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Climate Change in Israel

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Report Highlights:

The climate change projections for Israel are subject to two main uncertainties. First, incomplete knowledge of climate change science and second, the unknown evolution of future Israeli economic activity and the country's capacity to develop strategies to adapt to climate change. It would seem from recent events that Israeli agriculture is already experiencing the impacts of climate change. These include; a seven year period of drought in the south of the country, an increase in the incidence of extreme summer/winter temperatures and more flood and drought events.

Executive Summary:

Israel is approximately 470km in length and 135km at its widest point. At just 22,000 km^2 in size, slightly smaller than New Jersey, Israel makes up for its small size with a varied topography and climate. Arid zones comprise 45 percent of the area of the country. The remainder is made up of plains and valleys (25%), mountain ranges (16%), the Jordan Rift Valley (9%) and the coastal strip (5%). Israel lies in a transition zone between the hot and arid southern part of West Asia and the relatively cooler and wet northern Mediterranean region. As a result, there is a wide range of spatial and temporal variation in temperature and rainfall. The climate of much of the northwestern area is typically Mediterranean, with mild rainy winters, hot, dry summers and short transitional seasons. The southern and eastern parts are much drier, with semi-arid to arid climate. Throughout the area summers are completely dry, requiring irrigation for crop production.

Israel's population in 2010 reached 7.7 million, an eight-fold increase since its establishment in 1948. Israel's agricultural sector is characterized by an intensive system of production, stemming from the need to overcome the scarcity in natural resources; particularly water and arable land. Israeli agriculture is particularly vulnerable to climate change due to proximity to the arid line, the relatively low amount of cultivated areas, and the steep gradient from north to south and from west to east along the country.

The most recent climate change models project the following impacts of climate change on temperatures, rainfall and water supplies over the 21st century to 2100 in Israel:

1. An increase in temperature of 3-5 °C by 2100, with greater temperature variability.

2. A 10-30 percent reduction in current annual average rainfall.

3. A tendency towards more extreme events/years, leading to a greater incidence and severity of drought and flood events. The extreme rainfall paradox in the Mediterranean → Total rain decreases and extreme rainfall increases.

4. A decline in freshwater supplies by 60 percent from current levels by 2100, due to a lack of water recharge and sedimentation and salination of reservoirs.

Table 1: Summary of Possible Impacts on Agriculture and Adaption Options

Possible Impacts	Adaptation Options
• Shortage in water supply for agriculture. • Damages to crop productivity due to water deficiency and extreme climate conditions. e.g. fruit loss (fall-out) particularly in citrus. Longer periods of hot spells cause increase in water consumption and damage to young fruit. • Changes in crop growing seasons. • Salination and erosion of soil. • Reduced productivity of farm animals. • Shortage in fresh animal feed. • Increased risks of pests and farm animal diseases.	• Increased use of treated effluents in agriculture. • Efficient use of water and improved adjustment of crop location to water availability. • Improved modeling and forecasts. • Technological improvements in irrigation and cultivation methods and implementation of cultivation methods to prevent soil loss. • Genetic improvements in crops and farm animals. • Expansion and adjustment of crop varieties. • Adjustment of planting and harvesting dates. • Improvement of climate control systems in livestock farms. • Development of substitutes for grains in animal feed. • Selection of cattle species resistant to heat and pests and adaptation of animal husbandry methods. • Increased imports of Ag and food products.

** Sources: Israel National Report on Climate Change, Ministry of Environmental Protection.

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Agriculture in the Economy

As in most countries, the relative importance of agriculture in the Israeli economy has declined over the last two decades. In 2009 agriculture shares in total employment and domestic product totaled 2.1 percent and 2.0 percent, respectively.

Growing labor productivity was a key contributor to the almost two-fold increase in total factor productivity in agriculture from 1990-2009, much stronger than any other sector of the Israeli economy.

In addition to agricultural output, agriculture is also a public commodity which provides external benefits such as preservation of open space in the rural and urban environment, diverse and unique landscapes, contribution to tourism, pollutant absorption, and contribution to air quality. Nearly 40 percent of Israel's agriculture has landscape value, which is highly rated due to the density of population and the lack of green areas in the natural landscape. Therefore damage to agriculture, beyond damaging certain crops, may also have an adverse impact on green areas, tourism and more. The indirect economic benefits which Israeli agriculture provides were estimated at NIS 1.3 billion ($350 million) per year. This value incorporates different aspects. A savings of $50 million a year is estimated through the utilization of effluents in agriculture, at a quality lower than that required for discharge to natural streams. The absorption of approximately 2 million tons of CO_2 per year has been estimated at about $20 million per year, due to the possibility of emissions trading. The extent of agro-tourism has been estimated at approximately NIS 75 million ($20 million) per year, which is expected to increase with the growth in population and incoming tourism. Agriculture also serves as an open area for the development and conservation of wildlife and for rainwater infiltration to groundwater. Hence, the social-environmental contribution of agriculture goes beyond its business contribution.

Israel is unique amongst developed countries in that land and water resources are nearly all

state-owned. Another distinguishing characteristic of Israeli agriculture is the dominance of co-operative communities, principally the kibbutz and moshav. While the co-operative aspects of agricultural production management have gradually been replaced by more privatized management systems, these communities still account for approximately 80 percent of agricultural output.
Preliminary estimates for 2010 shows that agriculture production value increased by about 2 percent, compared to the previous year, totaling $7.03 billion.

Despite the many problems faced by Israeli farmers in recent years, such as drought and rising water prices, Israel's fresh agricultural exports rose 10.5 percent in 2010 compared to 2009, totaling $1.36 billion. In 2010 out of total production value, 19.3 percent was exported (up from 18.8 percent in previous year).

Due to the fact that agricultural products prices are increasing, combined with the assumption that the global economic situation will continue to improve in 2011, Post estimates that Israel's fresh agricultural exports value will increase by approximately 5 percent in 2011.
The main exports in 2010 were fresh vegetables (39.5%), citrus (12.7%), fruits (16.3%) flowers (8.9%), and field crops, mainly cotton and sunflower seeds for confectionery (6.5%), livestock and others (17%).

Table 2: Fresh Produce Export, CY

Fresh produce export 2010 compared to 2009

Million USD $ and percentage

Branch	2008	2009	2010	change in %
Export Gross	61339	47935	58430	21.9%
A. Agriculture export	1225	1229	1359	10.5%
Vegetable,potato,melon	473	505	537	6.4%
cotton and other field crop	99	68	88	29.9%
Citrus	101	138	173	24.7%
Avocado & other fruit	170	196	222	13.4%
Flowers	203	146	121	-16.7%
Livestock	32	32	37	16.8%
Others	145	143	178	24.8%
B.Food and beverage	*872*	*721*	*791*	*9.8%*
Total A+B fresh and processed	*2097*	*1951*	*2151*	*10.3%*
Fresh produce from total Israeli export	*2.0%*	*2.6%*	*2.3%*	*-9.3%*

Source: Israeli Ministry of Agriculture.

In 2009 of the approximate $6.9 billion (NIS 25.6 billion) in agriculture production, 18.8 percent was exported (up from 17.5 percent in previous year), 39.6 percent was consumed fresh in the local market, 34.0 percent was processed and the remainder, 7.6%, was used as intermediate produce (seeds, plants, day old chicks). Data for 2010 is not yet available.

In 2009, crop production accounted for 61 percent of total output value with livestock products contributing the remaining 39 percent. Fruit and vegetables are the most important products accounting for almost 50 percent of the total output value, with field crops contributing just 7 percent in 2009 – slightly less than in 1990. Poultry and cow's milk are the most important livestock products. Post estimates that the 2010 agriculture output value by market share did not change compared to 2009 data and market shares are not expected to change significantly in 2011.

Overall, agricultural output expanded by 60 percent during the period from 1990 to 2009, with livestock and crop output growing equally. However, a deficiency of water resources, with two-thirds of the land area defined as semi-arid or arid, exposes agriculture to risks from changing weather conditions and leads to large year-to-year fluctuations in volumes produced. Nevertheless, the 2.2 percent average annual growth rate of agricultural production over the period of 1990-2008 is above the rates registered in most OECD countries and significantly above Israel's population growth.

Table 3: Agricultural Output Value, Market Share, by Sector (2009)

Field Crops	**Vegetables, Potatoes & Melons**	**Citrus**	**Fruits excl. Citrus**	**Flowers & Plants**	**Poultry**	**Cattle, Sheep & Goats**	**Misc.**
6.3	23.9	5.2	19.4	3.3	18.4	18.0	5.5

Source: Central Bureau of Statistics

Agricultural land of around 380,000 hectares represents approximately 17 percent of the land area of Israel (2010 data is not yet available). It consists of 290,000 hectares of arable land and of about 90,000 hectares of pastures. In turn, 52 percent of the arable land is irrigated and the remaining 48 percent rain fed. Thirty eight percent of the cultivated area is in the northern parts of the country, 14 percent in the center and 48 percent is in Jerusalem area and southern region. Post estimates that agricultural land usage in 2010 and 2011 has not changed significantly compared to 2009 data.

Approximately 65,000 people are employed in the agricultural sector, representing 2.0 percent of Israel's total labor force. Out of total workers in the agricultural sector, approximately 23,000 (35%) are foreign workers mainly Thai workers and 6,100 workers are Palestinians (9%) from the Palestinian Authority. Fifty five percent (36,000) are Israelis, of which 21,000 are independent farm owners and collective farms members.

The agricultural sector has benefited from high levels of investment in research and development, well developed education systems and high-performing extension services. Israel is a world leader in many aspects of agricultural technology, particularly those associated with farming in arid conditions. Thus, agriculture relies not so much on a "natural" comparative advantage in farming, but on an "induced" comparative advantage built on technological progress. Expenditures on general services to the agricultural sector as a whole have increased, and particularly infrastructure related investments in recycled effluent water treatment. Israel also stands out compared to the OECD average, in terms of expenditures on research and development. During the last six years these accounted for 18 percent of total budgetary expenditures on agriculture. Israelis are justifiably proud of their accomplishments in the agriculture arena. In addition, agriculture has played a pivotal role in the culture and history of the country, and forms a core part of its identity.

According to the recent OECD report (OECD Review of Agricultural Policies in Israel, 2010), since the late 1980s Israel has gradually removed policies based on the provision of subsidies, central planning of agricultural industries, allocation of production quotas, price controls and import protection. Objectives are being more effectively met by policies that better target the intended outcomes while generating fewer distortions to trade and resource allocation. But, the government still plays a much larger role in the agricultural sector than in other industries, as reflected in its involvement in allocating key factors of agricultural production: land, water and foreign workers. Indirect assistance to the agricultural sector is provided via the permit system for foreign workers. Agricultural producers are protected (but consumers taxed) by high tariffs on imports of the majority of agro-food products. Water and capital continue to be subsidized. Some sectors such as milk and eggs are covered by sector-specific policy measures such as minimum guaranteed prices and production quotas aiming at securing profitability of production for a majority of producers. Progress in agricultural policy reforms is indicated by the fact that the level of support to agricultural producers has decreased gradually and that the cost of the support to the overall economy has been reduced.

Israel has opened (duty free) imports for land-intensive products, in particular for grains and oilseeds. It has also made substantial efforts to address growing concerns about the environmental situation of the country. However, the OECD report has recommended that further agricultural policy reforms are needed to reduce the cost for consumers and taxpayers and to improve the efficiency of the various policy measures applied. These reforms should include: reductions in administrative costs associated with agricultural land market transactions; better enforcement of labor market legislation; reduction and simplification of agricultural import tariffs; and implementation of less distortive policies for the livestock sector.

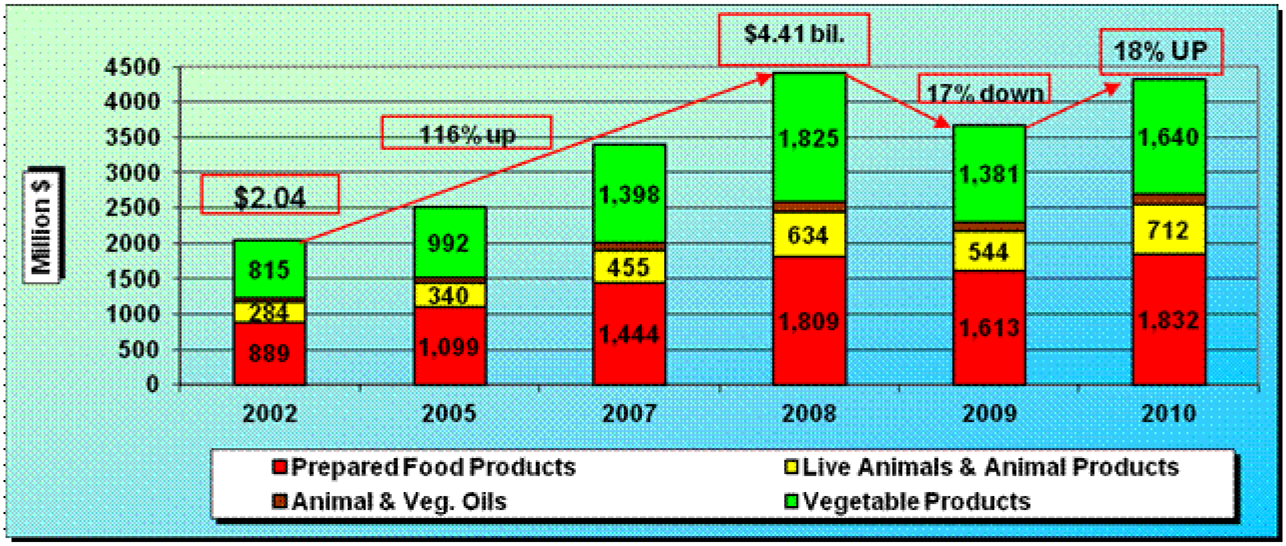
Agricultural Trade Environment

Israel has been a member of the World Trade Organization (WTO) since 1995. As a result of the implementation of the Uruguay Round Agreement on Agriculture, Israel now maintains a more transparent and more open trade regime. However, the tariff profile for agricultural products is very uneven – with very high tariffs for sensitive products such as dairy, meat, eggs and some fruits and vegetables, and low tariffs or sometimes duty-free entry for other commodities such as coarse grains and oilseeds. According to the recent OECD report, Israel should consider further reduction of trade barriers on agricultural products and further simplification of the current highly complex tariff profile.

Israel's has agreements on Trade in Agricultural Products with the U.S, EU, Mercosur countries, Turkey, Jordan and EFTA countries.

As result of the improved economic situation, total agricultural and food imports in 2010 increased nearly 18 percent compared to the previous year (from $3.68 billion to $4.33 billion). Out of total imports, $1.83 billion (42%) were food and beverages products. The weakening US dollar combined with the improved economic activity increased import demand for U.S. agricultural and food products. Agricultural and food imports from the U.S. increased 27 percent to $543 million in 2010, while imports of agricultural and food products from the EU increased 11 percent to $1.68 billion in 2010.

Chart 1: Israeli Imports of Agricultural, Processed Foods and Beverages Products



Source: Source: Central Bureau of Statistics

Israel's main agricultural imports are cereals, bovine meat, oilseeds, sugar, fish, and tropical products such as cocoa for further processing. Israel is almost completely dependent on imports to meet its grain, soybean and feed needs.

In turn, Israel is self-sufficient in the production of milk, poultry and eggs. The most important U.S. food and agriculture exports to Israel are coarse grains, oilseeds, dried nuts, fruits and prepared food products.

Climate Change Issues

Climate

Israel lies in a transition zone between the hot and arid southern part of West Asia and the relatively cooler and wet northern Mediterranean region. As a result, there is a wide range of spatial variation in temperature and rainfall. The climate of much of the northwestern part of the area is typically Mediterranean, with mild rainy winters, hot, dry summers and short transitional seasons. The southern and eastern parts are much drier, with semi-arid to arid climate. Throughout the area, summers are completely dry, requiring irrigation for crop production. Average annual rainfall varies from less than 30 millimeters (mm) in the southern part of Israel to as much as 1000 mm in the north. Rainfall along the Mediterranean coast ranges from 300 mm in the south to 600 mm in the north. More than 60 percent of the area receives less than 250 mm annually. As is typical of arid and semi-arid climates, there is considerable inter-annual variability in rainfall. Precipitation in wet years may be almost three times that of dry years.

The annual mean of rainy days is 50-70 in the northern and central parts of Israel, decreasing to less than 30 days in the southern region. These winter precipitations largely result from the relatively cold air masses passing over the warm Mediterranean Sea. The coastal area belongs to the dry summer subtropical (Mediterranean) climate; although it’s southern continuation belongs to the semi-arid climate, characterized by potential evaporation and transpiration exceeding precipitation. This marked transition between two climatic types along the coast may serve as an important indicator of the sensitivity of the Eastern Mediterranean Basin to regional climate change. Summer temperatures are generally high, with the average maximum ranging between 29°C to 33°C in the coastal plain and the mountains and around 40°C in the Jordan Valley (eastern Israel) and Arava (southern Israel). In the winter, maximum temperatures average about 17°C along the Mediterranean coast and about 10°C at higher altitudes. In the Jordan Valley and Arava, winter temperatures may exceed 25°C during the day and could drop to 7°C or lower at night.

Sources: Israel National Report on Climate Change, Ministry of Environmental Protection
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Water Resources

The critical challenge for Israel is how the projected 700 Mm3/y increase in total water consumption by 2025 (from the current level of around 2 000 Mm3/y), can be reconciled with the expectation that climate change and climate variability will lead to a reduction in water resource availability. For agriculture, possibilities exist to improve the efficiency in water use. While irrigated agriculture is expected to increase its total use of water from 2005 to 2025 by almost 270 Mm3/y, its overall share in total water consumption is projected to decline, while use of recycled effluent water and desalinated seawater by agriculture should increase on the account of freshwater.

Out of total water distribution, the market share of water for agriculture decreased significantly during recent years, from nearly 70 percent market share in 1990 to 57 percent market share in 2010. On the other hand, the market share of water for domestic consumption (household and public) increased from 24 percent market share in 1990 to 38 percent market share in 2010.

Agriculture consumes about 57 percent of the country's total of 2 billion cubic meters of water a year, yet only accounts for 2 percent of Israel's GDP. Considering these numbers, there are questions whether agricultural growth in a desert climate like Israel's is really sustainable. Israel's ideology of making the country bloom has encouraged heavy government subsidies for farming. Israeli farmers pay roughly 60 percent lower compared to water price that is used by urban residential users.

Temperature changes affect cloud characteristics, ground humidity, storm intensity, snowfall, and snow melting in different areas. Changes in precipitation affect the timing and intensity of droughts and floods, surface runoff regimes, and recharge rates of natural water reservoirs. In addition, patterns of vegetation and ground humidity also have an impact. An increase of 1-2°C and a decrease of 10 percent in precipitation, for instance, could lead to a decrease of 40-70 percent in the annual average flow of rivers, which will impact agriculture, water and energy supply. Israel's water potential, based on a 36 year multiannual average, is estimated at some 1555 million cubic meters (MCM) per year. Excluding the eastern mountain aquifer, the Negev and the Arava desert, the water potential is estimated at some 1400 MCM per year. However, according to Israel's Water Authority, high fluctuations are evident between the years, with a standard deviation of 477 MCM. Out of the total, some 650 MCM of water per year are from the Sea of Galilee (the only natural freshwater lake in Israel and a primary source of water), 110 MCM per year from the Western Galilee, 130 MCM per year from the eastern basins, 320 MCM per year from the mountain aquifer, 25 MCM per year from the Carmel coast, 250 MCM per year from the coastal aquifer, and 60 MCM per year from the Negev and Arava desert basins.

In the wake of six consecutive years of drought which have significantly reduced Israel's freshwater reserves and in preparation for future climate changes, Israel has decided to include climate change within the framework of its strategic program for the water sector. Israel's 2010 Climate Change Report, (by the Ministry of Environmental Protection) points to the following potential impacts of climate change on water in Israel:

- Increase in the frequency and severity of floods, which may cause major damage to property and people.
- Twenty five percent reduction in water availability for 2070- 2099 in comparison to 1961-1990.
- Reduction in groundwater recharge.
- Loss of an estimated 16 MCM of water for each kilometer along the coastal plain as a result of

a potential rise in sea level of 50 centimeters.
• Changes in the salinity level of the Sea of Galilee.

Source: Israel Water Authority

Agricultural Greenhouse Gas Emissions

Based on Central Bureau of Statistics data, Israel emitted more than 76 million tons of greenhouse gases per year (CO_2 equivalent) in 2007, a rise of 20 percent since 1996.

Agriculture's share in total Israeli greenhouse gas (GHG) emissions is relatively small at 4 percent in recent years. The main sources of agricultural emissions are from methane (CH_4, mainly livestock enteric fermentation) and nitrous oxide (N_2O, largely from application of inorganic fertilizers). Carbon dioxide (CO_2) emissions (principally from energy combustion in farming) account for a minor share of total agricultural GHG emissions measured in CO_2 equivalents.

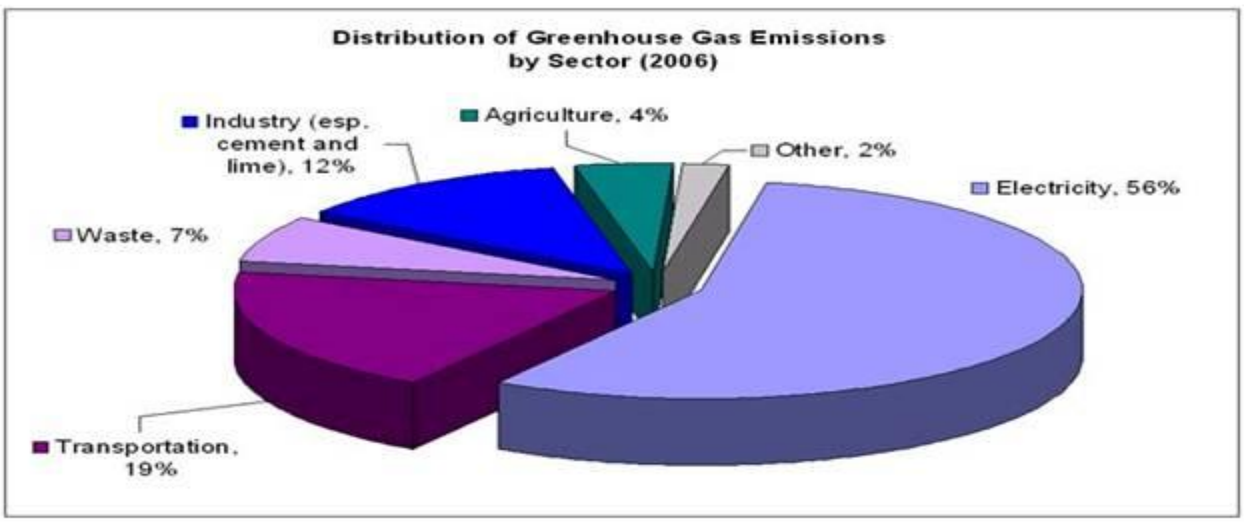
There was little change in total agricultural GHG emissions over the period from the early/mid 1990s to recent years. This reflects an increase in GHG emissions from rising numbers of livestock, largely offset by reductions in GHG emissions resulting from :

- A decline in inorganic fertilizer use since the late 1990s, associated with improved fertilizer management and increased use of wastewater;
- An increase in manure recycling and advanced waste-treatment methods, and establishing regional manure collection and recycling sites, resulting from the livestock reform programme;
- Improvements in cooling systems and management of dairy farms leading to an annual reduction in dairy cow GHG emissions equivalent to about 1% of total agricultural GHG

emissions;

- Implementation of a new programme of methane gas collection from landfills. Many of these emission mitigation actions in the agriculture sector reflect those that were recommended in the Israeli submission to the UNFCCC (2000). The UNFCCC has recommended further actions to reduce GHG emissions from agriculture, including wider use of minimum tillage and an increase in crop coverage.

Chart 2: Distribution of Greenhouses Gas Emissions by Sector in Israel, 2006



Sources: Israel National Report on Climate Change, Ministry of Environmental Protection.
Central Bureau of Statistics

In November 2010, the Israeli government approved NIS 2.2 billion national plan to reduce greenhouse gas emissions**.** The plan is expected to lead to more efficient energy consumption. Thus, Israel will join the international community in the global effort to deal with climate change and meet the demands of the OECD.

Implications of Climate Changes on Agriculture

Israeli agriculture is particularly vulnerable to climate change, due to the proximity to the aridity line, the relatively low amount of cultivated areas, and the steep gradient from north to south and from west to east along the country. Possible climate changes expected to impact agriculture include: change in precipitation amounts, change in temperature trends, ecological changes and increased concentrations of CO_2. Severe damage to agriculture is expected primarily as a result of the potential increase in extreme weather events, rather than as a result of changes in the annual average.

<u>Potential impacts of climate change on agriculture in Israel:</u>

- Damage to crops due to a reduction in water availability in the soil, 20 percent increase in water demand for irrigation, reduction in fruit and vegetable yields, emergence of new pests and pathogens and increase in the frequency of animal and plant diseases.
- Sharp cutbacks in allocations of freshwater resources for agricultural irrigation.
- Possible advantages to growth due to an increase in CO_2 concentrations in the atmosphere, but potentially also leading to reduced crop yields and intensified use of herbicides.
- Increased risk of soil erosion.
- Benefit to certain crops from higher winter temperatures.
- Reduced productivity of farm animals.
- Shortage of animal feed and increase in its cost.
- Shortening of the productivity season of pastureland.
- Damage to populations of pollinating insect species.

In addition, recent studies suggest that over the period up to 2020 climate change could be beneficial to agriculture, due to the ability of Israel to supply international markets earlier in the season (Fleischer *et al.*, 2008), although this result is contested in some models (Kan *et al.*, 2006).

Sources: Israel National Report on Climate Change, Ministry of Environmental Protection
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University.

Implication of Changes in Precipitation

An increase in extreme rain events will lead to increased surface runoff, increased transport of pollutants to surface water bodies, increased infiltration of pollutants into groundwater and damage to crops. An increase in extreme rain events will also increase the risk of soil erosion, whereas, approximately 40 percent of field crop areas and agricultural lands and 10 percent of fruit grove areas are classified in the category of severe erosion. Decreased amounts of precipitation will lead to decreased infiltration and decreased availability of water in the ground for summer and winter crops. In the wake of a decrease in precipitation, the rainy season may shorten, requiring earlier irrigation of summer crops, as well as extensive irrigation, as a result of inadequate flushing of salts from the soil profile during the winter.

In addition, farmers growing rain dependent crops are currently unprepared for drier conditions. Since water demand will increase with the expected decrease in precipitation, dramatic cuts in the allocation of freshwater sources to agriculture are expected in coming years, with the possibility of a complete ban on freshwater supply to agriculture during long periods of droughts. Studies have demonstrated the ways in which the expected decrease in precipitation in Israel will lead to economic damages in the agriculture sector. One study examined the influence of two climatic scenarios (A2 and B2) for the years 2070- 2100 on wheat, a central crop in the southern region of Israel, and cotton, which represents the more humid north. For wheat, under the A2 scenario, the profit turned negative (between -145 percent and -273 percent relative to current values), and under the B2 scenario (more moderate), a mixed trend was obtained (between -43 percent and +35 percent relative to current values), probably due to an increase of 17 percent and 10 percent in precipitation amounts in January and March, respectively, under this scenario. This demonstrates that even under the moderate B2 scenario, a change in the distribution of precipitation during the growth period significantly affects the expected crops. For cotton, on the other hand, under both scenarios, a significant decrease in crops was found, leading to significant economic losses (-240 percent under the A2 scenario and -173 percent under the B2 scenario, relative to current values), and an increase of 25 percent in water consumption. It was found that farmers could compensate for the water loss by nitrogen fertilization and additional irrigation, in the case of the moderate scenario, but not by changing the dates of seeding. Therefore it is anticipated that crops which are currently rain-dependent will become irrigation-dependent in the future, due to the expected decrease in water supply in the area. Another research study examined three damage scenarios to agriculture as a result of a possible 4 percent reduction in precipitation. According to the first scenario, an arbitrary cut in the production of all crop groups will lead to an annual loss of approximately $208 million. According to the second scenario, which included partial preparedness by the agricultural sector, the expected annual loss will be $101.5 million, including some $40 million from indirect cuts in water for irrigation. A third scenario took into account expanded use of desalination for the supply of potable water for household consumption. The annual cost of this scenario is approximately $126 million (cost assumed at 80 cents per cm of desalinated water). It should be noted that these two studies did not examine adaptation actions, such as technological improvements, crop improvements, agro-technical changes (such as crop rotation), and the effect of increases in CO2 concentrations and other atmospheric changes on crops.

Sources: Israel National Report on Climate Change, Ministry of Environmental Protection ;
Alpert, P., T. Ben-Gai, Y. Benjamini, A. Baharad, M. Colacino, E. Pierviali, C. Ramis, V. Homar, S. Michalides and A. Manes (2000) Evidence for trends to extremes in observed daily rainfall categories over the Mediterranean.

Implications of Changes in Temperatures

The implications of an increase or a decrease in temperatures depend on the intensity, frequency and duration of the heat or cold periods. A number of positive impacts are expected from temperature increases, due to the fact that farmers adapt their crops to the climatic conditions in the area. This adaptation is largely accomplished by utilization of the heat conditions. Thus, Israeli agriculture is relatively tolerant to heat conditions. In Israel, especially in warmer areas, fruit, vegetables and flowers are grown during the winter, and are primarily exported to Europe. This allows Israeli products to reach the market early, and to sell for high prices in the European and local markets. In this case, higher temperatures have an advantage by overcoming water scarcity while using irrigation. Another benefit to crop yields, in the wake of temperature changes, is expected from the change in seeding and blooming times of the crops. This change could prolong the growth season.
On the other hand, there is a tendency towards more extreme events/years, and the effects of extreme temperatures:

1) Fruit loss (fall-out) particularly in citrus

2) Longer periods of hot spells cause increase in water consumption and damage to young fruit.

One research study examined the economic implications of the adaptation of Israeli agriculture, excluding farm animals, to increased temperatures.
The study used a model which takes into account adaptation activities which farmers could take, such as crop rotation, changes of crop types, and technological techniques. When irrigation quotas were dictated to farmers, a slight increase in temperature (forecast for the year 2020) led to increased profits, but the continued increase in temperatures (expected by 2100) led to decreased profits. Without limits on the irrigation quotas, the temperature increase led to profit increases over time. Thus, additional irrigation helped to reduce the effects of the temperature. Nonetheless, it should be taken into account that the research assumption was that water supply will not change with climate change. A potential damage to agriculture, due to temperature change, could reduce the productivity of farm animals. Animals on an agricultural farm (chickens, cattle, sheep, etc.) are very sensitive to heat and, therefore, their suitability and ability to produce high quality yields, under Israel's heat conditions, is problematic. Nonetheless, Israel has been coping with the constraints of climate for many years, by such means as improved living conditions for the animals, use of better structures, air conditioning systems, and others. Hence, it is assumed that this sector will not be directly affected by climate change, in terms of expected increased temperatures and humidity in this region. Nonetheless, the need for heating or cooling of livestock sheds (and greenhouses) is expected to increase.

In addition, one of the main consequences of climate change on farm animals is on their food (animal feed) since 20 percent of the cow feed on Israeli farms grows in Israel and is based on rain water. A series of arid years, or an extremely arid year, could lead to a shortage of animal feed.

Sources: Israel National Report on Climate Change, Ministry of Environmental Protection
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Implications of Ecological Changes

Ecological changes, expected in the wake of climate change, include risks of wood drying or fires in dry habitats, and shortening of the production season of grazing areas, thus damaging animal feed. Also, in recent years, an increase has been observed in farm animal diseases, which originate from mosquitoes and pests. This increase could be caused by a number of factors, including climate change (i.e., rise in temperature, which leads to an increased rate of pathogen growth). The increase of nocturnal summer temperatures, observed in recent years, contributes to maintaining high temperatures during most hours of the day, which enables a more rapid growth of disease. In addition, a northbound migration of insect populations has been observed, with southern insect populations overtaking their habitats. In extreme weather areas, such as the Arava desert (southern part of Israel), a small change in climatic conditions is significant for insects, and could lead to the deterioration of certain insect species, which have managed to survive to date. In areas with moderate climate, a small change is not expected to lead to the deterioration of these populations.

** Source: Israel National Report on Climate Change, Ministry of Environmental Protection ;
Israeli Ministry of Agriculture

Economic Implications of Climate Changes

There are a number of economic considerations which accompany the implications of climate change on agriculture:

- A rise in the incidence, intensity and frequency of extreme weather events will damage crops and will cause severe economic damages. For instance, in 2008, damage from a freeze wave was estimated at more than NIS 500 million ($135 million).

- An expected decrease in water availability in the area will lead to heavy economic damages to agriculture. Nearly 60 percent of the water supply is diverted to irrigation, and water supply is heavily controlled via consumption quotas. Nearly all crops are irrigated, except field crops. In 2009, freshwater contributed only 47 percent of the water allocated for agricultural use and its relative part in agriculture continues to lessen with the years. Nonetheless, there are sectors which consume mostly fresh water, such as orchards, vegetables, flowers, and the cattle sector. A reduction of 50 percent or more in freshwater quantities for agriculture is very realistic according to the climatic scenarios expected in Israel, and the economic damage is estimated at billions of NIS. Reducing agricultural water consumption by 200 MCM per year, as expected according to several forecasts for 2020, will lead to reduced income of approximately $100 million a year and a loss of thousands of jobs.

- A decrease in the feed quality for livestock and an increase in its prices will lead to reduced profits. The shortening of the production season of grazing areas will lead to increased usage of more expensive feed substitutes. For instance, grazing lands in humid Mediterranean climate areas currently save cattle growers $83.2 per hectare a year and $116.5 per hectare a year for sheep growers.

- A loss of soil, due to erosion, is estimated at some NIS 15 ($4.3) per cubic meter. In the case of 100,000 hectares, which are a million cubic meters of land, the damage adds up to NIS 15 million ($4.3 million).

Sources: Israel National Report on Climate Change, Ministry of Environmental Protection ;
Israeli Ministry of Agriculture

Recommended Actions to Prepare for Anticipated Climate Change

Since climate change seems evident and mitigation efforts may not entirely halt the ongoing processes, it is highly recommended that a series of actions be taken to monitor, moderate and prevent some of the global warming impacts. International studies, especially the Stern Review on the Economics of Climate Change, have suggested that early proper action can greatly reduce the heavy economic costs of climate change. Therefore, each suggested action should be analyzed in terms of its economic benefits vs. the alternative "no action" option, and feasibility should be estimated in the local context. In addition, an overall analysis of the suggested actions should be conducted in order to prevent negative synergistic impacts of actions or inefficient use of resources. The following section presents a list of suggested actions in major relevant fields.

** Sources: Israel National Report on Climate Change, Ministry of Environmental Protection ;
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Crops

• Improvement of the quality of annual forecasts, development of models to predict crop growth, productivity, water and fertilizer consumption, models for pests, insects and plant diseases, and work plans derived from these in accordance with climate changes.

• Addition of variables which present the impacts on agriculture using statistical analysis, such as: frequency and strength of severe heat stress periods and freeze events, frequency of dry spells between rain events, and other events, which affect plant physiology. Improvement of the ability to identify significant trend changes in the relevant variables for climate change in statistical agriculture models.

• Increased use of effluents in Israel as a substitute for freshwater. Connection of all effluent reuse facilities to agricultural irrigation facilities in order to minimize the flow of treated wastewater to the sea. At the same time, it is important to irrigate crops with freshwater as well in order to neutralize soil salination and damage to soil fertility from reused water.

• Intensification of water conservation by increasing the use of crops which require lesser amounts of water and whose added value per cubic meter of water is higher (such as wheat, chickpeas, sunflowers, cauliflower, lettuce and garlic), use of saline water, integration of vegetables between rows of orchards and improvement of water technologies in order to improve irrigation efficiency (e.g., pulse irrigation, recovered wastewater and drip irrigation systems).

• Genetic improvement and selection of crops resistant to heat stress, dryness, and cold, and to the increase in CO_2 concentrations. Biotechnology allows for the introduction of species more tolerant to salt and pests and for a general improvement in crop yields and quality.

• Improvement in greenhouse technology, including applying changes to the variety of crops, used inputs, and climate control systems.

• Changes in planting and harvesting dates and selection of a wider seasonal variety. Advancing the planting times of crops could help cope with the rise in temperatures. Nonetheless, not all crops are suitable for this procedure. For example, researchers have found that early seeding is not an effective adaptation measure for wheat and is only slightly efficient for cotton.

• Preference of spring and autumn crops, with a short growth period, in order to avoid the heat stress of midsummer. Winter crops could become more productive than summer crops.

• Compatibility between the efficient water use of the different crops and selection of suitable areas to grow those crops.

• Implementation of methods to reduce erosion and prevent soil loss, in addition to increasing The infiltration of water into the fields. The 'no-till' method allows the preservation of the soil and reduction of erosion since there is no soil inversion, and seeding takes place near the vegetation harvested the previous year.

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Farm Animals

• Improvement of existing climate control systems, improvement of planning and the materials Used for livestock farms, shading and the use of sprinkler systems in order to relieve the farm animals of the heat stress.

• Selection of cattle species more resistant to heat conditions and pests, or genetic improvement of existing species (resistance to heat and pests, and effective food utilization), and timing breeding according to seasonal conditions.

• Development of methods to reduce and/or replace animal feed containing grains, including methods for recycling organic and industrial waste, which will be used as food for farm animals, instead of cereal crops.

• Development of methods to improve the nutrient quality of agricultural and waste by-products, such as straw.

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