The Israeli Water Crisis: Potential Solutions in the Agricultural Sector

THE ISRAELI WATER CRISIS:

POTENTIAL SOLUTIONS IN THE AGRICULTURAL SECTOR

By

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Abstract:

This thesis explores the history, politics, policies, and technologies that define Israel's struggle for water. A country wealthy in brainpower, Israel currently employs many viable options that have greened its desert. A discussion of the types of water and the methods and technologies with which to salvage them for use by the inhabitants and agriculture of Israel are included in this thesis. Current domestic and agricultural water usage in Israel is explored, and its future water demands projected. Introduced are the problems of this arid climate, its geography, soil, and population. This paper demonstrates that Israel's past and current water policies and laws have determined that obtaining and conserving water is beneficial at any price to maintain its stability and dominance in the region. However, as water issues are regional and, thereby, transboundary, this thesis concludes that Israel should work with its neighbors on cooperation on water issues as a way of improving peace.

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Introduction to Israel's Critical Issue of Water

With sixty percent of its land desert and a rapidly increasing population, Israel continues to face a historically deep strain on its water systems. Israel's political desire to have a strong centralized state helped to create water scarcity. According to Samer Alatout, a professor in the College of Agricultural and Life Sciences at the University of Wisconsin, prior to the establishment of the State of Israel, water policy was based on the belief that water was abundant. After the founding of the State, the theory changed to the recognition that water was actually quite scarce. Therefore, water became an important and necessary consideration for the construction of a strong, centralized nation and its growing economy (Alatout).

Until the early rainy months of 2012, the nation had officially been in a drought for the prior seven years. According to Israel's Water Authority Hydrology Service, these rains merely put a bandage on the country's hemorrhaging water crisis (WorldNewsTribune). By early in the following year, the "severe drought" warning had been lifted, but Israelis were warned not to take their current stable water situation for granted (Ben-David). If no earlier action had been taken, the lack of available usable water would have eventually begun to affect the lifestyles of civilians. Fortunately, Israelis have been proactive with this crisis. By 2014, Israel plans to have five desalination plants to supply usable water (Rabinovitch). If Israel and its neighbors continue to cooperate with one another in dealing with the region's water shortage, their prospects for future water resources should be brighter than those of their history. Israel is the only nation in the world reducing its deserts and increasing its fertile land (Yearwood).

Objectives of This Thesis

This thesis utilizes information studied while in the Overseas Program at Tel Aviv University during the Spring 2012, as well as research conducted during Senior Year at The University of Arizona, Tucson, to examine the history of the Israeli water crisis, specifically in the agricultural sector, and to showcase the current methods being used and planned to increase supply. It will introduce the problems of this arid climate, its history, geography, soil, and population. This paper will also review the water policies Israel has employed to increase its supplies and conserve its limited water reserve. The country has assertively advanced water reserves by funding water organizations and aiding agricultural water consumers (Tal, "Seeking Sustainability"). Over the past seventy-five years, Israel's national water company, Mekorot, has created a countrywide system of conduits and controls that move water amongst Israeli's primary water basins, including ground water from the Mountain and Coastal Aquifers, surface water from the Sea of Galilee, rivers, natural springs, floodwater reservoirs, and reclaimed and desalinated water ("Israel's Water Supply System").

A discussion of the types of water and the methods and technologies with which to salvage them for use by the inhabitants and agriculture of Israel will be included in this paper. Current domestic and agricultural water usage in Israel will be explored, and its future water demands will be projected. The pricing of agricultural water will be examined, as the question "at what price do the new technologies Israel employs become economical?" will be answered. With Israeli agricultural water usage at 1.016 million cubic meters (in 2009), there is a constant struggle between the municipal and industrial sectors in their fight against the agricultural sector for their share of the water (Israel Briefing Book). In this thesis, the political effects on Israel's available water will be surveyed; areas that will be specifically looked at will include the sharing of water with Palestinian territories. Finally, this thesis will summarize its conclusions. A thorough list of references will be provided.

Historical Background

Ancient Times

“King Solomon reminds us that where water is scarce, water is wealth: ‘I constructed pools of water to irrigate a forest springing up with trees…Thus I gained more wealth than anyone before me in Jerusalem (Eccles. 2:9; Covenant 19).’”

Israeli’s coastal aquifer, or basin, dates back to the Pleistocene Age, from approximately 2,588,000 to 11,700 years ago, and consists of tiers of calcareous sandstone, conductive rocks, and sand -- both claylike loam and granulated. Reaching from Mount Carmel in the north to the Sinai Peninsula in Egypt, and from the eastern base of the mountains to the ocean, east and west, the aquifer joins the National Carrier, which distributes groundwater across the country ("Water Resources of Israel").

Roughly 20,000 years old, the Sea of Galilee, also known as Lake Kinneret, had lower extremities reaching toward the very southern part of Israel and the city of Eilat, and became known as the Dead Sea. During biblical times, the Jordan River began north of the Galilee and also continued to the Dead Sea. The Bible refers to this river as a place Israelites used to cross to the Promised Land (Starr). Around 15,000 BCE, during the Geometric Kebaran Period, the hunter-gatherers evolved into agricultural people. Population density determined the speed at which different geographic areas evolved into growing their own sustenance (Grossman).

Canaan was an early name for the land now known as Israel. Although the Canaanites and Israelis had a mutual language and customs, they were bitter enemies (Canaan). The Canaanites, who thrived during the climatic crisis of 6200 BCE, were a blend of hunter-gatherers and farming cultures. They tamed wild animals and built crude shafts leading to water tunnels at Jerusalem and Megiddo. A ten-foot in diameter well descending 67 feet was built by the Canaanites at Beth Shemesh 30 kilometers west of Jerusalem, and survived through most of the Israelite period. At Tell ed-Duweir, now known as Tel Lachish, the Canaanites built a well that found water 120 feet below (De Vaux). The Israelite and Canaanite city of Hazor, just north of the Sea of Galilee, contained intricate tunnels and conduits.

Documented as early as 4000 BCE, ancient Israeli civilizations were built near perpetual springs and they battled over water rights with other groups. The water bountiful city of Beth-Shean in Galilee was established in this fashion and became an intersection of nations warring over jurisdiction of the Holy Land. Between these early times and the Roman-Byzantine period, twenty layers of society have been excavated. The sophisticated Philistine population of Beth-Shean utilized baths with heating systems (Starr 28-29).

Megiddo (also known as Armageddon and as Tell el-Mutesellim), was a city with thirty layers of urban settlements dating back to 3500 BCE (Hirst) and a view of the path from Egypt across to Syria and on to Mesopotamia (Gill). Amongst these layers were a Roman garrison, a Jewish community, and evidence of early Christianity (Hirst). From early in the twelfth century BCE, a well below the city furnished water to Megiddo (Lamon).

When King Melchizedek ruled in 2000 BCE, the city of Salem was established next to the underground Gihon Spring, just outside the city's walls (Wiemers). The spring caused the limestone of its hills to erode into caverns. Biblical Jerusalem, the Israelite capital and religious center, grew over the next four-hundred years to a population of 30,000. Saul was the first king of the unified Israel and reined from 1049 BCE to 1008 BCE. He was later succeeded by his son, King David (1000 BCE), who conquered Salem and renamed it the City of David. During the time period of 1000 BCE - 586 BCE, also known as the First Temple Period and the Phoenician/Jewish Age, the citizens of the City of David carved into the limestone beneath the city three intricate, progressive, and capable waterworks ("History of the Ancient").

North of the Kidron Valley, the Gihon rose in a cavern and then poured onto man-made graduated agricultural steps on the city's slopes. Planning of the water infrastructure took place over extended time periods. The biblical kings established these waterworks to provide water security during times of war (Geva).

Israel/Canaan during King David's rule ("Mid East Maps") http://www.mideastweb.org/palearly.htm

Photo: Vladimir Naykhin. IAA
"A Public Water Reservoir Dating to the First Temple Period Exposed for the First Time next to the Western Wall (September 2012)."
© Israel Antiquities Authority (Israel Antiquities Authority)

At the time, the Golan Heights, then named the Bashan Region, was inhabited by fifty percent of the Manasseh Tribe (Starr). The earlier quoted King Solomon, son of King David, reined from 970-931 BCE. During his reign, he built a 66,000-gallon water reservoir that was used for daily life and religious ceremonies ("Reservoir From the Time of King Solomon"). Following his rule, the Jewish nation was divided into northern (Israel) and southern (Judah) kingdoms. Judah's capital city was Jerusalem ("History of the Ancient").

Around the 9th century BCE, an extensive underground water system was built above a natural spring in Hazor. It was made of rock at the same time that a smaller but similar system was built in Megiddo ("Hazor"). During King Ahab's rule, 874–853 BCE, engineers carved a tunnel to reach a spring at the base of Megiddo's mound. Digging a giant vertical shaft in the city, the king's engineers added a horizontal tunnel of equal height to the spring, allowing its water to course throughout the city (Starr). Another city with tunnels and conduits was Zippori, also known as Sepphoris, Eirenopolis, Diocaesarea, and Tzippori, perched on a hill in the Lower Galilee between the Mediterranean and the Kinneret; the city had plentiful spring water and was surrounded by a fertile valley. Established during the Hellenistic period, during the middle of the first century BCE, the Roman governor Gabinius heralded Zippori as the administrative capital of Galilee ("Zippori").

In 695 BCE, in preparation for a possible attack by the Assyrians, King Hezekiah of Jerusalem ordered barricades and water systems to be added to protect the city's citizens (Starr). In 598/7 BCE, the Babylonians seized the city, destroying those water systems. Approximately a century-and-three-quarters later, the Babylonians destroyed the First Temple of Jerusalem ("The Destruction of the First"). The period of the Temple's reconstruction and the subsequent nearly 500 years of Jewish settlement were known as the Second Temple Period, from approximately 538 BCE and 70 CE (Starr). During the middle of this period, Alexander the Great and his Greek generals defeated the Persians, creating the Greek Empire. For several hundred years thereafter, the Greeks ruled, renaming Judah "Judea." When the Greeks invaded Egypt, the Jews aided them, and were allowed to live in Alexandria, Egypt (Stewart). Between the third and second centuries BCE, a military sailing harbor was constructed at Akko (Acre), a city located in the northernmost point of Haifa Bay (Lorenzi).

Around 142-143 BCE, Simon Maccabeus, brother of Judas Maccabeus, followed their brother Jonathan in spearheading a revolt against the Seleucid Dynasty. Simon became the first leader of the Hasmonean Dynasty. The Hasmonean kings built their winter palaces about 15 miles east of Jerusalem in the warm oasis of Jericho. There, in the Jordan Valley, nearly 1,300 feet below sea level, the soil was fertile and water was plentiful from neighboring springs. Among the numerous extraordinary essences and spices grown there was the opobalsamum plant, more commonly known as Mecca Myrrh, which produced an oil that was one of the most expensive ingredients of that time period and which made a great deal of money for its farmers (Geva, "Jericho").

During the first century BCE, the Romans conquered the Hasmonean Dynasty in Israel, ending their reign. Two-thousand years ago, the Romans built a spring and an aqueduct at Ramat HaNadiv, forty-five minutes north of modern Tel Aviv. They constructed a 50-meter tunnel to transport fresh spring water along a thin, low aqueduct that was carved into stone and covered with angled tiles to keep it clear of debris. The water was used in the caldarium, a room with water heated by hot air beneath the floor, much like today's saunas, inside the bathhouses, and was also used in recreational pools. In addition, the spring water was employed to irrigate the agriculture grown below the bathhouse (Bensinger).

Just before the start of the Common Era, at Masada, King Herod directed the construction of his mountaintop palace overlooking the Dead Sea. He also spent his winters in Jericho (Geva, "Jericho"). Herod's engineers built cisterns in the northern and western sides of the mountains that could hold ten-million gallons of water, an aqueduct at the top of the gorge, as well as a dam for capturing flood water. It is theorized that Herod wanted great quantities of water for both fending off the growing population of Jews who wanted to overthrow him and replace him with their former kings and for thwarting Cleopatra of Egypt's aspiration to rule his realm, the Kingdom of Judea. He used the southern area of the mountains for irrigation in order to have a self-supporting food supply (Langfur). With its public baths and swimming pools, Masada amazes today's archeologists with its advanced engineering (Convenant 31). Close to a thousand Jewish men, women, and children, survivors of the obliteration of Jerusalem, took over the king's complex for several years. The Romans fought to remove them, eventually climbing to the palace and invading it. Once inside, they discovered that the Jews had killed themselves in order not to be taken captive by the Romans ("History: Second Temple").

After the Jews attempted to overthrow the Romans during the Great Revolt of 66-70 CE, the Romans destroyed the Temple at Jerusalem in 70 CE, a feat they celebrated by building the Arch of Titus at the Forum in Rome. This defeat caused many Jews to flee ("Historical Background"). A subsequent aqueduct was built to deliver water from the pool to the Talmudic village of Shuni, now called Park Jabotinsky. This spring was a main water source for nearby Caesarea, as well. Another water source for Caesarea's population was the Ein Tzabarin Spring, which flowed in a tunnel that ran horizontally across the hillside, intersecting with a number of aqueducts. This Jewish takeover failed after a three-year battle and the Romans continued their rule.

Several decades later, fresh water from the Kabara Valley five kilometers away was delivered to Caesarea via a 200-meter long dam built by Roman laborers. The dam operated three wooden floodgates to raise the water level and manipulate its flow within the stone-carved aqueducts. It established a lake of 2.3 square miles in the Kabara Valley, supplied by runoff from the neighboring Carmel Mountains. The Romans then constructed a high aqueduct that ran parallel to the earlier one built by Herod. After this high aqueduct ceased working, clay pipes were installed on top of it (Bensinger).

Hadrian, the first Roman emperor of Israel, who began his rule in 118 CE, appeared to be a friend to the Jews, permitting them to return to Jerusalem and approving their rebuilding of the Holy Temple. However, he reneged on his promises, not allowing them to restructure the temple on its former site, prohibiting circumcisions, and deporting the Jews to North Africa. By 123 CE, the Jews began to revolt under the leadership of Shimon Bar-Kokhba, defeating two Roman leaders sent by Hadrian. Attacking the coastal areas, the Jews began ocean battles against the Romans. However, the large Roman Army, aided by Egyptian, British and Syrian armies, demolished more than a half a million Jewish soldiers in a second revolt in 135 CE. Jerusalem became Aelia Capitolina (also known as Syria Palestina – Philistine Syria or Palestine) and the surviving Jews were sold into slavery (Schoenberg). Despite the displacement of the Jewish people, Galilee, a large section in Northern Israel and the Haifa District, continued as the home of Jewish learning and societies until the 6th century CE ("Historical Background").

The Romans ruled until the Eastern Roman Empire, also known as the Byzantine Empire, seized power in 476 CE. During the Byzantine Empire of 313-636 CE, Emperor Constantine made Christianity the religion of Israel. In 614 CE, the Persians, aided by the Jews, invaded and took over Israel. The Jews were allowed to administer Jerusalem for several years, but were expelled in 629 CE when the Byzantines regained power ("Byzantine Rule").

The Prophet Mohammad established the Islamic religion in Arabia in 622 CE. Sixteen years later, the Islamic Caliph Umar I conquered Palestine for the Arabs. Constructing the Dome of the Rock on the Temple's site, the Arabs decreed Jerusalem as the third holiest location of Islam. Although Jerusalem continued to be called by its Roman name, Aeilia, for several centuries, it became known as al-Quds ("the Holy" in Arabic) during the 10th century CE ("The Muslim Period"). From their conquest until 1099 CE, the Arabs reigned over Palestine ("Historical Background").

The Crusader Domination (Latin Kingdom of Jerusalem), 1099-1291 CE, brought a revolution in the process employed to crush sugar cane. Their technique developed in Israel became the standard used in Europe. Prior to the Crusaders, dry mills powered by animals were used to crush sugar. The Crusaders' innovation was to use waterpower, thereby producing more sugar in less time. The sugar was mainly produced for foreign consumption (Peled).

Egypt's Kurdish ruler Saladin defeated the Crusaders in 1187 CE ("Historical Background"). The Muslim Saladin conquered the Kingdom of Jerusalem near the Lake of Galilee. Four years later, Christian Crusaders captured Acre, killing 2,000 Muslim soldiers. Although the Crusaders stayed by the coast to receive shipments and to benefit from the coastal air, they needed fresh water. They based out of the port of Jaffa that winter, heading for Jerusalem in June of 1192 CE. Richard the Lionheart, who suffered from a fever and requested fresh water and fruit from his enemy, led the Crusaders. Saladin complied, following Muslim law to help others in need, but also gaining knowledge about the Crusaders that would help his own soldiers in battle. Saladin discovered that the Crusaders lacked the men and arms to conquer the Arabs, so Richard I then instigated a truce that would allow pilgrims to visit the Holy City of Jerusalem (Trueman). For the greater portion of the next seven hundred years, Muslims ruled Jerusalem.

When Suleiman the Magnificent of Turkey conquered Jerusalem around 1516 CE, a four-hundred year Turkish Muslim rule over what is now known as Israel began. Running the country from Constantinople, now Istanbul, the Ottomans allowed the northern region of the country to deteriorate into a marshland overrun with malaria ("Historical Background"). However, the new rulers refurbished Jerusalem's aqueducts in 1532 CE to distribute water once more to its population ("The Muslim Period"). Jewish fishermen lived in Korazim in the 16th century ("Korazim").

In the first century of Ottoman Rule, the Code of Jewish law (*Shulhan Arukh*) was published in 1564 CE. Under the Ottoman rule's Civil Code, known as the Mejelle, ratified in 1858 CE, water was free for the public's use, including for drinking and irrigation, and its contamination was condemned (Laster and Livney 122). From 1856-1918 CE, Palestinians under

Ottoman rule believed that its ideology protected Islam from the interference and predominance of European culture and control. The first neighborhood outside Jerusalem, Mishkenot Sha'ananim, was settled in 1860 CE.

Ottomanism overlapped Arabism, from 1908 CE and into the beginning of World War I. Arabism had similar objectives to those of Ottomanism, but it differed because its supporters were not involved in the Ottoman government. Arabists wanted greater Arab self-rule from the Turks. Arab nationalism was a movement that arose as a response to pan-Turanianism, a "belief in the cultural and racial superiority of the Turks" (Muslih).

Pre-1948 – Zionist Aspirations

The first Aliya (ascent) of Jews coming to Israel and declaring it as their new home country, most of them Russians escaping pogroms, emigrated between 1882-1903 CE. These immigrants founded agricultural settlements that were supported by Jewish humanitarians ("Historical Background"). As early as 1902, Theodore Herzl, founder of political Zionism and the Jewish State, suggested ways of reducing Israel's water problems in his book Altneuland. His ideas included using the Jordan for irrigation and carrying water from the Mediterranean in Haifa through the valleys of Beit Shean and Jordan to meet up with another carrier from the Jordan River and Dead Sea to use for generating electricity (Kantor). Among Zionists' aspirations for their "new-old" home was the desire to control water resources. Herzl considered hydraulic engineers the true founders of the country (Zeitoun).

Palestinian nationalism evolved in the period between the First and Second World Wars as a result of the great number of Jewish Zionists immigrating to and purchasing homesteads in Palestine (Muslih). In 1913, the Franhia Plan was created by the Ottoman Empire, but did not succeed; it recommended employing the Jordan River as a source for irrigation and electricity

("Agreements, Plans"). The Franhia Plan would have served both the Palestinian Turks and the Jews, who numbered nearly fourteen percent of the population of Palestine by 1914 ("Historical Background"). On March 9, 1916, the British and French signed the Sykes-Picot Agreement, their plan to distribute the Ottoman lands that would be the future spoils of World War I. In the treaty, Palestine was to become an internationally controlled area (Gillon 132). This was the beginning of major conflict over water between Israel and its surrounding Arab neighbors (Eshel).

During WWI, British Foreign Minister Lord Balfour wrote The Balfour Declaration of 1917, in which he expressed the British government's "declaration of sympathy with Jewish Zionist aspirations" for an independent Jewish state in Palestine (Balfour). This wording suggests that the declaration was being put forth solely for the benefit of the Jewish people and not for Britain's own hidden agenda, which included a desire to terminate the Sykes-Picot Agreement. Therefore, this was not an altruistic gesture on the part of Great Britain but, rather, was an effort on the part of the British government to further its own imperial and domestic goals. In the end, England and the Zionists succeeded in accomplishing their mutual goal of a British Palestine, even though both parties had different motives. The British soon realized their mistake in their Palestinian involvement; they did not foresee the Arab anger in a Jewish national home in Palestine (Stork 10). The ramifications of the Balfour Declaration are still being felt today.

In 1922, the British Mandate, set up earlier in the century by the League of Nations to manage non-self-governing territories, gave the Jewish and Arab communities the privilege of handling their own internal affairs. As a result, Jewish government was established, and the economy, education, and culture thrived ("The Mandate"). The goal of the Mavromatis Plan of that same year was to drain the Hula swamps in northern Israel's agricultural Hula Valley, and to irrigate the Jordan Valley. To accomplish this, the plan called for altering the Yarmouk path towards the Kinneret and building a couple of hydropower dams (Kliot). A 1927 Greece v. Britain judgment decided by the Permanent Court of International Justice upheld Great Britain's Mandate and administration of Palestine to coordinate with the Jewish Agency to "construct or operate, upon fair and equitable terms, any public works, services and utilities, and to develop any of the natural resources of the country ("Case of the Readaptation"). Great Britain's 1928 Henriques Report added onto that country's earlier Mavromatis Plan with its strategy to irrigate the 7413 acres of the Yarmouk Triangle with its own waters (Phillips). The Yarmouk and Jordan Rivers and Lake Tibirius formed the Yarmouk Triangle (Sosland).

With the White Papers of 1930 and 1939, the British, forced by the Arabs to depart from their earlier mandated assurance of self-governance, constrained Jewish immigration and land acquisition ("The Mandate"). At a meeting of the Zionist Congress in Lucerne, Switzerland in 1935, the Jewish National Fund (JNF) stipulated that a land purchasing entity be established in Palestine for the purpose of overseeing the purchasing of land in Palestine by both the JNF and individuals. The Palestine Land Development Company came about as a result of this congress; however, it folded because the Zionist organization did not have the right to regulate private investment. Thereafter, this organization turned its attention to merely coordinating such purchases (Tuten).

In 1937, before the founding of modern Israel, Mekorot was established. The following year, Mekorot completed the Kishon Water Project. With approval from the British Mandate Government, this project consisted of building wells and flood-control dams, and using pipe to transport water to the agriculturally bountiful Jezreel Valley ("Milestones").

M.G. Ionides, director of development in Transjordan for Great Britain, proposed in 1939 that this area be surveyed and that plans be recommended for its development; this was known as the Ionides Survey (Elmusa). As a result, the survey proposed the deviation of the Yarmouk into two canals that would irrigate the Gor plains on either side of the Jordan. The objective was to use 460 million m^3 of water for irrigation of nearly 50,000 acres in the Jordan Valley and 26,000 acres in the Hula Valley (Kliot). The following year, the Mandate Government amended the Palestine Order of 1922, which thereafter made water an entirely public resource, governed by a Water Commissioner. Two years later, the Drainage Ordinance was created to build and sustain a drainage system in Palestine (Laster and Livney).

In 1944, the United States endorsed the Lowdermilk Plan, an ingenious idea by American Geophysical Union President Walter Clay Lowdermilk, which intended to replenish the Dead Sea by building an inland waterway from the Mediterranean Sea and use the Jordan and Litani Rivers to irrigate the Negev Desert ("Agreements, Plans"). It also entailed the creation of a seawater canal to link Haifa Bay to the Dead Sea, thereby producing hydroelectric power on a grand scale. Unfortunately, the plan was neither financially nor technically achievable ("The Lowdermilk Plan"). The Lowdermilk Plan was discarded when the State of Israel was formed ("Agreements, Plans").

The British Mandate's 1300-page document, the 1946 "A Survey of Palestine," was created for the United Nations Special Committee on Palestine (UNSCOP). The Mandate began with a chapter on Turkish Rule and continued with the occupation of Palestine by Allied Forces, The Balfour Declaration, The Covenant of the League of Nations, The Convention Between Great Britain and the United States, and The Mandate over Trans-Jordan. A historical section summarized the main events in Palestine since British Occupation in 1917. Included in this section was the three-year period that followed British occupation, during which there was military administration. The second period, from 1920-1923, included the implantation of the Balfour Declaration, Arab reactions, and efforts to develop a constitution. During this time, The Churchill Memorandum was written in 1922, and is annexed to this document. The Survey noted a brief peaceful period in the 1920s, followed by a four-year cold war between Arabs and the Jewish National Home. The document details that, by the mid-1930s, Jewish immigration had increased while Arab Nationalism raged in Palestine. It mentions the Royal and Partition Commissions in the late 1930s, as well as the White Paper of May 1939. At the beginning of WWII, the Survey notes the lack of politics in Israel. But, by the end of the war, Jews wanted their own state and unlimited immigration ("British Mandate: A Survey).

Covering topics such as population and economy, the Survey included sections on land, water and cultivation, geology, agriculture, climate and soils ("British Mandate: A Survey). At the time the Survey was written, Palestine was a land of 10,162 square miles, with an inland water expanse of 272 square miles, made up of Lakes Huleh and Tiberias and half of the Dead Sea. Palestine contained seven geographic regions: the maritime plain or Plain of Sharon ran north from Egypt to Mount Carmel just below Haifa; the coastal plain of Acre from Carmel to Ras en Naqura; a broad plain running from Haifa in the south to the Jordan Valley in the east (the western part was called the Plain of Esdraelon while the eastern was the Valley of Jezreel); the central range; the hills of Galilee, and Jordan Valley; and the district of Beersheba.

The United Nations Partition Plan of 1947 gave Israel the upper Jordan and, with it, the ability to implement the Lowdermilk Plan and the later Hays-Savage Plan. Dividing Palestine into two states, Jews were given 55% of the land, while Arabs were given the remainder (Attilli, Phillips, and Khalaf).

Post-1948 – June 1967 War – Ideological Era

The Ideological Era typified a violent period in the Israeli-Palestinian water crisis, with precipitous Israeli growth by Labour Zionists and minor progress by the Palestinian Arab Nationalists (Zeitoun). On May 14, 1948, the State of Israel was created and the British Mandate ended. The following day, Arab armies from Egypt, Syria, Jordan, Iraq, Saudi Arabia and Lebanon attacked the new Jewish state. Although the Arabs had more soldiers and better equipment, the Israelis were the superior soldiers. By the time fighting ended in January 1949, the Jews not only controlled the land the UN Partition Plan had apportioned to it (5,600 square miles), but had gained control over another 2,500 square miles. The West Bank and the eastern portion of Jerusalem were in the hands of Jordan and the Gaza Strip was controlled by Egypt. Over the next six months, the Israelis signed armistice agreements based on the forward positions of the armies at the time of ceasefire ("The War for Independence"). Following Israel's War of Independence, Israel, Egypt, Lebanon, Jordan and Syria failed to negotiate water rights over the Jordan River and each made its own plan for its use ("Historical review of the political").

In 1948, three years after the Lowdermilk Plan was proposed, the Hays-Savage Plan further defined the earlier plan. Since the United Nations Partition Plan of the prior year had set the boundaries, this Zionist plan disregarded any supposed Arab rights to the Jordan River Basin. It proposed diverting the Yarmouk into Lake Tiberias to replenish flows deterred from reaching Israel from the upper Jordan (Haddadin, "Diplomacy on the Jordan").

The MacDonald Report of 1950 was a commission by Jordan to British advisors Sir Murdoch MacDonald and partners for the development of the Jordan River. Further defining the Ionidis Plan, the plan "decreed that the waters of the basin could not be taken out of it for the benefit of out-of-basin irrigation before all the lands in the basin were adequately irrigated." As Palestinian refugees found asylum in this basin, tension between Israelis and Arabs escalated (Haddadin, "The Jordan River Basin"). Israel's unilateral 1951 All-Israel Plan called for drainage of the Hula Lake and swamps, altering the pattern of the upper Jordan River, and building a water delivery system to the Negev Desert and coastal plain (Wolf and Newton). From 1951-1953, Israel and Syria fired arms at one another due to conflict over water development in the demilitarized zone of the Jordan River and its tributaries (Wolf and Newton).

This "Water War" motivated President Eisenhower to appoint Ambassador Eric Johnston as his special representative to negotiate a settlement between the two warring nations (Beyth). Russia added its support to the negotiations after the United States' initial sponsorship of these many-sided negotiations between the aforementioned countries and transboundary riparians Jordan, Lebanon, and Palestine (Wolf and Newton). The insufficient amounts of water in the Jordan River (whose current annual discharge is approximately 600 million cubic meters) and in the Yarmouk River (whose current annual discharge is approximately 500 million cubic meters) made water supply a strategic problem; this ultimately resulted in the development of the Johnston Plan (Beyth). Over the subsequent two years, Johnston constructed a Jordan River water allocation arrangement, known as the 1955 (some say 1956) Unified (Johnston) Plan. The Johnston Plan allowed Lebanon to take 35 million cubic meters of water per year from the Jordan and Hasbani Rivers, a tributary to the Jordan (Blanford). It allotted Israel as much as one-sixteenth of the Yarmouk's stream, based on the country's bordering shores (Starr). Johnston's allocation recommendations were used through the 1990s (Stark).

In 1952, engineer M. E. Bunger of the United States came up with a plan for the U.N. Relief and Works Agency for Palestine Refugees (UNRWA) that would build a dam with a storage capability of 480 million m^3 at Maqarin on the Yarmouk River. This water was to be realigned at Addassiyah by another dam, causing it to fall into canals on Jordan's east Ghor ("Historical review of the political"). Expectations were that these facilities would irrigate 107,491 acres in Jordan and 14,826 acres in Syria ("Historical review of the political"). The dams' hydroelectric plants would produce 28,300 kWh per year for the two countries, allowing 100,000 people to settle (Wolf and Newton). The agreement to begin Bunger's plan was signed by Jordan and UNRWA in 1953, and Jordan settled with Syria to allocate the Yarmouk's water between them. However, Israel contested the plan, stating that it did not recognize Israel's riparian entitlements to the Yarmouk.

Building plans were halted and Israel, initiating work in 1953 on its National Water Carrier (then known as the Jordan Project), implemented a deviation of the Jordan at Jisr Banat Yaqub. The lower salt level at Jisr Banat Yaqub and the drop in elevation to Lake Tiberias allowed the employment of gravity to achieve the deviation. This diversion along the transboundary border caused the Syrians to begin firefights with Israel and to protest to the United Nations, which ruled in Syria's favor. This ruling forced Israel to build two large pumping stations, one at Sapir (Tabgha) and another at Tsalmon, in order for the water from the Kinneret to reach the National Water Carrier's highest point, near Eilabun. The pumps had to be able to force the water up 1,214 feet to join the Carrier (Kantor).

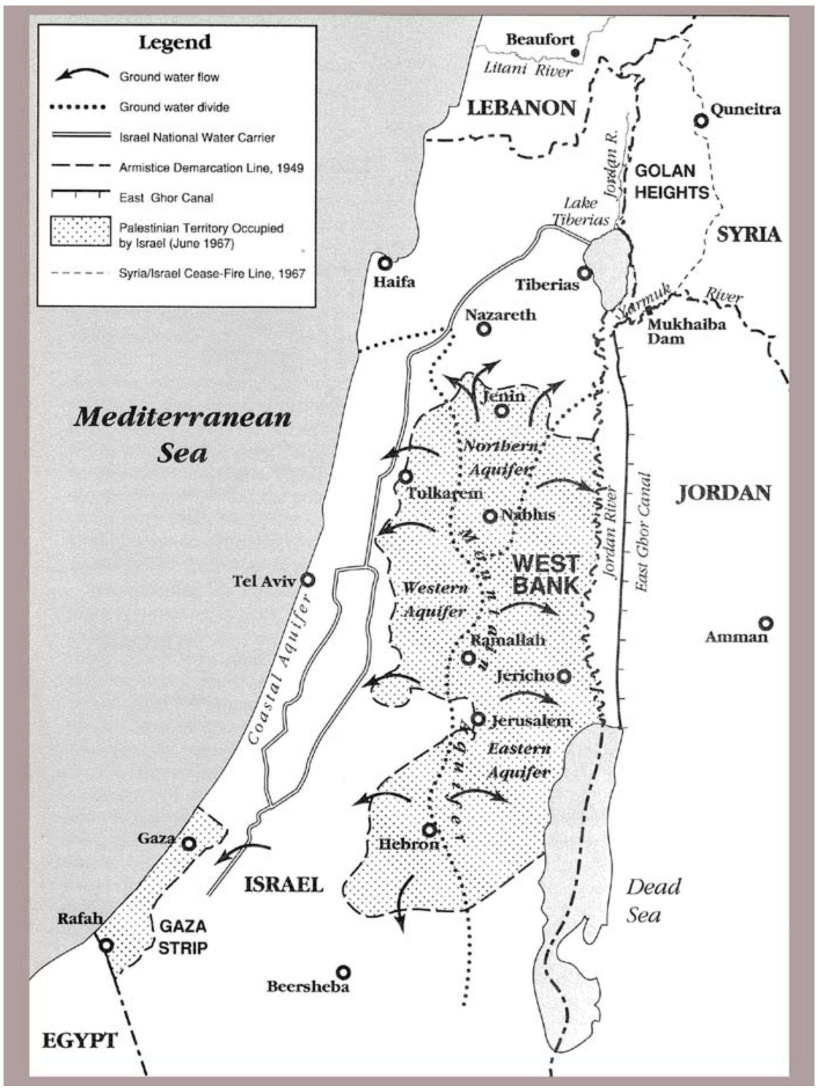
Israel continued with the river's diversion until the United States warned they would cut off funds. Israel selected Eshed Kinrot on Lake Tiberias in place of Jisr Banat Yaqub, even though it was a poorer location than the original site due to the high water salinity and the need for hydroelectric power rather than gravity as a source for pumping to the Water Carrier. When the United States denied funding to Jordan's Bunger Plan because it recognized Israel's right to the Yarmouk, the Bunger Plan was discarded ("Historical review of the political").

The 1953 Main Plan allotted the Jordan River waters in the amount of 394 million m^3 for Israel, 774 million m^3 for Jordan, and 45 million m^3 for Syria. This plan called for mainly in-basin utilization of Jordan waters and was against incorporating water from the Litani ("Historical review of the political"). Also in 1953, Israel announced its Seven-Year Plan, based on the Lowdermilk and Hayes Plans. It called for the incorporation "of the Litani, the use of Lake Tiberias as the main storage facility, out-of-basin use of the Jordan waters, and the Mediterranean-Dead Sea canal." Israel wanted about 30% of the 2,500 million m^3 collective Jordan and Litani water yield ("Historical review of the political").

Israel's 1954 Cotton Plan was its counterproposal to the United States' Johnston Plan. An American engineer consulting to the Israeli government, Joseph Cotton, reviewed the earlier plan and conceived one based on the prior Lowdermilk, Blass, and Hays-Savage Plans, challenging the Main Plan. The Cotton Plan proposed the use of out of basin water and land for irrigation (Haddadin, "The Jordan River Basin" 65). The Plan also proposed using the Litani River to provide irrigation water not afforded by the Jordan (Isaac and Hosh). It divided the Litani's waters into 1,290 million m^3 per year for Israel, 575 million m^3 to Jordan, 450.7 million m^3 to Lebanon, and 30 million m^3 to Syria ("Historical review of the political").

The 1954 Arab Plan for the Utilization of the Waters of the River Jordan and its Tributaries contended that waters beginning in Arab lands were Arab property; this belief included the Jordan, whose waters begin in Lebanon and Syria and flow into Israel. The Arab Plan presumed that water used for irrigation should be allotted to nations according to each country's rainfall inputs (Davis and Burke).

Around 1955-1956, the Israeli Ten-Year Plan was created for autonomous water development ("TED Case Studies"). Within this plan was the Israeli National Water Plan, with an outline for the former Jordan Project to become the National Water Carrier, connecting the regional water projects into a single network. From the 1950s to the 1960s, the National Water Carrier was built by Mekorot at a cost of approximately $115,000,000. Its purpose and function will be further examined in the Agricultural Water Delivery Section.



Map of Water Resources Shared by Israel and the Palestinian Territories (Scarborough)

While Israel built its National Water Carrier, Jordan's 1956 Great Yarmouk Project included the construction of the East Ghor Canal, which was begun in the following year. Other construction included the building of the Mukheiba and Maqarin Dams on the Yarmouk, used for storage and electricity, along with seven other dams for seasonal flow into the Jordan. Also built were a West Ghor Canal and a siphon over the Jordan to connect it with the East Ghor Canal. Pumping stations, flood fortification and drainage capacities, and horizontal canals were also built from 1957 to 1966 ("Historical review of the political").

Four laws passed in the last half of the 1950s are still in effect today. The Water Measurement Law of 1955 and The Water Drilling Control Law of the same year, as well as The Drainage and Control Law of 1957, and The Water Law of 1959, will be reviewed in the chapter in this thesis on Water Policy (Laster and Livney).

When Arab State Heads met in Cairo at the behest of Egypt's second President Nasser in January of 1964 to deliberate on methods of diverting and, thereby, incapacitating Israel's Jordan Headwaters plan (The Jordan Headwaters Diversion), Israel's Prime Minister Levi Eshkol announced to the Knesset that the country would continue to pull water from Lake Kinneret according to the boundaries set up in the Unified Plan. Eshkol continued: "Israel will oppose unilateral and illegal measures by the Arab States and will act to protect its vital interests ("Israeli Response to Arab League")."

The "War over Water," also known as the "Battle over Water" refers to a succession of quarrels between Israel and Palestine from November of 1964 until May of 1967 over the control of available water sources in the Jordan River drainage basin. In 1964, Syria diverted the waters from the Banyas and Hasbani to the Yarkmouk on Jordan's border, blocking Israel's primary water resources. Israel's response was to attack Syria's construction with long-range tank fire and airstrikes (Eshel).

A major war broke out in 1967, prompted by Syrian efforts to deter the waters allotted to Israel in the earlier Johnston Plan and the warring three years before (Starr). The War of 1967, also called the Six-Day War, was a decisive victory for Israel. Under the impression that an attack by Egypt, Syria, and other Arab nations was impending, Israel initiated an anticipatory strike against Egypt. Egypt's air force was caught off guard and completely destroyed on the ground. This allowed Israel to capture the Sinai Peninsula and the Gaza Strip. Israel warned Jordan not to participate in the war, but Jordan did not heed her advice and, instead, chose to attack Jerusalem. Jordan was defeated after three days and lost East Jerusalem and the West Bank. Israel then captured the Golan Heights from Syria. The entire war was over in six days ("The 1967 War").

Post-1967 War – 1995 Oslo II Agreement – Israeli Domination Era

During the Israeli Domination Era, Israel became more confident in its hydro-strategic circumstances and in its military power, the two factors keeping the Arabs from disputing Israel's rights for water usage (Zeitoun). Ten years after The Six-Day War, a committee, composed of members of Israel's Environmental Protection Service, Hydrological Service, Geological Institute, Ministry of Transportation, Dead Sea Works, Israel Electric Corporation, and like organizations, formed to explore the possibility of implementing the original Lowdermilk Plan. The potential pipeline from the Mediterranean to the Dead Sea would deliver enough force to operate a 600-MW power station and provide 20% of Israel's then energy requirements. Aside from providing hydroelectric power, the pipeline would reverse the declining level of the Dead Sea water and would bring water to the Negev Desert. The committee explored potential negative affects this plan might expose ("The Lowdermilk Plan").

In an interview in 1985 and in the middle of his country's three-year drought, Boutros Boutros-Ghali, Egypt's Minister of State for Foreign Affairs, stated that: "The next war in our region will be over water, not politics. Washington doesn't take this seriously, because everything for the United States relates to oil (Starr)." During this same time period, intelligence in the United States predicted that, of ten possible places where war could erupt over riparian water resources, most of them were located in the Middle East. Israel was among the countries already at the "red-line 'water barrier' – the point beyond which vastly accelerated efforts are required to keep pace with spiraling populations (Starr 48-49)."

The Integrated Joint Development Plan of 1991 intended to build a Mediterranean-Dead Sea Canal (Murakami). The Plan included a proposed Mediterranean-Dead Sea hydro-powered reverse osmosis (RO) desalination plant and river dams for groundwater recharge from the "Side Wadis" (small rivers) that travel from the mountains to the Jordan ("Hashemite Kingdom of Jordan").

On the White House lawn in Washington, D.C. in September of 1993, an agreement between Israel and the Palestine Liberation Organization, Oslo I, was signed. The Declaration of Principles on Interim Self-Government Arrangements created an on-going Council to encourage economic development, as well as a Palestinian Electricity Authority, a Gaza Sea Port Authority, a Palestinian Development Bank, a Palestinian Export Promotion Board, a Palestinian Environmental Authority, a Palestinian Land Authority and a Palestinian Water Administration Authority. The goals included co-operation with regard to water rights, a water development schedule to administer water resources in the West Bank and Gaza Strip, and further surveys of the groups' rights and equality of use to water resources ("Text: 1993 Declaration").

In the following year, Israel's 1994 Treaty of Peace with Jordan sought to resolve all of their water issues. The Declaration outlined each riparian's rights to the Jordan and Yarmouk Rivers' waters. It also specified usage of the Araba/Arava ground water in keeping with arranged values, quantities and quality. The two countries agreed not to damage each other's water resources. Agreeing that their water resources were lacking, they pledged to productively manage these resources, including transferring water between them. The two nations approved a plan to curtail waste, prevent contamination, and to jointly relieve shortages and undertake the development of ways to increase water resources ("Israel-Jordan Peace Treaty").

The Oslo II Interim Agreement was signed in 1995, settling disputes between Israel and the PLO over water, the right of Palestinian refugees to return to Palestine, control of Jerusalem, borders, and future Jewish West Bank settlements.

1995-2005/End of Oslo Process – Israeli Hegemony Era

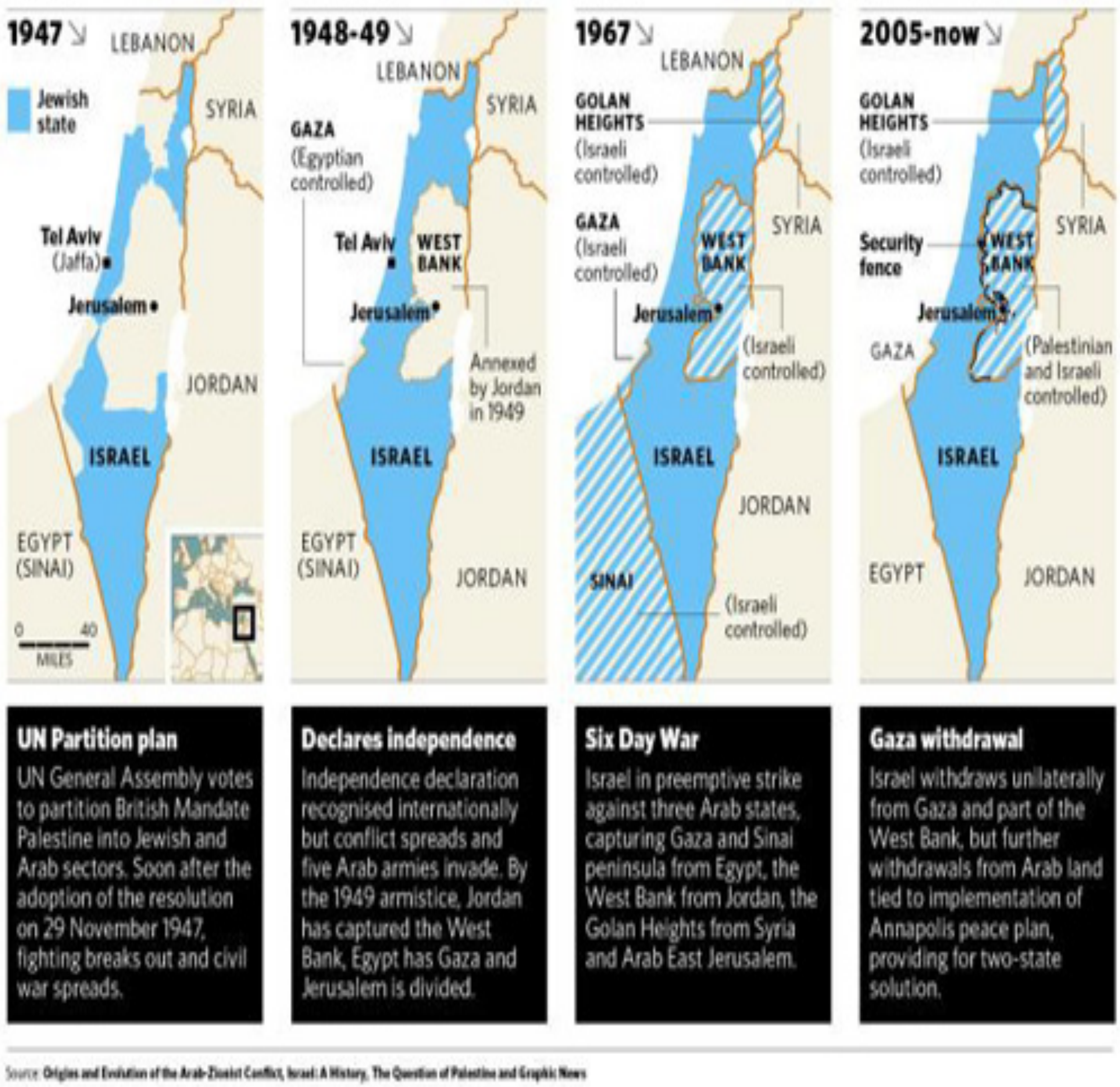
Hegemony refers to the concept that one nation dominates another and chooses to cooperate with its transboundary neighbors (Dinar). The Israeli Hegemony Era revealed conflict amongst various Israeli factions over how much cooperation should be extended to these neighbors (Zeitoun). During this time period, the Israeli Knesset preferred to expand water supply availability with new technological advances rather than alter policy to decrease demand. Most of the demand was attributed to the agricultural sector. Rather than a larger focus on rational, science-based decisions, the desire to grow and supply the State's citizens with Israeli-grown food and the constant threats from riparian nations informed the water politics and policy of this era. Although Israel was now behaving unilaterally, some aspects of the Oslo II remained in place into 2005. The Joint Water Commission (JWC), a combination of the Israel Water Commission and the Palestinian Water Authority, met to discuss water issues even during times of violent conflict (Zeitoun). This power disproportionateness will be further explored in the section of this thesis on Politics.

In a paper published in 1998 in the *Yale Forestry & Environmental Studies Bulletin*, Sharif S. Elmusa, a Senior Research Fellow at the Institute of Palestine Studies in Washington, D.C., writes that the Johnston Plan contained all of the crucial elements necessary for the settlement of any water conflict. Those elements include stipulations for the distribution of water resources to the various transboundary riparians, as well as plans for water diversion, oversight, and a multi-nation governing body (Elmusa). With only a few minor adjustments, the author suggests that the transboundary nations sharing the Jordan River Basin should "revisit" the Johnston Plan.

The United States, in 2002, supported a two-state solution between Israel and the Palestinians, known as the "Road Map to Peace." However, Israel's platform evolved from negotiation to blame and, finally, to unilateral action.

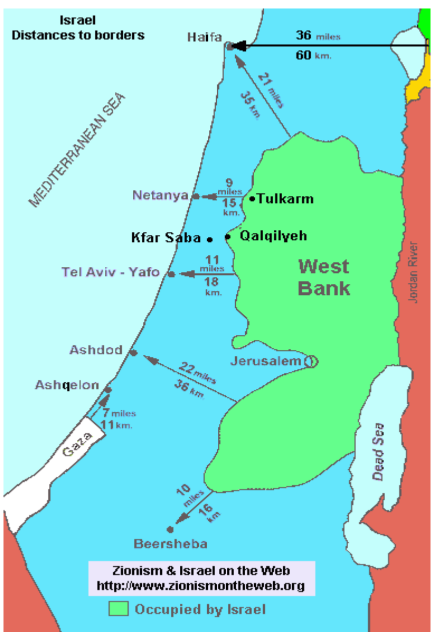
Current Borders

Since Israel's withdrawal from Gaza and portions of the West Bank in 2005, it currently shares borders with Lebanon, Syria, Jordan, Egypt, the Palestinian Authority in the West Bank, and Hamas in the Gaza Strip. In 1947, under the United Nations Partition plan for British Mandate Palestine, the area was to be divided into Arab and Jewish sections. Upon rejecting the UN plan, five Arab armies, those of Egypt, Jordan, Iraq, Syria, and Lebanon, attacked the newly independent Jewish state. At the end of the year-long war, Israel expanded its borders and Jordan took control of the West Bank, while Egypt took control of Gaza. Responding to threatening



Maps of Israel's borders from 1949-Present © 2013. The Regents of the University of California. All rights reserved. ("Comments on Israel's Borders")
http://www.international.ucla.edu/israel/events/showevent.asp?eventid=8468

actions by its neighbors, Israel launched a surprise attack in 1967, devastating the militaries of Egypt, Syria, and Jordan with a surprise attack. The Six Day War led to Israel's seizure of control of the Golan Heights, West Bank, Gaza, and the Sinai Peninsula. Israel returned Sinai to Egypt after the two countries signed a peace treaty in 1979. In 2005, Israel ceded control of Gaza, which is now ruled by Hamas. The Palestinian Authority (PA) and Israel govern the West Bank (Aran). The PA governs roughly 40% of the West Bank land and 96% of the population living in the entire West Bank. Israel governs the remaining land, but only 4% of the West Bank population. Israel provides the security services for more than 80% of the land and 45% of the population (Pundak).



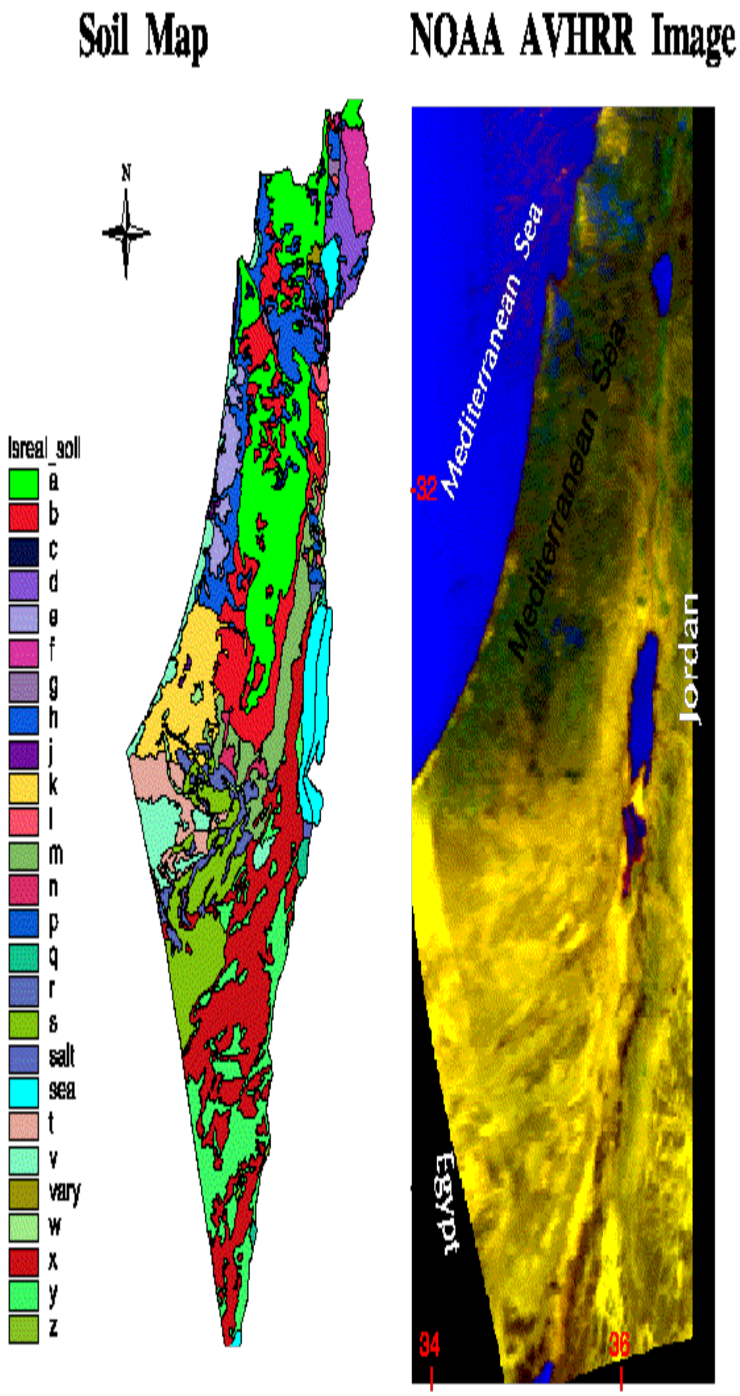
Map of Israel showing distances from borders and comparative size – The security problem ("Maps of Israel Showing Distances") http://www.zionismontheweb.org

Geography, Soil, and Climate

The Coastal Plain, The Gallilean-Samarian-Judean Highlands, The Negev Desert, and The Jordan Rift Valley comprise the geographic quadrants of Israel. The Coastal Plain is situated on the west side of the country and along the Mediterranean Sea. This region contains sandy shores and productive agricultural land, as well as uneven chalk and cliffs of sandstone. Over fifty percent of Israel's population dwells in The Coast Plain. Sitting between The Coastal Plain and The Jordan Rift Valley, The Galilean-Samarian-Judean Highlands consist of largely uninhabited hills reaching from the Gulf of Eilat to Lebanon ("Geography of Israel"). Following centuries of poor soil management, overgrazing, and deforestation, by 1948, the Negev Desert reached from the southern tip of Israel to just south of Tel Aviv (Yearwood). Earthquakes that divided the African and Arabian Plates created The Jordan Great Rift Valley; in addition, the geography has been transformed by volcanic eruptions ("Sea of Galilee"). Located in this Valley, Lake Kinneret is Israel's largest freshwater lake, providing half of all freshwater consumed by the country's population. Its primary supplier is the Jordan River; the lake also receives water from underground springs ("Sea of Galilee"). The Kinneret's surface area is approximately 65 square miles (Pan, Avissar, and Haidvogel).

The diversity of soils in Israel can be attributed to their location (which can be nearly 1,400 below sea level and as high as 7,300 feet above sea level), characteristics (including derivation from sand dunes, alluvium, basalt and rock), and reaction to the climate (which can be rainy in the north, dry in the south, and windier in certain areas of the country) ("Soils of Israel"). Israel's most productive agricultural soils are in the Jezreel Valley, which divides the Galilee and Samarian Hills ("The Land: Geography and Climate").

Israel is classified as having a subtropical, Mediterranean-type climate, with hot, dry summers and cool, wet winters in its northern and coastal expanses. Its southern and eastern locales are arid. In northern and central Israel, rainfall occurs between October and early May, with highest precipitation from December through February. There is little rain in the Negev Desert and in southern Israel ("Climate and Seasons"). The Dead Sea is drying up because the water flowing into it has decreased by 90%, currently receding at slightly more than 3 feet per year, having already lost 33% of its surface area ("Raising the Dead Water").



SOIL NAME (after Dan et al. 1986)	CODE
Terra rossas, brown rendzinas and pale rendzinas	a
Brown rendzinas and pale rendzinas	b
Pale rendzinas	c
Basaltic protogrumusols, basaltic brown grumusols and pale rendzinas	d
Hamra soils	e
Basaltic brown mediterranean soils and basaltic lithsols	f
Hydromorphic and gley soils	g
Grumusols	h
Pararendzinas	j
Dark brown soils	k
Calcareous serozems	l
Brown lithosols and loessial arid brown soils	m
Loessial arid brown soils	n
Alluvial arid brown soils	p
Solonchaks	q
Loessial serozems	r
Brown lithosols and loessial serozems	s
Sandy regosols and arid brown soils	t
Sand dunes	v
Regosols	w
Bare rocks and desert lithosols	x
Reg soils and coarse desert alluvium	y
Fine grained desert alluvial soils	z

Soils of Israel. ("Soils of Israel") http://cals.arizona.edu/oals/soils/israel/soilmap.html

Overview of the Agriculture Sector

With a total area of roughly 8,500 square miles ("Agriculture in Israel: Facts"), 24% of the State of Israel's land is agricultural ("Agricultural Land"). Of Israel's 2.7-million person labor force, 8.7% work in agriculture. In the Arava and Jordan Valleys, agriculture is the primary occupation. Israel grows nearly 70% of the food needed for its citizens (Fedler). The number of people fed per farmer has increased from 15 in 1955 to 100 in 2007, which is the norm for developed countries ("Agriculture in Israel: Facts"). The Southern District contains the largest total crop area, followed by the Northern District and then the Central District. Haifa slightly edges out Jerusalem with crop area, with the Tel Aviv District having the smallest total crop area ("OECD Review"). Output of vegetables, potatoes, and melons in 2007 was $5.5 billion, making up the largest portion of all agricultural production, at 24%. However, by 2011, this percentage had declined 2.5% ("Agriculture in Israel: The Industry"). From 2006 to 2007, Israeli exports increased by $431 million, from $1.741 to $2.172 billion. In the same time frame, Israel exported $1.76 billion in agricultural fertilizers and chemicals ("Agriculture in Israel: Facts").

Although only marginally larger than the U.S. state of New Jersey, Israel contains a great number of soil types. Due to its small size, Israel's farms are located throughout its entire territory, including the desert. The state contains 450,000 acres of irrigated land, and nearly the same number of acres are non-irrigated ("Agriculture in Israel: Facts"). A third of the irrigable land is in the north, and the remaining two-thirds are in the south. In 2010, Jerusalem and the Southern Districts grew nearly double the amount of field crops as the Northern and Haifa Districts, which grew 3.3 times as many field crops as the Central and Tel Aviv Districts ("Agricultural Crop Areas"). In the "Agricultural Water Use" section, the various types of agriculture produced and exported will be discussed.

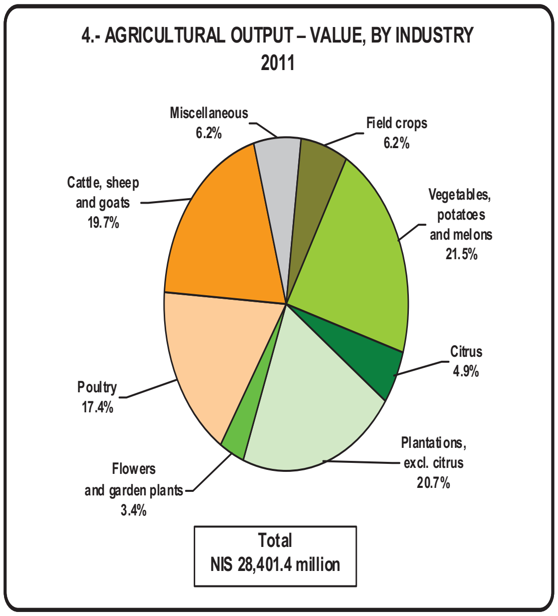
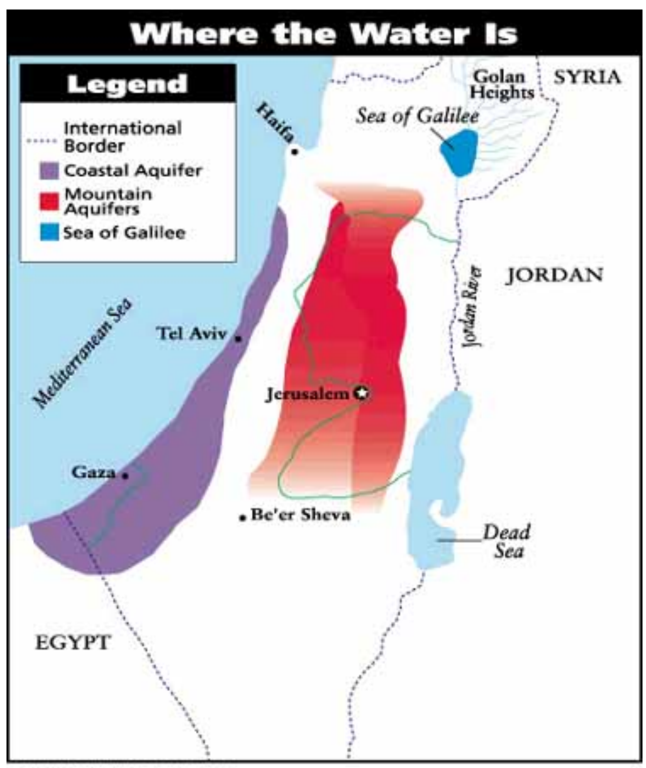


Chart of Agricultural Output by Industry Total in US Dollars: 7.8 billion dollars ("Agriculture in Israel: The Industry") http://www.cbs.gov.il/publications12/haklaut11/pdf/gr4_e.pdf

Israel's three main water sources are the Sea of Galilee, the Coastal aquifer, and the Mountain aquifer. Irrigated agriculture uses water from present potable water reservoirs, wastewater, rainfall enhancement, and desalination.

Coastal and Mountain Aquifers, Sea of Galilee, and Jordan River" ("Where the Water is.") http://www.aipac.org/resources/maps/



*AQUIFER LOCATIONS ARE APPROXIMATE

The table below from the paper entitled "Ashkelon seawater desalination project" by Yosef Dreizin shows the "capacities and quality ranges of Israel's current [2006] water supply sources." Each year, Israel has 1,675 million m^3/year of "naturally replenishing water sources."

Source	Average annual replenishment and/or availability (million m^3/y)	Quality range		
		TDS (ppm)	Chlorides (ppm)	Hardness (ppm as $CaCO_3$)
Sea of Galilee	470–600	450–650	180–250	200–245
Yarmuk River	25–70			
Mountain Aquifer	300–350	100–700	50–400	
Coastal aquifer	240–300	200–1,200	100–700	50–750
Eastern Basin	250–350		25–2,000	
Other water sources*	200		20–900	
Total natural water	1,480–1,870			250–350
Recycled wastewater	300–500	650–1,500	170–500	250–350
Total all available water sources (2010)	1,785–2,370			

*Other aquifers and basins (Galilee, Carmel), floodwater, etc.

Table of Capacities and Quality Ranges of Israel's Water Supply Sources. (Dreizin) http://water.gov.il/Hebrew/Planning-and-Development/Desalination/Documents/Ashkelon.pdf

The drinking water in Israel is known for its generally high levels of chloride concentrations, for being overly hard, and for its great number of total dissolved solids (TDS). The primary aquifers providing groundwater contain dangerously excessive levels of sodium, chloride and nitrate as a byproduct of agricultural irrigation. In addition, per the Israel Hydrological Service, these aquifers are replenished with water from the Sea of Galilee, which has a greater amount of salinity. Human sources of pollutants are occurring in the groundwater, as well, with toxins such as insecticides, heavy metals, and other industrial materials (Dreizin). As of 2010, the government planned to reduce the use of drinking quality water for irrigation from a little more than 40% to roughly 25% over the next four decades, with effluent water making up the difference (Rejwan).

Water Delivery

Map of Israel’s Water Systems

© 2002 The Knowers Ark Educational Foundation

http://www.theglobaleducationproject.org/mideast/info/maps/israel-water-systems-map.html

As previously mentioned, Mekorot's countrywide system of conduits and controls moves water amongst Israeli's primary water basins and transfers water from one pipeline to another ("Israel's Water Supply System"). Its National Water Carrier moves waters from the Tiberias and the Jordan to the shoreline plain and to the Negev Desert ("TED Case Studies"). It carries water from the Kinneret in the north, along with groundwater in its path to Mitzpe Ramon in the south, and moves water southward from the Sea of Galilee ("Agriculture in Israel: Facts"). In addition, the National Water Carrier combines waters from a series of tunnel, canals, and pipelines, supplying needed drinking water to the growing population and its higher standard of living. By the 1990s, the Carrier provided 50% of the country's drinking water (Kantor).

Agricultural Water Use

Former Prime Minister David Ben-Gurion dreamt of "making the desert bloom" as a way of securing Israel's food independence and using unexploited land (Bartleby). Since Israel's first prime minister made that statement in 1954, Israel has blossomed as it has turned the desert into agriculturally bountiful land. Since 1964, overall consumption of agricultural water in Israel has increased by only 25 million m^3. In fact, agricultural use of water has been on the decline since its all-time high of 1,249 million m^3 in 1970. Total usage in 2010 was 1,100 million m^3 ("Agriculture in Israel: The Industry").

Israel's ability to take advantage of its varied soils and climates with different technologies allow it to grow a long and diverse list of crops for both national use and for export. Certain crops are grown only in certain seasons. The crops examined in this section will begin with those produced for human consumption -- vegetables, citrus and exotic fruits, greenhouse and screenhouse plants, herbs (organic and non-organic), dairy products, fish, livestock, and swine, and will also include non-food crops (floriculture, cotton, jojoba, turf grass, and tobacco). Statistics on crops for national use and those for export will be included.

"Virtual water" refers to the volume of freshwater required to create a commodity, good or service, calculated at the product's production location (Hoeksta and Chapagain). By importing staple foods instead of growing them, Israel saves water, using its profits from valuable non-staple goods to buy these staple foods (Wallace). “The net virtual water import of a country is equal to the gross virtual water import minus the gross virtual water export.” Israel's annual net virtual water import for 2003 was 5.6 billion m^3 (Hoekstra).

Israel is the fifth largest exporter of avocados in the world, one of its top exportation products. Exports of this crop increased by 50% in 2010 to 72 million pounds. Pepper is Israel's second-most exported agricultural commodity. In third place are tomatoes, mainly of the cherry variety, grown both conventionally and organically. Basil, chives, and mint, among other green herbs, have increasingly been exported due to their higher quality as compared to competition from Egypt, Morocco, and Spain (Zomer). In 2010, the United States imported more frozen carrots from Israel than from any other market (Brunke and Boriss). With half of Israel's 2011 agricultural exports going to Asia, the country increased its gross sales by 18% in just one year; the total gross sales from the export of agricultural products for that year was $3.4 billion (Shamah).

Around the beginning of the Common Era, Korazim, a city north of the Kinneret, was known for its wheat and grain (“Korazim”). Today, Israeli wheat is mainly rain-fed and used primarily for bread, yielding 1.01-2.5 tons/acre. Wheat is grown both in the north as a winter crop for grain (producing 203,615 acres) and silage (producing 44,479 acres), and in the south, where it utilizes the dry agricultural land. The winter wheat harvest varies in size, contingent on the quantity of rainfall it receives, because it is mainly a non-irrigated crop (“Agriculture”). Due to almost a decade of recent drought in Israel, wheat production annually averages 220.5 million pounds (Shachar, “Grain”). It only supplies 15-20% of domestic consumption ("Agriculture in Israel: Facts"). With shortages of production of grains in Russia and the Ukraine, the primary providers of grain to Israel, Israel has turned to the United States to fill the gap of milling wheat imports. By 2011, the United States market share of milling wheat exported to Israel was expected to increase to 50% of Israel’s total wheat imports. Imported grain is also used for livestock ("Agriculture in Israel: Facts").

One-and-one-quarter million tons of corn is imported annually by Israel, including 60% of which comes from the United States. Israel farms little barley and what it does produce is used as silage. The barley is farmed in the southern portion of the country and is used by Arab sheepherders. Israel imports the remainder of its needs. All sorghum imported to Israel comes from the United States (Shachar, “Grain”).

Although farmers began to grow rice during the Second Temple Period and the crop was of economic significance during ancient times (“Rice”), since 1961, Israel’s milled rice production has steadily decreased to the point where the country has zero percent of the world's share ("Israel: Rice, Milled"). While local production has fallen, the population growth, including more North African immigrants and the Arab community, a desire for healthier and Asian foods, as well as greater household incomes, have increased Israelis’ demand for rice. The quarter of a million Southeast Asian workers in Israel create an additional demand for the importation of rice. Israel imports the majority of its rice from Thailand ($35.4 million) and Australia ($24.3 million) (Shachar, “Grain”). Imports of United States rice, the majority of which is medium grain grown in California, more than tripled from 2007-2010, rising to approximately 105 million pounds (Guinn).

Eliahu Navot, "The Father of the Soybean in Israel," introduced the soybean to the Middle East. With the approval of the Minister of Agriculture and Professor Chaim Weizmann, Navot left Israel in 1949 to travel the world for a year studying the soybean and its products, gaining first hand experience with its farmers and collecting varieties and recipes. Eleven years later, soy flour became the first commercial soy product produced in the Middle East, manufactured by an Israeli company. Known as “soya” in Israel, soy has been used to make Soya Schnitzel and Hamburger. Mayonnaise, margarine, milk, breakfast cereals, breads, pet food, meat extenders, and meatless products have all been made in Israel from the soybean (Shurtleff and Aoyagi).

Sugar has been grown and processed in Israel since 300 to 400 BCE (Schar, "Sugar Cane"). In 2009, Israel imported slightly more than 900 million pounds of sugar ("World Production, Supply"). Due to the large amount of sugar that is imported, sugar refineries in Israel were shut down around 1983.

In Israel, the Shamouti orange is the principal citrus consumed by volume sold (“Agriculture”). An increased amount of lemon farming that proactively sprayed pesticides against the white moth resulted in a 100% rise in Israel's 2011/12 lemon crop; Israeli lemon production for that period totaled 120 million pounds. By 2015, increased farming of easy peelers such as tangerines and mandarin oranges is expected to produce 25% more of these crops (Shachar, "Citrus").

Israel successfully exports citrus fruits, one of its primary export crops, because the country’s environmental conditions of temperature and soil create high quality, aesthetically pleasing and flavorful fruit. This citrus sells for a premium internationally, comprising approximately 7% of Israel's agricultural produce. Many variations of grapefruit are grown in Israel, including an unusual cross breed of the grapefruit and the red or white pomelo, on which the peel remains green. Pink grapefruit has become more popular than the white varieties (“Agriculture”). In the month of February 2013, Israel exported 3 million pounds of fruit and vegetable juices to the Russian Federation. Over the past three years, Israel has ranked fourth after China, Ukraine and the Netherlands in the amount of juices exported to Russia and Ukraine ("Israeli Juice Exports").

Currently, approximately 250 different types of exotic fruits are being produced east of the Carmel coastal mountain range above the Mediterranean and in the city of Rehovot, about 12.5 miles south of Tel Aviv in the Center District of the country. Examples of exotic fruits being grown in Israel are bananas that taste like apples, jackfruit (a sweet tasting shelled fruit which can weigh around 80 pounds), tomatoes that smell like lemons, and yellow cherry tomatoes, whose seeds sell in the foreign market for $160,000 a pound (Sanders). Israeli farmers have produced new types of exotic fruits to solve customer complaints, such as the mini watermelon; customers wanted a smaller version of the fruit because the original was too large to finish before spoiling (Sanders). Among exotic fruits grown in Israel are the pitaya, papaya, and passiflora. Other exotics include limes, kumquats (Chinese orange), and limquats (small juicy lemon) ("Agriculture in Israel: Facts"). Dates grow well in the mild climate beside the Sea of Galilee (“Sea of Galilee”). In the process of becoming a major producer of exotic fruits, Israel has established an organization known as the Israeli Exotic Fruit Society.

In order to boost profits for exported chickpeas, currently valued low by international customers, Israeli farmers are creating new versions of the pea, such as drought resistant types.

Israel has developed black chickpeas, which contain higher levels of antioxidants than other varieties (Sanders).

A mechanical grape harvester has aided the wine industry in the Haifa region known as Israel's wine country. In the 1920s, international banker Baron Benjamin de Rothschild grew jasmine for perfume extracts in the town named after him, Binyamina near Haifa ("Binyamina"). Binyamina Winery now has taken over the perfume factory's location and, as the fourth largest winery in the country, yields 2.8 million wine bottles each year. The company also produces liqueurs and brandy with its Hard Nut Liqueur label, commemorating Ben Gurion, who was often called a "hard nut to crack" ("Binyamina").

Nuts have been grown in Israel since ancient times. Walnut trees were brought to Israel from Lebanon and Persia, its nut eaten raw or made into oil and its wood used for burning in the Temple (Schar, "Walnut"). The large size of Israeli-grown peanuts makes them ideal for export in their shells, with about one-half of all peanuts exported ("Agriculture"). Israelis consume more pistachios per capita than any other nation (Barnea). While pistachio trees are not grown in Israel for commercial use, they do, however, grow wild (Schar, "Pistachio"). These nuts are imported from Turkey and the United States, and sometimes come into the country from Iran (Barnea). Compared to non-Israeli grown almonds, the Israeli almonds are of greater size than those the country imports. In addition, home-grown almonds provide more protein, Vitamin E, and calcium (Glazer).

Israel supplies potatoes to Europe during the winter. The most popular potatoes are the baby and new potatoes. Potatoes are farmed in the Hula Valley, the Sharon Valley, Sha'ar Ha Negev, Bney Shim'on, Eshkol, and the Arava desert. These locations can be viewed on the map provided. In Israel, potatoes play a major role in food during Jewish Holidays such as Hannukah and Passover. Around a tenth of the potato crop is processed, mainly into frozen french fries, potato crisps, and potato snacks (Nahmias, Shulam, and Shamash).

Greenhouses with screens, known as “screenhouses,” are used to produce various crops, especially those for export. These crops include tomatoes and cherry tomatoes, melons, peppers, and green herbs ("Agriculture in Israel: Facts"). In Kadesh Barnea, a tiny village in the desert, 2000 acres of cherry tomatoes produce 40,000 pounds/acre per year for export to Europe (Yearwood).

Israeli growers have found that trees are very productive when using brackish water (Yearwood), resulting in a resurgence of traditional produce for export, including olive oil, pomegranate, and almonds ("Agriculture in Israel: Facts"). The employment of brackish water has allowed Israel to export olive oil to countries that are known for being top manufacturers of it. Potatoes and tomatoes are also suitable for the use of brackish water. These vegetables are often exported to Russia (Yearwood).

Organic products, the fastest growing segment in Israeli agricultural production at a yearly growth rate of 25%, make up 15% of fresh export, mainly to Europe; produce grown includes potatoes, peppers, carrots, grapefruit (mostly red), avocados, and peppers ("Agriculture in Israel: Facts"). Using drip irrigation, which will be described in detail in the Technology Section below, and lower quality water on its poor soil, Israel has been able to supply Europe during the winter with melons, cherry tomatoes, and asparagus (Kraft).

The Talpiot artichoke is a medium-sized plant with curved edges that was developed in Israel. Unlike the California grown varieties that cultivate from crown divisions and sideshoots, the Talpiot is grown from seeds, producing only 60-70% that are marketable ("Globe Artichoke").

The fish feed market is expected to reach between 240-280 billion pounds of feed/year by 2013 (“Agriculture & Food”). A pair of Ben-Gurion University professors has developed an aquaculture method of employing low-quality, highly saline brackish water to create pools for breeding marine fish. These fish serve as a fresh source of protein for inhabitants of the Israeli desert. Different species of fish are farmed in brackish water ponds in the Negev desert (Kloosterman). The pond wastewater is an excellent fertilizing source for olive trees, which then produce olive oil (Yearwood). Aquarium fish, such as guppies, are also being raised in the desert for exportation to Europe (Kloosterman).

Modern cattle production in Israel began in 1880 on a dairy farm at an agricultural school known as Mikveh-Israel. Over the next ten years, Jewish settlers raised 774 head of small cows that produced from 650-2200 pounds of milk annually. Nearly twenty years later, an experimental farm purchased a herd of Damascus and Betruth dairy cows that produced 2200-11,000 pounds of milk. In 1921, Dutch cows were brought to Israel. Over the next fifteen years, local and Damascus cattle were bred with Dutch and Friesian bulls, and cows were later imported from other European countries. With an influx of new residents between 1950 and 1960, 18,600 head of cattle were imported to provide milk, with 61% of them being Holstein-Friesian from the United States. Successful at raising cattle, by 1960, Israel was exporting rather than importing this commodity, with 60 pregnant heifers sold to Iran. Five years later, frozen bull semen was being used both in Israel and for exportation. By 1974, 119,000 head of cattle existed on Israeli farms. The high in 1987 was 144,000 head. Since that time, cattle production has remained fairly consistent, never below 133,000 head in a year ("Milestones in the History"). In 2011, cattle, sheep, and goats made up 19.7% of Israel’s agricultural output ("Agriculture in Israel: The Industry”).

Today, cows in Israel produce 1,217 million liters of milk each year, comprising 9% of all agricultural sales in the nation. The Israeli Genetic Improvement System bred the Israeli-Holstein cow, genetically modified to handle the country's lengthy summers and local diseases. Compared to all other nations, the Israeli-Holstein cow produces the most volume and milk solids per cow per year ("Facts About the Dairy"). The butter industry comprises 2% of the dairy market in Israel, with Israelis using 18 million pounds of locally produced butter annually and importing another 1.1 million pounds (Palti). Each year, 11.1 million liters of premium goat's milk and 9 million liters of sheep's milk are exported as cheese to the United States and other countries ("Facts About the Dairy").

Israel's beef and veal meat production has remained steady since 2006, at an average of 106 million pounds, with a peak in 2008 of 112.5 million pounds ("Milestones in the History"). Israeli broiler meat (poultry) production has risen from 88 million pounds in 1964 to 430 million pounds in 2000. By 2011, poultry made up 17.4% of the State's agricultural production ("Agriculture in Israel: The Industry"). Of Israel's 26 pig farms, only one is Jewish-owned ("Ag Ministry") and is on a kibbutz, the Lahav. The other farms reside mainly in Christian Arab areas in the northern region of the State. The kibbutz skirts Jewish Kosher law forbidding the consumption of swine by using the pigs for research in its Animal Research Institute. The residents of the kibbutz are thus allowed to eat the excess swine (Yoskowitz).

With the price of cotton increasing, Israel's cotton production grew from 2010 to 2011 by nearly 135% ("Israel Cotton Production"). Despite Israel's water deficit, cotton yield and lint quality are not affected. Only the height and weight of the cotton plant are reduced due to water shortage. Lack of water before the plant flowers causes yield loss (Heuer and Nadler). During the 2011/2012 cotton season, 20,000 acres of non-Genetically Modified Organism (GMO) cotton were grown in Israel, producing a total of 15,000 tons, of which 10,000 tons were Pima and 5,000 tons were Acalpi. Acala is another variety grown, but to a lesser extent. The Pima cotton is Extra-Long Staple (ELS), the type farmed in the United States, while the Acalpi is Long Staple (LS). Some of the Pima cotton is grown organically ("Cotton in Israel").

Israel's climate makes it an attractive spot for growing summer flowers. It is the third largest supplier of flowers to the European Union (EU), exporting 90% of its flowers: 1.5 billion stems. This translates to $200 million dollars annually (Eisen). Some of the approximately 160 floral products currently grown in the country encompass solidago, gypsophilia, wax flower, roses, ornamental plants, limonium, lisianthus, and gerbera. ("Agriculture in Israel: Facts"). Israel accounts for nearly 30% of the world supply of jojoba oil exports ("Jojoba"). Jojoba is exported to the United States and Europe for use in cosmetic and lubrication products (Yearwood). Three-quarters of sunflowers grown in Israel are for export; a novel type of this flower is being crossbred that will resist disease and will produce larger seeds with new colors (“Agriculture”).

Human consumption of tobacco decreased in Israel during the thirty-year period of 1970-2000. Instead, Israeli tobacco crops are being used for beneficial purposes rather than for manufacturing cigarettes. Under the guidance of Hebrew University Professor Alexander Vainstein, Israeli scientists have genetically modified tobacco to create the anti-malaria drug artemisinin. The drug is usually produced from the costly and difficult to grow wild sweet wormwood plant. Due to the tobacco plant’s rapid growth, the scientists were able to duplicate the wormwood’s genes at minimal cost ("Israel Team Produces"). In addition, greenhouse-grown tobacco has been genetically modified to create collagen, a protein that can be used in humans to restore tissue, plug bone vacuums in cancer patients, heal acute wounds, and repair heart valves (Bernard).

Prices of Agricultural Water

According to Steven Plaut from the Institute for Advanced Strategic and Political Studies, as a result of surplus requirements from farmers, Israel's agricultural water is priced too low, causing the resource to deplete faster than normal. If pricing were based on its full value, Plaut writes that low-producing farmers would be forced out of business due to their powerlessness to pay water rates without the help of government subsidies. Although monetary penalties for water over-usage are levied upon growers, the water rates do not approach the actual costs to the State. Plaut says that the current water system "punishes the efficient while rewarding the inefficient." Water prices from 1999 reveal that average agricultural high-quality water use was 22 cents per m^3. Runoff and partially salinated water cost farmers 17 cents per m^3, while recycled wastewater was priced at 13 cents per m^3. Comparatively, industrial companies were charged 36 cents per m^3, with household users charged at the highest rate of 94 cents per m^3 (Plaut).

Since 2005, agricultural use of treated wastewater has lessened as a result of the water shortage. In Hebrew University's Agricultural Faculty's study on the economic results of the reduced agricultural efforts, $.70/$m^3$ was the "shadow price" this industry was willing to pay for one m^3 of water. The "shadow price" refers to "the maximum price that management is willing to pay for an extra unit of a given limited resource" (Tenne, Hoffman, Levi). A study by the University of Haifa in conjunction with the Hebrew University in Jerusalem researched which agricultural areas and crops in Israel might suffer most from reductions in water. Their model took into account the amount of water and its salt levels as it affected the output of forty-five different crops. The researchers also looked at the results of the quality of water provided to the agricultural sector: "potable, high quality Soil Aquifer Treated (SAT) municipal wastewater, tertiary treated municipal wastewater and slightly brackish water." Then, they experimented with various influences such as irrigation systems and land usage to forecast agricultural yields and profits. The results proved that the usage of water for crops should be restricted by price rather than by Israel Water Authority (IWA) allotment (Tenne, Hoffman, Levi).

Technology

Due to its scarcity of water and limited agricultural land, Israel has researched and developed methods of compensating for these shortages that have made it a global leader in agro-technology. Heralding back to the days of King Herod and his cisterns, Israel has been at the forefront of using water technology to make the country self-sufficient. Israel collects rainwater in nearly 200 reservoirs spread around its rain gradient; these reservoirs are placed mainly in semi-arid and hyper-arid regions. The reservoirs amass 125 million m^3/year, making up 7% of the entire water in Israel's system, efficiently irrigating 74,000 acres of farmland. Floodwater from rains are trapped and collected by the reservoirs, which, in turn, refill the groundwater. Constructing rainwater reservoirs with a volume of up to 2 million m^3 can cost up to $5 million (Tal, "Seeking Sustainability"). The Jewish National Fund has been instrumental in creating rainwater reservoirs and has programs that educate students about water problems. One such program involves a rainwater collection tank at schools, which can provide enough water for nearly all of its requirements ("Water Projects").

Israel's agricultural sector is growing, seeing increases in productivity and in agricultural exports. One of the technological methods employed by Israel is drip irrigation. The earliest use of drip irrigation dates back to ancient times, when farmers placed below the ground clay pots containing water; the water contained in the pots would slowly make its way to the crops' roots.

More recently, in 1866, experimenters in Afghanistan created a technique utilizing clay pipe to blend irrigation and drainage methods (Emmons).

Modern drip irrigation is an innovative agricultural technology created in the 1920s on Kibbutz Netafim, west of the city of Beersheva. In the early 1960s, Simcha and Yeshayahu Blass invented a more intricate adaptation of drip irrigation that utilized the "spoon-feeding" of plant roots with water, nutrition and air (Yearwood). Drip irrigation works by secreting "water directly to the soil adjacent to the root system, which absorbs the water immediately." This almost completely reduces evaporation, a major concern in arid zones. Another water-saving benefit of drip irrigation compared to normal irrigation and sprinkler systems is that it only waters the root system, not unused space. Plants using drip irrigation absorb ninety-five percent of water used, while conventional irrigation plants absorb less than half of that amount (Sitton). This method of irrigation has the capability of providing from one to twenty liters of water per hour, making it appropriate for extreme agronomy, and is often used in greenhouses ("Agriculture"). Drip irrigation can be used on farmland that is not flat, unlike conventional irrigation. There has even been success using saline water with underground drip irrigation (Oron). This method would help the Israeli water crisis even more because it would relieve some of the pressure created by agricultural needs. Without this technology, farming on Israel's current and future scale would be impossible. Drip irrigation has been implemented all over the world and has saved countless amounts of water, however it has only been used by half a percent of total world irrigation (Yearwood). Since drip irrigation has been implemented in Israel, the use of water per unit of land area has declined from its high in the mid-Seventies of 3,500 m^3/acre to today's rate of 2,225 m^3/acre ("Israel's Chronic Water Problem"). Drip irrigation is employed in approximately 90-95% of Israel's agrarian sector (Mandell).

Drip irrigation methods include traditional, subsurface, and alternative. The traditional method is above ground and "contains a main line and sub-main lines/header," which deliver water to drip lines that sends water to the exit points at the plant bases. The system has a pressure regulator, an on-and-off valve and another valve that keeps water from returning; it also has the ability to deliver fertilizer to the plants. A more advanced set-up employs drains, meters, air vents, timers, and controllers (Sustainable Agriculture Initiative). Subsurface drip irrigation (SDI) is a technique that employs underground plastic drip pipes to deliver water and nutrients. Watering above ground wastes valuable water through evaporation; subsurface irrigation eliminates this loss and cultivates bigger crops. In addition, subsurface drip helps to prevent weeds and disease. An SDI set up may have greater start-up costs than an above-ground system. Also, its expenses will fluctuate depending on “water source, quality, filtration need, choice of material, soil characteristics and degree of automation desired” (Reich). While there are low cost alternatives used in other countries, including India and other less developed countries, these methods are not regularly utilized in Israel. By minimizing water usage and costs, drip irrigation assists agribusiness in becoming more flexible and lucrative.

The use of computers in drip irrigation has the advantage of performing in real-time, allowing for continuous monitoring and reducing worker costs. Any method of irrigation can employ computers, which can be designed to irrigate at intervals and can facilitate an automatic shutdown when the wrong amounts of water are used (“Agriculture”). Computers can also aid in the implementation of the water-conserving micro-spraying-and-sprinkling irrigation techniques that irrigate individual trees by their own sprayers.

Percentagewise, Israel recycles more wastewater than other nations (Izhak), and was the first country to create guidelines for wastewater usage, doing so in 1953 (Tal, "Seeking

Sustainability"). Roughly three-quarters of Israel's treated wastewater is recycled for agricultural irrigation. There are different ways to treat the water, such as bacteria treatments and electro-chemical systems ("Israel Leading the Way"). Bacteria treatments work using biological reactors with big surface areas; a large surface area is important for the growth of bacteria that attach to the contaminated particles in the water during the first steps of treatment as a means of separating the contaminated particles from the water. As the bacteria hit new surfaces, they automatically divide and grow, consuming contaminated particles in their wake ("Israel Leading the Way"). Electro-chemical systems work by having "metal electrodes in the water release positively charted electrons that attract the negatively charged particles pulling them down to the bottom of the basin." To finish the purification process, the remaining chemicals are abstracted ("Israel Leading the Way").

Treated wastewater has a cost-benefit over desalinating water, one of Israel's other techniques; typically, it costs half as much as desalinization (Izhak). The employment of treated wastewater for agriculture is safe, alleviating water shortages and decreasing water pollution. Another benefit of wastewater is that it contains nutrients, resulting in the discontinuation of the use of costly chemical fertilizers ("Reuse of Wastewater"). A large amount of the treated wastewater is sent to the Negev desert to cultivate carrots, oranges, lettuce, and many more plants (Distel).

Mekorot, Israel's national water company, operates The Dan Region Reclamation Project, the largest wastewater treatment plant in Israel and the most sophisticated one in the Middle East ("Wastewater Treatment and Reclamation"). At the Shafdan, facultative oxidation ponds – ponds "where biological activity is combined with anaerobic bacteria"-- and mechanical-biological plants treat public wastewater with an activated sludge process that uses nitrification and denitrification methods (Avsar). Then, using the "Soil-Aquifer Treatment" (SAT), the recycled sewage water is sent downward into permeable sand that filters out microorganisms and makes the water safe to use for irrigation (Banin).

Since some wastewater comes from chemical factories, it may consist of compounds that have contaminating and deterring effects on treatment processes. Treating such wastewater with an aerobic method based on membrane bioreactor (MBR) technology has been explored. In addition, compounds found in the wastewater, such as phenol, can affect treatment. A study found that fast-growing *E. coli* cells were more likely to be damaged by hydrophobic compounds than non-growing cells (Galil).

The Jewish National Fund helped create a wetlands system at The Ramon Air Force Base in the Negev Desert. The manmade wetlands cleanse the base's sewage by mimicking the biofiltration system of actual wetlands. This creates an additional eighty-million gallons of reusable water for agriculture ("Water Projects").

With its lack of fresh water sources, Israel has turned to the Mediterranean and Red Seas for its water. Israel will have five desalination plants before 2014, which will supply eighty-five percent of the nation's home water usage (Rabinovitch). By 2014 and 2040, respectively, Israel will produce 577 million and 1.75 billion cubic meters of water per year (Tenne 4). Desalination is the process of removing salt from saline water. Israel's has three existing seawater desalination plants, Hadera, Palmachim, and Ashkelon. Soreq A and Ashdod facilities will be completed by 2014, while the Western Galilee and Soreq B plants will not be ready till 2020 (Tenne, Hoffman, Levi). The three existing plants contribute approximately 42% of the water in the national and regional grids. The remaining portion comes from groundwater and the Sea of Galilee.

From 2005-2010, desalinated water contributed roughly 800 million m^3 to the national water system. Without this addition of water, Israel's natural water sources would have breached the safe zone, causing irreparable destruction to water quality (Tenne, Hoffman, Levi). Israel's desalination plants use reverse osmosis, where "water from a pressurized saline solution is separated from the dissolved salts by flowing through a water-permeable membrane" ("Desalination by Reverse Osmosis"). Although the Ashkelon desalination plant uses the reverse osmosis technique ("Ashkelon, Israel"), it, like other giant desalination plants, uses a centralized, not localized, system of pumping seawater to high pressure. The plant uses a tool called Dweer, manufactured by the Swiss company Calder, which recovers 95% of the energy it uses, thereby lowering Ashkelon's expenses. In addition, Ashkelon operates an electrical grid, as well as a gas turbine power station that produces 80 MW of the energy the plant uses, with 56 of those megawatts supplying desalination ("Low Energy Consumption"). The Ashkelon plant was the largest of its kind in the world until Hadera was constructed in 2009. Hadera outputs 140 million m^3 of water per year, requiring a great deal of electricity, delivered by a coal fire power-driven station located at Orot Rabin. The plant also employs an ERI PX Pressure Exchanger, which can lower power consumption by 60% ("Hadera Desalination Plant"). Opening in the summer of 2013, the desalination plant at Sorek will be superior to Hadera, making it one of the largest in the world (Mandell), desalinating 510,000m^3/day of seawater. An independent power producer will provide the plant's electricity ("Sorek Desalination Plant").

As demonstrated in the figure below, Israeli desalination plants are some of the most cost effective and efficient plants in the world, with a cost range per cubic meter between US fifty-two cents to sixty-five cents (Tenne 9). This is much cheaper than the proposed fresh water pipeline from Turkey, which is estimated to cost around a dollar per cubic meter (Vidal).

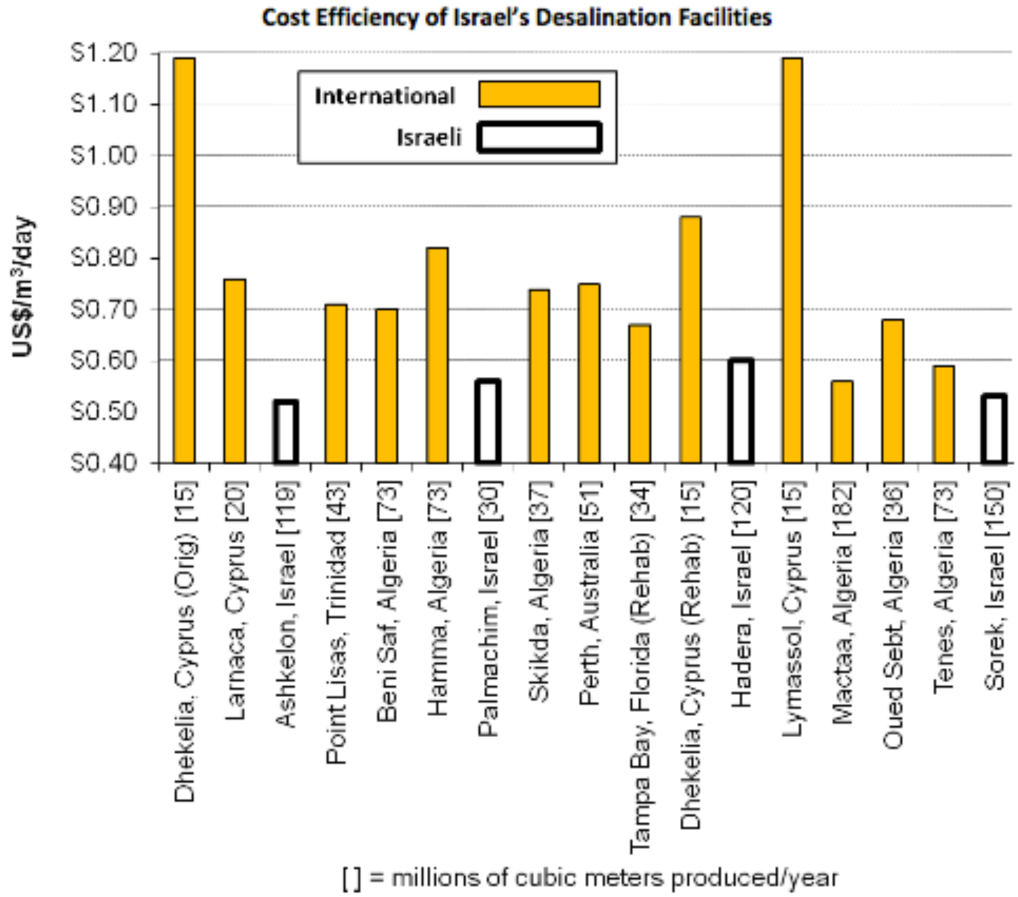


Figure 8 – A cost-comparison among international large-scale seawater reverse osmosis (SWRO) desalination plants that have been built between 1997 and 2010 (ordered from left to right by operation-launch date). Israeli desalination facilities are shown in open bars, and facilities from other countries are shown by closed bars. Annual production volumes are indicated within square-brackets on the x-axis, in millions of cubic meters. Source: Water Authority, Desalination Department

(Rejwan) http://www.water.gov.il/Hebrew/ProfessionalInfoAndData/2012/04-The-State-of-Israel-National-Water-Efficiency-Report.pdf

Its state-of-the-art technology affords Israel one cubic meter of desalinated water for 3.5 kilowatt hours, providing enough water to cover the average citizen's weekly consumption (Mandell). Some of the criticism Israeli desalination has received concerns possible consequences of brine ejections into narrow portions of the seas, reduction of public coastal access, and the increase in air pollution (Tal 1083). Aware of these problems, Israel is currently researching and implementing solutions.

Israel also plans to expand its current brackish water plants; its first commercial plant was established in 1987 (WATEC 2007). Brackish water is salty water, but with a lower salt concentration than seawater. Brackish water has a salinity level of 10,000 milligrams per liter of water, while seawater contains 40,000 milligrams per liter. Currently, Israel has nine brackish desalination water plants that supply 30 million m^3 of water per year, and expects to double output by the end of 2013 (Tenne 6). In 2008, Mekorot and the Israeli Water Authority created a long-term plan to expand the country's brackish water facilities. At that time, the country desalinated approximately 16,500 m^3/day of brackish water. The two agencies expected their $300 million blueprint to increase desalination of brackish water to an amount in the range of 220,000 m^3/day and 274,000 m^3/day ("Israel's Brackish Water"). A number of Israel's desalination plants, including those in Eilat, Arava, and the southern plains of Carmel near the ocean, process this water from land-based wells. Brackish water plants are more energy efficient than seawater desalination plants and will produce water at roughly $0.30/ m^3 (Tal, "Seeking Sustainability").

Resourceful in its nonconventional technological inventions to generate and save water, Israel has become the world leader in this arena. Although cloud seeding was discovered at the General Electric Lab in New York in 1946 ("Cloud Seeding FAQ"), Israel has been at the forefront of this technology for the past fifty years. Israel has experimented with several different techniques for cloud seeding in order to provide new rainfall. Other drought-ridden countries around the world have also employed the static, dynamic, and hygroscopic cloud seeding methods. Static cloud seeding, which disperses silver iodide throughout clouds with the intention of aiding in the distribution of water, is thought to be the most reliable technique. Dynamic cloud seeding enhances vertical air currents using ice crystals, but is a less reliable method. Hygroscopic cloud seeding explodes salts into the bottom of clouds and is still an experimental technique (Silverman and Lamb). Recently, however, Israeli scientists have discovered that cloud seeding is not as successful at creating rain as was once believed. Instead, they attribute heavy rainfall to changing weather patterns. However, these scientists believe that the seeding of orographic clouds that originate rapidly in mountainous areas hasten the formation of precipitation ("Cloud Seeding Not Effective").

In another less than conventional method of protecting its valuable water resources, Israel has installed primary surface water runoff interception projects at Kefar Baruch, Dalya, Menashe, Shikma, Bsor and Arava to retain rainfall and recharge groundwater. The country has one-hundred other smaller such projects that sanitize effluents from local sewage treatment plants. The Dan Region Scheme recharges secondary effluents from the Tel-Aviv Metropolitan into the local aquifer (Shevah).

The State's triennial International Agricultural Exhibition and Conference, "Agritech Israel," draws Ministers of Agriculture, policy-makers, agricultural professionals, and practitioners from all over the world who represent countries interested in learning ways of boosting agricultural efficiency. The conference offers a rare opportunity to witness the most advanced technology in the areas of water management and irrigation, plant life for water scarce climates, greenhouse agronomy, and organic, ecological and new hybrid seed specimens. In 2009, nearly 20% of those attending were involved with irrigation and water management. Roughly 15% were involved in livestock and dairy farming, while 4% were actively propagating plant materials, that is, generating new plants from seeds, bulbs, and cuttings ("Facts and Figures on Agritech"). The 2012 conference hosted 80 official foreign delegations and numerous unofficial groups from Arab countries. The largest contingent included 2,000 farmers from India. In the next section, Israel's water policy and its effects on agriculture will be examined.

Water Policy

As the 21st century began, former Israeli Water Commissioner Dan Zaslavsky wrote that the country's water issues revolved around its relations with bordering countries, over-pumping, water pollution, and water policy (Zaslavsky). Israeli water policy deals with lack of supply and quality issues, as well as compromise with nearby riparian nations. In addition, political, cultural, and social needs sway policy decisions. Policymakers must also consider climate, pollution, and immigration. Each sector fights for its own share of water. To combat these problems, the government has legislated legal criteria for water use and offers financial enticements to the water sector. Financed by both the public and private sectors, water and wastewater technologies have been developed (Netanyahu).

Since 1940, the Minister of Health has overseen the sanitation of drinking water and its resources, as well as the planning, building, and business of drinking water facilities. The Water Measurement Law of 1955 established that any water purchased must be measured in order to preserve water. Consumers are required to employ their own measuring devices. This law began an era of government oversight over water. The Water Drillings Control Law, also of 1955, which polices the drilling and installation of wells, requires a permit from The Governmental Authority for Water and Sewerage. It is an important law because its requirements extend to pre-drilling and ensure control of Israel's water resources ("Water Legislation").

The Drainage and Control Law of 1957 safeguards surface and drainage waters; it disallows diversions to waterways sans authorization from the Director of the Governmental

Authority. This law to regulate the movement of flood and drainage waters created a National Drainage Board. More than half of the Drainage Board members are non-officials from the agricultural sector. The Drainage Board authorizes construction of drainage systems ("Water Legislation").

The Water Law of 1959, establishing water resources as public property, created the position of a Water Commissioner who, with authorization from the Knesset, oversees the development and apportionment of water resources, ensuring its safety and conservation, and determines the amount charged to water customers (Israel Briefing Book). The agricultural sector receives water subsidized by Mekorot, which is then reimbursed by the government (Netanyahu). This law authorizes the Water Commissioner to control the creation, reserve, and allocation of water. The Water Commissioner is sanctioned to ration water as needed and to implement regulations to keep the water safe for human consumption and for agricultural needs ("Water Legislation"). The law was amended in May 2006 to establish an entity to oversee water and sewerage. The National Authority for Water and Sewerage controls the water sector, implementing water policy and making certain that guidelines are followed with regard to the production, provision, and quality of water, rates, usage, and the avoidance of hazardous occurrences to drinking water. The Minister of Health continues to control drinking water under this law, while the Minister of Agriculture oversees drainage and flood control and the Minister of the Environment handles pollution control (Laster and Livney).

In 1965, The Streams and Springs Authorities Law was passed to preserve an appropriate water level. The Drainage Board also oversees its compliance. Not only is Israel concerned with expanding its water levels, but the nation also desires to conserve water. Conserving the limited water Israel already has is the most economical option, but this is becoming increasingly harder as the nation lives a more western lifestyle. In an attempt to conserve its water, Israel has been updating its eroding plumbing foundation, putting restrictions on washing cars, toilet-flushing (dual lever), and the practice of spray irrigation. Using price as a deterrent to high water usage has been shown to be an ineffective tool because “water is highly inelastic and thus not responsive to price regulation” (Tal, "Seeking Sustainability"). In 2009, after many years of drought, the Israeli Water Authority first sought to cut home water usage by 10%; it distributed “chaschams,” low-flow faucet aerators, to 1.2 million homes. The Water Authority also charged a “drought fee” to homes using above-average amounts of water (Damast). The government has made the saying “don’t waste a drop” familiar to all Israelis, and Israeli policymakers and citizens have been proactive ("Israel Briefing Book"). Daily activities such as using two different size toilet "flushers" to conserve wasted water and drinking available tap water instead of only bottled water are just a few ways that Israelis are attempting to help the situation. Some Israelis place buckets in their showers to catch the cold water that is normally wasted. They then use this water in their gardens or other places around the house. Parks in Israel now try to incorporate mainly drought-resistant plants. In order to stop contamination of current water sources, the government limits what can be built above groundwater sources and monitors “water recharge, water table levels, abstraction, salinity (chlorides) and pollution (nitrates) data” (“Israel’s Chronic Water Problem”). These little steps will go a long way, and with an optimistic outlook on the situation along with positive policy-making, Israel will be a desert without the "constant water problem."

The Politics of the Competition for Water

Providing financial aid to the water infrastructure is considered as important a factor in Israel's national security as is funding the military and, therefore, is not influenced by state and global market forces (Tal, "Water Management"). The movement toward a centralized state evolved out of political ideology, electoral politics, and varied interests. In the 1950s, Israel's water experts were influenced by their political beliefs. Competition for water between agriculture and industry was sharply debated at that time. Under discussion were the nation's water potential and the specifics of the diversion project. Israelis who were focused on the country's economics disagreed with the Zionist settlers who were more interested in agriculture and their links to the land. Alatout states that a newer and more realistic view of water scarcity led to further political debate and government management of the State's resources (Alatout).

Due to prior deficiencies in the administration of the water sector, a new water law restructured the Water Commission in 2007 into the National Water and Sewage Authority (Netanyahu). The Water Authority administers and allocates water resources for the entire State of Israel and all of its water sectors, with a mission to preserve and protect the quality and quantity of its water resources, as well as establish tariffs and levies to the various sectors. It regulates Mekorot and the many municipal water companies. The Authority's task is to safeguard the supply of potable water and to increase the treatment of sewage and other low quality water for use in the agricultural sector. It is authorized to cooperate with other countries in sharing water and in creating solutions to water issues (Slepner). Israel and its transboundary riparians work together, sometimes secretly and other times publicly, to collect data, as in the example of the JWC discussed earlier in this thesis, while simultaneously acting in conflict, both politically and militarily. Even as the Good Water Neighbours Project of 2001, uniting the mayors of towns along the Jordan River, allowed the sharing of strategies between Israel, Jordan, and Palestine to conserve this river, the Second Intifada between Israel and the Palestinians was taking place (Zeitoun and Mirumachi).

For the year 2009, Israel's agriculture sector used slightly more than 1 billion m^3 of water, the domestic sector used almost 700 million m^3 of water, and the industrial sector used a little more than a 100 million m^3 of water ("Israel Briefing Book"). Additionally, Israel's agricultural sector used roughly 600 million m^3 of effluent and brackish water.

Municipal

Under the National Water and Sewage Authority, the Water Authority Commission enforces its rulings over Israeli municipalities. In order to supply its urban consumers, 56 Municipal Water Corporations were founded. Private, international, and foreign companies were also engaged to supply water to urban dwellers. To cover the price of freshwater water retrieval, urban consumers paid more. This evolved the water sector into a separate and exclusive sector of the economy (Netanyahu). While household income affects the price of water, households with more occupants tend to save more money on a per person basis.

Household water consumption can be influenced positively by water conservation education, the use of drought-resistant landscaping, and fees for using more water than what is considered the norm ("Water for the Future"). The Israeli Water Authority conducted a national media awareness campaign from 2008 to 2010 that educated its citizens on the necessity to lower household water use due to the gravity of the country's potable water reserves. In the domestic sector, in 1996, the annual per capita usage of water was 58.1 cubic meters. By the beginning of the campaign, the 2008 residential per capita usage of water (use in homes and personal gardening) had risen to 59.3 cubic meters, while the municipal per capita consumption (local governmental use) was 83.7 cubic meters. In the private and public sectors (the national total from all sectors, including cities, kibbutzim, settlements, minority villages, and army camps, and excluding industrial and agricultural uses), water consumption that year hit a low for the period of 1996-2008 of 103 cubic meters per person (Lev). The following year, the campaign resulted in a 10% reduction (76 million m3) of total water used (Rejwan).

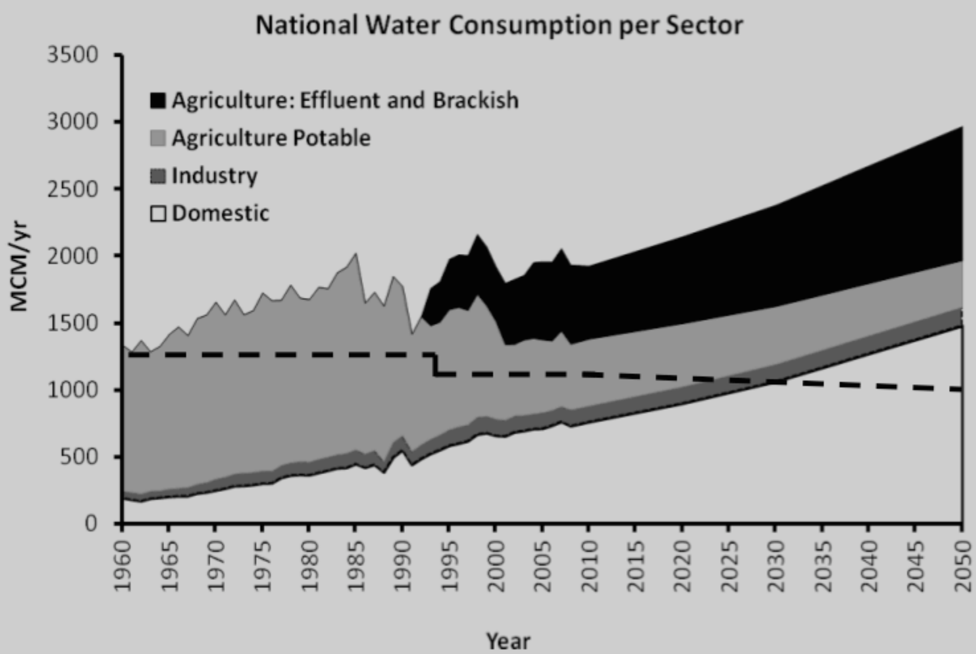


Figure 3: Historical and projected annual water consumption per sector from 1960-2050, in millions of cubic meters (MCM/yr). Consumption from the agricultural sector is shown in two categories: (1) potable water, and (2) alternative water sources (effluent and brackish water). The black dashed line identifies the average natural water supply: 1250 MCM/yr (1932 -1992),1155 MCM/yr (1993 -2010), decline to 1020 MCM/yr (2011-2050).[4] Data source: Water Authority Planning Department; For 2010 onwards, source: *A Long-Term Master Plan for the Water Sector* – 2010 Policy Document of the Ministry of National Infrastructures, Water Authority, Planning Department.

(Rejwan)

http://www.water.gov.il/Hebrew/ProfessionalInfoAndData/2012/04-The-State-of-Israel-National-Water-Efficiency-Report.pdf

Industrial

Industrial water use differs amongst the various industries in Israel, and all are affected by the technologies implemented. Through government regulation and active recycling of its water, industries in Israel have decreased total water use, as well as the amount of wastewater discharged. Prior to the 1970s, much of Israel's industry revolved around the agricultural sector, including the manufacture of farming and agricultural equipment, food processing, and the making of pesticides and fertilizers. This was followed by a period of weapons manufacturing and innovative technology servicing the aviation and weaponry sectors. These industries evolved into today's high-tech businesses that attracted exiled Israelis working in the Silicon Valley in California to return home to open new businesses and to bring international companies to the State. Émigrés from the former Soviet Union added an extremely qualified group of scientists, doctors, engineers and technicians to the work force. In 2006, industry brought in 21.6% of the Gross National Product, while agriculture only brought in 2.5% ("Economy: Sectors").

Agricultural

The agricultural lobby in Israel is so powerful that a 2002 Israeli Parliamentary Committee Inquiry discovered that most Water Commissioners are selected on the basis of their political views on this lobby, contingent on the opinion of the current government (Zeitoun). Since August 2007, Israel has removed prior price subsidies for farmers. The subsidies led to irresponsible water use and decrease of overall supply. Water priced at its actual cost decreased farmer demand because it is more elastic than residential water; therefore, it is more responsive to price increases. This "new" available water can now be used in the domestic and industrial sectors ("TED Case Studies").

Summary and Conclusions

At the beginning of this century, United States Senator Paul Simon stated that, although nations fight over oil, alternatives exist. He continued: "How much more intractable might wars be that are fought over water, an ever scarcer commodity for which there is no substitute (Fisher and Huber-Lee)?" The struggle for water inspired Israel to become innovative in overcoming the obstacles of water scarcity. A country wealthy in brainpower, Israel currently employs many viable options that have greened its desert. Israel’s past and current water policies and laws have determined that obtaining and conserving this precious resource is advantageous at any price to maintain its stability and dominance in the region. However, its control over the water in this region has resulted in conflict with its neighbors. Over the past several years, boycott campaigns by organizations as varied as the Arab League, the Co-Op (the fifth largest UK supermarket chain), Palestine United, The Congress of South African Trade Unions, The Church of England, and the Canadian Union of Public Employees have threatened Israel's agricultural exports, its economy, and its image. The Palestinian Boycott, Divestment, Sanctions Movement (BDS) and similar organizations call for divestment and sanctions from products produced in the Golan Heights, West Bank, and East Jerusalem, in addition to boycotting exportation of Israeli crops and goods. The EU has banned funding of Israeli institutions and companies in the affected areas. Israel has become more isolated on the world trade scene since the EU began blocking Israeli products from receiving customs exemptions and examining ways to label settlement exports ("Israeli Leaders Condemn"). Israel needs to be more proactive in initiating its own media campaign to counter negative websites and groups who oppose its trading of crops and goods.

Israel’s use of virtual water to import staple foods instead of growing them locally not only saves precious water but also helps its economic relations with other countries. According to Franklin M. Fisher and Annette Huber-Lee in their article “Economics, Water Management, and Conflict Resolution in the Middle East and Beyond,” by computing its economic value, water can indeed be traded, thereby paving the way to better water management and harmony amongst transboundary water riparians. Israel and Syria both depend on the Banias River, which originates in the Golan's mountains, to supply the Jordan River. With an annual Gross Domestic Product (GDP) of around $242 billion in 2011, even if Israel lost the all of the 125 million m^3 of water supplied each year by the Banias, it would translate to only a cost of $5 million annually of its usual water supply and not even $40 million in a drought year. Replacing this water by desalination would cost Israel approximately $75 million annually. These costs are insignificant versus the GDP and should not interfere with peaceful negotiations. Several years ago, Israel decried Lebanon's plans to pump the Hasbani River as an act of war, even though the allocation of such waters would have had few consequences to Israel. Fisher and Huber-Lee suggest using short-term licenses for the usage of a neighboring country's waters. The quantities and prices would be negotiated and agreed to in advance, with the countries trading for concessions they desire more than water (Fisher and Huber-Lee).

Although there are costs involved, desalination proves an effective method of providing potable water and serves as an integral part of Israel’s strategy to increase its water supply. In the future, the energy needed to desalinate water will decrease, as will the costs, because new technology will be more efficient and the process will be updated as new technology becomes available. However, the country should be cautious so as to not pollute its seas when returning the remaining saltwater and its resulting concentrated brine and elevated iron content. Brackish water offers another important source of water. Derived from underground sources, it is less salty than desalinated seawater. In addition, brackish water is both more environmentally friendly and less expensive to produce than desalinated seawater. Israel’s exploitation of treated wastewater has proven extremely beneficial, especially as more research reveals which agriculture grows most productively utilizing it. This otherwise wasted water, valuable due to its nutrients, can instead be tapped for agriculture. Drip irrigation’s large initial costs depend on the size of the system and the methods employed but, when used properly, can reduce water costs and increase productivity, leading to higher revenues. The state's proactivity and water conservation techniques following recent years of drought have prevented further water loss.

As a high-tech nation, Israel should reevaluate its stance on the importance of agriculture, since it produces so little of its GDP yet uses 70% of its water. Because the water was, for decades, offered at so low a price to the agricultural sector, it encouraged irresponsible usage. In recent years, subsidies to farmers have moved toward a fairer market price as compared to the costs offered to other sectors. Israel needs to continue its progress toward a more market-based pricing structure of its water. Over the next five years, desalination will supply a huge proportion of Israel's usable water and, over the next quarter of a century, the country will more than triple its production of water. While the benefits of producing more water are great, the costs are high. Yet, the positive side to water production is that it provides more employment and economic stimulus.

However, as water issues are regional and, thereby, transboundary, Israel should work with its neighbors on cooperation on water issues as a way of improving peace. The less-developed nations neighboring Israel have far lower per capita GDPs, which, according to Yoffe, Wold, and Giordano in their article "Conflict and Cooperation Over International Freshwater Resources: Indicators of Basins at Risk," increases the likelihood of conflicting over water. This is why Israel should trade its advanced technology in agriculture and water to its transboundary neighbors for greater cooperation on a wide range of issues. In its past dealings with neighboring countries, Israel has restricted Palestinian and Jordanian scientists from attending conferences where information can be exchanged, while various Israeli authorities, scientists, and negotiation experts have had their invitations rescinded from international conferences due to the influence of the BDS Movement. All nations must learn to be more cooperative. With continued cooperation with its transboundary riparians, as in the case of the aforementioned mayors along the Jordan, and with research, development, and the use of advanced technologies, Israel shows great prospects for remaining in the green in its battle against water scarcity, thus preventing further water crises.

WORKS CITED

"Ag Ministry Seeking to Move Pig Farms to Country's South." *ThePigSite*. 5m Publishing, 25 June 2012. Web. 21 May 2013.

"Agreements, Plans, Negotiations and Positions." *PASSIA*. Palestinian Academic Society for the Study of International Affiars, n.d. Web. 24 Nov. 2012.

"Agricultural Crop Areas, By Natural Region." *CBS*. Israel Central Bureau of Statistics, 2010. Web. 2 Jan. 2013.

"Agricultural land (% of land area) in Israel." *TradingEconomics*. Trading Economics, 2012. Web. 2 Jan. 2013.

"Agriculture." *ThinkQuest*. Think Quest, n.d. Web. 12 March 2013.

"Agriculture & Food." *Mofet-Venture*. Mofet, n.d. Web. 2 Jan. 2013.

"Agriculture In Israel: Facts and Figures." *MOAG*. Ministry of Agriculture and Rural Development, 2008. Web. 2 Jan. 2013.

"Agriculture in Israel: The Industry Account; Price Indices of Output and Input; 2010-2011." CBS. Central Bureau of Statistics (Israel), 8 Feb. 2012. Web. 24 Dec. 2012.

Aran, Gideon. "Some Comments on Israel's Borders: The Hebrew Bible and the Middle East Conflict." *UCLA*. UCLA Younes and Soraya Nazarian Center for Israel Studies, n.d. Web. 27 May 2013.

"Ashkelon, Israel." *Water-Technology*. Water-Technology, n.d. Web. 11 March 2013.

Attili, Shaddad, David Phillips, and Adla Khalaf. "Historical Developmental Plans of the Jordan River Basin." *NAD-PLO*. Negoations Affairs Department of the Palestinian Liberation Organization, n.d. Web. 30 Nov. 2012.

Avsar, Yasar, et al. "Rehabilitation of Wastewater Treatment Plant of Sakhnin City in Israel by

Using Advanced Technologies." *EC*. European Commission, n.d. Web. 11 March 2013.

Banin, Amos. "Geochemistry of Wastewater Recharge: Managing Heavy Metals Sorption and Controlling Soil Degradation Processes in Recharge Basins of the Shafdan Wastewater Reclamation Plant." Hebrew University of Jerusalem Agriculture Department, 5 Feb 2009. Web. 11 March 2013.

Barnea, Nahum. "US Envoy Slams Israel Over 'Illegal Importation of Pistachio from Iran." *YNETNews*. YNET News, 15 June. 2008. Web. 20 May 2013.

Ben-David, Amir. "Israel's Water Crisis is Over." *YNetNews*. YNet News, 2 Apr. 2013. Web. 5 June 2013.

Bensinger, Ethan. "Aqueducts and Tunnels: Wonders of Roman Technology That Brought Water to the People." *SightSeeingInIsrael*. Sight Seeing in Israel, 30 Jan. 2008. Web. 4 Feb 2013.

Bernard, John. "Tobacco That Heals." *MFA*. Israel Ministry of Foreign Affairs, 17 Oct. 2010. Web. 21 May 2013.

Blanford, Nicholas. "Water War Reignites Between Israel and Lebanon Over Hasbani-Analysis." *DailyStar*. The Daily Star, 10 Jul. 2012. Web. 2 Dec. 2012.

"British Mandate: A Survey of Palestine, prepared by the British Mandate for UN prior to proposing the 1947 partition plan." *PalestinianRemembered*. Palestinian Remembered, 10 May 2002. Web. 3 Dec. 2012.

Bruce, Deborah L., et al. "Delineation of the coastal aquifer of Israel based on repetitive analysis of 14C and tritium." *Journal of Hydrology.* September 15, 2007. Web. 17 March 2013.

Brunke, Henrich and Hayley Boriss. "Carrot Profile." *AGMRC*. Agricultural Marketing Research Center, Jun. 2011. Web. 20 May 2013.

"Byzantine Rule (313-636)." *JewishVirtualLibrary*. The American-Israeli Cooperative Enterprise, n.d. Web. 17 Mar. 2013.

"Canaan." *NewWorldEncyclopedia*. New World Encyclopedia, n.d. Web. 16 Feb. 2013.

"Case of the Readaptation of the Mavrommatis Jerusalem Concessions." *WorldCourt*. A.W. Sijthoff's Publishing Company, 10 Oct. 1927. Web. 19 Mar. 2013.

"Climate and Seasons in Israel." *Science*. Israel Science and Technology Directory, 2013. Web. 3 June 2013.

"Cloud Seeding Frequently Asked Questions." *NAWCInc*. North American Weather Consultants, n.d. Web. 4 June 2013.

"Cloud Seeding Not Effective at Porducing Rain as Once Though, New Research Shows." *ScienceDaily*. Science Daily, 1 Nov. 2010. Web. 4 June 2013.

"Cotton in Israel 2010/11 towards a brighter 2011/12." *Cotton*. The Israel Cotton Board, n.d. Web. 15 May 2013.

Davis, Diana K. Edmund Burke. "Environemental Imaginaries of the Middle East and North Africa." *GoogleBooks*. Ohio University Press, 20 Dec. 2012. Web. 3 Dec. 2012.

"Desalination by Reverse Osmosis." *OAS*. Organization of American States, n.d. Web. 12 March 2013.

De Vaux, Roland. *Ancient Israel: Its Life and Institutions*. Grand Rapids: Wm. B. Eerdmans Publishing, 1997. Web. 16 Feb. 2013.

Dinar, Shlomi. *International Water Treaties: Negotiation and Cooperation Along Transboundary Rivers*. New York: Routledge, 2008. Web. 11 Mar. 2013.

Distel, Oded. "Innovative Wastewater Treatment and Recycling Solutions are Flowing From Israel." *WaterOnline*. Water Online, 21 Oct. 2008. Web. 12 March 2013.

Dreizin, Yosef. "Ashkelon Seawater Desalination Project — Off-Taker's Self Costs, Supplied Water Costs, Total Costs and Benefits." *Water*. Israel Water Authority, 9 Feb. 2005. Web. 27 Dec. 2012.

"Economy: Sectors of the Israeli Economy." *MFA*. Israel Ministry of Foreign Affairs, n.d. Web. 8 June 2013.

Eisen, Sara. "Business is Blooming for Israeli Flowers." *Israel21c*. Israel 21c, 22 Feb. 2006. Web. 21 May 2013.

Elmusa, Sharif S. "Toward a Unified Management Regime in the Jordan Basin: The Johnston Plan Revisted." *Yale*. *Yale Forestry & Environmental Studies Bulletin*, 1998. Web. 25 Nov. 2012.

Emmons, Robert D. *Turfgrass Science and Management*. Clifton Park: Delmar Cengage Learning, 1995. Web. 15 May 2013.

"Facts About the Dairy Industry in Israel." *IsraelDairy*. Israeli Dairy Board, n.d. Web. 19 May 2013.

"Facts and Figures on Agritech 2009." *Kenes*. Kenes Group, 2012. Web. 27 Dec. 2012.

Fedler, Jon. "Focus on Israel: Israel's Agriculture in the 21st Century." *MFA*. Israel Ministry of Foreign Affairs, 24 Dec. 2002. Web. 2 Jan. 2013.

Fisher, Franklin M. & Annette Huber-Lee. "Economics, Water Management, and Conflict Resolution in the Middle East and Beyond." Environment: Science and Policy for Sustainable Development 48.3 (2006): 26-41. Web. 22 Jul. 2013.

Galil, Noah I., and Chaim Sheindorf. "Biological Treatment of Industrial Wastewater by a Membrane Bioreactor. *Technion*. Technion, 19 April 2005. Web. 11 March 2013.

"Geography of Israel." *BJE*. NSW Board of Jewish Education, n.d. Web. 3 June 2013.

Geva, Hillel. “Jericho- The Winter Palace of King Herod.” *JewishVirtualLibrary*. The American-Israeli Cooperative Enterprise, n.d. Web. 17 Mar. 2013.

Geva, Hillel. “Jerusalem-Water Systems of Biblical Times.” *JewishVirtualLibrary*. The American-Israeli Cooperative Enterprise, n.d. Web. 23 Nov. 2012

Gill, N.S. "Pharaoh Thutmose III and the Battle of Megiddo." *About*. About, n.d. Web. 15 Feb. 2013.

Gillon, D. Z. “The Antecedents of the Balfour Declaration.” *Middle Eastern Studies* 5.2 (1969): 131-150. *JSTOR*. Web. 14 April 2012.

Glazer, Phyllis. "Almonds on my Mind." *JPost*. The Jerusalem Post, 21 Jan. 2012. Web. 20 May 2013.

"Globe Artichoke." *NWREC*. Oregon State University North Willamette Research & Extension Center, 23 Dec. 2002. Web. 20 May 2013.

Grossman, Lior. “A Computerized Simulation of the Process that Led to the Beginning of Agriculture in the Levant.” *Antiquities*. Israel Antiquities Authority, n.d. Web. 28 Dec. 2012.

Guinn, Jim. "U.S. Rice Export Update: The volume of U.S. rice exports set a new record in 2010." *RiceFarming*. One Grower Publishing, n.d. Web. 19 May 2013.

Haddadin, Munther J. *Diplomacy on the Jordan: International Conflict and Negotiated Resolution.* Norwell: Kluwer Academic Publisher, 2002. Web. 24 Nov. 2012.

Haddadin, Munther J. “The Jordan River Basin: Water Conflict and Negotiated Resolution.” *UNESCO*. United Nations Educational, Scientific, and Cultural Organization, n.d. Web. 24 Nov. 2012.

"Hadera Desalination Plant, Israel." TheGreenage. The Greenage, n.d. Web. 18 Jul. 2013.

"Hashemite Kingdom of Jordan." *GIZ*. GIZ, n.d. Web. 4 Dec. 2012.

"Hazor." *Bibarch*. Biblical Archeology, n.d. Web. 23 Nov. 2012.

"Hazor." *JewishVirtualLibrary*. The American-Israeli Cooperative Enterprise, 2008. Web. 17 Feb. 2013.

Hirst, Kris. "Megiddo." *About*. About, n.d. Web. 15 Feb. 2013.

"Historical Background 70 CE-1917." *IJS*. Israel & Judaism Studies, n.d. Web. 17 Mar. 2013.

"Historical Review of the Political Riparian Issues in the Development of the Jordan River and Basin Management." *UNU*. United Nations University, n.d. Web. 25 Nov. 2012.

"History of the Ancient Middle East." *Essential-Humanities*. Essential Humanities, n.d. Web. 20 Nov. 2012.

"History: Second Temple Period- Return to Zion." *MFA*. Israel Ministry of Foreign Affairs, n.d. Web. 12 June 2013.

Hoekstra, Arjen. "Virtual Water Trade: Proceedings of the International Expert Meeting on Virtual Water Trade." *WaterFootprint*. Water Footprint, Feb 2003. Web. 2 June 2013.

Hoekstra, Arjen Y. and Ashok Chapagain. "Water Footprints of Nations: Water Use by People as a Function of Their Consumption Pattern." *Water Resources Management* 21.1 (2007): 35-48. Web. 2 June 2013.

Isaac, Jad and Leonardo Hosh. "Roots of the Water Conflict in the Middle East." *MACAM*. University of Waterloo Canada, 7 May 1992. Web. 1 Dec 2012.

"Israel Briefing Book: Israel Overview—Water." *JewishVirtualLibrary.* The American-Israeli Cooperative Enterprise, n.d. Web. 27 Dec. 2012.

"Israel Cotton Production by Year." *IndexMundi*. Index Mundi, 2012. Web. 15 May 2013.

"Israel-Jordan Peace Treaty." *MFA.* Israel Ministry of Foreign Affairs, 26 Oct. 1994. Web. 3 Dec 2012.

"Israel Leading the Way in Wastewater Treatment Techniques." *ISRAEL21c*. Israel21c, 24 Dec. 2006. Web. 11 March 2013.

"Israel Overview—Water." *JewishVirtualLibrary.* The American-Israeli Cooperative Enterprise, n.d. Web. 12 March 2013.

"Israel: Rice, Milled, Area Harvested (Hectare)." *FactFish*. Fact Fish, n.d. Web. 19 May 2013.

"Israeli Juice Exports to Russia Down in February." *Fruit-Inform*. Fruit-Inform, 10 Apr. 2013. Web. 20 May 2013.

"Israeli Leaders Condemn EU Ban on Settlement Funding." *FoxNews*. Fox News, 16 Jul. 2013. Web. 24 Jul. 2013.

"Israeli Response to Arab League Plan to Divert Jordan." *JewishVirtualLibrary*. The American-Israeli Cooperative Enterprise, 21 Jan. 1964. Web. 3 Dec. 2012.

"Israeli Team Produces Anti-Malaria Drug From Tobacco Plants." *WallStreetDaily*. Wall Street Daily, 18 Jan. 2012. Web. 21 May 2013.

"Israel's Brackish Water Challenge*." Global Water Intelligence* 9.7 (2008): n.p. Web. 3 Apr. 2013.

"Israel's Chronic Water Problem." *JewishVirtualLibrary.* The American-Israeli Cooperative Enterprise, n.d. Web. 12 March 2013.

"Israel's Water Supply System." *Merkorot.* Israel National Water Co, n.d. Web. 28 Dec. 2012.

Izhak, Hila. "Israel is a World Leader in Recycling Treated Wastewater." *Mekorot*. Mekorot Israeli National Water Co., n.d. Web. 11 March 2013.

"Jojoba." *NRIA*. New Rural Industries Australia, n.d. Web. 21 May 2013.

Kantor, Shmuel. “The National Water Carrier.” *Haifa*. University of Haifa, n.d. Web. 3 Dec. 2012.

Kliot, Nurit. *Water Resources and Conflict in the Middle East*. Psychology Press, 1994: 154, 234. *GoogleBooks*. Web. 24 Nov. 2012.

Kloosterman, Karin. "Top 10 ways Israel Fights Desertification." *Israel21c*. Israel 21c, 15 Jul. 2012. Web. 21 May 2013.

“Korazim.” *GoIsrael*. Go Israel, n.d. Web. 23 Nov. 2012.

Lamon, Robert S. "The Megiddo Water System." *UChicago*. University of Chicago Oriental Institute, 9 Mar. 2011. Web. 15 Feb. 2013

Langfur, Stephen. “Masada.” *NETours*. Near East Tourist Agency, n.d. Web. 23 Nov. 2012.

Laster, Richard, Livney, Dan, and Blanpain, Roger. *Environmental Law in Israel*. Fredrick: Aspen Publishers, 2011. Web. 7 Jan. 2013.

Lev, Yakov. "Israeli Experience in Water Saving in the Municipal Sector." Water. Israel Water Authority, n.d. Web. 23 Jul. 2013.

Lonergan, Stephen C. and Brooks, David B. *WATERSHED: The Role of Fresh Water in the Israeli-Palestinian Conflict*. Ottawa: International Development Research Center, 1995. Web. 16 March 2013.

Lorenzi, Rossella. “Ancient Hellenistic Harbor Found in Israel.” *Discovery*. Discovery News, 17 Jul. 2012. Web. 17 Mar. 2013.

"Low Energy Consumption in the Ashkelon Seawater Desalination Plant." SolutionsforWater. Solutions for Water, n.d. Web. 18 Jul. 2013.

Mandell, Meredith. "Water From the Sea: The Risks and Rewards of Israel's Huge Bet on Desalination." *IBTimes*. International Business Times, 14 Jul. 2012. Web. 10 June 2013.

"Map of Ancient Israel (Canaan) after conquest by 12 Tribes." Zionism and Israel Information Center. Web. 17 March 2013.

"Maps of Israel Showing Distances From Borders and Comparative Size - the Security Problem." *ZionismOnTheWeb*. Zionism On The Web, n.d. Web. 23 May 2013.

"Mid East Maps-Canaan and the Israelite Kingdom." *MidEastWeb*. Mid East Web Gateway. Web. 17 March 2013.

Murakami, Masahiro. "Managing Water for Peace in the Middle East: Alternative Strategies." *UNU*. The United Nations University, 1995. Web. 4 Dec. 2012.

Netanyahu, Sinaia. "Israel: Water Pricing and Command and Control for Water Demand Management in Cities and Agriculture." *UN*. United Nations, 2011. Web. 7 Jan. 2013.

"OECD Review of Agricultural Policies: Israel." *OECD*. The Organization for Economic Co-operation and Development, 2010. Web. 2 Jan. 2013.

Oron, Gideon, et al. "Improved Saline-Water Use Under Subsurface Drip Irrigation." *Agriculture Water Management* 39 (1999): 19-33. Web. 12 March 2013.

Palti, Michal. "Israel Faces Worst Butter Shortage in Country's History." *Haaretz*. Haaretz, 17 Nov. 2010. Web. 19 May 2013.

Pan, Hai, Roni Avissar, and Dale Haidvogel. "Summer Circulation and Temperature of Lake Kinneret." *AMetSoc*. American Meteorological Society, Jan. 2002. Web. 3 June 2013.

Peled, Anat. "Sugar in the Kingdom of Jerusalem – A Crusader Industry between East and West." Israel Antiquieties Authority, n.d. Web. 15 Feb. 2013.

Phillips, David J.H. et al. "The Jordan River Basin: 1. Clarification of the Allocations in the Johnston Plan." *Water International* 32.1 (2007): 16-38. Web. 24 Nov. 2012.

Pundak, Ron. "Decoding Bibi's West Bank Agenda." *Haaretz*. Haaretz, 1 Aug. 2012.

Web. 27 May 2013.

Rabinovitch, Ari. “Desalination Plant Could Make Israel Water Exporter.” *Reuters*. Reuters, 6 Dec. 2011. Web. 11 March 2013.

"Raising the Dead Water and Peace." *Journal of International Affairs* 59.1 (2005): 240-243. Web. 27 May 2013.

Rejwan, Ariel. "The State of Israel: National Water Efficiency Report." *Water*. Planning Department of the Israeli Water Authority, April 2011. Web. 27 Dec. 2012.

“Reuse of Wastewater for Agriculture.” *IWMI*. International Water Management Institute, n.d. Web. 11 March 2013.

"Rice." *JewishVirtualLibrary*. The American-Israeli Cooperative Enterprise, 2008. Web. 19 May. 2013.

Sanders, Edmund. "Israel Plows New Ground in Exotic Crops." *LATimes*. Los Angeles Times, 29 May 2010. Web. 12 June 2013.

Scarborough, Megan. "Water and Peace: LBJ School Professor Advances Diplomacy in the Middle East Through Environmental Policy." *UTexas*. University of Texas LBJ School of Public Affairs, n.d. Web. 4 June 2013.

Schar, Douglas. "Pistachio." *DoctorSchar*. Doctor Schar, n.d. Web. 20 May 2013.

Schar, Douglas. "Walnut." *DoctorSchar*. Doctor Schar, n.d. Web. 20 May 2013.

"Sea of Galilee." *NewWorldEncyclopedia*. New World Encyclopedia, 2 Apr. 2008. Web. 3 June 2013.

Shachar, Gilad. "Israel: Citrus Annual Report.” *USDA*. USDA Foreign Agricultural Service, 22 Dec. 2011. Web. 20 May 2013.

Shachar, Gilad. "Israel: Grain and Feed Annual Report." *USDA*. USDA Foreign Agricultural Service, 22 Mar. 2011. Web. 19 May 2013.

Shamah, David. “Thousands Flock to Israel’s ‘Woodstock of Agricultural Technology.” *TimesofIsrael*. Times of Israel, 17 May 2012. Web. 2 Jan. 2013.

Shurtleff, William and Akiko Aoyagi. *History of Soybeans and Soyfood in the Middle East (1909-2007): Extensively Annotated Bibliography and Sourcebook*. Lafayette: Soyinfo Center, 2008. Web. 20 May 2013.

Silverman, Jacob and Robert Lamb. "Can China Control the Weather?" *HowStuffWorks*. How Stuff Works, n.d. Web. 4 June 2013.

Sitton, Dov. “Development of Limited Water Resources: Historical and Technological Aspects.” *MFA*. Israel Ministry of Foreign Affairs, October 2000. Web. 11 March 2013.

Slepner, Olga. "Israel Water Authority- Towards WWF VI." *Water*. State of Israel Water Authority, n.d. Web. 5 June 2013.

"Soils of Israel.” *Arizona*. University of Arizona Office of Arid Land Studies, 15 Nov. 2001. Web. 2 Jan. 2013.

“Sorek Desalination Plant, Israel.” *Water-Technology*. Water-Technology, n.d. Web. 18 July 2013.

Sosland, Jeffrey. *Cooperating Rivals: The Riparian Politics of the Jordan River Basin.* New York: SUNY Press, 2007. Web. 19 Mar. 2013.

Stark, Alex. “Water wars? The Role of Hegemony in the Jordan River, Nile River, and Columbia River Basins.” *e-IR*. e-International Relations, 25 Feb. 2011. Web. 2 Dec. 2012.

Starr, Joyce Shira. *Covenant Over Middle Eastern Waters: Key to World Survival*. New York: H Holt, 1995. Book.

Stewart, Robert C. “The History of Ancient Israel.” *Evolutionary-Metaphysics*. The Academy of Evolutionary Metaphysics, 2005. Web. 17 Mar. 2013.

Tal, Alon. “Seeking Sustainability: Israel’s Evolving Water Management Strategy.” *Science, New Series* 313.5790 (2006): 1081-1084. Web. 11 March 2013.

“TED Case Studies: Dead Sea Canal.” *American*. American University, n.d. Web. 15 Nov. 2012.

Tenne, Abraham. “Sea Water Desalination in Israel: Planning, Coping With Difficulties, and Economic Aspects of Long-Term Risks.” *Water.* Israeli Water Authority, Oct. 2010. Web. 11 March 2013.

“Text: 1993 Declaration of Principles.” *BBC*. British Broadcasting Corporation, 29 Nov. 2001. Web. 3 Dec. 2012.

“The 1967 War.” *ADL*. Anti-Defamation League, 1999. Web. 3 Dec. 2012.

“The Destruction of the First Holy Temple” *Chabad*. Chabad, n.d. Web. 20 Nov. 2012.

“The Lowdermilk Plan: An old dream and a new reality.” *Eos, Transactions American Geophysical Union* 58.10 (1977): 953-953. Web. 19 Feb. 2013.

“The Mandate.” *JewishVirtualLibrary*. The American-Israeli Cooperative Enterprise, n.d. Web. 24 Nov. 2012

“The Muslim Period.” *American*. American University, n.d. Web. 17 Mar. 2013.

“The Story of Binyamina Winery.” *BinyaminaWines*. Binyamina Wines, n.d. Web. 4 Jan. 2013.

“The War for Independence.” *ADL*. Anti-Defamation League, 1999. Web. 25 Nov. 2012.

“Water Legislation.” *Emwis-il*. Semide/Emwis. Web. 3 Nov. 2012.

Trueman, Chris. “Saladin.” *HistoryLearningSite*. History Learning Site, n.d. Web. 19 Mar. 2013.

Tuten, Eric Engel. “Between Capital and Land: The Jewish National Fund’s finances and land-purchase priorities in Palestine, 1939-1945.” *GoogleBooks*. RouteledgeCurzon, 2005.

Web. 24 Nov. 2012.

Vidal, John. “Israeli Water for Arms Deal with Turkey.” *Guardian*. The Guardian, 6 Jan. 2004. Web. 11 March 2013.

Wallace, J.S. "Increasing Agricultural Water Use Efficiency to Meet Future Food Production." *Agriculture, Ecosystems and Environment* 82 (2000): 105–119. Web. 2 June 2013.

“Water for the Future: The West Bank and Gaza Strip, Israel, and Jordan”. *NAP*. National Academy of Sciences, 1999. Web. 5 June 2013.

“Water Projects.” *JNF*. Jewish National Fund, n.d. Web. 11 March 2013.

“Water Resources of Israel.” *GSI*. Geological Survey of Israel, n.d. Web. 21 Nov. 2012.

“Wastewater Treatment and Reclamation.” *Mekorot*. Mekorot Israeli National Water Co., n.d. Web. 13 March 2013.

“Wet Winter Ends Israel’s 7 Years of Drought; Half of Water Now Supplied by Desalination.” *WorldTribune*. World News Tribune, 25 March 2012. Web. 13 Aug. 2012.

"Where the Water is." *AIPAC*. The American Israel Public Affairs Committee, n.d. Web. 11 June 2013.

Wolf, Aaron T. and Joshua T. Newton. “The Jordan River-Johnston Negotiations 1953-1955; Yarmuk Mediations 1980s." *ORST*. Oregon State University Institute for Water and Watersheds. Web. 24 Nov. 2012.

"World Production, Supply, and Distribution of Centrifugal Sugar." *USDA*. USDA Foreign Agricultural Service, n.d. Web. 19 May 2013.

Yarmuk Mediations 1980s.” *ORST*. Oregon State University Program in Water Conflict Management and Transformation, n.d. Web. 1 Dec. 2012.

Yearwood, Pauline Dubkin. “In the Desert: Why Israel is a Model for Some of the World’s

Driest Countries.” *AAGBU*. *Chicago Jewish News.* 5 January 2007. Web. 11 March 2013.

Yoffe, Shira, Aaron T. Wolfe, and Mark Giordano. "Conflict and Cooperation Over International Freshwater Resources: Indicators of Basins at Risk." Journal of the American Water Resources Association, 2003. Web. 10 March 2013.

Yoskowitz, Jeffrey. "On Israel's Only Jewish-Run Pig Farm, It's The Swine That Bring Home the Bacon." *Forward*. The Jewish Daily Forward, 24 Apr. 2008. Web. 21 May 2013.

Zaslavsky, Dan. “Definition of Israel’s Water Problems.” BIU, Bar-Ilan Univerisity, 14 June 2000. Web. 13 June 2013.

Zeitoun, Mark and Naho Mirumachi. "Transboundary Water Interaction I: Reconsidering Conflict and Cooperation." *UEA*. Springer Science+Business Media B.V., 7 Aug. 2008.

“Zippori - ‘The Ornament of All Galilee.’” *MFA*. Israel Ministry of Foreign Affairs, 29 July 1988. Web. 23 Nov. 2012.