TAUB CENTER
FOR SOCIAL POLICY STUDIES IN ISRAEL

Climate Sensitivity and Regulatory Deficiencies: Environmental Health Challenges in Israel

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Taub Center for Social Policy Studies in Israel

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Research and Policy Initiative for Environment and Health

The Taub Center Research and Policy Initiative for Environment and Health is a joint project of the Forum for Health and the Environment and the Taub Center for Social Policy Studies in Israel, made possible through the generous support of Yad Hanadiv. The Initiative focuses on applied research and the promotion of policies related to an array of environmental issues, among them climate change and the built environment, air and water quality, exposure to chemicals and waste management, all with a special emphasis on the impact on the health of the population of Israel.

The goals of the Initiative are to assist in the advancement of public policy in the field of the environment and health through making applied knowledge accessible to policy and decision makers. The activities of the Initiative are accompanied by a Steering Committee composed of leading academics who are committed to promoting effective policies in the fields of the environment and health in Israel. The Steering Committee is comprised of the Founding Committee of the Forum for Health and the Environment and representatives of Yad Hanadiv and the Taub Center.

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Climate Sensitivity and Regulatory Deficiencies: Environmental Health Challenges in Israel

Maya Sadeh and Rakefet Shafran-Nathan

Introduction

Israel's rapid population growth rate and the climatic changes in the Mediterranean Basin, which is characterized by climatic sensitivity, present the State with numerous challenges. In some areas, Israel is more advanced than the OECD countries, primarily in the fields of water management, desalination, and the treatment of waste water and its use in agriculture and industry (WHO, 2022). Currently, approximately 50% of drinking water in Israel comes from desalination, and this figure will rise to about 65% over the next two years with the activation of two new desalination plants. This is particularly important given the predicted decline of annual precipitation by 15%–25% by the end of this century, together with changes in the distribution, frequency, and strength of precipitation. This will move Israel closer to hydrological independence and reduce sensitivity to the natural hydrological system.

In responding to other challenges, however, Israel is about a decade behind the leading OECD countries. In this chapter, we focus on two environmental areas that have an impact on quality of life and physical health: rising heat stress due to climate change and waste treatment in Israel. This chapter also includes a Spotlight on an important aspect of health and the environment: indoor air pollution due to lengthy periods spent in closed, air-conditioned spaces without an exchange of fresh air.

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It is important to emphasize that all of these issues are interrelated. High greenhouse gas emissions, due in part to particularly high rates of waste buried in landfills in Israel, is one of the factors responsible for the rising incidence and severity of heavy heat burdens. Due to heat stress, people are less inclined to go outdoors and spend longer periods in air-conditioned spaces, increasing their exposure to indoor air pollution. Refuse burial has additional negative consequences, such as air pollution and the creation of runoff that enters groundwater sources. Taken together, all of these factors serve to heighten the exposure of the population to environmental pollution and raise the morbidity and mortality risk.

Heat stress

Forecasts and models show that the Eastern Mediterranean Basin is particularly sensitive to climate changes, especially in the form of heatwaves.[1] Figures show that the rate of temperature rise in this region is twice that in other regions (Cramer et al., 2018; Zittis et al., 2022). Israel's geographical region is particularly sensitive to increasingly extreme climatic conditions and an increase in extreme events (Yosef et al., 2018; 2019). In Israel itself, the average temperature has risen by 1.4°C since 1950, and an increase in the frequency of heatwaves has also been observed (Yosef et al., 2019).

Despite Israel's small area, these changes do not influence all parts of the country equally. Israel is located at the confluence of four climatic zones: wet Mediterranean, dry Mediterranean, semi-arid, and arid. In general, Israel suffers from a serious water shortage. Average annual precipitation ranges from 1,000 mm at Harashim in the Galil to 22 mm in the Eilat area. Summers in Israel are hot and dry, without precipitation. Some of the climatic zones are characterized by heatwaves in the transitional seasons and by droughts. An additional factor that influences climatic variance in Israel is topography: elevations range from -410 meters in the Dead Sea area to 2,814 meters on Mt. Hermon.

1 The term climate change refers to events whose incidence shows a trend toward a statistically significant change (increase or decrease), for example, an increase in the number of summer nights when the temperature is above average (Ministry of Environmental Protection, 2017; Troen, 2021). Like many other natural phenomena, those relating to climate are cyclical. Accordingly, climate change does not refer to a single event, but to a consistent change in the trend relative to the long-term average. The Israel Meteorological Service notes changes in trends relative to the average for at least 30 years.

This broad climatic and topographical range in a small area makes Israel highly sensitive to climate changes. For example, climate change can cause the aridity line (the line marking 200 mm of precipitation) to move north, thereby extending the arid climatic zone at the expense of the semi-arid and Mediterranean zones. This process is liable to cause water and irrigation problems and increased costs in agriculture, a rise in heat stress due to rising relative humidity (we will discuss this aspect in greater detail), rising ambient temperatures, and soil erosion. Other phenomena associated with climate change include floods, increasing prevalence of droughts, a rise in the sea level, the salination of the coastal aquifer, damage to the coastal environment, and the penetration of seawater into stream runoff.

Emission of greenhouse gases and rising temperatures

Since the beginning of the Industrial Revolution some 250 years ago, the concentration of greenhouse gases in the earth's atmosphere has risen. Most of the increase is attributed to human activity, and particularly to the burning of fossil fuels and organic matter in processes that result in the emission of greenhouse gases. The presence of greenhouse gases in the atmosphere in high concentrations exacerbates the greenhouse effect and leads to an increase in air and ground temperatures. This has far-reaching consequences for all aspects of life, particularly for health, the economy, and society.

At the Paris Climate Conference in 2015, most of the countries of the world undertook to reduce emissions in their territory. The Paris Agreement set a target limitation on the increase in global warming of 1.5°C by 2050. The agreement drew two key scenarios. The first, RCP2.6, assumes that the countries of the world will gradually reduce emissions, reaching zero emissions by the end of the twenty-first century. This will limit the rise in the average global temperature to 2°C by the end of the century. The second scenario, RCP8.5, reflects a business as usual approach, according to which emissions will not be reduced and may even increase. The result will be an average increase of 4°C in the global temperature by the end of the twenty-first century. Israel signed the agreement in April 2016.

In order to meet the global warming target set in the agreement, the Ministry of Environmental Protection prepared a national plan that is meant to be updated periodically as needed (Proactor et al., 2016).[2] However, implementation has repeatedly been delayed. The Climate Law was presented to the Israeli public in 2021, but only a draft form of the law was passed at its first reading two-and-a-half years later (September, 2023). The draft version of the Climate Law, 2023, set an interim target of reducing emissions by 30% by 2030; in other words, the quantity of annual emissions will be 70% of that measured in 2015, the year when the Paris Agreement was signed.[3] This target is approximately 20 percentage points lower than the targets set by the European Union countries, which have undertaken to cut their emissions by 50%–55%. Israel's ultimate goal is to reach zero emissions by 2050. We should note that the law permits the amendment of the emission reduction targets based on economic needs, so that the target is provisional and non-binding. Until now, the law has not been passed by the Knesset.

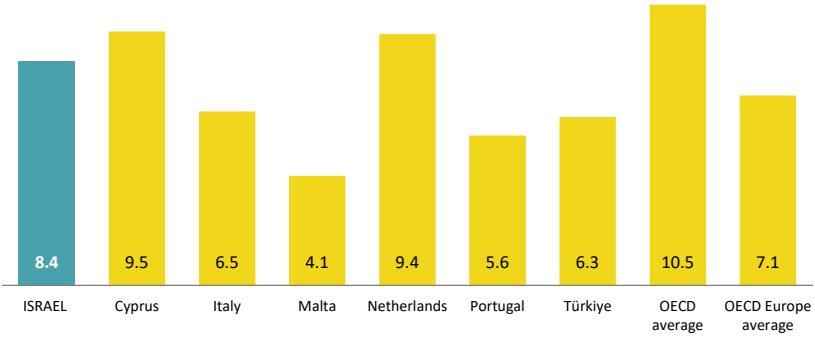
Figures 1a and 1b show the level of annual greenhouse gas emission per capita and by sector in Israel and in a number of countries similar to Israel in terms of their population, population density, or climatic conditions. As can be seen, per capita emissions in Israel are relatively high, though not the highest (Figure 1a). A look at the contribution of various industry sectors (Figure 1b) shows that the contribution of the energy production sector to total emissions in Israel is about 20% higher than in the comparison countries. However, it should be noted that Israel does not report on emissions originating from the consumption of electricity for domestic use (heating and cooling), and it is possible that this component was included in the emissions of the energy production sector. This sector is one of the main sources of greenhouse gas emissions and on average accounted for 44% of total emissions in 2020 in the selected countries. Emissions in the transportation sector contribute 20% of total emissions on average, while the industrial sector and waste account for 10% and 8% on average, respectively.

2 After signing the agreement, other countries enacted comprehensive climate laws; these include Norway and Sweden, which enacted climate laws in 2017, and Germany, New Zealand, and the Netherlands, which did so in 2019 (Ben-Yehuda, 2019).

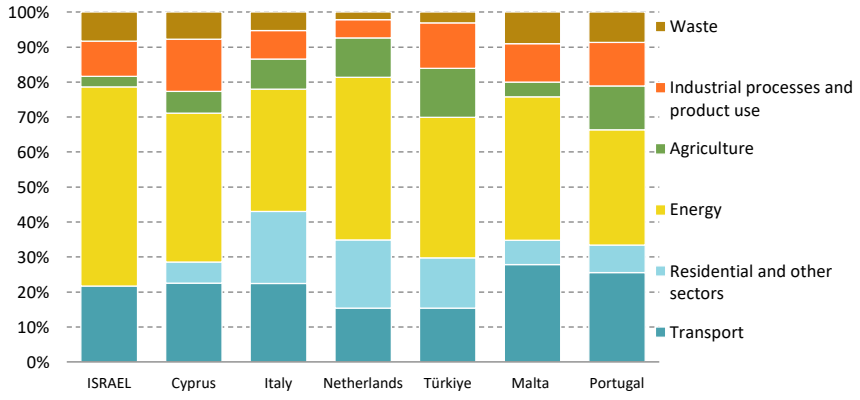
3 The draft version of the law received the status of a government decision. See Government Decision No. 927 of September 22, 2023, Climate Law draft, 2023.

Figure 1. Level of annual emissions of carbon dioxide per capita, Israel and selected OECD countries, 2020

a. Per capita, thousands of tons



b. By industry sector, percent



Note: The comparison countries are similar to Israel in terms of population, population density, or climatic conditions.

Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: OECD

Reduction of emissions and transition to renewable energy

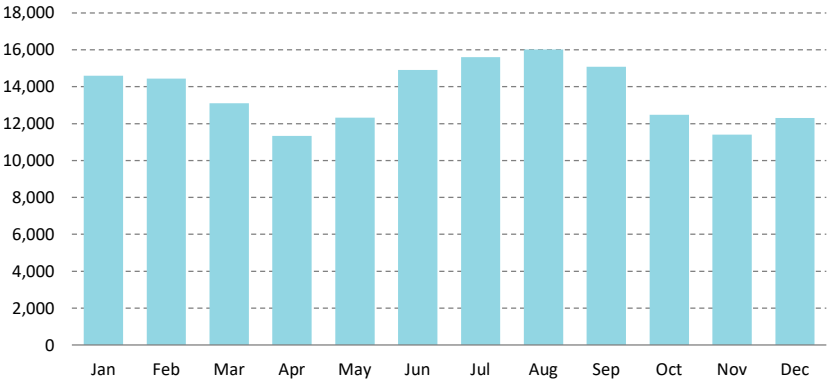
One of the greenhouse gases present in high concentrations in the atmosphere is carbon dioxide, which is emitted during the burning of fossil fuels such as crude oil, coal, and natural gas used in the production of energy for industry, power stations, and transportation. The main way to reduce carbon dioxide emissions is to convert to the production of energy from renewable sources, alongside a reduction of consumption of electricity produced by the burning of fossil fuels, and the reduction in the use of private vehicles powered by gasoline or diesel and a transition to electric vehicles.

According to figures for 2022 from the Israel Greenhouse Gas Emissions Registry (GGER) at the Ministry of Environmental Protection, despite a decrease of 22% in total greenhouse gas emissions in Israel over the past decade, an increase of 1.5% was recorded in 2022 in carbon dioxide emissions. The increase is the result of the rate of growth in electricity production from traditional sources being greater than the rate of growth in electricity production from renewable sources (GGER, 2023). With that, the use of renewable energies for the production of electricity, which began in 2012, has risen over the years — from 0.3% of total production in 2012 to 10% in 2022. Production of electricity from renewable energy sources is projected to reach 20% by 2025 and 30% by 2030 (Botosh, 2023).

The capacity for the production of energy from renewable sources fluctuates over the year due to seasonal differences in the number of daylight hours, wind strength, the solar trajectory, cloud cover, and so forth. Figure 2 describes the potential for production during peak hours for each month. Figure 3 shows the proportion of electricity production from renewable sources out of total electricity production for 2022, by month. As seen in the figure, during the summer months (May–September), the proportion of electricity produced from renewable sources is relatively high, averaging approximately 20%, while between November and March, the proportion is negligible.

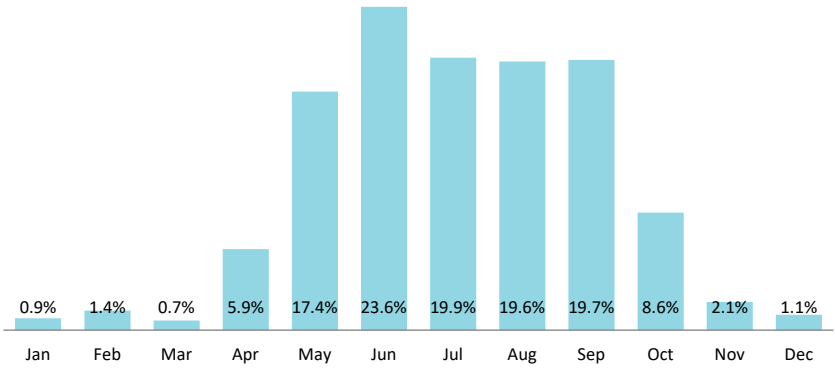
Figure 2. Average potential production of electricity from renewable sources during peak hours, by month

Mega watts



Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: Noga, The Israel Independent System Operator Ltd.

Figure 3. Proportion of production of electricity from renewable sources out of total production, by month, 2022



Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: Noga, The Israel Independent System Operator Ltd.

Exposure to continuous heat stress due to climate change

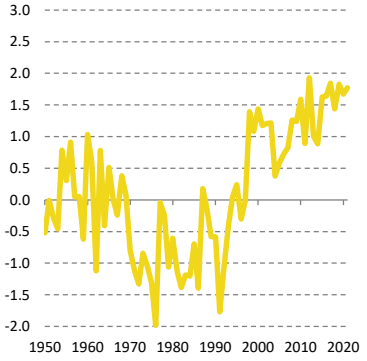
Studies show that rising heat stress due to climate change influences the quality of water and food, health, the economy, and other areas of life; moreover, this increase does not influence the whole population equally (Romanello et al., 2022). We will focus here on the impact of changes in continuous heat stress during the summer season in Israel over recent decades.

The first question that arises in the context of climate change is whether there is a consistent trend, and whether it is positive or negative. Figure 4 presents the change (the difference) for each year relative to the average for the first 30 years of measurement in Israel (1950–1979) for four key climate parameters: temperature, relative humidity, heat stress, and absolute humidity. For all the parameters, the analysis is relative to the seasonal average.[4] As the figure shows, for three of the parameters — temperature, absolute humidity, and heat stress (calculated by weighting the relative humidity and temperature values) — a consistent rise can be seen from the beginning of the 21st century relative to the period 1950–1979.

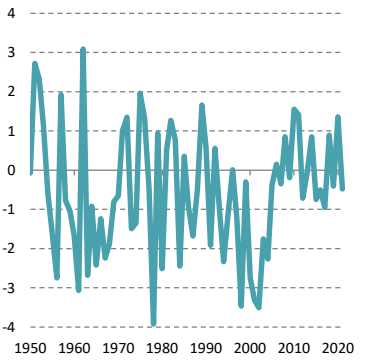
4 The calculation was undertaken for all measurement stations over seven decades for each year between 1950 and 2021 and every day during the summer months (May 15–September 15) at 2:00 PM. Since complete data were not available from every measurement station, we used only the hourly measurements of temperature and relative humidity from stations that the Meteorological Service defined as homogeneous stations. At these stations, the temperature data underwent a homogenization process intended to adjust the data series to changes in the measurement conditions over time. For further details, see the website of the Israel Meteorological Service, Homogenized Data System.

Figure 4. Change in temperature, heat index, relative humidity, and absolute humidity relative to the average between 1950 and 1979

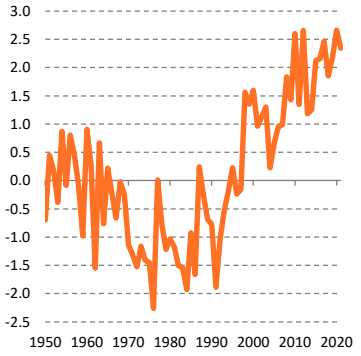
a. Mean seasonal temperature anomalies (°C)



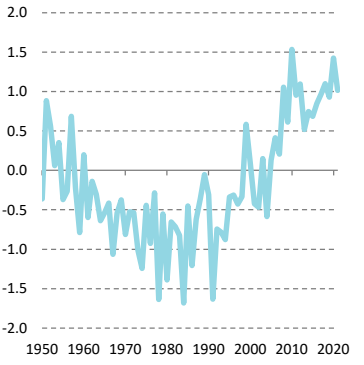
b. Mean seasonal relative humidity anomalies (%)



c. Mean seasonal heat index anomalies (°C)



d. Mean seasonal absolute humidity anomalies (g m^{-3})



Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: Israel Meteorological Service

The heat index combines air temperature and relative humidity measured simultaneously at the meteorological stations and creates an index that represents the level of discomfort people feel (denoted in degrees Celsius; for the index calculation formula, see footnote 6). Relative humidity increases thermal discomfort and reduces the body's ability to cool itself through perspiration. In normal conditions, when the human body is exposed to high temperatures, it keeps itself within the normal temperature range (between 36.1°C and 37.2°C) through thermo-regulation and such means as heat evaporation (by sweating), radiation (releasing heat into the air), convection (through cool air surrounding the body), and conduction (through contact with cold surfaces or with water surrounding the body) — all methods that are context dependent. When these cooling means are not sufficient, or when the humidity in the air is high and perspiration is ineffective, the core temperature of the body rises.

Short-term exposure to extreme heat stress may cause acute morbidity and mortality. Prolonged exposure over several months to heat stress above a given threshold may cause morbidity, both directly but primarily through indirect impact on physical and mental health due to the difficulty in performing physical activity outdoors and exposure to indoor air pollution.

The scientific literature proposes various indices for measuring heat stress.[5] The Israel Meteorological Service uses an index formulated by Prof. Ezra Zohar (Table 1). Since this index was originally developed for soldiers, farmers, and those working outdoors, the threshold temperature for defining very severe heat stress is 30°C. Relative humidity is calculated as the average of two simultaneous measurements using a dry and a wet thermometer. This index does not specify the health consequences that may be caused by prolonged exposure in each category.

5 Cohen et al. (2013) counted 44 indices for measuring heat stress in the literature.

Table 1. Heat index of the Israel Meteorological Service

Category	Limits
No heat stress	< 22°C
Mild heat stress	22°C–23.9°C
Moderate heat stress	24°C–25.9°C
Moderate heavy heat stress	26°C–27.9°C
Heavy heat stress	28°C–29.9°C
Extreme heat stress	> 30°C

Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: Israel Meteorological Service

To demonstrate the change in the severity of heat stress in Israel, we examined heat stress over seven decades, from the early 1950s through the beginning of the 2020s using the index of the US National Oceanic and Atmospheric Administration (NOAA). We chose this index because it associates each level of heat stress with possible health consequences (Table 2).

Table 2. The NOAA Heat Stress Index

Category	Limits	Health effects
No heat stress	< 26.9°C	No health effects
Caution	27°C–32°C	Possible tiredness with prolonged exposure Continued activity is likely to result in heat cramps
Extreme caution	32°C–41°C	Heat cramps and heat stroke are possible Continued activity is likely to result in heat stroke
Danger	41°C–54°C	Likely heat stroke with continued activity
Extreme danger	> 54°C	Imminent heat stroke

Note: The calculation relates to situations in which the temperature and relative humidity are above the lowest threshold of thermal discomfort, 27°C. For the measurement of thermal discomfort in conditions when there is no heat stress, other formulas should be used. For further details, see: Anderson et al., 2013.
Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: NOAA

In order to sample the change that occurred over the past seven decades in the exposure of the population in Israel to heat stress, we calculated the average heat stress for each decade at each meteorological station defined by the Israel Meteorological Service as a homogeneous station (see footnote 4). The calculation of the heat stress was based on the temperature and relative humidity values measured in the summer months every day at 2:00 PM,

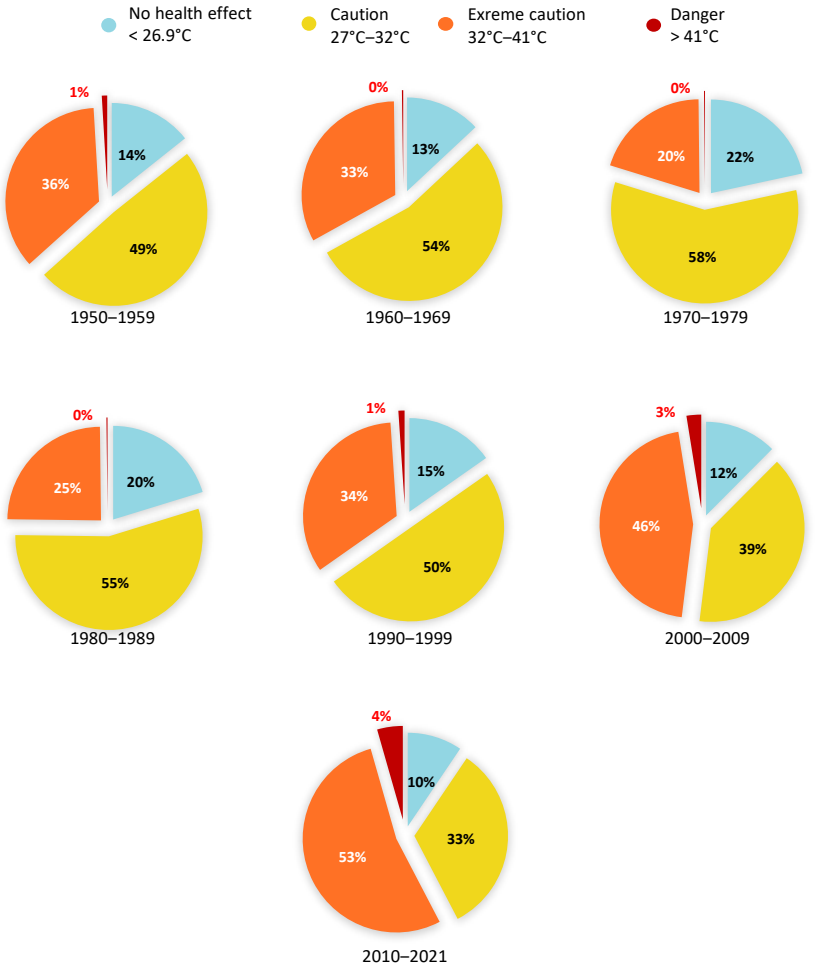
from 1950 through 2021.[6] We then classified the heat indices for each decade according to the NOAA index categories, allowing an examination of the change in exposure to heat stress between the different decades.

Figure 5 describes the average exposure to heat stress at 2:00 PM in the summer months in each decade. As can be seen, most of the measurements showed heat stress above the threshold value indicative of potential health consequences (27°C and 40% relative humidity). From the 1950s through the 1980s, there was an increase in the proportion of stations at which the average heat index for the given decade at 2:00 PM was lower than the threshold value liable to lead to health consequences: from 14% of stations in the 1950s to 22% in the 1970s. In other words, a decline in the strength of heat stress. From the 1980s on, however, the proportion of stations at which the average heat index for the decade is below this threshold has fallen consistently, reaching 10% of stations over the last decade (2010–2021). The figure also shows that, since the 1980s, there has been an increase in the share of stations at which the average heat index for the decade is within the extreme caution zone (32°C–41°C), and over the past two decades, this proportion has reached approximately 50%. Finally, since the 1990s, there has been a consistent rise in the share of stations where the average heat stress for the decade is in the danger zone (41°C and over), from 1% in the 1990s to 4% in the last decade. These findings are consistent with those found in a research conducted in Haifa, that found in July and August 2015, heat stress for eight hours a day reached the level of having health consequences according to the NOAA index (Shafran-Nathan & Broday, 2022).

6 The following formula was used for the calculation, where T represents the temperature, RH represents relative humidity, and HI indicates the heat index.

$$HI = -8.79 + 1.61\,T + 2.34\,RH - 0.15\,T\,RH - 0.012\,T^2 - 0.016\,RH^2 + 0.0022\,T^2\,RH + 0.00073\,T\,RH^2 - 0.0000036\,T^2\,RH^2$$

Figure 5. Average exposure to heat stress at 2:00 PM in the summer months (May 15–September 15), by decade



Note: The percentages in each pie slice are the share of meteorological stations in the relevant category according to the NOAA index for the decade.

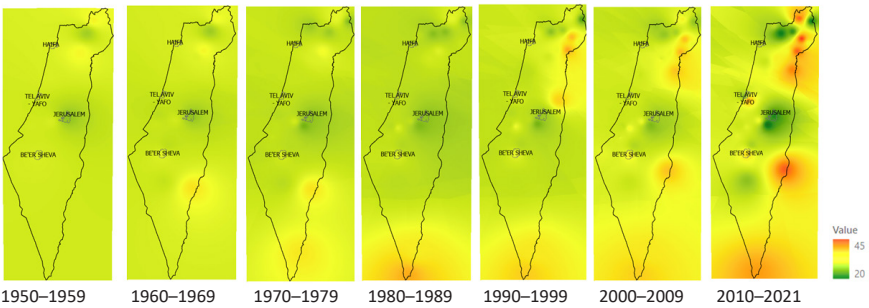
Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: Israel Meteorological Service

Given the broad climatic range in Israel, we sought to include an examination of heat stress from a spatial perspective. We calculated the hourly heat stress based on the NOAA index for every day during the summer months at 2:00 PM over 71 years (1950–2021).[7] The calculation was made using a spatial interpolation of the average data from the meteorological stations for each decade. The calculation of the average heat indices for each decade accounts for both the location of the meteorological stations and the distance between the stations, in order to complete missing data on heat stress for locations where there are no stations. Accordingly, the accuracy of this method depends on the distribution of meteorological stations — the fewer stations in a given area, the greater the variance.

Figure 6 highlights two key trends in terms of the changes in heat stress over the seven decades. The first is an upward trend in average heat index values, from values below the threshold (i.e., values that do not entail heath consequences) to values ranging from caution to maximum caution. The second trend that emerges is a rise in values, particularly in the south of Israel until the 1980s, and, thereafter, also in inland areas and in the east, including the Golan. We should note that alongside areas in which an increase was seen in heat index values, other areas experience low heat stress during the summer months (shades of green). In some areas this is due to relatively low humidity, despite high temperatures. It is important to emphasize that, over all the decades, the average heat index is above 27°C.

7 The calculation was based on data from the Israel Meteorological Service archives. See the IMW website, Meteorological Databases.

Figure 6. Spatial interpolation of average heat index data, by decade



Note: The heat index is calculated using the NOAA index. The calculation is based on hourly data as measured by the Israel Meteorological Service since 1950 for every day in the summer months (May 15 to September 15) at 2:00 PM. The average heat index is between 20°C (green) and 45°C (red). The data were collected in a variety of meteorological stations throughout Israel.

Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: Israel Meteorological Service

The health consequences of prolonged exposure to heat stress

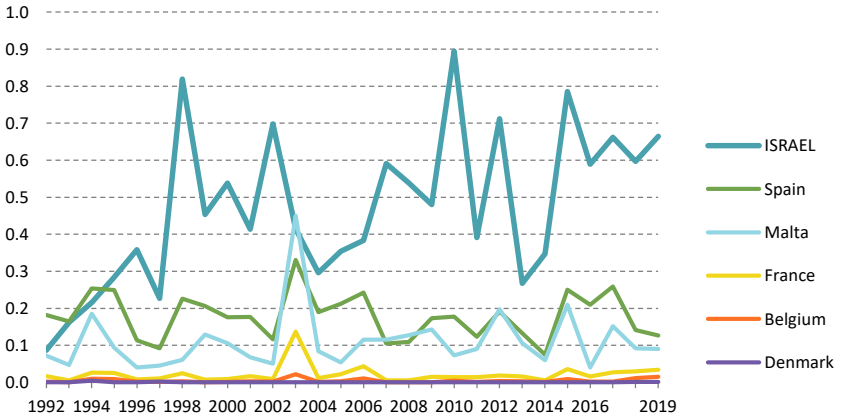
Over the past two years, various government ministries have made efforts to develop strategies and regulations for confronting extreme climate conditions, with an emphasis on heatwaves. However, similar emphasis has not been placed on prolonged exposure to heat stress during the summer months, which has a considerable impact on human health.

Prolonged exposure to heat stress is liable to exacerbate existing health conditions, such as high blood pressure and asthma, and the occurrence of dehydration, heatstroke, and even death. Exposure to extreme heat has been found to be directly related to a range of health conditions, including renal failure, negative birth outcomes such as premature birth and stillbirth (Kloog et al., 2015; Paz et al., 2016), impaired sleep, impact on mental health (Romanello et al., 2022; Yarza et al., 2020), exacerbation of heart diseases (stroke and ischemic heart disease) and respiratory diseases, an increase in infectious diseases, such as leishmaniasis and West Nile fever (Ministry of Health, 2020), and a rise in mortality due to accidents of various kinds.

Mortality risk

In the early 1990s, the risk of mortality due to high temperatures (relative to the optimal temperature) per 100,000 persons was negligible. Over the years, as temperatures have risen, the risk has increased. A similar trend has been observed in countries with a similar health system and climate to Israel (Figure 7). A preliminary study prepared by the Ministry of Environmental Protection together with Dan Yamin and Erez Shmueli found that, between 2012 and 2020, there was an average excess mortality of 45 persons a year in Israel due to exposure to high temperatures during heatwaves; the risk was particularly high among those aged 70 and over.[8]

Figure 7. Mortality rate from high temperatures per 100,000, international comparison



Note: Comparison countries have similar health system and climate to Israel.

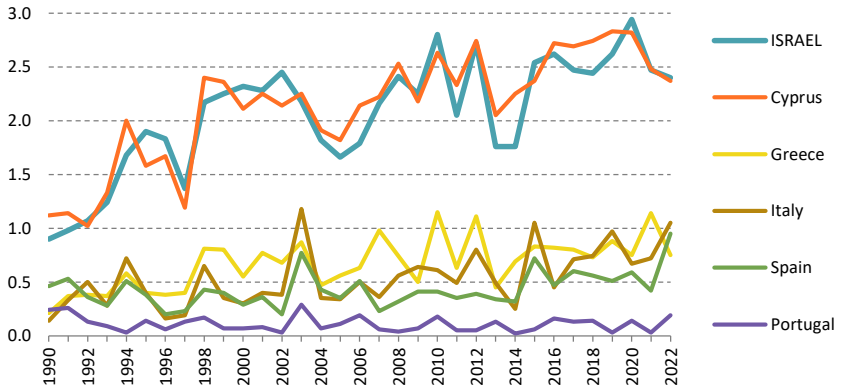
Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: Global Health Data Exchange

8 See the website of the Ministry of Environmental Protection, Ministry of Environmental Protection study casts light for the first time on the connection between heatwaves and the climate crisis and mortality in Israel.

Impact on physical activity

A lack of physical activity accounts for 7% of all mortality and 8% of mortality due to heart and vascular disease; the risk in countries with high per capita income is twice that in countries with low per capita income (Katzmarzyk et al., 2020). Physical activity reduces the risk of heart and vascular diseases, depression and dementia, diabetes, cancer, and more (Santos et al., 2023). Figure 8 shows the number of hours a day when light physical exercise outdoors is liable to pose a health risk in Israel and in five Western countries with a similar climate. As the figure shows, the number of dangerous hours has increased significantly in Israel and Cyprus, by a factor of over three in the past three decades. Conversely, in Spain and Portugal, in the western part of the Mediterranean Basin, there have been no significant changes over this period, and there has even been a slight fall relative to the early 1990s. Thus, heat stress also has an indirect health impact, since it restricts the ability to work and perform physical activity outdoors (Romanello et al., 2022).

Figure 8. Number of hours (averaged per person per day) during which high heat stress posed at least a moderate risk during light outdoor physical activity, countries in the Mediterranean Basin



Note: Comparison countries have a climate similar to Israel.

Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: Lancet Countdown 2023

Impact on mental health

Heatwaves and increased humidity have been found to be associated with an increase in suicide rates and an increase in morbidity due to mood disturbances, including depression and anxiety. A study undertaken in the Be'er Sheva District found an increase in suicide attempts during the summer after the temperature rose by 5°C. The number of suicide attempts is particularly high among individuals with an existing psychiatric diagnosis and among patients with a history of recurring suicide attempts (Yarza et al., 2020).

Rise in hospitalizations due to rising temperatures

Figures from Israel show an increase in the number of visits to urgent medical facilities with a diagnosis of dehydration or heatstroke between 2010 and 2019, and particularly since 2015. The highest number of visits was observed among very young children, aged birth to 4 years, and among the elderly, aged 75 and older. In addition, an increase of 1.47% was found in visits to the hospital emergency rooms for every rise of 1°C in the temperature. The leading causes of hospitalization during heatwaves are strokes and heart and vascular diseases (Berman & Krigel, 2020). A study in Israel found that a rise of 1°C in the summer was associated with an increase of approximately 10% in instances of strokes or transient ischemic attacks. By contrast, an increase in the temperature differential between day and night was found to be associated with a lower risk of such events (Vered et al., 2020).

Reducing heat stress

The two leading strategies for confronting climate change are the mitigation of emissions and adaptation. According to the Intergovernmental Panel on Climate Change (IPCC), personal, communal, and systemic adaptation can significantly reduce morbidity and mortality rates resulting from climate change (IPCC, 2023). Thus, it is vital to invest in the development of climatic, health, and social resilience and in the establishment of the necessary infrastructures to confront climate change, even if this entails a considerable investment of time and resources. As noted, adaptive capacity helps reduce the risks and negative consequences associated with climate events (ongoing or extreme), contributes to the response to the consequences and damages of such events, and improves preparedness for similar events in the future. Indices for adaptability include the availability of health services, community

hospitalization solutions, the rehabilitation of damaged infrastructures (water, electricity), housing solutions and alternative employment solutions (if required), economic resilience, and social cohesion on the community level (Pörtner et al., 2022; Schmeltz & Marcotullio, 2019).

The World Health Organization has determined that the most vulnerable populations to climate change, and particularly to heat stress, are populations of low socioeconomic status, elderly citizens, infants and children, pregnant women, the homeless, migrants, athletes, soldiers, farmers and manual laborers, migrant workers, and tourists. Other populations at high risk are those with chronic illnesses (diabetes, cardiovascular diseases, and respiratory diseases) whose condition may worsen with exposure to heat, as well as populations living in unsuitable conditions (defective infrastructures), and particularly in conditions of energy poverty (in terms of the safe and regular supply of energy). Lastly, the level of risk is also higher in urban areas (due to the creation of urban heat islands) (WHO, 2022).

In order to illustrate the association between populations at risk and the lack of infrastructure that can mitigate the impact of heat stress, we calculated the connection between the lack of tree shade and socioeconomic status.[9] The calculation estimated the relation between standardized socioeconomic status values for each statistical area in 2020 and the proportion of shading in the residential built-up area. The results show a positive and statistically significant correlation (correlation of 22.3%) between socioeconomic status and the proportion of shading from trees in a built-up area. In other words, the higher the socioeconomic status, the greater the share of shading. The results also reveal variance between statistical areas in terms of the reduction of heat stress due to natural shading.

Figure 9 shows the average percentage of shading from tree canopies in selected cities in Israel according to socioeconomic cluster. As the figure shows, the percentage of shading broadly rises in Tel Aviv, Haifa, and Jerusalem as socioeconomic status rises. Conversely, in Rehovot, Be'er Sheva, and Netanya there are no statistically significant differences in shading between different socioeconomic clusters.

9 For the purpose of the calculation, we assumed that the tree canopy represents the area of shade, though it should be recalled that the location of the shade changes over the course of the day as a function of the location of the sun in the sky.

Figure 9. Average proportion of shading from trees in selected cities by socioeconomic cluster, 2020

Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: CBS; Survey of Israel

Reduction of urban heat islands through the creation of green zones

Israel is one of a group of countries in which vegetation cover in built-up areas is very sparse (Romanello et al., 2022). Thus, the potential for the creation of urban heat islands in Israel is relatively great.

Urban heat islands are a phenomenon whereby the climate in a city is hotter than in the surrounding open or natural areas. Vegetation cover, stone and asphalt cover, building height, exposed soil, topographical contours and inclines are among the factors that increase or reduce heat stress in the urban area. The main factors responsible for the creation of heat islands are a lack of ventilation, construction materials and paved roads, and the percentage of building cover. The use of air-conditioners also contributes to an increase in urban heat stress (Salamanca et al., 2014). The temperature increase may be significant and can average between 1°C and 4°C.

Differences in heat stress exist between urban and rural areas, and within urban areas between areas of high building density and roads and areas of parks, gardens, and shaded boulevards. Micro-environments are created in built-up areas that constitute centers of elevated heat stress. Conversely, green zones within the urban area are seen as reducing urban heat stress by

increasing evapotranspiration, which contributes to reducing heat stress in the immediate surroundings (Aram et al., 2019). In addition, parks and green zones in the urban area also serve as biofilters that help increase the infiltration of urban runoff and prevent flooding in winter. A green environment traps carbon and leads to the local cooling of the urban heat island. It also offers numerous health advantages: reduced exposure to air and noise pollution, reduced psychological stress, and the availability of space for social encounters and physical activity. Heat stress in the urban environment can be reduced by means of relatively simple actions, such as establishing green roofs and walls, planting groves of trees, and painting sidewalks and roads with paints and materials that increase the reflection of radiation into the atmosphere.

Reduction of urban heat islands by shading

The main actions taken by Israel to date to reduce urban heat islands are in the area of shading. In 2013, the State Comptroller examined the issue of the prevention and treatment of skin cancer, with a major focus on melanoma, which is mainly caused by sun exposure (or by artificial sunbathing devices).[10] Among other findings, the Comptroller noted the lack of adequate shading in educational institutions and at bathing and leisure sites (beaches, swimming pools, playgrounds, etc.). He noted the importance of increasing the proportion of shading in such places (State Comptroller, 2014). In 2019, regulations were introduced regarding the shading of playgrounds, requiring shading of at least 70% of the area of the playground between 10:00 AM and 4:00 PM during the summer, by natural or artificial means.[11]

In addition to preventing skin cancer, shading offers additional advantages. For example, it can increase the possibility of physical activity outdoors and contribute to reducing exposure to pollutants. A cost-benefit analysis of shading in Israel examined the economic benefits of shading in terms of public health in three areas — skin cancer, physical activity, and exposure to pollutants — relative to the costs of natural and artificial shading. The analysis showed that shading can offer clear economic benefits estimated to be in the millions of shekels per year. A comparison between the two types of shading

10 According to Ministry of Health figures, in 2023 Israel was 23rd in the world in deep penetrating melanoma, with 10.3 patients per 100,000 people. See the Ministry of Health website, National Cancer Registry.

11 See Planning and Building Regulations (Shading of Playgrounds), 2019.

did not indicate any major differences in terms of benefits. However, it should be recalled that the full benefit of natural shading is only expressed after eight years (the time required for a tree to reach its intended size). Conversely, the cost of natural shading is slightly lower than that of artificial shading, and it is also more effective in terms of reducing urban heat stress (Becker & Neviot, 2019).

The progress in the field of shading suggests that policy makers are aware of its importance. In January 2022, the government adopted a decision regarding the shading and cooling of the urban area by means of street trees.[12] The main points in the decision are: (1) Setting a target of 70% for cover by tree shade of streets with a high walkability index by 2040 (in local authorities interested in this target); (2) Establishing a target of promoting the urban forest in 100 local authorities by 2030; (3) Protecting healthy mature trees; (4) Allocating the necessary resources for the afforestation of the urban area. A preliminary examination by the Survey of Israel (MAPI) shows that fewer than 1% of streets in Israel are adequately shaded (at least 50% shading), and only 7.6% of streets have moderate shading — 20%–50% shade.[13] In other words, a great deal of work remains to be done to reduce heat stress in urban areas through natural shading.

12 Government Decision No. 1022, January 23, 2022, Shading and Cooling of the Urban Area by Means of Street Trees as Part of the Preparation for Climate Changes.

13 See the MAPI website, Mapping Tree Canopies.

SPOTLIGHT

Indoor Air Pollution

The increase in heat stress and in the number of hot days over the year means that people spend more time in air-conditioned spaces with internal air replacement and a low proportion of external air. However, while environmental (outdoor) air pollution is monitored and regulated, there is no similar attention paid to the issue of indoor air pollution, despite the fact that in modern times people spend most of their time in closed spaces.

Indoor air pollution is caused by both internal and external sources. The main external sources influencing indoor air quality are direct emissions from industry and transportation that penetrate buildings through ventilation and air-conditioning systems or through openings in the building. Internal sources are volatile organic compounds (VOCs) emitted from household products, furniture, and consumer items such as cleaning materials, glue and paint, perfumes and makeup products, as well as domestic heating and cooking systems (Bass Spector, 2011) and organic waste. Indoor air quality is influenced by chemical pollutants such as carbon monoxide and nitrogen compounds, pesticides, fire and smoke retardants, biological pollutants such as mold and bacteria, and physical pollutants such as radiation.

Lengthy respiratory exposure to volatile organic compounds has acute and chronic health implications, including damage to the liver, kidneys, and nervous system, the development of asthma and allergies, and the development of cancerous cells (Di Lena et al., 2016). The US Environmental Protection Agency (EPA)

emphasized that the health and environmental dangers of indoor pollution are no less severe than those of outdoor pollution, and in most cases more so.[14] In Israel, domestic products are responsible for 46% of the emission of VOCs, while the industrial sector is responsible for 18% (GGER, 2022).[15]

Exposure to environmental tobacco smoke is associated with diverse diseases, such as asthma, other respiratory diseases, and cancer. A study by the Ministry of Health on the exposure of children to environmental tobacco smoke (passive smoking) found that one-third of the children sampled (aged 4–11) were exposed. The exposure was higher among the children of parents who smoke and children who live in homes where indoor smoking is permitted. In addition, an inverse relation was found between exposure of children to environmental tobacco smoke and parental education and income (Berman et al., 2021).

Regulation – Recommendations and reality

The Planning and Building Regulations require the ventilation of buildings in order to improve the quality of indoor air. Israeli Standard 6210, Ventilation for Acceptable Indoor Air Quality, defines threshold values for certain pollutants, but it is not binding. In 2009, recommendations were made for Israeli regulations in this field based on a review of the international standards, but the recommendations were not implemented.

14 See the EPA website, Indoor Air Quality (IAQ).

15 In this context we should note that elevated exposure to VOCs and toxic fire retardants also occurs in vehicles, particularly ones that have been stationary for long periods in sunlight (Dubowski et al., 2018). An effective solution to this problem can be the covering of public parking lots and installation of solar panels on the roofs. This will serve two purposes: a reduction in emissions from electricity production and a reduction in exposure levels to pollutants in vehicles that have been stationary in sunlight.

A review by the Israel Society of Ecology and Environmental Sciences found that the subject of indoor air pollution falls under the responsibility of four government ministries. There were plans to establish a governmental agency to coordinate activity in this field, but these were never realized (Halasz & Cohen, 2022). Unfortunately, the Ministry of Environmental Protection does not have sufficient resources and personnel to push this issue.

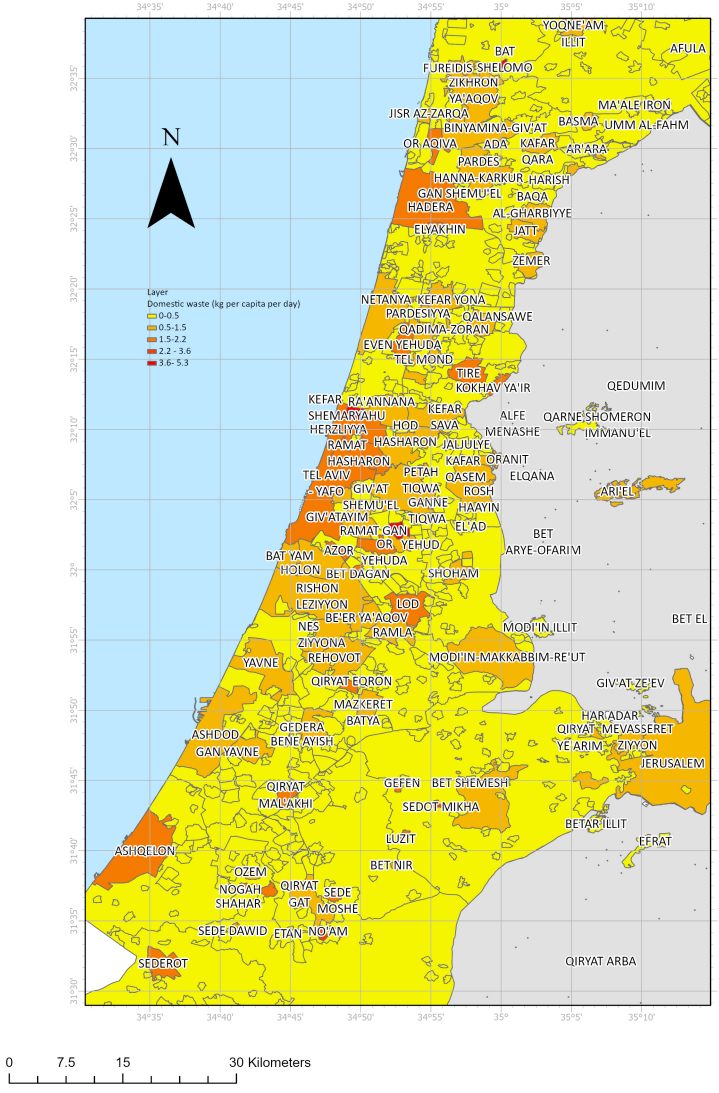
The rising severity and frequency of extreme climate events such as heatwaves means that people spend more time in enclosed spaces, heightening exposure to indoor pollution and increasing the risk of morbidity. Decision makers should advance this issue, including the establishment of criteria for indoor air quality, monitoring, and information services to raise public awareness of the issue.

Waste treatment in Israel

Israel generates large amounts of municipal solid waste (MSW) relative to the OECD countries. In 2020, Israel generated 614 kg of waste per capita, compared to the OECD average of 534 kg (OECD, 2023).

As Figure 10 shows, the quantity of waste generated varies between different local authorities. According to figures from the Central Bureau of Statistics (CBS, 2023), in 81% of local authorities in Israel waste generation is 1.2–2.4 kg per capita per day, while in 6.8% of authorities it is 1 kg or less per capita per day.

Figure 10. Daily domestic waste generation per capita, by local authority, 2021

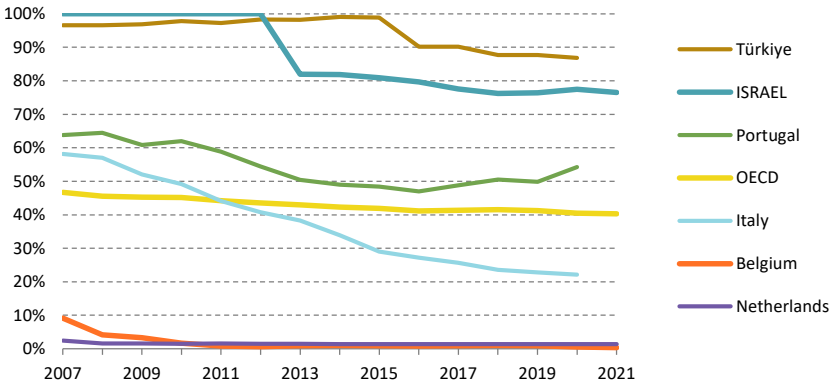


Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: CBS, 2023

Waste management methods

In broad terms, there are three methods for waste management: waste sorting at source and recycling; recovery (production of energy from waste); and burial. The goal, though, should be to reduce the quantities of waste generated through reduction at source and recycling.[16] In Israel, approximately 80% of waste is transferred to landfill without treatment, compared to an average of approximately 40% in the OECD countries (OECD, 2023). One of the reasons for the high waste burial rates in Israel is the low levy imposed on local authorities. The landfill levy is currently uniform and very low relative to other high-income countries, and it does not create an incentive to reduce waste burial and develop alternatives. The Bank of Israel has recommended increasing the tax and the introduction of a differential system based on the size of the local authority and the number of residents it serves (Bank of Israel, 2019). Figure 11 presents an international comparison of domestic waste burial rates.

Figure 11. Domestic waste burial rates, Israel and selected OECD countries



Note: For Italy, Portugal, and Türkiye the latest available data are from 2020.
Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: OECD

16 See the Ministry of Environmental Protection website, Reduction, Reuse, Recycling, Recovery of Energy, Burial: The Hierarchy of Waste Treatment.

The Ministry of Environmental Protection is promoting a comprehensive strategic plan for a sustainable waste regime in 2021–2030 and a transition to a circular economy by 2050. The main goal of the plan is to reduce waste burial rates from 80% as of 2020 to 20% by 2050.[17]

Treatment of organic waste

According to a report by the Knesset Research and Information Center, in 2020, approximately 35% of urban waste generated in Israel was organic waste (Eliyahu, 2022). Although organic waste can be recycled and used to produce fertilizer and biogas, less than one-fourth of this waste (23%) is recycled, while the remainder is sent to landfill without treatment. It is important to note that, due to the processes of disintegration of organic material, untreated organic waste that is buried in the ground becomes a source of greenhouse gases, particularly methane, which is ranked second in terms of its contribution to climate change with a higher capacity to trap heat in the atmosphere than carbon dioxide (OECD, 2023). Measurements of methane from waste burial sites have found emission rates that are 5–7 times higher than that reported by the GGER.[18] Additional environmental damage caused by the burial of untreated waste includes the emission of pollutants into the air, soil and water pollution, spontaneous fires during the decomposition process, odor hazards, etc. (Eliyahu, 2022).

One of the most widespread environmental hazards in Israel is the burning of waste in unregulated burial sites. In the absence of enforcement in the rural sector, waste burning blackspots contribute to the emission of pollutants such as nitrogen compounds, carbon dioxide, and benzine. According to the GGER report, in 2022, there were 9,144 incidents of waste burning in Israel (GGER, 2023); 46% of all carcinogens or suspected carcinogens emitted into the air originate from urban waste burning and 28% from the burning of agricultural waste. Another type of unregulated activity is the dumping of building waste at unsupervised locations. Apart from damaging the landscape and natural environment and using valuable areas, this practice is liable to lead to the emission of pollutants such as asbestos and inhalable particulate matter (PM2.5) that are directly related to respiratory and lung diseases.

17 See the Ministry of Environmental Protection website, Waste Strategy 2030, Circular Economy 2050; see also: Lester and Carny, 2020.

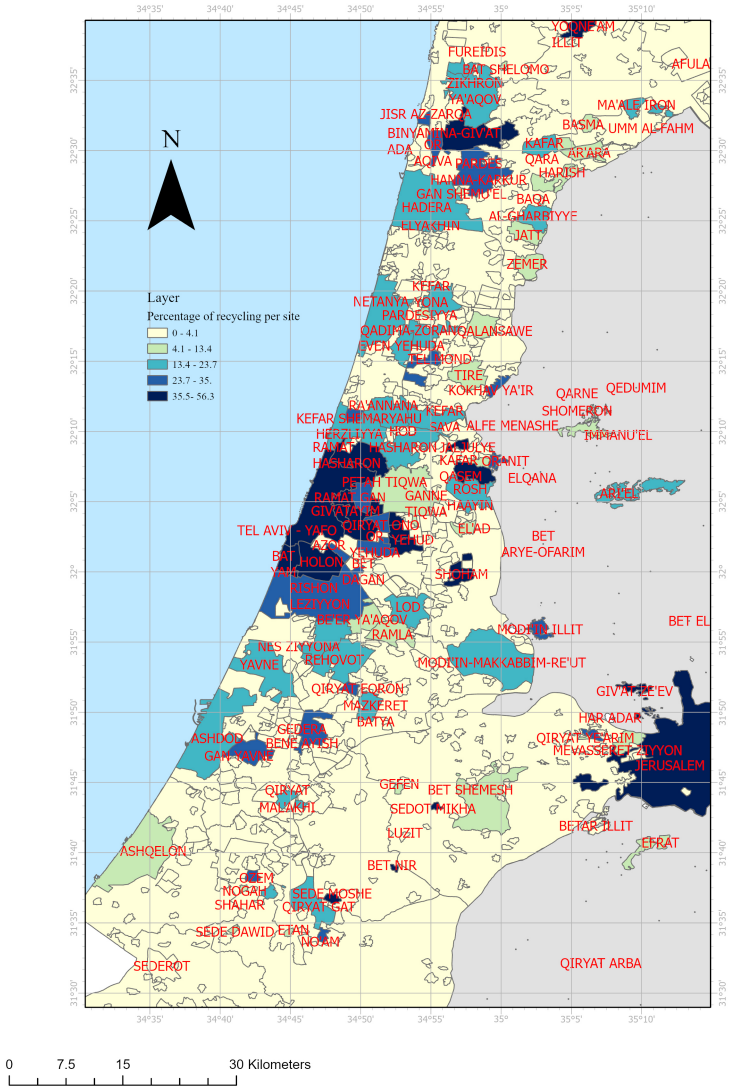
18 See the website of SP Interface.

Recycling of packaging

The Packaging Law enacted in 2011 established that, as the agencies responsible for waste removal, local authorities would be responsible for establishing arrangements for the sorting, collection, removal, and burial of packaging waste; for establishing a prohibition against the dumping of such waste; and for inspection and enforcement means to ensure their implementation.[19] According to the CBS's file of local authorities, in 2021, only 14.4% of local authorities achieved a recycling rate of 35% of the waste generated in their area, while in 30% of local authorities the maximum recycling rate was 6% (Figure 12). The highest recycling rate in Israel is 56% (CBS, 2023).

19 Regulation of Treatment of Packaging Law, 2011.

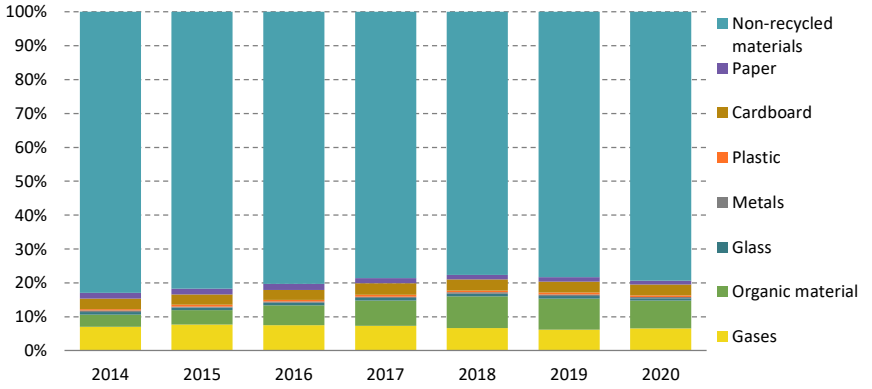
Figure 12. Recycling rates in local authorities in Israel, 2021



Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: CBS, 2023

Figure 13 shows the recycling rates for domestic and commercial waste by type of waste. The figure highlights the high rates of waste burial, which have barely been reduced over the years. Hopefully, the Ministry of Environmental Protection's plan for a sustainable waste regime will secure its target of reducing burial rates to 20% by 2050.

Figure 13. Recycling rates for domestic and commercial waste, by type of waste



Source: Maya Sadeh and Rakefet Shafran-Nathan, Taub Center | Data: CBS, 2023

The Maintenance of Cleanliness Fund

The Maintenance of Cleanliness Fund was established in 1986 under the terms of the Maintenance of Cleanliness Law, 1984.[20] The goal of the Fund is to gather financial means for maintaining the adequate cleanliness of the environment. The Fund is managed by the Ministry of Environmental Protection and receives its income from the landfill levy imposed on local authorities. One of the goals of the landfill levy is to incentivize local authorities to reduce the quantity of waste sent to landfills. In 2021, the State Comptroller examined various aspects of the Fund's activities, particularly the use of the income from the landfill levy, which is the Fund's main financial source (State Comptroller, 2022). As noted, the vision of the Ministry of Environmental Protection calls

20 Maintenance of Cleanliness Law, 1984.

for the transformation of Israel's economy by 2050 from one that is linear — wasteful in its consumption of resources and polluting — to one that is circular and seeks to achieve zero waste.[21] However, the State Comptroller's report revealed that only 37% of the money received from the landfill levy had been utilized; by the end of 2020, the Fund had accumulated a surplus of over NIS 3.2 billion. The Comptroller also found that, despite the considerable financial resources available to the Fund, its activities had not achieved its main goal: a reduction in the rates of waste burial in landfill and the mitigation of the accompanying damage, particularly through the allocation of resources for the development, establishment, and increased efficiency of alternatives to waste burial that are less damaging to the environment.

The updated waste strategy of the Ministry of Environmental Protection details the type and quantity of waste treatment facilities required for its implementation: waste sorting facilities, treatment facilities for mixed waste, facilities for the recovery of energy from waste, etc. In the first stage, in order to transition to a sustainable waste regime, waste sorting should be introduced in metropolitan areas through the creation of waste sorting facilities for the organic flow, together with the introduction of incentives for reduction and waste sorting at source (Lester & Carny, 2020). Four waste sorting facilities are currently operational in Israel and several more are at various stages of establishment. However, in order to meet the plan targets, additional sorting facilities are needed, as well as facilities for treating organic waste and converting it into compost and biogas. The most significant obstacle that this program faces is that local authorities do not want to have these facilities in their localities.

Given rapid population growth and economic prosperity, leading to an increase in consumption and a concomitant increase in the quantity of waste per capita, as well as the fact that most landfills in Israel have reached their maximum capacity, waste treatment is one of the most acute environmental problems facing the country.

21 See the Ministry of Environmental Protection website, Waste Strategy 2030, Circular Economy 2050, as well as Lester and Carny, 2021.

Conclusion

In this chapter we have focused on two key environmental issues in Israel: heat stress and the changes in recent decades, together with the resultant health consequences and coping strategies; and the issue of waste and waste treatment methods. We also cast a Spotlight on indoor air pollution, a phenomenon that has not received adequate attention in Israel in an era when people spend lengthy periods of time in enclosed spaces. Regrettably, information on the impact of rising heat stress — like that of other climatic phenomena — on the physical and mental health of the population in Israel is limited due to a lack of available data. In order to enhance the response to the impact of climate change on health, it is vital to take steps to collect data and make them available to researchers and decision makers alike. It is also essential to strengthen the manpower resources working on these issues in the Ministry of Health and the Ministry of Environmental Protection.

The State of Israel has set itself ambitious targets for 2050 in the environmental field: a substantial reduction of nearly 80% in the emission of greenhouse gases and waste burial, alongside a transition to a circular economy; the production of energy from renewable sources and the development of solutions for energy storage; and the reduction of heat stress in urban areas. Currently, Israel is a long way from achieving these targets and steps must be taken on the national and local government level if they are to be met.

On the national level, action would need to be taken to enact legislation, such as the Climate Law, in order to provide a statutory framework for the necessary steps. The considerable sums accumulated in the Maintenance of Cleanliness Fund should be utilized to implement the transition to a circular economy that minimizes waste. On the local level, it is important that the local authorities be strengthened to enable them to implement the circular economy, including assistance in establishing waste management infrastructures, the provision of incentives to reduce waste, and the reduction of waste burial rates. A further local dimension is the reduction of heat stress in urban areas by creating a continuum of shading and by using building materials that absorb less radiation.

It would behoove the State of Israel to invest in developing climatic, health, and social resilience and act to strengthen the resilience and adaptiveness of communities to mitigate the negative consequences of climatic phenomena. These actions are essential to coping with forecasted climate changes and those that we are already experiencing today.

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