

The Need for International Cooperation between Israel and Other Middle East Nations to Protect the Jordan River Landscape

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Abstract

The Jordan River, also referred to as *Nahr Al Sharieat* in Arabic, is a long river in the Middle East that flows from north to south through the Sea of Galilee to the Dead Sea. The Jordan River is bordered by the Golan Heights and the Hashemite Kingdom of Jordan in the east and by Israel and the Palestinian West Bank (Judea and Samaria) in the west. Soil tunnels, including those in the Jordan River watershed and on the Israel, Syria, and Lebanon borders, have a long history of use for warfare, as invasion pathways, smuggling, and storage of rockets, missiles and ordnance and are causes of serious political tension between the countries. Soil tunnel construction and destruction often has adverse environmental and human health impacts in the Jordan River landscape. Due to agricultural wastes, the discharge of untreated sewage, and diversion of saline springs into the river water there has been serious deterioration in the water quality in the lower courses of the Jordan River. The primary objective of this research is to encourage the development of a multi-country clean-up, mitigation, and protection plan for the Jordan River.

Keywords

Jordan River, Jordan, Israel, Lebanon, Syria, Dead Sea, Sea of Galilee, Six-Day War, Soil Tunnels

1. Introduction

The Jordan River originates in the Anti-Lebanon Mountain Range (**Figure 1**), close to the boundary between Lebanon and Syria. In the upper course, the river receives waters from the Banian River, Hasbani River, Dan River, and the Iyyon Stream. The river then passes through the Hula Valley in the northern part of



Figure 1. Jordan River with buildings. Photo credit: World Atlas.

Israel [1]. The Jordan River cuts a gorge at the southern end of the Hula Valley and then drops down sharply to Lake Tiberias or the northern shores of the Sea of Galilee. From the Lake/Sea, the river again flows southwards and is joined by the Yarmouk River and the Zarqa River. Here, the river confluences with two more tributaries, the Harod and Yabis Rivers. The Jordan River finally empties into the Dead Sea (**Figure 2**).

After the Mediterranean Sea, the Jordan River is the second largest source of water in Israel. Currently, the Jordan River discharges about 20 to 30 million cubic meters of water annually into the Dead Sea. This is much less than the historic discharge of 1300 million cubic meters of water per year [1]. The lower course of the Jordan River from the exact point where it exits the Sea of Galilee to the Dead Sea is referred to as the Jordan Valley. This 105 km long Jordan Valley has the lowest elevation in the world starting at -212 m and ending at -400 m and forms a part of the Jordan Rift Valley (**Figure 3**).

The environmental impact of the creation and bombing of the soil tunnels was never included in the initial military analysis. The military strategy and need to win the war are always the priority and collateral damage to the environment can take decades to document, if ever. The primary objective of this research is to encourage the development of a multi-country clean-up, mitigation, and protection plan for the Jordan River.

2. Natural and Cultural Resources

2.1. Geography

The 360 km Jordan River flows south through Israel to the Sea of Galilee and the Dead Sea (**Figure 4**). The Jordan River length from the headwaters source to the Dead Sea is only 220 km but the meandering river flows 360 km. The Jordan River is bordered by Israel and Palestinian West Bank (or Judea/Samaria) on the east by Jordan and by the Golan Heights. The Jordan River headwaters are on



Figure 2. Jordan River flowing into the Dead Sea. Photo credit: World Atlas.



Figure 3. Rift valley with view of mountains and Jordan River. Photo credit: Encyclopedia Britannica.

the southern slopes of Mount Hermon in the Anti-Lebanon Mountain Range, very close to the Syria and Lebanon border. The Jordan River passes through the Hula Valley in Israel. The river cuts through a gorge and then drops down sharply to the Sea of Galilee [2]. The Jordan River outlets into the Dead Sea and is Israel's second largest source of water.

The Jordan Valley constitutes a rift valley running north and south and a segment of the extensive East African Rift System that extends from southern Turkey, southward via the Red Sea, into eastern Africa. The valley itself averages about 10 km in width but becomes narrower in some places e.g., at each end of the Sea of Galilee. The valley lies much lower than the surrounding landscape, especially in the south, where the surrounding land can rise some 900 m or more above the river. The valley walls are sheer, steep, and bare, and they are broken only by the gorges of tributary wadis.



Figure 4. Map of Mid East including Lebanon, Syria, Israel, and Jordan. Photo credit: Washington Post.

The three principal sources of Jordan River water (**Figure 5**) all rise at the foot of Mount Hermon. The longest of those is the Ḥāṣḥbānī, which rises in Lebanon, near Ḥāṣḥbayyā, at an elevation of 550 meters. The Bāniyās River flows from Syria in the east. Between the two is the Dan River, the waters of which are particularly fresh. Just inside Israel, those three rivers join in the Ḥula Valley. The plain of the Ḥula Valley was formerly occupied by marshes and a lake. In the 1950s, 60 square km were drained for agricultural use. By the 1990s, portions of the area had become flooded and much of the valley's soil had been degraded. The decision was made to retain the lake and surrounding wetlands area as a protected nature reserve. Migratory birds and some native plants and animals returned.

The Jordan has cut a gorge through a basaltic barrier at the southern end of the valley (**Figure 6**). The river then drops sharply down to the northern shore of the Sea of Galilee. The lake level historically was measured at 209 meters

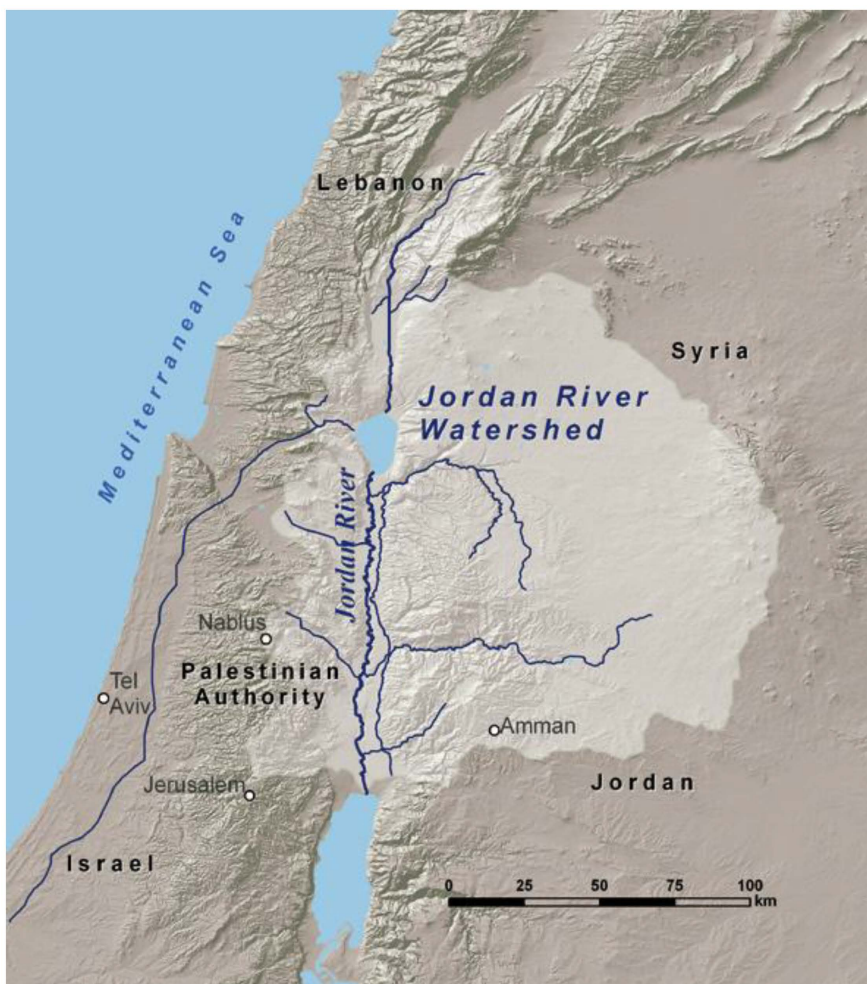


Figure 5. Rivers in Jordan River watershed. Photo credit: World Atlas.

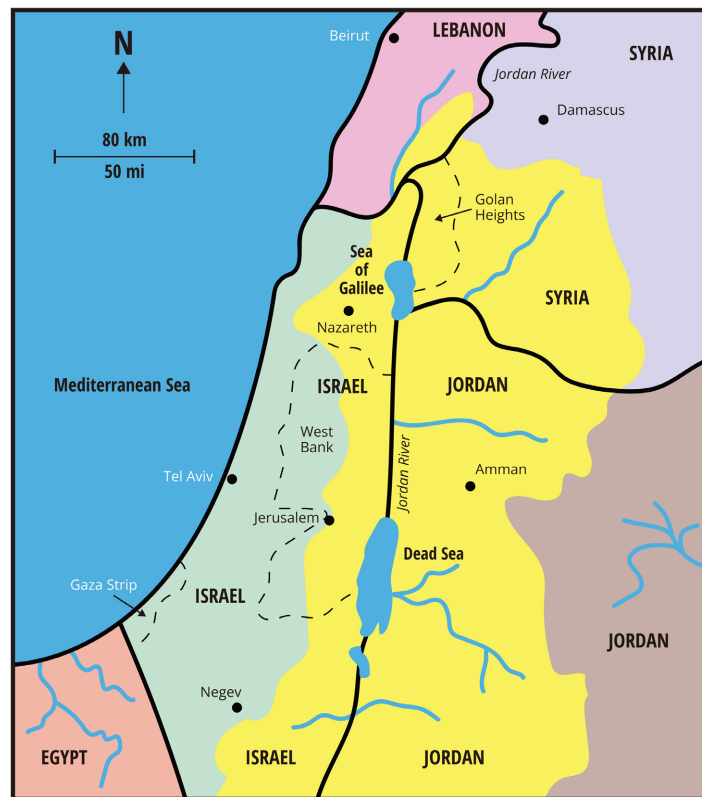


Figure 6. Valley cut by the flowing Jordan River into the Dead Sea. Photo credit: Wikipedia.

below sea level. For the last few decades, the water level averaged some 2 to 4 m lower. The Sea of Galilee nonetheless helps govern the river's rate of flow. South

of the Sea of Galilee, the Jordan receives water from its main tributary, the Yarmūk River, which is the border between Syria and Jordan. It is then joined by two more tributaries, the Yābis on the left bank and the Harrod on the right. The Jordan River's plain then spreads out to a width of about 24 km. The flat arid terraces along the Jordan are known as the Ghawr (Ghor). These terraces were cut by wadis or rivers into rocky towers, badlands, and pinnacles forming a maze of ravines and crests that resemble a lunar landscape.

The valley that the Jordan has cut into the plain is between 15 to 60 m deep and 400 to 3000 m wide. Along this stretch, the Jordan's floodplain is known as the Zūr. The river has so many meanders that the river course runs for 215 km. However, the actual distance between the Dead Sea and the Sea of Galilee is only 105 km. The Zūr, which floods frequently, was formerly covered with thickets of tamarisk, reeds, willows, and white poplars. After dams were built to control the river's flow, the floodplain land was converted to irrigated fields. The Jordan drains into the Dead Sea (Figure 7) through a gently sloping broad delta. Although the bordering plateaus receive relatively abundant rainfall, the Jordan



LEGEND

 Jordan Watershed	 Jordan	 Water
 Israel	 Syria	 River
 Lebanon	 Egypt	 Country Border

Figure 7. Jordan River watershed boundary. The Jordan River watershed is in Israel, Jordan, Lebanon, and Syria. Map by Cruz Dragosavac.

Valley itself receives little rainfall. The Hula Valley yearly rainfall total is about 550 mm a year, whereas only about 75 mm fall north of the Dead Sea. Winters along the river are mild, especially in the south and the summers are torrid.

The Jordan is fed by runoff water falling on the neighboring plateaus. The rainwater then flows into the Jordan through rivers or wadis. The Jordan itself is shallow (**Figure 8**) and the high-water period lasts from January to March. Its low-water period occurs at the end of summer and the beginning of autumn. The Jordan current is relatively swift, and the tributaries transport considerable silt load. The river flow rate diminishes as it flows south because of evaporation losses and infiltration. Inflow from the Yarmūk River historically nearly doubled the Jordan's flow. However, the Yarmūk's contribution was subsequently reduced because of upstream dams. The existence of thermal springs in the Tiberias region on the western side of the Sea of Galilee and concentration of gypsum give the Jordan's waters a relatively high degree of salinity. When the water is used for irrigation, it can leave salt residue on the soil.

2.2. Jordan and Israel Soils

The geology of Israel includes igneous and metamorphic crystalline basement rocks from the Precambrian. These bedrocks are overlain by a lengthy sequence of Pleistocene sedimentary rocks that are overlain with sand dunes, alluvium, and playa deposits [3]. An important part of Israel's [3] and Jordan's soils (**Figure 9**) and (**Figure 10**) formed in limestone or basalt. These soils have a red color (Terra Rossa or Red Mediterranean Soil in old classification systems; Vertisols and Inceptisols orders due to their high clay and oxides contents in the USDA Soil Taxonomy).

After the formation of the Jordan Rift Valley [4] soil genesis indicates that they were influenced by a sequence of climatic changes. Slope, erosion by water, and colluvial activities have played a most significant role in their formation. The presence of deep soils, with high clay content rich in oxides and clay films,



Figure 8. People being baptized on Jordan River. Photo credit: World Atlas.

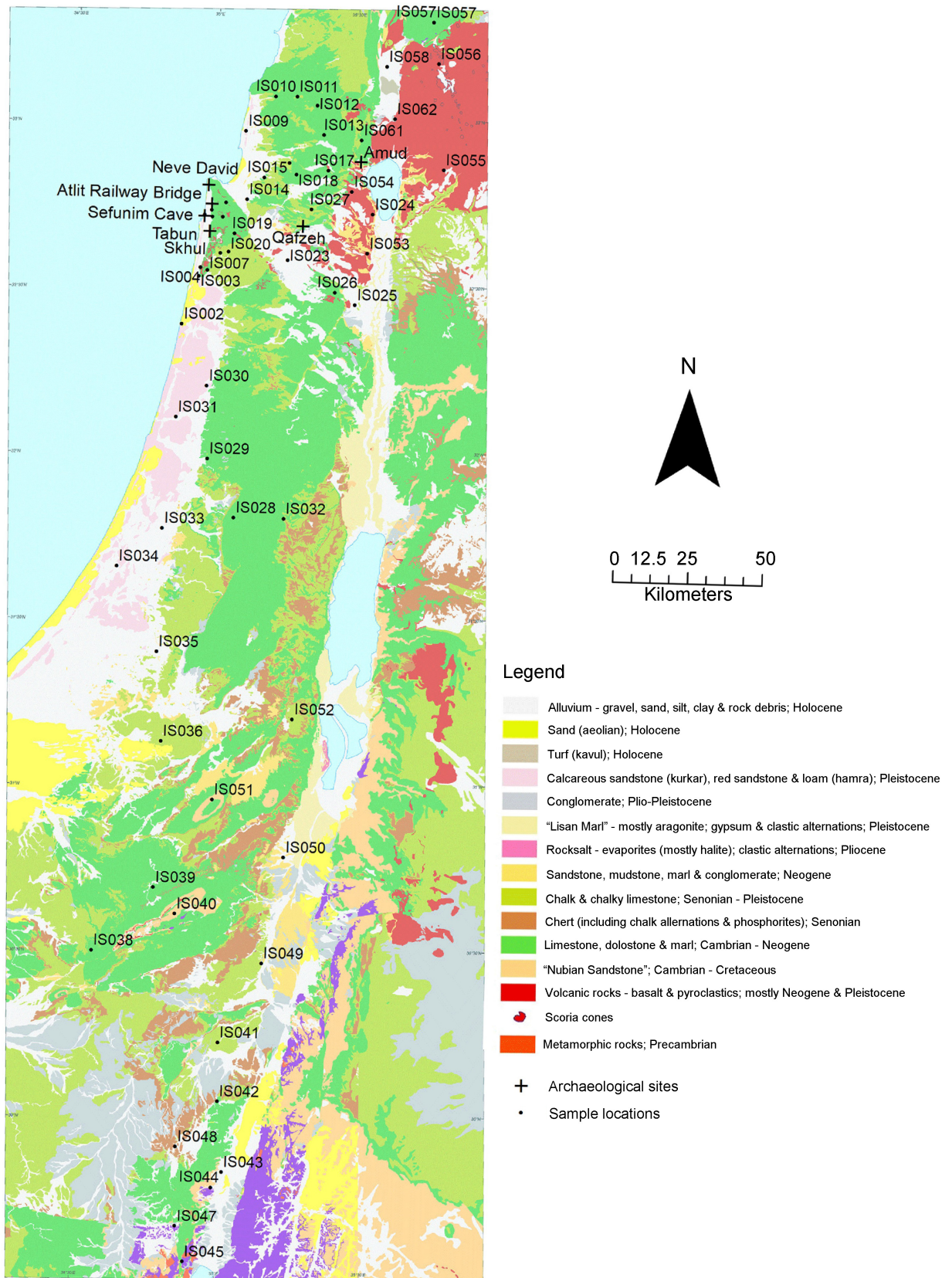


Figure 9. Israel soils (lithological) map. Sampling locations overlain on lithological map. Photo credit: Sneh and Rosensaft, JOSICIS data base.

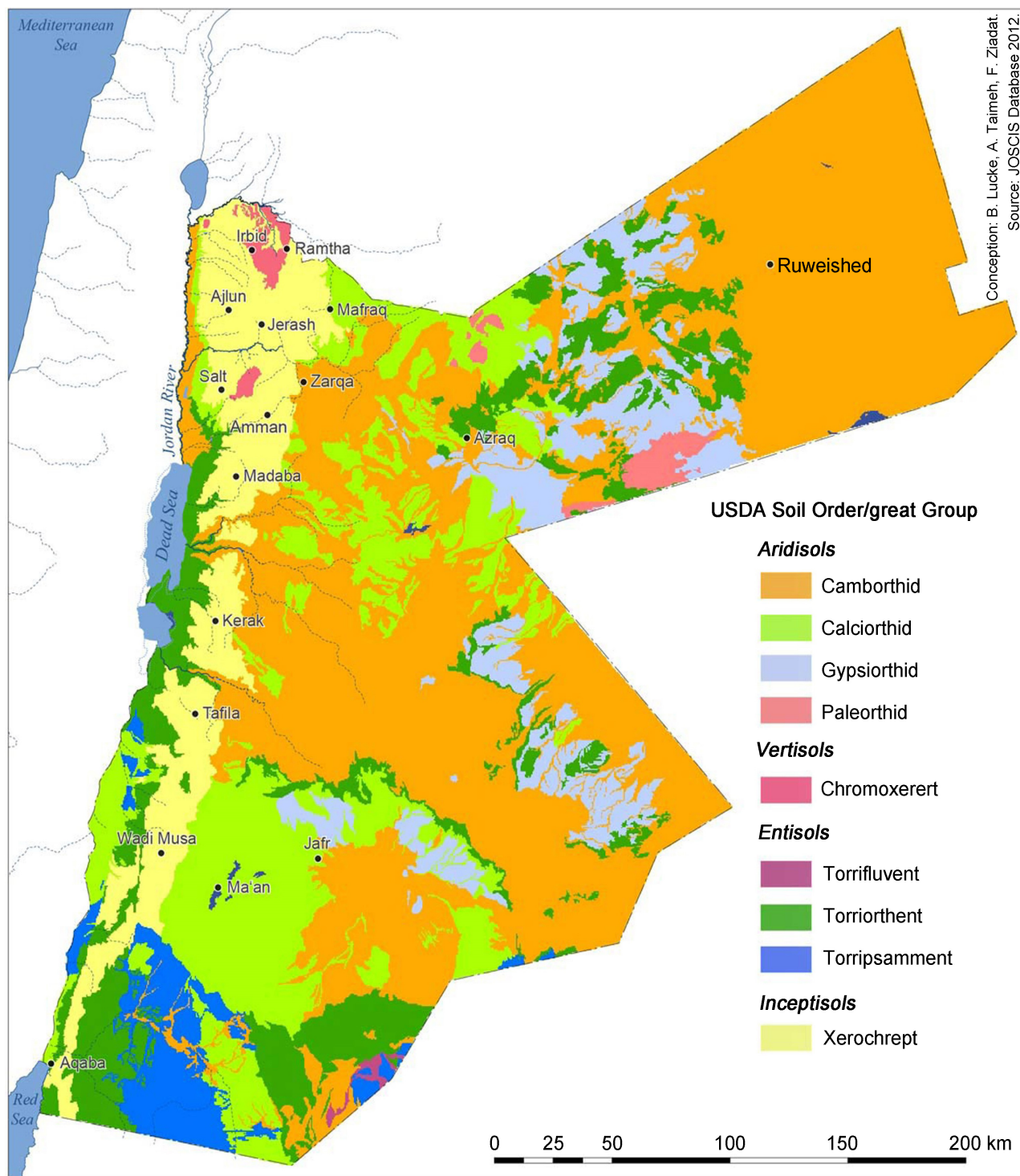


Figure 10. Jordan soil map. Photo credit: Lucke B., Tamel, A. and Ziadat, F.

indicate that the soils were formed in a more humid climate. This soil genesis theory is supported by buried paleosols in the steppe and desert. These areas have an average annual rainfall of less than 30 mm. However, the genesis of Terra Rossa is not completely known. These soils could either have been derived from bedrock, from aerosols, or formed by metasomatic processes [4]. Isovolu-

metric replacement could be confirmed for some Terrae Rosa in north-west Jordan. The genesis of these soils could have taken place during shorter time periods and require less rock dissolution or aerosols than previously thought.

Lucke *et al.* [4] noted “*Soil fertility generally varies from one soil order to another. The most fertile soils are those of the Inceptisols and Vertisols, due to their high clay content and high cation exchange capacity. However, these soils suffer from low organic matter and nitrogen contents, and sometimes iron, zinc, and phosphorus deficiency due to high carbonate content. The Vertisols induce physical stress on plant roots due to cracking which is driven by swelling and shrinking due to moisture variations. Therefore, they are suitable only for field crops, while trees are not recommended. Slopes are often covered by Xerorthents, which are generally shallow soils and recommended for forest plantation. Even if irrigation water is available, Aridisols in the dry regions pose various problems for cultivation that result from high carbonate, gypsum, or salt contents. Entisols are difficult to cultivate as well because they are dominated by sandy, gravelly, stony, or shallow substrate. Although some agricultural studies concluded that the cultivated soils in Jordan were strongly eroded and degraded due to man-made mismanagement in the past, historic erosion-sedimentation cycles in Jordan might in fact relate more strongly to climatic fluctuations. Overall erosion in Transjordan might not have exceeded the geological rate and the country could be in the stable state of completed erosion*” [4].

2.3. Cultural History

Originally, the Jordan River was called the “*Aulon*” by the Greeks. After the Crusades, the river’s Arabic name “*Nahr Al Sharieal*” became more common. The Jordan River is highly revered by Muslims, Christians, and Jews. Christians believe that Jesus Christ was baptized by John the Baptist in the Jordan River according to the New Testament. For Jewish believers, the Torah gives an account of escaping slavery in Egypt across the Sinai and eventually crossing the Jordan River to the “*Promised Land*”.

Throughout the nineteenth century, Europeans thoroughly explored the Jordan River and the Dead Sea. In 1964, a pumping station was built by Israel to diverted Sea of Galilee waters to the National Water Carrier. At the same time, a channel was constructed that diverted water from the Yarmouk River to the East Ghor Canal. In Syria, several reservoirs have been built to hold the waters of the Yarmouk River a main tributary of the Jordan River [2]. The Jordan River has been a cause of serious political tension between the countries of Jordan, Israel, and Syria for assuming control over the waters of the river. In addition, there has been a serious deterioration in the water quality in the lower courses of the Jordan River. The deterioration was mainly due to the discharge of untreated sewage, agricultural wastes, and diversion of saline springs into the river water. The Friend of the Earth Middle East organization in 2007 had listed the Jordan River as one of the most endangered ecological sites in the world. The biggest

problem was the lack of cooperation between Israel and other Middle East nations in protecting the Jordan River [5] [6].

2.4. Environment and Natural Resources

2.4.1. Ecology

Hamidan [7] found “*The Jordan River basin has a unique ichthyofauna as it serves as the meeting point for several different biogeographic regions, including the northern Palearctic, the Afrotropics, East & South Asia, and the Mediterranean. Native fish include cyprinids such as the Jordan bream (Acanthobrama lissneri), Jordan himri (Carasobarbus canis), Jordan barbel (Luciobarbus longiceps), Levantine scraper (Capoeta damascina; the most common native fish in the basin), red garra (Garra rufa), and Damascus garra (Garra nana), hillstream loaches such as the Palestine loach (Oxynoemacheilus insignis), catfish such as the African sharptooth catfish (Clarias gariepinus), cichlids such as the blue tilapia (Oreochromis aureus), redbelly tilapia (Coptodon zillii), and mango tilapia (Sarotherodon galilaeus), and blennies such as the freshwater blenny (Salariopsis fluviatilis). The Jordan bream and Jordan barbel are thought to be endemic to the Jordan River basin. The Jordan basin may have also served as the center of diversification for several now-widespread Palearctic fish groups*” [7]. The earliest Neanderthal residents of the region food source were thought to be a native freshwater reptile, the Balkan terrapin (*Mauremys rivulata*) [8].

2.4.2. Primary Environmental and Natural Resource Issues

The flow rate of the Jordan River once was 1.3 billion cubic meters per year. By 2010, the flow rate into the Dead Sea was just 20 to 30 million cubic meters per year [9]. A small section of the northernmost portion of the Lower Jordan, the first ca. 3-kilometer below the Sea of Galilee, has been kept pristine for baptism (Figure 11) and local tourism (Figure 12). Most polluted is the 100-kilometer downstream stretch from the confluence with the Yarmouk to the Dead Sea [6]. In 2007, FoEME named the Jordan River as one of the world’s 100 most endangered ecological sites. The primary reason for the lack of mitigation and restoration was the lack of cooperation between Israel and neighboring Arab states [10].

Hamidan [7] noted that “*Several introduced species of fish are known from the region, including common carp (Cyprinus carpio), grass carp (Ctenopharyngodon idella), black carp (Hypophthalmichthys molitrix), rainbow trout (Oncorhynchus mykiss), Nile tilapia (Oreochromis niloticus), and sea mullet (Mugil cephalus). Many of these introduced fish either prey on or outcompete native fish and threaten their populations, especially the more endangered species*” [7].

2.4.3. Roads, Border Crossings and Bridges

Route 90 parallels the Jordan River on the western side and connects the northern and southern tips of the Israeli-occupied West Bank [2]. There are two bridge border crossings between Israel and Jordan.



Figure 11. Baptizing in Jordan River. Photo credit: Encyclopedia of Britannica.



Figure 12. Christian women walking to the Jordan River. Photo credit: Wikipedia.

Pletcher and Ha-Yarden [2] identified “*The northern one, Jordan River Crossing or Sheikh Hussein Bridge, is near Beit She’an and the southern one, Allenby Bridge (also King Hussein Bridge), is near Jericho.*

North to south:

- *Daughters of Jacob Bridge (Hebrew: Gesher Bnot Ya’akov, ‘Daughters of Jacob Bridge’) is the most famous one within Israel.*

- *Arik Bridge at the northern end of the Sea of Galilee, allows access to the central Golan Heights, was crucial in the 1967 and 1973 wars.*
- *Al-Sinnabra, at the spot where the river used to exit the Sea of Galilee in the past; few remains excavated by archaeologists.*
- *Jisr el-Majami north of Beit She'an/Beisan; closed.*
- *Damiya or Adam Bridge halfway between Jericho and Beit She'an; closed.*
- *King Abdullah Bridge south of the Allenby Bridge; closed* [2].

2.4.4. Importance as a Water Source

The Jordan River was the largest water resource for Israel until the first decade of the twenty-first century. Now desalinated sea water from the Mediterranean is the primary water source. After 1964, Israel's National Water Carrier canal delivered water from the Sea of Galilee to the Israeli coastal plain until prolonged drought led to abandoning this solution in favor of desalination.

Jordan receives 50,000,000 cubic meters of water from the river, a quantity determined under terms of a treaty with Israel [11]. In the past, one of the main water resources in Jordan was the Jordan River, with a flow of 1.3 billion-m³ per year (BCM/yr). However, after Israel built the National Water Carrier in 1953 and diverted water from Lake Tiberias to Israel's coastal plains and southern desert, the flow of the Lower Jordan River dropped significantly. To compensate for the water loss, Israel provided 50 MCM/yr from Lake Tiberias to Jordan as part of the 1994 peace treaty. A 2010 study found that the Lower Jordan River has been reduced to 2% of its historic flow [12]. With high levels of salinity and pollution from untreated wastewater and agricultural fertilizer upstream in Israel and the West Bank Water quality has also deteriorated sharply [13].

2.4.5. Six-Day War or Arab-Israeli War of 1967

Pletcher and Ha-Yarden [2] noted that "*The Six-Day War was between Israel and the Arab countries of Egypt, Syria, and Jordan. Palestinian guerrilla attacks on Israel from bases in Syria led to increased hostility between the countries. A series of miscalculations by both sides followed. Syria feared that an invasion by Israel was forthcoming and appealed to Egypt for support. Egypt answered by ordering the withdrawal of UN peacekeeping forces from the Sinai and by moving troops into the area. Amid increasingly belligerent language from both sides, Egypt signed a mutual defense treaty with Jordan. Israel, surrounded and fearing an Arab attack was imminent, launched what it felt was a preemptive strike against the three Arab states on June 5, 1967. Israeli forces captured the Sinai Peninsula, Gaza Strip, West Bank of the Jordan River, Old City of Jerusalem, and the Golan Heights. The status of these occupied territories subsequently became a major point of contention between the two sides*" [2].

Conflict over the waters of the Jordan River was a contributing factor to the Six-Day War. Starting in 1965, Syria attempted to divert some of its headwaters, in collaboration with Lebanon and Jordan [14]. The diversion would have reduced the water availability for Israel's carrier by about 35%, and Israel's overall

water supply by about 11% [15].

3. Results

3.1. Use of Earthen Tunnels in Warfare and Smuggling

Olson and Speidel [16] found “*Earthen tunnels have been used to cross under country borders, in military conflicts and to smuggle supplies, people, weapons, and drugs. Tunneling is a battle military tactic that goes back more than 2500 years. Earthen tunnels have been dug between Lebanon and Israel, Syria and Israel, Gaza and Israel, and Egypt and Gaza to permit the movement of soldiers, supplies, weapons, and drugs under the borders. North Korea, Iraq, and Iran used tunnels to hide weapons, including nuclear, and other military equipment and supplies. In the early 2000s, ISIS created many earthen tunnels under Iraqi and Syrian cities for military use. Machinery can be used to drill through bedrock permitting deeper and longer tunnels for troop movement or smuggling. However, when drilling through bedrock under international borders, the process creates both noise and vibrations which were often detected by the enemy. Once discovered, the tunnels were collapsed by blowing up the tunnel, injection of gas, filling with water or wastewater, or inserting barriers*” [16].

3.2. Lebanon’s Land of Tunnels in the Jordan River Watershed

A report released by the Alma Center [17], which researches security challenges to Israel from Lebanon and Syria (**Figure 13**), exposed “*what it described as a large-scale inter-regional Hezbollah tunnel system in different parts of Lebanon. The tunnel system is designed to move personnel and weapons around and out of the sight of the Israel Defense Forces. Some of the tunnels are large enough for pick-up trucks with multi-barrel rocket launchers—like the one used by Hezbollah to fire on Israel last week—to move tens of kilometers underground, according to the report, meaning that the truck can fire on Israel, vanish into a tunnel, and re-emerge tens of kilometers away*” [17]. The network of tunnels connects the Beqaa area, with Hezbollah’s central headquarter and logistical operational rear base (**Figure 14**), to Southern Lebanon, according to the report.

Lappin [17] estimated “*the cumulative length of all the tunnels can reach up to hundreds of kilometers. Like Hamas tunnels, the Lebanese tunnels contain underground command and control rooms, weapons and supply depots, field hospitals and shafts used to fire a wide range of rockets and missiles. The shafts open for a short period of time for the purpose of firing their armament and are then immediately shut closed for the purpose of reloading the hydraulic launcher with new ordinance*”.

“*After the Second Lebanon War of 2006, Hezbollah, with the help of the North Koreans and the Iranians, set up a project forming a network of ‘inter-regional tunnels in Lebanon, a network significantly larger than the ‘Hamas’ metro (Hamas used Iranian and North Korean knowledge to build its tunnels as well). It is not merely a network of offensive and infrastructure local tunnels, in*



Figure 13. Israel borders with soil tunnel locations. Published with copyright permission from the editor of the Open Journal of Soil Science.



Figure 14. A tunnel connecting the Beirut area. Photo credit: Wikipedia.

or near villages, it's a network of tens of kilometers of regional tunnels that extend and connect the Beirut area (Hezbollah's central headquarters) and the Beqaa area (Hezbollah's logistical operational rear base) to southern Lebanon (which is divided into two staging areas named by Hezbollah 'the lines of defense')" [17].

Beeri [18] called this inter-regional tunnel network "Hezbollah's Land of the Tunnels". Various reports indicate that in the late 1980s, and even more so after the Second Lebanon War (2006), North Korean advisors significantly assisted Hezbollah's tunnel project. Beeri [18] found that "Hezbollah, inspired and supported by the Iranians, saw North Korea as a professional authority about tunneling, based on the extensive North Korean experience that had accumulated in building tunnels for military use since the 1950s. Hezbollah's model is the same as the North Korean model: tunnels in which hundreds of combatants, fully equipped, can pass stealthily and rapidly underground. It's two types of tunnels we're talking about: offensive tunnels and infrastructure tunnels. While in Israel, professional officials believed that breaking rocks in the mountainous areas of the Galilee on the Israeli Lebanese border can be very difficult if not impossible, but, the tunnels excavated between the two Koreas (north and south), were excavated in a mountainous terrain, which is considered even more rugged and solid than the terrain in the Galilee region. As it turned out, at least six Hezbollah offensive tunnels built and excavated into Israeli territory for many years, with the inspiration and support of North Korea and Iran, were exposed by the IDF in December 2018 as part of Operation Northern Shield" [18].

3.3. Jordan River Watershed: Syria and Israel Border

Olson and Speidel [16] determined "The Syrian conflict has moved subterranean warfare to the forefront and provided a physical link to these tactics that go back to ancient times. Most of Syria's modern cities are built on layer after layer of ancient structures. The city of Aleppo, for example, is believed to have been continuously inhabited since the Copper Age, around 6000BC, and Damascus was an urban center 2000 years before Julius Caesar. British archaeologists concluded in 2009 that remains of 20 Roman soldiers unearthed in a tunnel beneath the town's ramparts had been killed in a clash with the invading Persians seeking to dig their way into the fortress. Persians, in about 256 AD, may have been an earliest user of chemical warfare—pumping in a poisonous mix of burning sulfur crystals and bitumen that killed the Romans in minutes. In 2019 the Kurds found three major ISIS soil tunnels and cave complexes on the Turkey border with Syria".

"Fighters of the Islamic Front rebel group blasted the large Syrian Army base at Wadi al-Deif in Idlib province in March 2014 from an unexpected quarter [16]. They detonated an estimated 60 mt of explosives stacked at the end of an 850-m tunnel the Syrian's had spent weeks digging. The huge explosion, which killed dozens of Syrian officers and blew an entire hillside hundreds of meters

into the air. While barbaric it did demonstrate a successful use of tunnels as a military tactic” [16].

Across the Middle East, it seems that everyone is going underground again [17]-[21], including Hamas, Hezbollah, and ISIS. Iran has constructed extensive nuclear facilities in underground bunkers and inside mountains to protect them from potential Israeli or US air strikes [17].

Olson and Speidel [16] found *“even the Syrian regime were tunneling. The Jaysh al-Islam coalition released a documentary that revealed a self-contained underground complex constructed in the bowels of Damascus under the Harasta quarter for Syrian President Bashar Assad and his inner circle. It included an intelligence center and chemical decontamination chambers. According to the Pentagon’s Joint Improvised-Threat Defeat Organization, there have been more than 50 major tunnel bombings occurring in Syria and Iraq as insurgent groups resorted to a primitive combat strategy to counter the technological superiority of the state military forces”.*

“Some of the bombings have been pulverizing powerful. The March 4, 2015, tunnel bombing of the Syrian Air Force headquarters in Aleppo was so strong that it was registered as a 2.3-magnitude earthquake by the European-Mediterranean Seismological Center west of the city. There had never been such an intense network of tunnels as there is in Syria. It started in Homs in 2012. Military analysts estimate that the Syrian rebel groups have dug between 500 and 1000 tunnel systems. The environmental impact of the creation and bombing of the soil tunnels is never included in the analysis. It can take decades, if ever, for the impact of the soil tunnels and subsequent bombings to be documented”.

“ISIS has built extensive networks under cities it had conquered to evade round-the-clock air strikes by the United States and its allies and used tunnels to pump oil from captured fields, a key source of funding. Approximately 30 or 40 tunnels were found inside Sinjar, an Iraqi town captured by the jihadists in 2014 and retaken in November 2015 by the Kurdish” [16].

3.4. Jordan River Watershed: Lebanon and Israel Border

Olson and Speidel [16] determined *“The Iranian-backed Hezbollah used a pioneering tunnel system in south Lebanon (Figure 14) during its 34-day war with Israel in 2006. It also prepared for another conflict with its old enemy, Israel, by creating an advanced tunnel network on Israel’s northern border. This reputedly includes assault tunnels far into the Jewish state, just like Hamas’s infiltration tunnels into Israel’s southern desert”.*

“The network, much of which appeared to have been carved out of the rock with pneumatic drills, included prayer rooms, sleeping quarters and electrically powered fans to keep the air circulating through the underground system. It was a city under the city. Israel’s military has been seeking ways to counter this old-new form of warfare, which has redefined the concept of the front line, but has not come up with a foolproof system. These tunnels could be constructed in

an arid climate with a low permanent water table. The parent material is unconsolidated and overlies bedrock which can be excavated with power drills” [16].

Olson and Speidel [16] reported “*Hezbollah built a vast network of advanced tunnels (Figure 13) along the Lebanon border with Israel for use in a future war and using them to conceal tens of thousands of rockets aimed at the Jewish state. The group has built a sprawling underground array of tunnels, bunkers, and surveillance outposts along the border with Israel, which it manned at peak readiness for battle*”.

“The soil tunnels were highly advanced, with durable concrete, a 24-hour power supply via underground generators, a ventilation system to prevent damaging military equipment and a web of secondary escape shafts in case of attack. The tunnels housed tens of thousands of rockets ready for launch and were wrapped individually in protective materials to preserve them”.

“Hezbollah was constantly surveying the Israeli border area with electronic equipment as well as observation posts equipped with night-vision technology. Tunnel construction was said to be continuing around the clock, using primitive means rather than advanced machinery to avoid detection by Israeli surveillance” [16].

Miller [22] found “*Most of the weapons have been transferred to Lebanon through war-torn Syria, coming from Hezbollah’s key allies, the Syrian government and Iran. Tunneling in the rocky terrain of the Lebanon-Israel border is much tougher than in the sandy unconsolidated ground along Gaza’s border. Geologists suggested tunneling in the rocky terrain of southern Lebanon was not as difficult as it appeared. A cross-border tunnel hundreds of meters long can be dug in six months. The arid climate and low water table allowed soil (Aridisols) tunnel construction. These soil tunnels were blocked and/or blown up” [22].*

In May 2021, Israel Defense Forces (IDF) exposed to Hamas’ huge network of tunnels in the Gaza Strip, nicknamed by the IDF the “*Hamas Metro*”. Lappin [17] suggested “*after the Second Lebanon War of 2006, Hezbollah, with the help of the North Koreans and the Iranians, set up a project forming a network of ‘inter-regional’ tunnels in Lebanon, a network significantly larger than the ‘Hamas’ metro (in our assessment, Hamas used Iranian and North Korean knowledge to build its tunnels as well). It is not merely a network of offensive and infrastructure local tunnels, in or near villages, it’s a network of tens of kilometers of regional tunnels that extend and connect the Beirut area (Hezbollah’s central headquarters) and the Beqaa area (Hezbollah’s logistical operational rear base) to southern Lebanon (which is divided into two staging areas named by Hezbollah ‘the lines of defense’). IDF called this inter-regional tunnel network ‘Hezbollah’s Land of the Tunnels’. Various reports indicate that in the late 1980s, and even more so after the Second Lebanon War (2006), North Korean advisors significantly assisted Hezbollah’s tunnel project. Hezbollah, inspired and supported by the Iranians, saw North Korea as a professional authority about tunneling, based on the extensive North Korean experience that had accumulated in build-*

ing tunnels for military use since the 1950s. Hezbollah's model is the same as the North Korean model: tunnels in which hundreds of combatants, fully equipped, can pass stealthily and rapidly underground. It's two types of tunnels we're talking about: offensive tunnels and infrastructure tunnels. While in Israel, professional officials believed that breaking rocks in the mountainous areas of the Galilee on the Israeli Lebanese border can be very difficult if not impossible, but the tunnels excavated between the two Koreas (north and south), were excavated in a mountainous terrain, which is considered even more rugged and solid than the terrain in the Galilee region. As it turned out, at least 6 Hezbollah offensive tunnels built and excavated into Israeli territory for many years, with the inspiration and support of North Korea and Iran, were exposed by the IDF in December 2018 as part of Operation Northern Shield" [17].

Major Tal Beeri [18], head of the research department at Alma and former member of the IDF said " *Hamas didn't invent tunnels. Usually, Hamas is the last in the food chain when it comes to new tools used by the radical axis. The discovery of the tunnel network in Gaza leads to the conclusion that this has been happening in Lebanon for a long time. The Iranians and North Koreans are mentors for both organizations. Hamas are the ones copying here. Hezbollah are usually the pioneers. So, imagine what is happening in Lebanon now*".

Regarding the Lebanese tunneling network project Beeri [18] suggested "*that it began before 2006, but there is no doubt that it gained significant momentum after that year. The tunnel project is the result of close cooperation between North Korea, Iran, which paid for the project and supported it, and Hezbollah. The triangle of cooperation between these three entities goes back to the 1980s. Since 2006, North Korean advisors significantly assisted Hezbollah's tunnel project. Hezbollah, inspired and supported by the Iranians, saw North Korea as a professional authority about tunneling, based on the expansive North Korean experience that has accumulated in building tunnels for military use since the 1950s*" [18].

A report released by the Alma Center [17] stated "*In 2018, the IDF exposed six offensive Hezbollah cross-border tunnels excavated into Israeli territory. Their discovery spelled the end of the concept held by some in Israel that the challenge of breaking rocks in mountainous areas as in Lebanon was a serious barrier to Hezbollah tunnel building. A second type of tunnel network, described as local infrastructure tunnels, is located within and near the Shi'ite villages that act as Hezbollah's staging areas. But the report exposed a new, third type of tunnel, which it called 'inter-regional tunnels of enormous magnitude, spanning at least tens of kilometers' across Lebanon*" [17].

Beeri [18] said "*In 2008, we uncovered an indication from a Christian Lebanese information source, describing a big project by Hezbollah in whole areas of Southern Lebanon, which began east of Sidon*". He then "*described getting access to eyewitness accounts from local residents who were stopped by Hezbollah from entering certain areas. They didn't understand why Hezbollah was*

stopping them. What they could see was what resembled industrial work, sand digging, concrete in the area. But nothing was being built above ground. They saw Iranians and foreign nationals that they later realized were North Koreans”.

Later, Alma obtained a map of Southern Lebanon divided up into polygon shapes, and within them, circles. Beeri [18] said IDF asked “*Could this be some sort of sketch of a route of a military system? A tunnel system?*” IDF connected the eyewitness reports of the digging and the fortification work that could not be seen overground and the map [18]. According to eyewitness reports, the Hezbollah carried out fortification work in those geographical areas using large quantities of construction materials. The work was carried out by a Korean company under the supervision of an Iranian Revolutionary Guard Corps officer. While the actual construction was conducted by Hezbollah’s Jihad Construction Foundation, the report, named a North Korean company, called Korea Mining Development Trading Corporation (KOMID), as the company doing the work.

The Jihad Construction Foundation reportedly received assistance from companies that acted as civilian cover for the construction of the long tunnels. One of the suspected companies, said Beeri, is the “*Beqaa for Construction and Contracting*” company. The company was set up in 2005 under the auspices of Iran’s Islamic Revolutionary Guards Corps. Until 2013, it was headed by Major General Hassan Shateri, a senior IRGC officer who was mysteriously killed in Syria in 2013. It is highly likely that Shateri was responsible for carrying out Hezbollah’s tunneling project in Lebanon according to the Alma report. It sketched out the route of one tunnel, stretching 45 kilometers south of Beirut, east of Sidon, in an area of Southern Lebanon that Hezbollah describes as its “*second line of defense*” against a potential Israeli ground maneuver.

Ultimately, the tunnels enable the secretive movement of Hezbollah’s forces and weapons.

3.5. Jordan River Is a Tourist and Pilgrim Baptism Site

The restoration of the Jordan River is complicated by national and religious histories, water usage by border countries, and climate change. Christians visit sites along the river that have historical significance to the Biblical narrative and faith practices [23].

A stretch of the river, for instance, was a hostile frontier between once-warring Israel and Jordan. River water also separates Jordan on its eastern bank from the Israeli-occupied West Bank, seized by Israel in a 1967 war and sought by the Palestinians for a state. Yana Abu Taleb, the Jordanian director of EcoPeace Middle East [23] said “*It’s a victim of the conflict. It’s a victim of people, because it’s what we did as people to the river, basically, and now adding to all this it’s a victim of climate change,*” which brings together Jordanian, Israeli, and Palestinian lobbies and environmentalists for regional collaboration on saving the river. The river is a victim in every way.

For years, EcoPeace [23] has said “*that the Lower Jordan River, which runs south from the Sea of Galilee, is particularly threatened by decades of water diversions for agriculture and domestic use and by pollution. Only a tiny fraction of its historical water flow now reaches its terminus in the Dead Sea, not far south from the baptismal site. That’s one of the reasons the Dead Sea has been shrinking*”.

The Bible says Jesus was baptized in the Jordan River. The river’s modern-day Jordan, eastern bank, and its western one both house baptismal sites, where rituals of faith unfold, a reflection of the river’s enduring historical, religious, and cultural allure [23]. The river holds further significance as the scene of miracles in the Old Testament. After years of wandering the desert, the ancient Israelites are said to have crossed the Jordan on dry ground after the water was stopped for them to pass.

The West Bank and Jordanian sites both give visitors access to the river, where they come face to face, a narrow stretch of the river water between them [23]. An Israeli flag, at the West Bank’s Qasr al-Yahud, serves as a reminder to those in Jordan that the river is a frontier separating the two countries. That site is also billed as where, according to tradition, Jesus was baptized. Jordan and Israel compete for these people’s tourism dollars.

Fam [23] noted “*On the West Bank, a team from The HALO Trust, a British-American charity, has cleared mines from areas housing churches in the vicinity of the Qasr al-Yahud site as recently as 2020. The site itself had opened for the public years earlier after Israel cleared a narrow road to the river, while the churches area remained off-limits and frozen in time for decade*”. Ronen Shimon [23], who is part of the HALO effort said “*Work began to clear those mines in 2018, but only after three years of building trust and getting onboard all involved, from Israeli and Palestinian authorities to several Christian denominations that own the churches and lands. Nothing is simple here in the West Bank*”.

It’s against that turbulent backdrop that EcoPeace Middle East has been urging regional collaboration on the Jordan between rivals who have long had every motivation to squeeze as much water as possible out of the river or its tributaries. Gidon Bromberg, the group’s Israeli director [23] stated “*There’s legitimate need for the water. ... Water is scarce. But the conflict creates an incentive to take everything. Any fresh water left in the river would have in the past been seen as empowering the enemy. ... You take everything that you can*”.

The result is that the Lower Jordan’s annual discharge into the Dead Sea was estimated at 20 million to 200 million cubic meters per year compared to a historic amount of 1.3 billion cubic meters per year, according to a report published in 2013 by a U.N. commission and a German federal institute. Bromberg puts the current figure at no more than 70 million cubic meters per year. Bromberg [23] said “*The pollution that’s coming into the river is coming from Jordanian, Palestinian, and Israeli sides and a little bit also from Syria. Israel, from a histor-*

ical perspective, has taken about half the water, and Syria and Jordan have taken the other half.

Water use in the Jordan River basin is unevenly developed, the U.N.-German report [23] said, “*adding that the Palestinians can no longer access or use water from the Jordan River itself. Syria doesn’t have access to the river but has built dams in the Yarmouk River sub-basin, which is part of the Jordan River basin*”.

Nada Majdalani, EcoPeace’s Palestinian director [23] said “*For Palestinians in the West Bank, the only way to see the Jordan River is to visit the Israeli-run baptismal site there. The Jordan River in the past, for Palestinians, meant livelihoods and economic stability and growth. It has been reduced to an ambition of statehood and sovereignty over water resources. The river’s decline, she said, is especially disappointing to elderly Palestinians who remember how the river looked ...and how they used to go fishing, how they used to have a dip in the river. EcoPeace has been documenting the ‘lose-lose’ nature of the river’s deterioration for all parties. From a Jewish tradition, you know, the river and its banks are a place of miracles. Well, it doesn’t reflect a place of miracles in its current depleted state*” [23].

In late July of 2022, the Israeli government approved plans to rehabilitate a stretch of the Lower Jordan, a decision described by Environmental Protection Minister Tamar Zandberg as “*historic and the beginning of a correction*”. Zandberg [23] said “*For decades it was neglected and most of its waters were taken, and it effectively turned into a sewage canal. In an era of climate crisis and a serious ecological crisis, there is great significance to rehabilitating the River Jordan and returning it to nature, public, and hikers. The plan focuses on a stretch that runs in Israeli territory and reflects Israel’s improved water situation given its desalination program, which has left it much less reliant on water it has been using from the Sea of Galilee. Now, we’re more equipped to do it. We have water*” [23].

The decision would showcase the river’s potential and pave the way for broader collaboration on the rest of the Lower Jordan as well as send a signal to Jordan that Israel is committed to our mutual assets, including the river. Zandberg [23] said “*It can provide a success story on that segment, and then it will enable more successful partnerships in the future. That’s something that hasn’t always come easily. Politics, sometimes, interferes and budget issues and the trust... between the parties*”.

Abu Taleb, the EcoPeace group’s Jordanian director [23] said “*A regional rehabilitation and development master plan announced in 2015 by EcoPeace and others was adopted by the Jordanian government but not by the Israelis or Palestinians due to outstanding ‘final-status’ peace process issues, according to the group. That plan suggests the lower part of the Jordan River will require at least 400 million cubic meters of freshwater per year to reach ‘an acceptable rehabilitation level’. Creation of a trust fund to finance de-pollution projects—an effort that EcoPeace had viewed as less politically controversial—stalled after a 2017*

diplomatic crisis between Israel and Jordan and amid years of strained ties under the government of former Israeli Prime Minister Benjamin Netanyahu. There have been signs of improved ties. Not everyone in the region welcomes, or trusts, EcoPeace's calls for cooperation. Our job is tough. Our messages are challenged because of having that, you know, Israeli chapter, we're always accused of being 'normalizers', or having normal relations with Israel. That is a contentious topic, unpopular among many ordinary Arabs, citing factors such as Israel's open-ended occupation of lands it captured in 1967 and a lack of a resolution to the Palestinian issue. The water knows no borders" [23].

Bromberg [23] said “*he has run into criticism from a vocal minority in Israel 'inappropriately' branding their work as benefiting Jordanians and Palestinians at the expense of Israeli interests. 'Sadly, there are people who think that if you're working with the other side, you must be working for the other side exclusively'.*”

Politics aside, the strain on some governments to meet water needs complicates calls to add water to the river. Jordan, for instance, is one of the world's most water-scarce nations, and its challenges are compounded by a growing population swelled by waves of refugees. Khalil Al-Absi, an official with the Jordan Valley Authority [23], said “*We are under stress, so we don't have a surplus to add to the Jordan River and to revive it despite the great importance of this to the Jordanians. Solutions require concerted (regional) effort and the international community's help. We have many beautiful ideas for the Jordan River but there are limitations. Climate change threatens to exacerbate such problems. The impact of climate change is seriously influencing the water resources.*”

According to the World Bank, the Middle East and North Africa region faces the greatest expected economic losses from climate-related water scarcity, estimated at 6% to 14% of GDP by 2050. Advocates, like Bromberg, acknowledge that climate change makes a Jordan revival harder—but argue that restoring the river and its banks offers economic incentives. Bromberg [23] said “*The climate crisis brings home the issue of urgency that rehabilitating the river is perhaps the only way to prevent further instability in the valley because it can create alternative revenues through tourism.*” Because of all the river's challenges, Al-Absi [23], the Jordanian official, said “*The alternative could be grim. If there is no water, people won't come despite (the presence) of religious sites. Water is life. Without water, there is no life.*”

4. Conclusions

Soil tunnels, including those in the Jordan River watershed and on the Israel, Syria, and Lebanon borders, have a long history of use for warfare, as invasion pathways, smuggling, and storage of rockets, missiles, ordnance and are a cause of serious political tension between the countries. Invisible roads migrants seeking asylum for safety and economic opportunity and for illegal smuggling of drugs and human trafficking. Soil tunnel construction and destruction often has

adverse environmental and human health impacts in the Jordan River landscape. These underground networks shelter soldiers, store weapons and supplies, are transport corridors, and serve as communication and intelligence conduits. Although peace may be elusive, the history of soil tunnels suggests several defensive approaches that can reduce Israeli vulnerability to illegal infiltration and increase homeland security.

The Jordan River has been a cause of serious political tension between the countries of Jordan, Israel, and Syria for assuming control over the waters of the river. Consequently, there has been a serious deterioration in the Jordan River water quality, especially in the lower courses mainly due to the discharge of agricultural wastes, untreated sewage, and diversion of saline springs into the river water. The primary goal of this research is to encourage the development of a multi-country clean-up, mitigation, and protection plan for the Jordan River.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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