The National Master Plan for Forests and Forestation is an essential factor in the preservation of forests, providing tools and methods for detailed planning of forests. Likewise a strategy exists to enable the transfer of forested areas to the status of nature reserves and national parks.

  A further tool for regulation is the "Forest Reserve", proclaimed in the British Mandate period. These reserves have continued to exist until the present day, and are articulated in Israel's Forest Ordinance. The Jewish National Fund plans to examine the issue of forest reserves and to increase accessibility to these areas.

- **Pressure**

  The capacity to stand firm against development pressures is conditional on the continued protection of forests through planning and legislation as well as proper management and the creation of educational, tourist and social content and activities in forested areas. These activities require the allocation of major resources and are not always at the top of the agenda. There is therefore a need for public, social and political activity and awareness to place the subject of forestation high on the agenda.

- **Trends**

  The major trend in the history of forestation in Israel, namely the addition of planted forests, for the most part pine, is slowly dwindling. This is due to the simple fact that the rocky areas most suitable for planting have already been utilized for this purpose. Most of the planting has taken place in the northern Negev, around villages, or in restored forests damaged by fires, thinning out or old age. The central trend in forestation is expected to be cultivation and maintenance of existing forests, increase of the carrying capacity of forests for social activities and continuation of the preservation of natural wooded areas.

6.1.3. *Urbanization*

6.1.3.1. Introduction

a. Urbanization – The indicator represents the ratio of the population living in urban areas. This indicator is the most commonly used index of the degree of urbanization. Agenda 21 calls for a balance between urban and rural development patterns. In addition, urbanization is recognized as an intrinsic dimension of economic and social development. Urban areas have distinctive characteristics reflecting the social fabric and density of their population, and the nature and scale of economic activities. Urbanization has profound social and economic implications that exceed the urban boundaries. Although many urban areas impose environmental and developmental pressure such as housing shortages, traffic congestion, air and water pollution, and waste disposal, Agenda 21 notes the potential of urban societies for sustainable development if properly managed.[8]

8. United Nations Department of Economic and Social Affairs http://www.un.org/esa/sustdev/natlinfo/indicators/indisd/english/chapt7e.htm.

b. **Urbanization in Israel** – The presentation of data on urbanization encounters problems of inconsistent national definitions of urban localities by different countries, and lack of an agreed upon international definition. Countries usually define the demarcation of urban areas on the basis of the size of localities, classification of areas as administrative centers, or classification of areas according to special criteria such as population density or type of economic activity of the residents. Although the formal administrative definition for an urban locality in Israel is based on size of population (over 2,000 inhabitants), experts disagree with this cut-off point. Using the formal definition of urban localities, the rate of urbanization in Israel exceeds 90%. This high rate has been relatively stable for the past ten years. The question arises whether the presentation of data based on this definition would be of use in reflecting the actual rate of the population defined as urban. In Israel, localities with up to 20,000 inhabitants are often a rural nature and depend on larger urban centers for many services. Furthermore, there are Arab localities in Israel with a population of more than 30,000 inhabitants, which mainly base their economy on agriculture, making it difficult to define these localities as urban.

   Therefore Israel's steering committee on sustainable development indicators decided to define urban localities as localities with a population of over 50,000 inhabitants. Such a definition would include only metropolitan cities and small cities with some metropolitan features and would be more indicative of self-sufficient cities and efficiency in the use of land resources.

c. **Relation to international conventions and treaties** - Not applicable. International agreements have not established specific national or global targets for this indicator.

6.1.3.2. Methods

a. **Definition** - The percentage of the total population of a country living in localities of over 50,000 inhabitants.

b. **Unit of measurement** – percentages.

c. **Categorization rationale** - The Central Bureau of Statistics in its Statistical Abstract of Israel categorizes any locality with more than 2,000 residents as urban, and any with less than this number as rural. Within the category of urban, the following five groups are used: localities with more than 50,000 inhabitants (large cities); 20,000-49,999 (medium-sized cities); 10,000-19,999 (towns); 2,000 to 9,999 (small towns); and less than 2,000 inhabitants (villages).

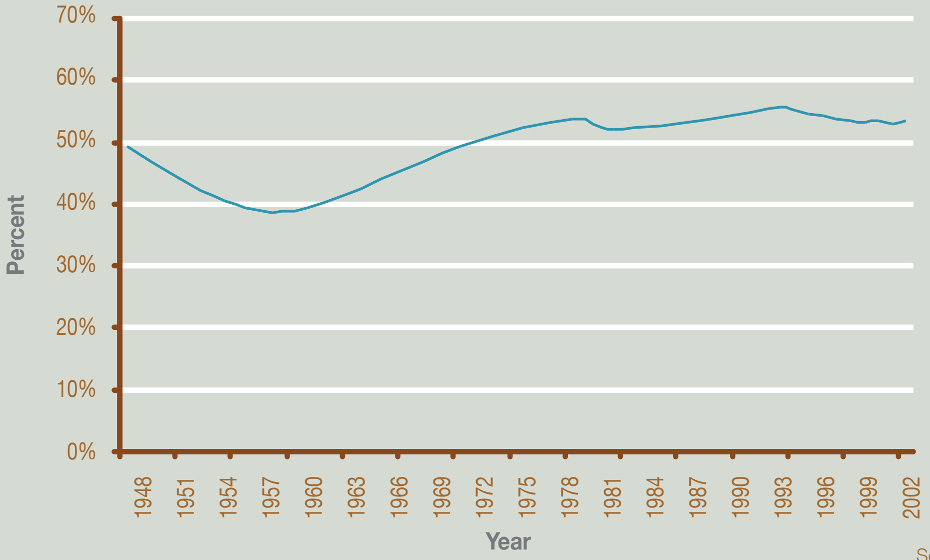
d. **Data sources** - Data provided by the Central Bureau of Statistics, based on population and housing censuses (1961, 1972, 1983, 1995), and on internal migration movements as registered in the Population Register.

e. **Data limitations** - Until 1961, data were only available for the *de facto* population. From 1961 onwards, the data relate to the *de jure* population.[9]

[9] The de facto population includes residents and immigrants residing in Israel and temporary residents. The population excludes residents who were absent from the country for more than 12 consecutive months.

6.1.3.3. Results

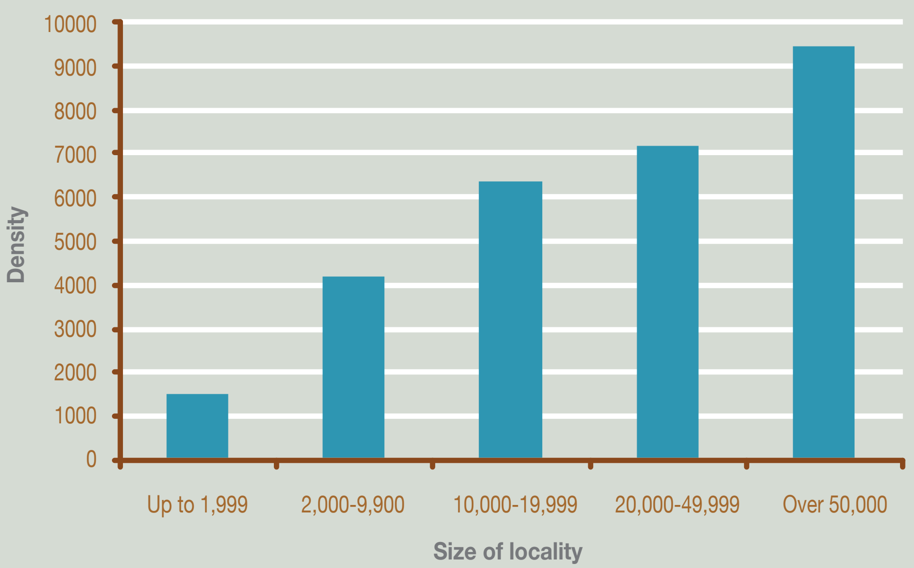
Chart 6.5 Population in Cities with over 50,000 Residents (percent)



Source: CBS

The data show that as of 1980, the percent of the population residing in localities with over 50,000 inhabitants is very stable, remaining at levels of 50-55%.

Chart 6.6 Population Density by Locality Size in (2003) (Inhabitants per km²)



Source : The Jerusalem Institute for Israel Studies

Table 6.3 Israel's Population by Type of Urban Settlement 1963-2003

Israel's Population by Type of Urban Settlement 1961-2003					
Year	**1961**	**1972**	**1983**	**1995**	**2003**
Thousands					
Over 50,000	881.4	1,592.1	2,146.0	3,121.0	3,581.7
20,000 – 49,999	471	501.3	699.5	962.1	1,470.7
10,000-19,999	175.3	350.6	350.9	471.3	595.3
2,000-9,999	309.8	345.1	419.7	547.5	538.6
Up to 1,999	341.9	358.5	421.6	510.4	562.1
Total	**2,179.4**	**3,147.6**	**4,037.7**	**5,612.3**	**6,748.4**
	Percentage				
Over 50,000	40	51	53	56	53
20,000–49, 999	22	16	17	17	22
10,000-19,999	8	11	9	8	9
2,000-9,999	14	11	10	10	8
Up to 1,999	16	11	10	9	8
Total	**100**	**100**	**100**	**100**	**100**

Source: CBS

6.1.3.4. Discussion

a. **Status and trends in Israel** - In 2003, 53% of Israel's population resided in cities with over 50,000 inhabitants.[10] Overall, the past 57 years have seen an increase in urbanization. In 1948, before the first wave of Jewish refugee immigration, 49% of the population resided in such cities. As a result of subsequent immigration waves and government policy, the rate dropped to 40% in 1955 and to a low of 39% in 1960. The period of 1961 to 1980 witnessed an increase in the percentage of the population residing in medium-sized and large cities. The rate of urbanization rose to 49% in 1972 and to 54% in 1980. In 1995, it stood at its highest rate ever: 56%. This peak did not remain at this height, falling again to 53% (see Table 6.3). The movement away from the larger cities was absorbed by smaller cities (20,000 to 49,999 inhabitants).

The decrease in the rate of urbanization in the 1950s resulted from a policy of dispersion enacted during this decade, which was intended to balance the distribution of the population and strengthen sparsely populated areas of the country, namely the Galilee and the Negev. Likewise, during this period a program entitled "from the city to the village," which encouraged families to move from cities to villages, was implemented. During the 1960s, the rate

[10] In 2003, cities of 50,000 residents or more were: Jerusalem, Tel Aviv, Haifa, Rishon le Zion, Ashdod, Ashkelon, Be'er Sheva, Bnei Brak, Bat Yam, Holon, Netanya, Petach Tikva, Ramat Gan, Herzaliya, Hadera, Kfar Saba, Lod, Nazereth, Rechovot, Ramle, Ra'anana and Beit Shemesh.

of urbanization rose as new immigrants settled in the large cities.

The source of the increase in the urbanization rate, which occurred in the first half of the 1990s, was largely the massive wave of immigration from the former Soviet Union. Unlike the previous government policy of settling new immigrants in peripheral areas, these immigrants were given the option to choose their place of residence. They were also, for the most part, characterized by a culture of urban living, and thus a significant proportion chose to settle in large cities, such as Jerusalem, Tel Aviv, Haifa, Be'er Sheva, Ashdod, Netanya, and Bat Yam, in which there was a relatively extensive supply of housing available (National Master Plan 31).

b. Sources of pressure on urbanization - The decrease in the rate of urbanization witnessed between 1995 and 2003 largely resulted from the movement of the population in the largest urban areas to medium-sized cities, often located on the outskirts of metropolitan areas. Examples of such cities include Modi'in, Rosh ha'Ayin, Hod ha'Sharon, Karmiel, Nahariya, or Kiryat Ata. It is important to note in relation to these medium-sized cities, that they are less efficient in terms of land use than larger cities with over 50,000 inhabitants, since they are characterized by lower building density. However, an increase in the population of these medium-sized cities is more efficient in terms of land use than population increases in villages and small towns, since these are characterized by an even lower building density and thus are extremely inefficient in terms of land use. In 2003, population density in large cities was 9,400 people per km^2, while that of medium-sized cities was 7,200 people per km^2. In villages, population density stood at 1,500 per km^2.

Although higher building density in cities creates more effective land usage, without suitable planning, development and management it may also lead to a decline in quality of life and the environment (air pollution, noise, lack of open space, traffic congestion and so forth). Planning and managing large cities is a much more complicated challenge in comparison to performing the same activities in small cities and villages.

The phenomenon of population growth in small cities and villages is accompanied by a number of problems and sources of pressure on the state. On the environmental level, these localities tend to expand into wide spaces (urban sprawl) and are characterized by low-density building, which is wasteful in terms of land use. As a result, their growth has led to a decline in the amount of open space, which is compounded by the need to build attendant infrastructure (transport, water, electricity, sewage), which at times cuts through or damages open areas. A further consequence of this phenomenon and the resulting sprawl has been a reduction in the amount of permeation to the water table (and a drop in its quality) accompanied by a rise in the quantity of surface water flowing into drainage and sewer systems and to the sea. The location of these localities on the outskirts of metropolitan regions has led to a greater reliance on private vehicles and a reduction in the advantages of pubic transport (which itself leads to an increase in pollution). On the economic level, these small towns and villages require substantial investment in order to create the appropriate infrastructure and public services (health, education, welfare). Social effects are also manifest since the populations of small towns and villages tend to be homogenous (in comparison to large cities). This living style allows inhabitants to be surrounded by those similar to them both socially and economically and to monitor and control the admission of different socio-economic sectors of the population. This is liable to cause a widening of social gaps and damage to social integration.

c. **Israel in an international perspective**- Because of the different definition of urban areas among countries, it is difficult to effectively compare the size of localities in Israel and the rate of urbanization with statistics from other countries and to draw conclusions on an international level.

d. **Expectation for the future** - regulation, pressure, trend - On the basis of these results, it may be possible to predict that the rate of urbanization in cities of over 50,000 inhabitants will continue to gradually decline, whilst the population of medium-sized urban cities will increase. If this occurs, with the passage of time, the populations of these medium-sized cities will grow to the point at which they themselves will become large cities with populations of over 50,000 inhabitants.

The reality described above stands in direct contradiction to two aims of sustainable development: equality between generations and equality within the present generation. The first of these represents a desire to preserve as much freedom of choice as possible for future generations, so that they may define their own way of life. A substantial decrease in the amount of available land in the coming decades will remove one aspect of this freedom. The second aim is relevant to the current situation and may be characterized as equal allocation of land resources within the present generation. In reality, it can be observed that currently 57% of the total population live in 38% of the built-up areas in Israel.

6.2. AIR

6.2.1. Carbon Dioxide Emissions per Capita

6.2.1.1. Introduction

a. **Carbon dioxide emissions per capita** - This indicator measures the contribution of Israel's population to emissions of carbon dioxide (CO_2), the main greenhouse gas, which is released, for the most part, from the combustion of fossil fuels.[11] CO_2 is one of the gases that absorbs the radiation emitted by the earth; this radiation is then transformed into heat which raises the heat of the atmosphere. In the opinion of many experts, an increase in greenhouse gas concentrations in the atmosphere leads to global warming and global climate changes. This indicator measures CO_2 emissions in tons per capita in order to facilitate international comparison.

A rise in CO_2 emissions is likely to increase the "human pressure" on the stability of the earth's climate as a result of global warming. The possible hazards which may result from this include: a rise in the heat of the earth's surface, a rise in sea level and flooding of coastal areas, an increase in extreme weather phenomena such as droughts and floods and a reduction in biodiversity as a result of harm to habitats.

b. **Carbon dioxide emissions per capita in Israel** - The total contribution of CO_2 emissions by Israel to the world total is small; however the level of emissions per capita is comparatively high and places Israel high on the international ranking, alongside developed western European countries. Over 95% of Israel's CO_2 emissions result from fuel combustion, whose main contributors are the energy industry and land transport.

[11] Indicators of Sustainable Development, Eurostat, 1997

c. **Relation to international conventions and treaties** - The United Nations Framework Convention on Climate Change was signed at the 1992 Earth Summit in Rio de Janeiro. This treaty, designed to address global warming, called for a reduction of greenhouse gas emissions to 1990 levels and for their stabilization within the following decade. However, no specific steps were included within the treaty to ensure this reduction. In 1997, the Kyoto Protocol was signed, which set targets for emissions reduction by developed countries and established reporting and follow-up mechanisms. Israel ratified the Climate Change Convention in 1996 and the Kyoto Convention in 2004.

6.2.1.2. Methods

a. **Definition** - Carbon dioxide is a colorless, odorless and non-poisonous gas, created as a result of burning carbon in the presence of enough oxygen and also as a result of the breathing processes of both animals and plants. Conversely, the process of photosynthesis in plants absorbs carbon dioxide from the atmosphere.

   Carbon dioxide emissions per capita are calculated by dividing the total anthropogenic emissions in Israel (apart from breathing) by the average annual population.

b. **Unit of measurement** - tons per capita.

c. **Methods of calculation** - Two series of data are presented:

   1 – Total amount of CO_2 emissions per capita.

   2 – CO_2 emissions per capita as a result of fuel combustion only.

   Emissions in the first series were calculated according to the guidelines and coefficients of the Intergovernmental Panel on Climate Change (IPCC). Emission sources include fuel combustion in energy production, industry, transport and various other industrial processes (such as cement production). Emissions were calculated using CO_2 emission coefficients in accordance with the quantities of fuel and raw materials consumed. In addition, the amounts of CO_2 absorbed by forests were calculated and deducted from the total emissions.

   Emissions in the second series were calculated on the basis of the coefficients provided by the Air Quality Division of the Ministry of the Environment, in accordance with the amounts of fuel consumed.

d. **Data sources**

   CO_2 emissions in the first series (1996, 2000) – Air Quality Division, Ministry of the Environment.

   CO_2 emissions in the first series (2003) and the second series – Central Bureau of Statistics.

   Average annual population - Central Bureau of Statistics.

e. **Data limitations** - In the first series, total CO_2 emissions were calculated for the years 1996, 2000 and 2003. In the second series, the calculations represent CO_2 emissions from fuel combustion alone for the years 1980 to 2004. Since CO_2 emissions from fuel combustion account for more than 95% of the total emissions, and since statistics for these emissions exist in the Central Bureau of Statistics for a substantial time period, this series is also presented.

Most CO_2 coefficients are general and only take into account the amounts of fossil fuels and raw materials consumed and not the specific technologies involved in the combustion process. There are some differences between the calculated amounts of emissions in these two series, due to variations in methodology, data sources and coefficients.

6.2.1.3. Results

- **Series 1**

- CO_2 emissions in the year 2003 totaled 63,729 thousand tons. This total demonstrates a 4% increase compared to the year 2000 and a 23% increase compared to the year 1996.

- Emissions from fuel combustion account for 97% of total emissions for the years for which totals were calculated.

The data for CO_2 emissions are detailed in Table 6.4 as follows:

Table 6.4: Emissions of CO_2 (1000 tons)

	1996	2000	2003
Total	**51,862**	**61,007**	**63,729**
From fuel combustion	50,344	58,917	62,015
From other sources	1,518	2,090	1,715

Source: Ministry of the Environment, CBS

CO_2 emissions per capita for the years 1996, 2000 and 2003 totaled 9.12, 9.7 and 9.53 tons respectively. These statistics demonstrate a rise of 6% from 1996 to 2000 and a decline of 2% from 2000 to 2003.

The distribution of CO_2 emissions by source depicts different trends. While emissions originating from energy, industry and transport increased by 20% and 13% respectively, emissions from manufacture and construction declined by 22%.

Table 6.5 Emissions of CO_2 Per Capita (Tons)

	1996	2000	2003
Total	**9.12**	**9.70**	**9.53**
From fuel combustion	**8.86**	**9.37**	**9.27**
Thereof:			
Energy industries	5.01	5.79	5.99
Manufacture and construction industries	1.18	1.10	0.92
Transportation	1.94	2.23	2.19
Fuel combustion, other	0.73	0.25	0.17
Other sources	**0.27**	**0.33**	**0.26**

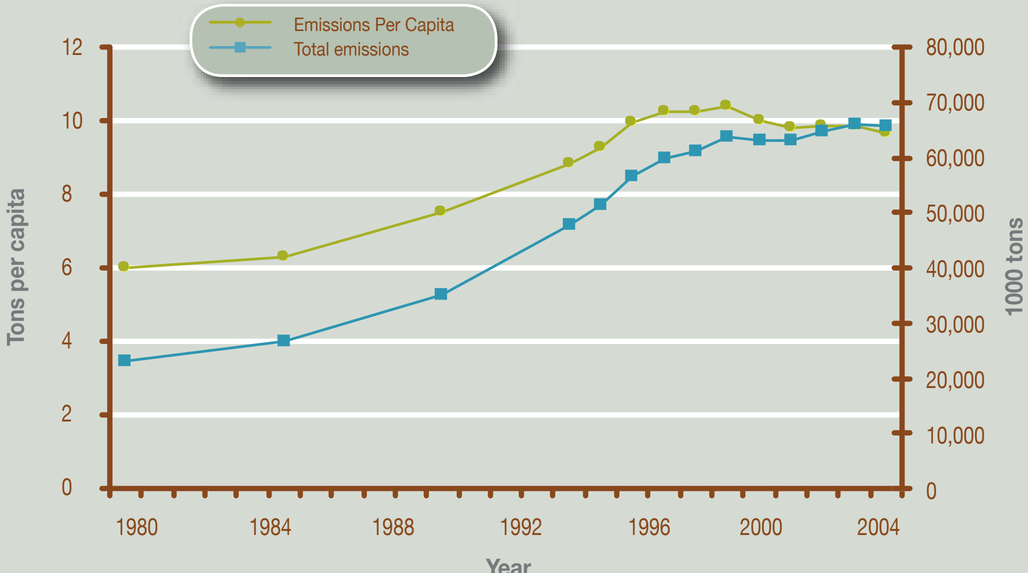
Source: Ministry of the Environment, CBS

Over the years, fuel combustion in the following sectors has accounted for most of the total CO_2 emissions per capita: energy production (about 60%), transport (about 20%) and the manufacture and construction industries (about 10%) (see Table 6.5).

- **Series 2**

A continuous rise in total CO_2 emissions was observed until the late 1990s; this stabilized at the onset of the new millennium. Emissions per capita stabilized since the mid 1990s and even declined slightly from the onset of the new millennium.

Chart 6.7 Emissions of CO2 from Fuel Combustion, Total and Per Capita Emissions

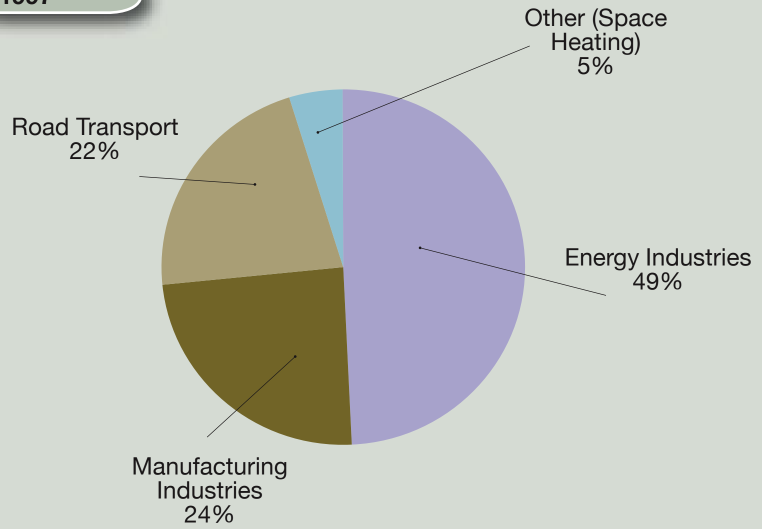


Source: CBS

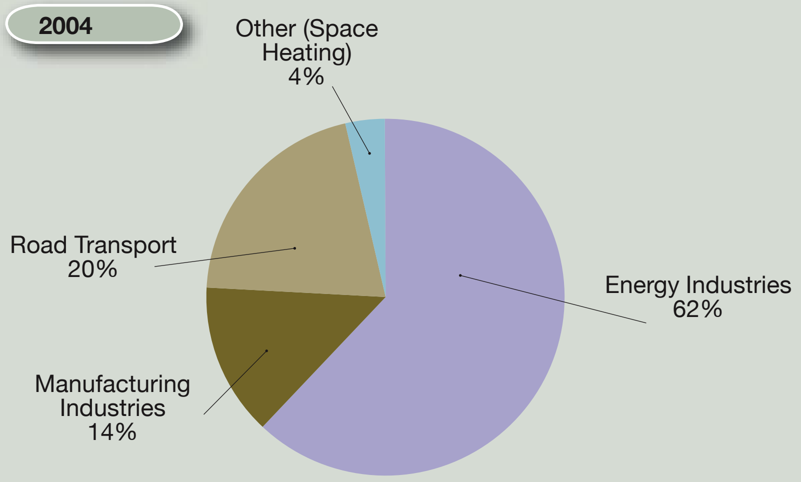
The distribution of emissions from fuel combustion by major sectors, particularly energy production, transport and the manufacture and construction industries, for the years 1997 and 2004 is presented in Chart 6.8. Between the years 1997 and 2004, the contribution of the energy industry rose from 49% of emissions to 60%. At the same time, the contribution of the manufacture and construction industries declined from 24% to 14%

Chart 6.8 Distribution of CO_2 Emissions from Fuel Combustion by Source

1997



2004

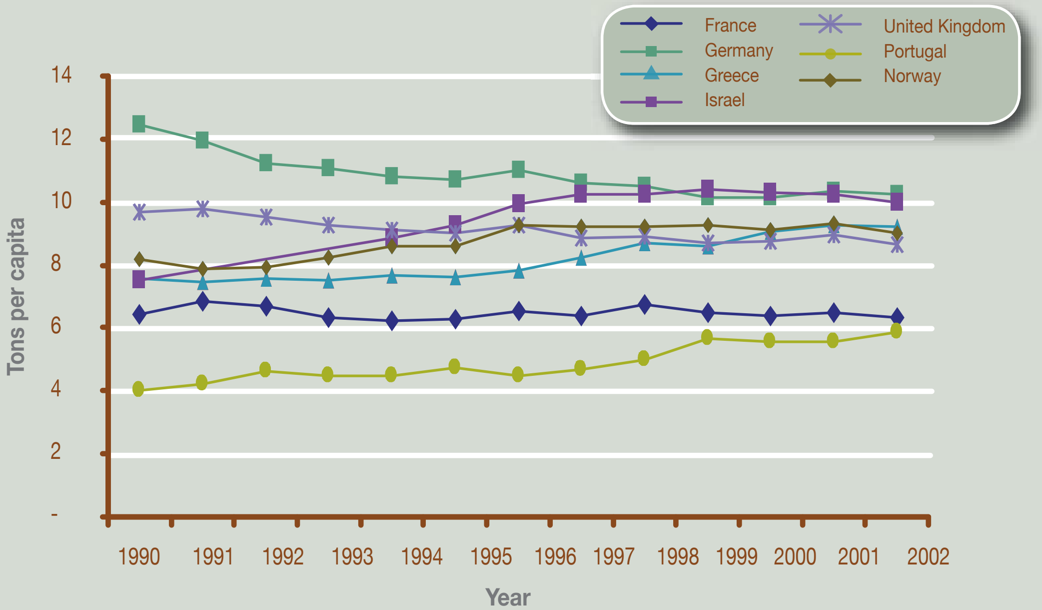


Source: CBS

- **International comparison**

Israel's total CO_2 emissions per capita were in the lower range of European countries in 1990 and reached the level of the highest European country (Germany) in 2002. However, since 1997, a trend of stabilization has occurred in Israel as well as in other European countries.

Chart 6.9 CO_2 Emissions Per Capita from Fuel Combustion by Country



Source: IPCC, US Census bureau, Population Division

6.2.1.4. Discussion

a. **Status and trends in Israel** - Over the past three decades, there has been a sharp rise in total CO_2 emissions in Israel. This trend began to moderate and stabilize since the year 1997. A similar trend was observed for CO_2 emissions per capita. However, since 1999, a moderate decline has been noted. These trends are in accordance with those revealed in the energy consumption per capita indicator and the changes in standard of living presented in the GDP per capita indicator. These changes resulted from a combination of economic factors. On the one hand, the rise in CO_2 emissions per capita in the energy and transport industries resulted from the rise in standard of living, whilst at the same time, the decline in CO_2 emissions per capita in the manufacture and construction industries resulted from the decline in activity in these sectors.

b. **Sources of pressure** - Continued anthropogenic CO_2 emissions result in constant pressure on the environment and global warming. This cannot be directly linked to one specific country but is rather the result of the combined emissions of all of the world's states. Within the framework of international decisions to reduce emissions, it was determined that each country must work towards and contribute to the global effort to reduce greenhouse gas emissions.

Economic growth leads to rises in standards of living and to increased energy consumption. In Israel the main sectors which contribute to CO_2 emissions are the energy and transport sectors. In order to slow the rate at which the atmosphere's temperature is currently rising and to reduce harm to future generations, it is necessary to take action to reduce emissions from these sectors in particular.

Amongst the possible ways in which CO_2 emissions can be reduced are:

- Using technologies for energy production which are not dependent on fossil fuel combustion, such as solar, nuclear, and wind energies.
- Increasing the efficiency of energy production, for example by means of technologies which utilize the residual heat created in power stations.
- Using energy saving systems and reducing energy consumption by insulating structures and changing energy consumption patterns.
- Improving transport efficiency by, for example, shifting to public transportation and energy saving vehicles.

c. **Legal situation** - Israel is not defined as a developed country according to the Climate Change Convention and therefore it is not currently subject to any practical limitations on greenhouse gas emissions, although it must report its national inventory of anthropogenic emissions and removals. Within the framework of the Kyoto Protocol, a mechanism has been developed (the Clean Development Mechanism), which allows flexibility in meeting the reduction targets of developed countries in return for their investment in emission-reduction technologies in developing countries.[12]

Israel, which created a Designated National Authority for the Clean Development Mechanism in 2004, is able to voluntary reduce emissions through accepting investments of developed countries in emission reduction technologies. In 2005, Israel and Italy signed a Memorandum of Understanding on cooperation in the area of climate change and development and implementation of projects under the Clean Development Mechanism.

d. **Israel in an international perspective**- At the beginning of the 1990s, Israel experienced a sharp rise in CO_2 emissions, whilst during the same period in Europe most countries maintained stable levels of emissions; in some countries there was a moderate rise in emissions whilst others experienced a decline.

As was the case in Israel, stabilization of CO_2 emissions per capita began internationally towards the end of the 1990s. The level of CO_2 emissions per capita in Israel in the year 2003 was very similar to that of European states with high emissions levels.

e. **Future expectations: regulation, pressure and trends** - Within the framework of the Climate Change Convention,

[12] CDM, Environment Ministry, March 2004, Second Edition.

Israel's position is likely to change in the coming years from the status of a developing country to that of a developed one. This change will force Israel to take action to reduce CO_2 emissions in order to meet the reduction targets which will be imposed on it.

If Israel's economic growth will continue in coming years, a rise in energy demand will likely result in a concomitant rise in CO_2 emissions. This will occur if Israel continues to use fossil fuels in energy production and transport. If, however, a substantial application of means for emission reduction in electricity production and public transport occurs, the trend of moderation in CO_2 emissions is likely to continue and a reduction in total emissions would be possible.

6.3. WATER

6.3.1. Salinity of Groundwater in the Mountain and Coastal Aquifers

6.3.1.1. Introduction

a. **Groundwater salinity** - This indicator measures one aspect of the natural characteristics of water resources. Its integration with pollution indicators and water level indicators reflects the general condition of the aquifers.

The indicator monitors changes in chloride concentrations in aquifers over time as a function of water management. Groundwater salinity is an important indicator of water quality and is an important tool for determining the state of a country's water resources. Changes in groundwater salinity are significantly influenced by human activity and therefore, on the basis of indicator trends, countries can assess damages caused by certain actions and formulate strategies for coping with these damages.

The indicator is especially relevant for sustainable development since it relates to both present and future generations. Increased salinity in a specific freshwater source means access to poorer water quality for the population that relies on that source. It also means that damages to this body of water may be irreversible, hence depriving future generations of the ability to depend on this source as a freshwater source.

b. **Groundwater salinity in Israel** - Israel is highly dependent on groundwater for freshwater supply. 70% of Israel's freshwater supply comes from groundwater, mainly from two aquifers: the coastal aquifer and the mountain aquifer. Furthermore, due to the climatic conditions in the country and the increasing demand for freshwater, water quality is subject to a continuous risk from human overexploitation of water resources[13].

6.3.1.2. Methods

a. **Definition** - Annual average of salinity (chloride concentrations) measured from all drills and wells in the coastal and mountain aquifers, several times per year for each aquifer, since 1957.

b. **Unit of measurement** -The data refer to concentrations and are presented in milligrams of chloride per 1 liter of water (mg /l chloride).

13 Haim Gvirtzman, 2002, Israel Water Resources

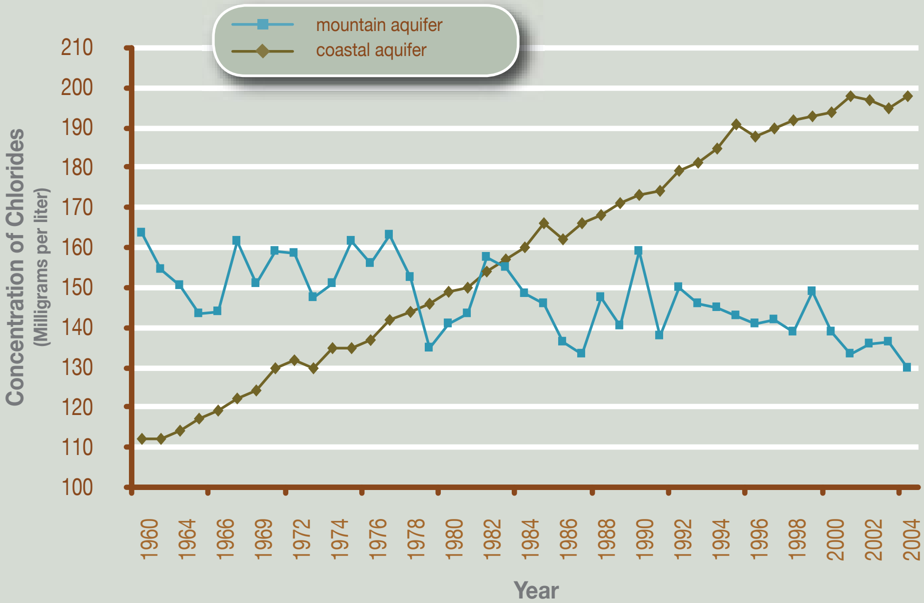
c. **Data source**: Hydrological Service.

d. **Data limitations**

- There may be cases in which the number and location of drills were altered and therefore these were eliminated from the database.
- In cases where drills went out of service, the salinity data are included in subsequent years and the last result is imputed in the following year.
- In some cases, measurements may not represent water quality in the aquifer and may be biased.

6.3.1.3. Results

Chart 6.10 Groundwater Salinity



Source: Hydrological Service

Salinity in the mountain aquifer fluctuates over the years with no clear trend, and salinity levels in the past 45 years have ranged between 130 to 164 mg /l chloride. Nevertheless, the current state does not necessarily predict future salinity trends for the mountain aquifer. Extreme changes in the aquifer's water level may cause its high-quality water to become diluted with other water bodies that have higher salinity. Such water bodies exist in the western parts of the aquifer and in some of its deep regions.

The coastal aquifer depicts a clear trend of increase in water salinity. The average increase is 2 mg/l chloride per year, from 112 mg/l in 1960 to 197 mg/l in 2004. If the current trend continues, salinity is expected to reach a level of 250 mg/l chloride in 2028.

International standards recommend a maximum concentration of 250 mg/l chloride (World Health Organization, 2004), but in Israel, this concentration is only the recommended threshold and the maximum permitted concentration is 600 mg/l chloride.

6.3.1.4. Discussion

a. **Status and trends** - Salinity in the mountain aquifer has remained within accepted levels throughout the years, and does not present an apparent trend of increase. On the other hand, the state of the coastal aquifer has deteriorated over the last five decades. Therefore, the discussion will mainly focus on the coastal aquifer.

- **Over pumping in the vicinity of the seawater/groundwater interface** - Near the coastline, there is a pressure balance between the freshwater of the coastal aquifer and the salty water of the sea. The intensity of the water pressure is determined by the water density and water level in the aquifer. In the vicinity of the interface (the boundary that separates between seawater and freshwater), the water of the coastal aquifer has low salinity and density. The density of the seawater, however, is higher and therefore exerts higher pressure per an equal volume of water. In order to apply equal pressure in the opposite direction, the aquifer level has to be higher than the sea level. A decline in aquifer water level as a result of over pumping reduces the pressure exerted by the aquifer water and disrupts the balance between the two water bodies. As a result, seawater flows in the direction of the coastal aquifer and salinates its water. At present, this phenomenon is limited to a distance of 1.5 to 2 km from the interface. Seawater intrusion into the coastal aquifer has raised water salinity to high levels and as a result, pumping from many wells along the coastline has been terminated.

- **Penetration of saline water from lateral flow from the east** - In the eastern border of the coastal aquifer, mainly in its central and southern parts, there is a natural process of saline water penetration from neighboring aquifers. This salination is also affected by the aquifer interface and it appears that low water levels intensify the salination process.

- **Human activity above the aquifer and aquifer management** - Salination is mainly caused by the soil interface above the aquifer. Unsustainable management of the aquifer in Israel has led to a reduction of natural drainage so that the natural drainage of salts to the sea is virtually non-existent. Instead of the natural drainage process, the water is abstracted in a closed system that causes inevitable accumulation of salts. In addition, several other processes intensify the salination load, including:

  - Irrigation with water from Lake Kinneret (Sea of Galilee) whose salinity is higher than the salinity of the aquifer (250 mg/l chloride on average).

  - Irrigation with effluents. Domestic and industrial water use adds salts to the wastewater and causes salination that penetrates to the aquifer.

  - Partial evaporation of irrigation water as well as salinity on the ground surface increase the concentration of salts in the water prior to penetration into the aquifer.

- Discharge of effluents and untreated sewage from domestic and industrial sources into streams leaches into the aquifer and causes salination.

- The use of fertilizers and pesticides increases salination since they penetrate into the aquifer with irrigation or rainwater.

- Recharge of excess water from Lake Kinneret, streams or effluents, such as effluent recharge in the Dan Region Reclamation Project, causes salination because these water sources have higher salinity levels than groundwater.

b. **Sources of pressure**

Environment

- Increased salinity in the coastal aquifer increases the salinity of drilled well water.

- Increased water salinity causes ecological changes to wetland habitats.

Society

The present generation

- Higher salinity means lower water quality.

- Inequality within the generation: The poorer population that solely relies on water from aquifer wells drinks low quality water, whereas the more affluent population can afford purification systems and bottled mineral water.

- Farmers have to cope with saline water, which limits cultivation methods and crop variety.

- Various industries, which depend on low salinity water for their production processes, have to invest in technology for reducing water salinity.

- Increased water salinity reduces the abstraction potential of the water economy. In drought years, the ability to maneuver between different water sources decreases, and the capacity to cope with water crises is limited.

- Increased aquifer salinity is only considered a nuisance since it changes the flavor of the water, but it is not expected to become a direct health hazard. Therefore, it does not harm present generations.

- Other indicators of water quality, such as concentration of carcinogenic substances, faecal coliforms and nitrates, may indicate more concrete health hazards.

Future generations

- In the long run, the trend of increasing salinity threatens the use of the coastal aquifer as a drinking water source. If this trend continues, the salinity level in the coastal aquifer may exceed the recommended level of 250 mg/l chloride by the year 2028. Water abstraction is not expected to stop, but water quality will decline. This will be problematic to the public and will increase the financial burden on future generations that will need to desalinate the aquifer water or generate alternative water sources.

- Increased water salinity will reduce the range of agricultural and industrial possibilities for future generations, in terms of production methods and variety of crops and goods.

- Increased salinity will pose difficulties for the coming generations: It will reduce the abstraction potential and consequently, the capacity to cope with crisis situations. These may include drought years, increased cost of energy for water desalination and higher corrosion of water supply infrastructure.

- There have been claims that increased salinity may increase the proportion of blood circulatory system diseases and hypertension.

Economy

- Water source salination contradicts sustainable development policy. A decline in drinking water quality requires future investment in water treatment measures such as desalination.

- Aquifer salination will limit the agricultural activity in the area of the coastal aquifer, and may even end it completely. This may cause financial losses to the agriculture sector and limit Israel's food production capacity. This trend may also increase pressures to change land use designations from agricultural land to built-up areas.

c. Recommendations for further research for the indicator

- Other indicators related to water quality, such as drinking water quality, stream water quality, or aquifer condition, should be examined.

- The resolution of the indicator should be determined (i.e., entire coastal aquifer, certain parts, etc.) in order to estimate trends and provide alerts for specified areas.

- The extent to which the current indicator integrates with other water quality indicators in the coastal aquifer and in general should be estimated.

- On the assumption that human activity above the aquifer significantly contributes to its salination and can be controlled by enforcement policy, some of the response actions may be defined as new indicators as well. A possible example for such an indicator is the volume of collected farm animal waste.

- In the mountain aquifer, the indicator should be as precise as possible in order to measure the risk of salination in the entire aquifer, including the penetration of water from neighboring saline water bodies.

6.4. ECONOMIC ACTIVITY

6.4.1. Number of Passenger Cars per 1,000 Inhabitants (Motorization Rate)

6.4.1.1. Introduction

a. Motorization rate - The motorization rate or the number of passenger cars per 1,000 inhabitants is a common indicator in international comparisons of economic development and quality of life. High motorization levels are usually equated with high levels of economic development and quality of life, although the relationship is definitely not synchronized.

From the perspective of sustainable development, the motorization rate can be used as an indicator for the pressures exerted by human activities on both the natural and the built-up environment. There are multiple environmental pressures related to high motorization rates, which include the use of non-renewable energy sources, local and global air pollution, reduction in open space, and fragmentation of natural habitats.

It is notable that the severest environmental impacts are related to car *use* rather than car *ownership*. This is especially true for the use of non-renewable energy sources, as well as local and global air pollution. For this reason, various bodies use indicators linked to car use rather than ownership, such as the total number of passenger kilometers, passenger kilometers per person, or energy use by the transport sector. The last criterion is used as the key transport indicator by the EU Sustainable Development Strategy.[14] Since data on car use are generally less easily accessible or more difficult to compare, and since car ownership generally translates into car use at the personal level, motorization rates can be used as an important and 'proxy indicator' of the environmental pressures generated by the transport sector.

b. Motorization rate in Israel – Israel is a country with a relatively high population density and a high growth rate. At the same time, it is also a small country whose population is mainly located in the center of the country. Therefore it would be important to view the data on this indicator together with data on the infrastructure required to respond to the increase in the motorization rate in a country such as Israel.

c. Relation to international convention and treaties – Not applicable.

6.4.1.2. Methods

a. Definitions -The motorization rate is the number of passenger cars per 1,000 inhabitants.

b. Data sources - The Central Bureau of Statistics, based on statistics of the Licensing Department of the Ministry of Transportation. The data include the register of licensed vehicles in Israel, which is comprised of all classes of private vehicles licensed until the end of the current year, or whose license expired during the course of this year.

c. Data limitations -

- Since 1960, data have not included vehicles whose licenses have been invalid for more than one year. It is

[14] For a short description of the transport indicators used for the EU Sustainable Development Strategy see the internet site of Eurostat: http://epp.eurostat.cec.eu.int/portal/page?_pageid=1998,47433161,1998_47437045&_dad=portal&_schema=PORTAL.

probable that there are vehicles in use whose license has expired and thus are not found in the official register. At the same time, vehicles not used in Israel (for example, those banned from the road) were not subtracted from the total figure.

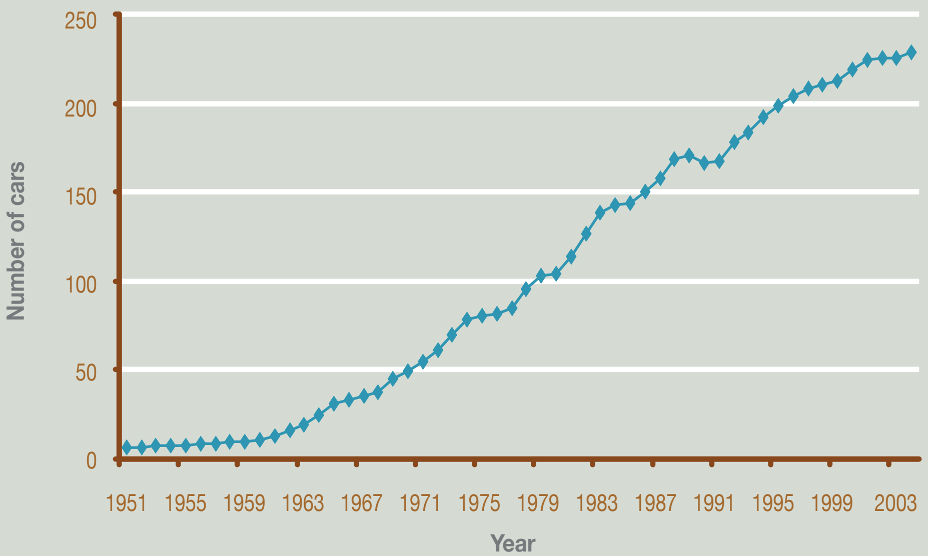
- The data relate only to private vehicles and include rented and company cars but not taxis, buses, trucks, army and police vehicles, towed vehicles, tractors, vehicles belonging to foreign citizens or those holding temporary driving licenses, vehicles belonging to tourists in the country for less than three months, or diplomatic and UN vehicles.

- In addition to the above limitations, the data on the motorization rate do not include mopeds, scooters and motors. This is especially relevant for the international comparison, as the importance of two-wheeled motorized vehicles differs substantially between countries (see below).

6.4.1.3. Results

Between the years 1951 and 2004, there was a continuous increase in the number of private cars per 1,000 residents in Israel. In these years, the motorization level increased from 6 cars per 1,000 residents in 1951 to 11 in 1960, 49 in 1970, 105 in 1980, 167 in 1990 and 228 in 2004. The accelerated growth rate was most substantial in the periods of 1960-1969 (an increase of 300%) and 1970-1979 (an increase of 111%). There was a small decrease in the rate of motorization in the years 1989-1990 which resulted from a population increase in the wake of the mass wave of immigration from the former Soviet Union, which was faster than the rate of the immigrants' acquisition of new vehicles. On the basis of current conditions, it is anticipated that the increase in the rate of motorization will continue in coming years.

Chart 6.11 Number of Private Cars per 1000 Inhabitants



Source: CBS, Ministry of Transport

International comparison

International comparison shows that Israel has a substantially lower motorization rate than Western European countries, but a higher one than Eastern European and some of the poorer countries in the Mediterranean Basin. The motorization rate in the large Western European countries ranges between 400 and 600 cars per 1,000 inhabitants. Among the Mediterranean countries, Italy has the highest motorization rate with 590 cars per 1,000 inhabitants. As in other countries, motorization rates in Israel have risen, but generally at a slower pace: for example, the motorization rate in OECD countries has increased at a rate of 2.7% per year during the period 1970-1992.[15] In most Western European countries, this growth slowed down during the 1990s to 1-1.5%, but has been substantially higher for Spain and Greece. Amongst the countries in the Mediterranean Basin, Israel is most comparable to Greece, although car ownership levels have seen a stronger increase in Greece than in Israel.[16]

Table 6.6 Motorization Rates in Selected Countries.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Annual growth
United state	-	-	-	733	739	750	747	752	762	771	-	-	0.9%
Western European countries													
Germany	489	447	478	488	495	500	504	508	516	532	539	541	1.0%
France	417	419	423	430	434	439	448	459	469	476	485	490	1.6%
United kingdom	383	382	371	376	374	387	397	403	414	420	433	447	1.5%
Netherlands	370	373	376	383	366	374	380	390	401	411	418	424	1.3%
Countries from the Mediterranean basin													
Spain	322	336	344	351	362	376	389	407	425	437	451	460	3.9%
Italy	503	518	521	540	529	531	535	548	556	564	579	590	1.6%
Greece	173	177	189	199	207	218	232	247	269	293	312	331	8.3%
turkey	-	-	-	-	51	54	58	61	64	68	66	66	4.2%
Israel	168	178	184	192	198	204	208	211	212	220	224	225	3.1%

Source: Eurostat 2005

15 OECD/ECMT (1995) Urban travel and sustainable development. Paris, OECD/European Conference of Ministers of Transport (ECMT), pp. 34-36.

16 Eurostat: http://epp.eurostat.cec.eu.int/portal/page?_pageid=1996,39140985&_dad=portal&_schema= PORTAL&screen=detailref&language=en&product=Yearlies_new_transport&root=Yearlies_new_transport/G/en032.

6.4.1.4. Discussion

a. **Status and trends** -The increase in motorization rate over the past decades is a result of a complex combination of factors, including economic, demographic, urban/land use factors, as well as policy factors.

In economic terms, rising income levels over the past decades have enabled more and more Israeli households to purchase cars. During the same period, the costs of buying and running a car have dropped in real terms, while the price of public transport tickets has risen. Moreover, tax policies have given strong incentives for car purchase and use. This includes the widespread practice of linking salary payments to car ownership, most notably among employees in the government sector. Tax regulations have contributed tremendously to the rising popularity of car leasing in recent years, among both employers and employees. The popularity of car leasing is reflected in sales figures: leased cars currently account for more than half of all new car sales in Israel, a figure that is substantially higher than in many European countries.[17] Free gasoline is usually part of leasing contracts, which further stimulates the use of the private car for both work and other purposes. In contrast, employers can only cover a limited amount of public transport costs for the employee without paying taxes on this compensation.[18]

The rise in car ownership levels is also intricately linked to the investments in road infrastructure over the past decades. Investments have made it more attractive to drive a car, thus encouraging people to purchase vehicles; in turn, rising car ownership levels have triggered ongoing investment in road infrastructure. Road improvements have contributed to the spread of land uses over larger geographical areas, resulting in the growth of suburbs around the major urban centers and the development of employment and retail centers along major roads. Neighborhoods and employment centers located in the suburbs were especially designed for cars, while existing urban areas were not adapted to growing car use, thereby limiting the possibilities of car-free mobility. The introduction of minimum parking norms in the early 1970s further strengthened the trend towards a land use pattern developed around the needs of the private car. Overall, both transport and land use policies have focused on the private car rather than on other modes of transport.

Demographic factors have added to these factors: older generations which were not accustomed to car use have been 'replaced' with new generations raised in a car-oriented society, thus further contributing to an overall rise in car ownership levels.

b. **Sources of pressure** - Rising motorization rates result in a number of pressures on Israeli society. The most important, from the perspective of sustainable development, is obviously the environmental pressure that is generated by car ownership and use. From the perspective of the Israeli population, the most crucial environmental pressure is the rise in air pollution in urban areas. From a global perspective, Israel's rising contribution to resource depletion and the greenhouse effect needs to be considered.

17 Haaretz English Edition, Leasing firm New Kopel-SIXT targets non-corporate clients, 10 October 2005.
18 Windsor, A. and M. Omer (2005) Transport to the workplace: current situation in Israel. Tel Aviv, Transport Today & Tomorrow/Ministry of the Environment (Hebrew).

The second pressure concerns the transport sector itself and is related to the demand for road space that results from the increasing motorization rate. While car ownership does not necessarily imply car use, it usually does result in this when transport alternatives are perceived as unattractive and inefficient, which is largely the case in Israel. As a result, the increase in the motorization rate has resulted in a strong growth in the number of kilometers traveled by car. Road building has not been able to keep pace with the growth in car ownership, largely because road building in itself is a trigger for growing car ownership. Data underline this tension: while car ownership rose by 800% and car kilometers increased by 700% in the period 1970-2000, the area used for roads increased by 'only' about 100%.[19] The result has been a strong growth in traffic congestion with all its related costs to the economy in terms of lost working hours and productivity.

The second pressure is also directly related to the increasing road congestion on the main highways to and around the large cities, which has strengthened the processes of sub-urbanization of population, employment and retail centers. The outer ring of the Tel Aviv metropolitan area, for instance, has seen its share of the total regional population grow from 54% to 60% during the period 1995-2000, at the expense of the center and the inner circle of the metropolitan area.[20] This process of sub-urbanization and the related extension of the road system threaten to diminish the limited open space on Israel's coastal plain. This can have far-reaching consequences in terms of air and water quality, water quantity in the coastal aquifers, the urban heat island effect and general quality of life.

The growing motorization rate may also further increase Israel's dependence on imports of cars and gasoline. Israel has no automobile industry and hardly any natural energy sources and thus heavily depends on imports. Gasoline use in Israel has grown by 134% in the period 1985-2000, in comparison to a population growth of 49%. The rise in prices of crude oil and gasoline since 2004 suggests that dependence on imported oil may become a large burden for the Israeli economy.[21]

c. International perspective - The motorization rate in Israel is low in comparison to other developed countries in the Mediterranean Basin such as Spain or Italy. Furthermore, the growth in car ownership levels in Israel is well below the increase in Greece over the last decade. These observations are easily translated into an expectation of a further increase in the motorization rate in the coming years. However, it remains to be seen whether car ownership levels in Israel stay low if they are correlated with key factors that influence the motorization rate. These factors include level of economic development and demographic situation.

The level of economic development is one of the key factors that influence car ownership levels, with richer countries generally characterized by higher motorization rates. While the relationship is definitely not balanced, it seems clear that an improvement in the

19 Hanson, M. (2004) Where are we moving to? Transport policy and the environment. Tel Aviv, Babel Publishing House, pp. 7-8 (in Hebrew).
20 Hanson, M. (2004) Where are we moving to? Transport policy and the environment. Tel Aviv, Babel Publishing House, pp. 27-32 (in Hebrew).
21 Hanson, M. (2004) Where are we moving to? Transport policy and the environment. Tel Aviv, Babel Publishing House, pp. 13-15 (Hebrew).

economic situation within a country will generally go hand in hand with higher car ownership levels, *ceteris paribus*. Given the differences in economic level between most Western countries and Israel, it may come as no surprise that Israel currently has a lower motorization rate.

Second, demographic factors are important in interpreting motorization rates for a number of reasons. One of these is the share of the population below driving age (in most countries 18 years). The smaller the share of young people in the total population, the higher the motorization rate will be, *ceteris paribus*, since car ownership is only relevant for the population that is allowed to drive. In this sense, it would be better to calculate the motorization rate for the adult population. The number of households also plays a role, as car ownership is a household rather than a personal decision and most car-owning households still possess 'only' one car. Thus, the more households in a country in comparison to its population, the higher the motorization rates may be expected to be.

A third demographic factor concerns the historical development in car ownership levels. If car ownership started to develop relatively recently, a large share of the older population may be expected to be without cars.

All these factors suggest that Israel's motorization rate is not as low as it seems to be at face value: Israel has a relatively young population, a relatively low number of households per 1,000 inhabitants, and a relatively large share of older people without a driving license.

d. Expectations for the future - Expectations for the future are mixed. On the one hand, the Israeli government plans to invest a substantial share of its budget in the extension of the country's road infrastructure. These investments are partly a response to the high levels of congestion in the existing road system, but also a response to the expectation of ongoing growth in car ownership to 'European' levels. Obviously, the investments themselves will substantially contribute to this growth. On the other hand, current government policies show a redirection towards a more sustainable transport system. This is reflected in the investments in new train lines and stations, the development of light rail and rapid bus transit systems in major cities, initiatives to improve the quality of the bus system and changes in the planning system (among which are people-friendly guidelines for street design and restrictive parking norms). These initiatives suggest that sustainable modes of transport will be in a better position to compete with the private car in the future. However, given the time needed to implement the various initiatives, the ongoing massive investments in road infrastructure, and the existence of financial incentives for car use as mentioned above, it may be expected that the motorization rate will continue to grow in the coming years.

6.4.2. *Annual Energy Consumption per Capita*

6.4.2.1. Introduction

a. General description and relevance to sustainable development – Energy use is a key aspect of consumption and production. It has been traditionally regarded as a driving force for economic progress. However, increasing energy production, use and the resulting byproducts, have had major impacts on the environment, including air pollution, depletion of natural resources and more. The major challenge facing sustainable development with regard to energy consumption is decoupling energy use from development. The long-term aim for development and prosperity is to meet energy demands through greater efficiency rather than through an increase in energy production [(1)].

The energy consumption per capita indicator is closely linked to many other economic and environmental indicators, such as population growth, GDP per capita, transport fuel consumption, environmentally adjusted domestic product, proven energy reserves, consumption of renewable to non-renewable energy resources, land use change, energy use in agriculture, emissions of greenhouse gases, production of ozone depleting substances, generation of waste, etc. [(2)]

b. **Energy consumption in Israel** – The Israeli strategy for sustainable development defines a number of goals, among them the conservation of land, water and energy resources. The indicator of energy consumption per capita is regarded as one of the indicators for measuring progress towards this goal. Within the set of indicators derived from the Israeli strategy, this indicator is part of the component concerning efficient use of resources [(3)].

Today about 90% of energy use in Israel is based on imported fossil fuels, and although research and development in the field of solar energy use is advanced there remains much work ahead, in terms of implementing new technologies[(4)]. It is also worth mentioning that the highest rate of increase in energy consumption in Israel is in electricity use: approximately 3.5% of annual growth in the past ten years. Electricity consumption comprises about 25% of the total energy consumption in Israel. Furthermore, out of the total primary energy supply (fuels) in the year 2004, 51% was used for electricity production. This has implications for the energy efficiency solutions that Israel needs to develop.

c. **Relation to international conventions and treaties** – Agenda 21 states two main objectives related to energy consumption[(5)]:

   i. To promote patterns of consumption and production that reduce environmental stress and meet the basic needs of humanity.

   ii. To develop a better understanding of the role of consumption and how to bring about more sustainable consumption patterns.

   The indicator of energy consumption per capita is used to monitor progress towards achieving these goals.

6.4.2.2. Methods

a. **Definition** – The amount of energy – liquid, solid, gas or electricity - used by an individual in a given year in the country. The consumption is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. The data used

(1) Indicators for Sustainable Development in the Mediterranean Region, Blue Plan, 1999.
(2) United Nations Department of Economic and Social Affairs: http://www.un.org/esa/sustdev/natlinfo/indicators/indisd/english/chapt4e.htm
(3) Sustainable Development Indicators in Israel, Summary Report Phase 1, 2004.
(4) Agenda 21and the Rio Declaration, Background and Israeli Aspects, Ministry of the Environment, 2002.
(5) United Nations Department of Economic and Social Affairs http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter4.htm

to calculate this indicator are the total primary energy supply (TPES), which specify all the energy at the disposal of the economy in the period under review. The use of these data enables international comparisons. The amount of energy is divided by the average population at a given year.

b. **Unit of measurement** – Tons of oil equivalent (toe), which equal 10^7 kilocalories. Conversion into this unit is based on the net calorific value of each energy product.

c. **Data sources** -

   I. Crude oil and its products – Israel Fuel Authority, oil refineries, the Central Bureau of Statistics' import/export data, large consumers of fuel products and fuel companies.

   II. Electricity – the Israel Electric Corporation and several small manufacturing enterprises.

   III. Population estimates - The Central Bureau of Statistics (based on population censuses and updates of vital events and migrations in the Population Register).

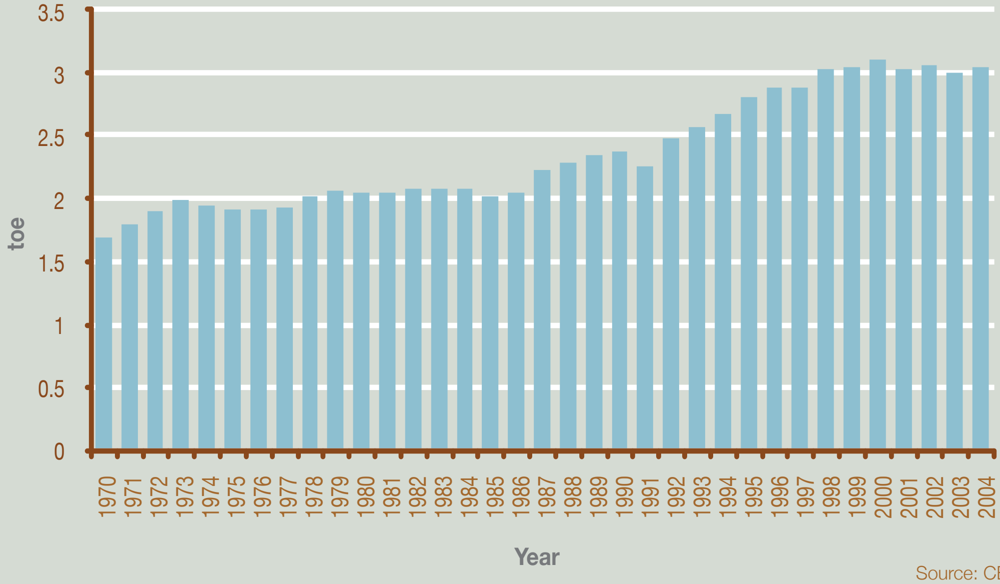
   IV. The Central Bureau of Statistics' energy database.

d. **Data limitations** – Since this indicator is calculated by the aggregation of different consumption data, calculated in different units, it might not accurately measure variations in the rates of consumption. This can lead to invalid calculations and interpretations, and misallocation of resources.

6.4.2.3. Results

Chart 6.12 shows energy consumption per capita in Israel since 1970.

Chart 6.12 Energy Supply per Capita in Israel



Source: CBS

Energy supply per capita has almost doubled in the last quarter of the century, from 1.69 toe in 1970 to 3.04 in 2004. Although total energy consumption has increased by an average annual rate of 4.3%, consumption per capita has increased annually only by 1.8%. This can be explained by the relatively high population growth rate in the country during the last decade of the previous century.

- **International comparisons**

Chart 6.13 presents data on energy consumption per capita in selected countries (developed and neighboring Mediterranean countries) in the year 2002.

Chart 6.13 Worldwide Energy Consumption per Capita in (2002)

Source: The World Bank

The data show that the level of energy consumption per capita in Israel in the year 2002 (3.05 toe) is at the same level as European Mediterranean countries, such as Spain, Italy and Greece (these countries are also similar to Israel in their GDP per capita) rather than at the level of other southeast Mediterranean countries.

6.4.2.4. Discussion

a. **Status and trends** - One trend that stands out from the data on energy consumption in Israel is the rise in per capita consumption since 1992. This increase, by an annual average of 2.4%, can be explained by the large immigration wave that came to Israel from the former Soviet Union starting from the end of 1989 (more than a million immigrants have entered the country since that year). The immigration wave led to changes to the demographic and socio-economic structure of Israel and caused an increase in consumption per capita and in energy consumption per capita.

If the immigration wave is added to the relatively high natural growth rate in Israel and to the increase in standard of living (see HDI indicator) it is possible to understand how energy consumption per capita in Israel has reached its current level.

The stabilization of per capita consumption in the past five years can be explained by the reduction in immigration following this wave and by the economic recession experienced by Israel in the past few years.

b. **Sources of pressures**

- Pressures on the environment

  ✦ Air pollution

  The increase in energy consumption can be explained mainly by the increase in the motorization rate and electricity demand. Together, these have a significant impact on the environment, resulting in a rise in air pollutant emissions and greenhouse gas emissions.

  Electricity - As mentioned previously, electricity consumption has increased in the past ten years by an annual average rate of about 3.5%. Therefore in order to understand the implication of this increase on air pollution, it is necessary to examine the sources for the production of electricity. In 2004 there was a change in fuels used for electricity production. One power station, producing about 10% of annual production, switched from oil to natural gas. This is an example of a change that reduces some air pollutant emissions whilst meeting the demands of increased consumption.

  ✦ Using up global natural resources

  As most of the energy consumed in Israel is based on imported fuels, the use of domestic natural resources is limited. Nevertheless the increase in energy consumption in Israel contributes to the global loss of natural resources, since it is not decoupled from development.

- Pressures on the economy

  Since most of the energy use in Israel is based on imported fossil fuels, the increase in consumption leads to an increase in the dependence on imports and at the same time adds to the national external debt.

c. **Israel's status in an international perspective** -The developments in Israel in the past 15 years have brought energy consumption per capita to levels similar to those of developed countries. This means that Israel must undertake the obligation of developed countries to formulate a plan for achieving energy efficiency. Agenda 21 states, "*Developed countries should take the lead in achieving sustainable consumption patterns*". Therefore, Israel should invest, in the near future, in research and development of renewable energy sources and in energy conservation technologies.

d. Future trends -Energy consumption per capita will probably continue to increase in the near future, although not at the same rate as during the 1990s, due mainly to the lower immigration rates expected in coming years.

It may also be assumed that electricity consumption will continue to increase.

In light of this, and in order to meet the goals of sustainable development (specifically the goals of the Israeli strategy for sustainable development), efforts should be made in several directions:

- Enhancing energy efficiency and use of renewable energy sources in the production of electricity.
- Lowering air pollutant emissions from fuel combustion in transportation and electricity production.
- Developing means for energy conservation and raising public awareness of this issue.
- Developing local standards for energy efficiency and conservation.

e. Recommendations for future research

- Data for this indicator may be broken down into sectors (commercial, residential, industrial) for in-depth analysis. This can help in identifying the sectors on which planning strategies for energy efficiency should focus.
- An indicator of share of consumption of renewable resources should be calculated and analyzed alongside the indicator of energy consumption per capita. Data on the current use of solar energy by households and the business sector is essential for monitoring trends of renewable energy use. As of today there are no reliable data for calculating this indicator.
- In order to provide additional information on energy efficiency, an indicator of energy intensity should be calculated in order to link energy consumption to the country's GDP.
- A new indicator may be introduced measuring the rate of adoption of energy efficient technologies. Such an indicator could help in analyzing causes for increase/decrease in energy consumption per capita.

6.5. HUMAN DEVELOPMENT INDEX (HDI)

6.5.1. Introduction

a. Human Development Index (HDI) - The human development index (HDI) is a composite index that measures a country's average achievements in three basic dimensions of human development: a long and healthy life, as measured by life expectancy at birth; knowledge, as measured by the adult literacy rate and the combined gross enrollment ratio for primary, secondary and tertiary schools; and a decent standard of living, as measured by GDP per capita in purchasing power parity (PPP US dollars). The index is published every year by the UNDP in the Human Development Report (HDR) and is a part of an extensive set of indices and indicators aimed at measuring the state of human development. The rationale underlying the necessity for this index (along with other human development indicators) is that people are the real wealth of nations and that the basic purpose of development is to enlarge human freedoms. The process of development can expand human capabilities by expanding the choices that people have to live full and creative lives. People are both the beneficiaries of such development and the agents of the progress and change that bring it about. This process must benefit all individuals equitably, and build on the participation of each of them. The three dimensions covered by the HDI allow a broader view of a country's development than does income alone. While the concept of human development is much broader than any single composite index can measure, the HDI offers a powerful alternative to income as a summary measure of human well-being. It provides a useful entry point into the rich information contained in various indicators on different aspects of human development. An important criterion for choosing the dimensions covered by the HDI or any other human development indicator is that it measures capabilities that are universally valued and are basic to life, in a sense that their absence would foreclose many other choices. This is why the HDI is a very efficient index for monitoring long-term trends in human development, which enables trend analysis within a country and comparisons across countries.

b. HDI in an Israeli perspective - The importance of this index for Israel, as is the case for other countries, is that it facilitates the ability to monitor progress in the well-being of Israelis and enables comparisons with other countries. Since Israel can be considered a developed country in some aspects and a developing country in others, it is important to see whether its developmental state in the dimensions covered by the HDI is progressing in a positive direction. Furthermore, the index should be broken down into its components in order to identify the strengths and weaknesses specific to Israel so that policy makers can use the data for affirmative actions.

6.5.2. *Methods*

a. **Definitions**

Human development index (HDI) - A composite index measuring average achievement in three basic dimensions of human development - a long and healthy life, knowledge and a decent standard of living.

Life expectancy at birth - The number of years a newborn would live if prevailing patterns of mortality at the time of birth were to stay the same throughout the child's life.

Literacy rate (adult) - The percentage of people aged 15 and above who can, with understanding, both read and write a short, simple statement on their everyday life.

Real GDP per capita (PPP$) - The GDP per capita of a country converted into US dollars on the basis of the purchasing power parity exchange rate.

Enrollment - The gross enrollment ratio is the number of students enrolled in a level of education, regardless of age, as a percentage of the population of official school age for that level. The net enrollment ratio is the number of children of official school age (as defined by the education system) enrolled in school as a percentage of the number of children of official school age in the population.

Primary education - Education at the first level (level 1), the main function of which is to provide the basic elements of education.

Secondary education - Education at the second level (levels 2 and 3) based on at least four years of previous instruction at the first level and providing general or specialized instruction or both, such as middle school, secondary school, high school, teacher training school at this level and vocational or technical school.

Tertiary education - Education at the third level (levels 5, 6 and 7) such as universities, teachers colleges and higher-level professional schools requiring, as a minimum condition of admission, the successful completion of education at the second level or evidence of the attainment of an equivalent level of knowledge.

b. Method of calculation - Prior to calculating the HDI itself, an index needs to be created for each of these dimensions. To calculate these dimension indices, minimum and maximum values (goalposts) are chosen for each underlying indicator: life expectancy, education and GDP indices

Education index = 2/3 (adult literacy index) + 1/3 (gross enrollment index)

HDI = 1/3 (life expectancy index) + 1/3 (education index) + 1/3 (GDP index)

For further information on the calculation of the HDI see HDR 2005 (Technical note 1).

A HDI value higher than 0.8 is considered high while a value lower than 0.5 is considered low.

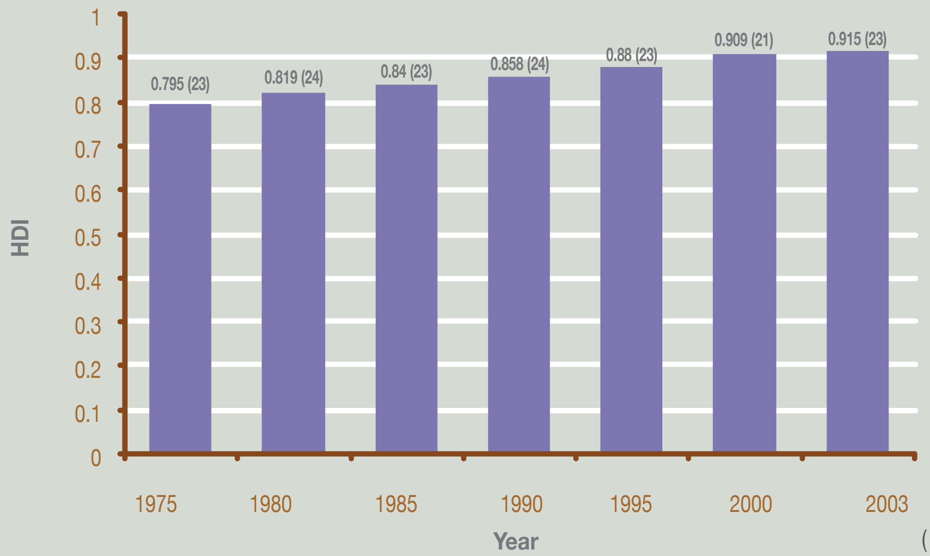
c. Data sources - All HDI data, including for Israel, were obtained from the UNDP Human Development Report 2005. International data were used to maintain standardization so that reliable comparisons may be made between countries.

Additional data on Israel's GDP per capita were obtained from the Central Bureau of Statistics.

d. Data limitations -Discrepancies might be detected when comparing the international data to the local data due to differences in definitions and calculation methods.

6.5.3. Results

Chart 6.14 Human Development Index Trends in Israel

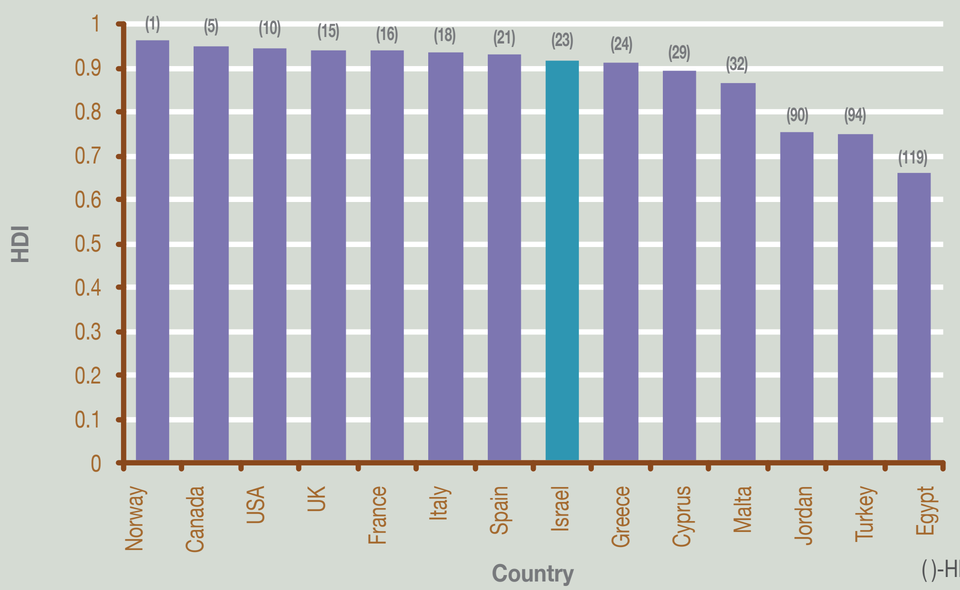


( )-HDI Rank

Source: HDR 2005

Since 1980, Israel's HDI values have remained above 0.8. Throughout the years, Israel's HDI rank has remained stable, ranking between 21 to 24 out of 177 countries. Israel is also defined as a high-income country.

Chart 6.15 Human Development Index - International Comparisons (2003)

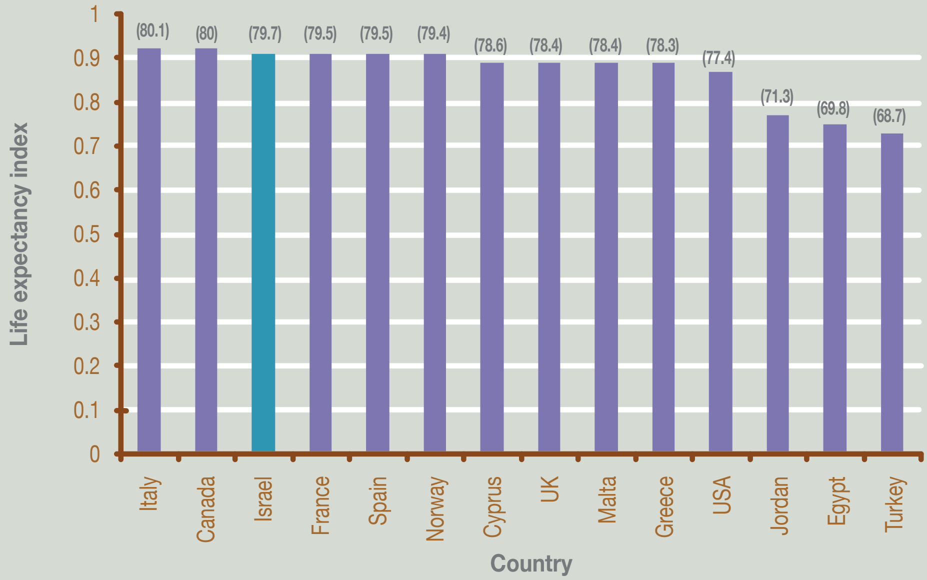


( )-HDI Rank

Source: HDR 2005

In the year 2003, Israel's HDI was 0.915, similar to European Mediterranean countries such as Spain and Greece. These countries are also similar to Israel in their GDP index (Israel and Greece – 0.88, Spain – 0.9). Israel's education index value is 0.95, the same as the value for Italy and slightly lower than Greece, Spain, France, USA and Canada (0.97). Israel has the same life expectancy index as France, Spain and Norway (0.91) and has the highest life expectancy among these four countries (79.7 years, see Chart 6.16).

Chart 6.16 Life Expectancy Index International Comparison (2003)

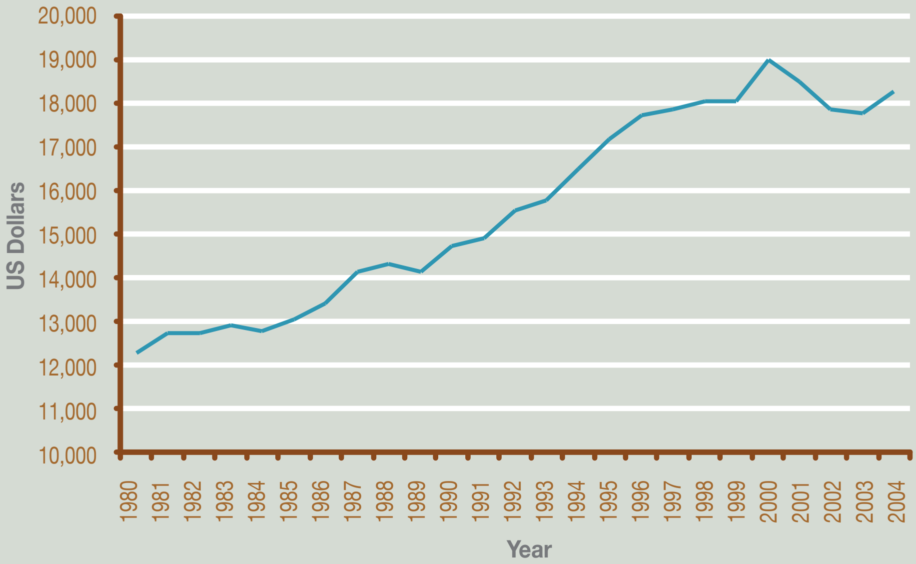


( )-life Expectancy

Source: HDR 2005

In 2000, Israel reached its highest HDI rank (21). In that year, GDP per capita in Israel (Chart 6.17) also reached its highest level (19,005 US$). After 2000, GDP per capita declined due to a few years of recession. In 2004 GDP per capita began to increase once again.

Chart 6.17 GDP per Capita in Israel (PPP in fixed prices 1995)



Source: CBS

6.5.4. *Discussion*

a. Status and trends -In light of Israel's HDI values and rank over the years, it can be said that, based on the dimensions covered by the HDI, Israel's human development state is improving at a constant pace. The dimension of "a long and healthy life" is clearly the strongest point within Israel's HDI, while the weakest point is probably the dimension of "a decent standard of living" measured by GDP per capita. However, the latter dimension is largely influenced by special political circumstances in Israel, which do not exist in other developed high-income countries. With regard to the dimension of "knowledge," Israel hasn't yet reached a 100% literacy rate, though the rate is high and the gross enrollment rate has grown constantly. It should be noted in this regard that high immigration rates from less developed countries have a negative impact on literacy rates in Israel.

b. Israel's status in an international perspective - Israel has maintained its HDI rank throughout the years. The main difference between Israel and the countries ranked higher is the GDP index. In the past two years, GDP per capita started to increase again. This might facilitate an improvement in the overall state of human development in the country in the coming years. At the same time, it is important to ascertain whether the increase in GDP is a result of positive growth trends that do not harm the environment and social welfare.

c. Expectations for the future - In view of the HDI trend in Israel, it is probable to expect that the HDI will continue to increase in coming years. On the other hand, it is also clear that the HDI alone cannot measure the state of human development in all its complexity. For a complete analysis, all of the indicators published in the Human Development Report should be taken into account.

Furthermore, the HDI should be used as a tool to identify those weaker groups in the country's population, which are not actually represented by the HDI value of the country. For example, emphasis should be placed on the illiterate population group (in Israel – the older population, Bedouins, and immigrants from less developed countries).

Finally, as an indicator for sustainable development, the HDI is a good tool for indicating the direction in which the country is moving, but it should be supported by other specific indicators of sustainable development.

ACRONYMS

BCM	Billion Cubic Meters
BOD	Biochemical Oxygen Demand
BSL	Below Sea Level
CBS	Central Bureau of Statistics
COD	Chemical Oxygen Demand
DRRP	Dan Region Reclamation Project
ECMT	European Conference of Ministers of Transport
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographical Information system
GWP	Global Warming Potential
HC	Hydrocarbon
HDI	Human Development Index
HDR	Human Development Report
HFCs	Hydrofluorocarbons
ICS	Intermittent Control System
IEA	The International Energy Agency
IMS	Israel Meteorological Service

IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
JNF	Jewish National Fund
LPG	Liquefied Petroleum Gas
MANA	Nation Air Monitoring Network
MCM	Million Cubic Meters
MED-Env II	MEDSTAT-Environment project, Phase 2
Mg/liter	milligrams per liter
MSL	Mean Sea Level
NMVOCs	Non-Methane Volatile Organic Compounds
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organization for Economic Co-operation and Development
Pb	lead
PCPD	Per Capita Per Day
PFCs	Perfluorocarbons
PPP	Purchasing Power Parity
SAR	Sodium Absorption Ratio
SAT	Soil Aquifer Treatment
SDI	Sustainable Development Indicators
SPM	Suspended Particulate Matter
TOE	Tons of Oil Equivalent
TPES	Total Primary Energy Supply
TSS	Total Suspended Solids
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFF	United Nations Forests Forum
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WWF	World Wildlife Fund

REFERENCES

1. Agami, M. 1975, Survey of Extinct and About to Become Extinct Plants and Animals in Israel. Environmental Protection Service (Hebrew).
2. Agenda 21and the Rio Declaration, 2002, Background and Israeli Aspects, Ministry of the Environment (Hebrew).
3. Ashkenazi, S. Chacham, E., 1987, The Names of Vertebrates in Israel. Nature and Parks Authority (Hebrew).
4. Central Bureau of Statistics, Various Years, Motor Vehicles.
5. Central Bureau of Statistics, Various Years, Statistical Abstract of Israel.
6. Eurostat,http://epp.eurostat.cec.eu.int/portal/page?_pageid=1996,39140985&_dad=portal&_schema=PORTAL&screen=detailref&language=en&product=Yearlies_new_transport&root=Yearlies_new_transport/G/en032.
7. Eurostat,http://epp.eurostat.cec.eu.int/portal/page?_pageid=1998,47433161,1998_47437045&_dad=portal&_schema=PORTAL
8. Gvirtzman, H. 2002, Israel Water Resources, Chapters in Hydrology and Environmental Sciences. Yad Ben Zvi Press Jerusalem (Hebrew).
9. Haaretz English Edition, 10 October 2005, Leasing firm New Kopel-SIXT targets non-corporate clients.
10. Hanson, M., 2004, Where are we moving to? Transport policy and the environment. Tel Aviv, Babel Publishing House (Hebrew).
11. IEC, (2003-2005), Statistical Report 2002-2004, Israel Electric Corporation Ltd. (Hebrew).
12. Indicators for Sustainable Development in the Mediterranean Region, 1999, Blue Plan.
13. Indicators of Sustainable Development, 1997, EUROSTAT.
14. IPCC, 1997, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. United Nations Environment Programme (UNEP), The Organization for Economic Co-operation and Development (OECD), The International Energy Agency (IEA) and the International Panel on Climate Change (IPCC)

1. Volume 1: Reporting Instructions
2. Volume 2: Workbook
3. Volume 3 Reference Manual

15. Israel Ministry of the Environment, 1999, Management of Coastal Zone in Israel, (Hebrew).
16. Koch J., Shafat S., 2002, Greenhouse Gases in Israel, Inventory Update of Emissions and Removals for. Ministry of the Environment, Industries Cluster, Air Quality Division. (Hebrew).
17. Mekorot, 2003, Monitoring Report for the Third Line Dan Region Project (Hebrew).
18. Mey-Marom A., Dayan U. and Koch J., 2001, Inventory of Emissions and Removals of Greenhouse Gases in Israel. Ministry of the Environment, Industries Cluster, Air Quality Division. (Hebrew).
19. Ministry of the Environment, National Air Monitoring Network ("MANA"), (2000-2004), Air Quality Monitoring Results (Hebrew).
20. Nature and Parks Authority and the Society for Protection of Nature, 2002, Endangered Species in Israel, Red List of Threatened Animals, Vertebrates (Hebrew).
21. OECD/ECMT, 1995, Urban travel and sustainable development. Paris. OECD/ European Conference of Ministers of Transport (ECMT).
22. Organization for Economic Co-operation and Development (OECD) , 2001, Environmental Outlook
23. Rio Earth Summit 1992, http://www.un.org/documents/ga/conf151/aconf15126-3annex3.htm
24. Tartakovski et al., 1997,Evaluation of Pollutant Emission Factors from Motor Vehicles in Israel. Technion, Israel Institute of Technology (Hebrew).
25. Tartakovski L. et al., 2000, Evaluation of Pollutant Emission Factors from Diesel Vehicles in Israel (stage 1 - busses). Technion, Israel Institute of Technology (Hebrew).
26. Tartakovski L. et al., 2001, Evaluation of Emission Factors from Motorcycles in Israel. Technion, Israel Institute of Technology (Hebrew).
27. The Jerusalem Institute for Israel studies, 2004, Sustainable Development Indicators in Israel - Summary Report Phase 1 (Hebrew).
28. The World Bank, 2005, “The Little Green Data Book”.
29. United Nations Convention for Combating Desertification, http://www.unccd.int/php/countryinfo.php?country=ISR
30. United Nations Department of Economic and Social Affairs http://www.un.org/esa/agenda21/natlinfo/countr/israel/natur.htm#desert
31. United Nations Department of Economic and Social Affairs http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter4.htm
32. United Nations Department of Economic and Social Affairs http://www.un.org/esa/sustdev/natlinfo/indicators/indisd/english/chapt7e.htm
33. United Nations Department of Economic and Social Affairs http://www.un.org/esa/sustdev/natlinfo/indicatoors/indisd/english/chapt4e.htm
34. United Nations Development Program (UNDP), 2005, Human Development Report (HDR), http://hdr.undp.org

35. United Nations, 2001, Forum on Forests Report on the organizational and first sessions.
36. United Nations. http://www.un.org/esa/forests/documents-unff.html
37. Windsor A. and Omer M., 2005, Transport to the workplace: current situation in Israel. Tel Aviv, Transport Today & Tomorrow/Ministry of the Environment (Hebrew).