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Rehabilitating Israel's streams and rivers

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ABSTRACT

By the 1960s, the intermittent streams in Israel, emptying either into the Mediterranean or into the Dead Sea in the east, became perennial sewage conduits, with the local aquatic habitat decimated or changed beyond recognition. The natural flow of water that had once offered a seasonal pulse to these ephemeral wadis was typically tapped for agricultural utilization of drinking water. During the past two decades, there appeared initial signs that this ecological misfortune was reversible. In 2003, Israel's water law was finally amended, adding 'nature' to the list of legitimate recipients of fresh water allocations (along with agriculture, industry and household uses). New standards were set for waste-water treatment. Recent advances in the construction of Israel's desalination infrastructure have added substantial quantities of fresh water to Israel's national grid and raise the prospects of a new deal for Israel's streams. Improved regulation by Israel's agencies and upgraded levels of sewage treatment also promised to improve conditions in the contaminated waterways. This article offers an historic retrospective of the progress of Israel's streams made thus far and future restoration challenges.

Keywords: Streams; rehabilitaition; restoration; Israel; rivers

> For your God has brought you into a good land, a land of streams of water, fountains and aquifers that spring out of valleys and hills. (Deuteronomy 8:7)

1 Introduction: a brief history of stream degradation in Israel

A central impulse of Zionist vision at the end of the nineteenth century was the desire of Jews to 'redeem a land' which had for a millennia been neglected by a litany of conquerors who held little regard for the local natural resources (Tal 2008). Water resources were an integral part of the 'Promised Land' that inspired the renewal of Jewish nationalism in the late nineteenth century. The streams of Canaan are mentioned throughout the Bible and provided a backdrop for the pastoral and agricultural communities of the Israelites. Abraham and Isaac spent much of their life in and around the banks of the Gerar Stream (Genesis 20:1). Great battles took place alongside the torrential Kishon which 'swept them (Israel's enemies) away' (Judges 5:21). The formidable barrier that the Yarkon River posed to military forces can be inferred from the Book of Joshua and Samuel and the fortresses that survive along its banks. And of course the River Jordan, while never that 'deep and wide', still demarcated a clear border to the Promised Land that the Israelites needed to cross after 40 years of wandering in the desert and was the site of John's transformational baptism of Jesus. In a land that was fundamentally dry and devoid of vegetation, the Zionist poets and novelists of the period waxed eloquent about the wondrous waters of the land, which at the end of the nineteenth century remained largely intact and unsullied.

But this quickly changed with the advent of intensive development in Israel during the twentieth century. The surface waters of the land reflected *de facto* policies of exploitation, neglect and abuse. Streams were tapped for human activities, rerouted to reduce flood risk and inundated with pollution. The primary drivers behind the significant environmental ruin are described and the extent of the damage is detailed. But the focus of this article is the recent efforts to rehabilitate the beleaguered surface waters of Israel. (Given the magnitude of the damage inflicted and changes to the watersheds, Israel's streams can only be 'rehabilitated' rather than fully 'restored' to their original condition.) This distinction is not widely recognized in Israeli water management nomenclature, but this article will use the term rehabilitate to reflect the fact that significant ecological restoration of natural ecosystems is beyond the scope of currently proposed policies.

The legal, institutional and political frameworks that have emerged over the past 20 years for rehabilitation are described

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along with specific projects and initiatives which signal a shift in public policy and the start of a rejuvenation process in and around Israel's streams. The high expectations among ecological advocates and the general public, however, have not been met and progress, thus, far has been largely limited to symbolic or cosmetic projects with little meaningful improvement in the biological integrity of Israel's streams. As climate change has recently appeared to reduce the annual precipitation levels (Alpert *et al*. 2008), there has been very little water available to maintain in-stream flow at desired levels. Recent advances in Israel's desalination infrastructure add substantial quantities of fresh water to Israel's national grid and, together with improved regulation and upgraded sewage treatment, raise the prospects of a new deal for Israel's streams. The remaining obstacles to rehabilitation will be identified along with suggestions for a more effective national strategy to bring life back to Israel's streams and rivers.

1.1 *Development and degradation*

The waters of Palestine were fundamentally different from the perennial rushing rivers that informed the geographical experience of the European pioneers who answered the call to develop Palestine as a Jewish state. Sixteen primary streams flow into the Mediterranean while another fifteen reach the Jordan River or the Kinneret Lake (Israel Ministry of Environment 2012). At the turn of the twentieth century, the Yarkon River along with the Jordan River and its tributaries were still perennial streams with meaningful year-round flow, albeit seasonal. But they were the exception. Most of Israel's streams naturally are 'intermittent' or 'ephemeral'.[1] Indeed, to call Israeli natural water channels 'rivers' technically constitutes a misnomer. Given their modest size and flow, almost all are more appropriately categorized as 'streams'.

Before the modern period, these local streams contained healthy aquatic ecosystems that were habitats for fish, turtles and even crocodiles. They also provided innumerable 'ecosystem services' including watering holes for terrestrial wildlife and grazing, a source of primitive irrigation, power for the occasional mill and of course myriad cultural services for local communities. Indeed, the contribution of these water bodies to the recreational and spiritual heritage of the region is well known and reflected in their ritualistic roles and the frequency of their appearance in the Scriptures and Koran (Hillel 1996).

In practice, however, the Mediterranean climate and the surface water system it supported were poorly understood and even less appreciated as hydrological assets by Zionist land managers. The paramount economic priority during the first half of the twentieth century was agriculture production and water resources were scarce, often malarial and in need of development. Israel's farm lobby not only enjoyed the support of Israel's government, but also of a nation that glorified the new Jewish farmer as it sought to redefine itself according to a Romantic 'ruralist' ethos (De-Shalit 1995).

Initially, with the help of sundry Zionist development agencies, and to a lesser extent the British Mandate government, the steadily growing Jewish community in Palestine began to create reliable, potable and abundant access to water. To pool the limited communal resources of the incipient Zionist public in Palestine and to create a coordinated strategy, a public water corporation 'Mekorot' was organized for Palestine's Jewish sector (Galnoor 1980). Headed by Levi Skolnick (later Israeli Prime Minister, Levi Eshkol), the company provided engineering services and began to create an integrated water supply system. Mekorot's first major project involved tapping the Kishon Stream to provide irrigation to the local Jewish farms (Blass 1973). Many more such projects would follow. The general orientation was one which focused on water's instrumental value in agricultural development and as an essential resource for Zionist settlement and economic progress. Unexploited water was considered a wasted resource and a sign of inefficiency and poor performance.

The imperative of water resource development and increasing water supply was manifested in Israel's public policies from the country's inception. The country's first Prime Minister David Ben Gurion articulated the view in his 1956 essay 'Southbound'.

> Water and power, these are the two main things lacking in our country, even in the north, and they seem to be completely absent in the south …. There are plentiful resources of water and power which we have not yet exploited because we did not know the secret of their use. But it does not follow that what we did not know yesterday, we shall not know tomorrow. The groundwaters, springs, rivers and brooks of our country are limited and scanty. Even these have not been fully exploited; the water of the Jordan flows down to the Dead Sea, and the Yarkon water falls into the Mediterranean: a considerable proportion of the water of Lake Kinerret evaporates and even the rains, plentiful in the north and minimal in the south, flow wasted, in large measures to the Mediterranean or the Dead Sea, without fully benefiting the thirsty soil. (Ben Gurion 1956)

When Israel finally codified its Water Law in 1959, the orientation was fundamentally anthropocentric, involving economic objectives. For instance, though the law was considered progressive for its time, specifying that water was a public good and that the government had a responsibility to manage it for the public's benefit, section 6 of the law defined those activities for which water could be utilized. These were: (1) household-needs; (2) agriculture; (3) industry; (4) industry, commerce; and (5) public services. Legally at least, nature was not a legitimate user of water. This oversight reflected not so much a cavalier attitude towards Israel's streams as a reflection of values that prioritized economic development with little regard for the carrying capacity or the hydrological integrity of the country's water resources.

2 Developing Israel's water infrastructure

In practice, this perspective translated into an aggressive national strategy of water infrastructure development. In the 1950s, Israel

was still an indigent country, with enormous economic stress associated with maintaining a large military and absorbing a huge influx of refugees that doubled the nation's population in a decade (Sadan 1994). And yet, money was found to begin an ambitious network of water carriers which more than doubled the amount of available water across the country.

The first carrier tapped the headwaters of the Yarkon River at Rosh Ha-Ayin and delivered 100 million cubic metres (mcm) of water each year to the agricultural communities in the arid Negev region. During the British Mandate, Jerusalem's water had come from the same high-quality Rosh Ha-Ayin springs, using boosters to pump the water up the Judean hills. Under the new regime, the capitol's water supply came from other wells within the coastal plain. The Yarkon's rushing Rosh Ha-Ayin waters were now funneled into 66 inch pipes (the largest in use anywhere in the world at the time) for irrigation and drinking water in the south (Orni and Efrat 1973). During the early 1960s, another 45 mcm of water were added to the system. The Yarkon Stream that was left behind was a putrid trickle of raw sewage and effluents.

A far larger carrier project soon began with the goal of collecting and delivering the considerable Jordan River flow to this new water delivery grid. Israel's original plan to utilize the Jordan headwaters at the Daughters of Jacob bridge in the Galilee was scrapped in 1953 when Syria protested vehemently and the issue was brought to the U.N. Security Council (Blass 1973). An alternative plan was formulated that utilized the same waterway downstream as it settled in the Kinneret Lake (Sea of Galilee). The system went on line in 1964 after 8 years of construction. The National Water Carrier pumped the moderately saline water from the Kinneret 151 m above sea level where it was treated in a reservoir and then delivered to the users around the country as far as southern outposts like Mitspeh Ramon. Because the Kinneret is the lowest fresh water lake in the world (roughly 210 m below sea level), pumping the water into the national grid began with a substantial climb. The National Water Carrier required 100 MW of electricity an hour, some 2% of the entire national production at the time (Shoham and Sarig 1995). The level of political commitment to water resource development during this period was evident during the duration of the Carrier's construction as the project cost the government 80% of all water infrastructure allocations (Galnoor 1980).

The new carrier water infrastructure could not have come too soon. Israel did not wait for the injection of such massive quantities of the Kinneret into its water system before expanding its agricultural activities. Beyond the geometric population growth, agricultural activity was rapidly expanding with yields growing close to 400% during this 15-year period. In the early 1960s, the number of citizens working in agriculture peaked at roughly 130,000 (around 25% of the total work force) (Kimhi 2004), more than 10 times the percentage ($>2\%$) of the work force currently in agriculture (CBS 2012). The new irrigation systems required unprecedented amounts of water.

Without a clear idea of the hydrological constraints for the country aquifers, water managers began a policy of overpumping which led to massive salinization of the groundwater, largely from sea water intrusion. Contamination was not immediate and it would take years to reach dangerous salinity levels, but the rising trends were steady. Water was heavily subsidized during Israel's first 40 years, especially to farmers and there were many government officials who opposed pricing water altogether. By the 1950s, Tel Aviv's wells were already too salty to drink (Blass 1973).

Other surface water resources were damaged irreparably during this period. The Huleh wetlands and lake were home to an extraordinary collection of biodiversity that included the greatest concentration of aquatic plants in the entire Near East, 18 species of fish and countless local and migratory bird species (Zigelman and Gershuni 1954). In order to free up more arable agricultural lands, the marsh was completely drained and the ecosystem extirpated. This was the largest of the major 'swamp draining' projects conducted by Zionist land agencies which together erased some 97% of Israel's natural wetlands (Glazman 2006).

Another systemic change that emerged during this period was the cessation of flow from the Kinneret Lake to the River Jordan, which in turn ran into the Dead Sea. In their natural state, the waters of the Jordan tributaries gush down the Galilee hills and the Golan Heights into the Kinneret Lake. When the lake would fill up towards winter's end, the overflow would provide about half of the volume of the lower Jordan which meandered along the Riff Valley to the Dead Sea. This changed during the 1930s when Pinchas Rutenberg, the entrepreneurial founder of electricity plants in Palestine decided to build the 'Degania Dam: at the southern tip of the Kinneret – named after the nearby kibbutz. The objective was to regulate the flow of the river to meet the production needs of a new hydroelectric plant in Naharayim that lay at the confluence of the Jordan and the Yarmuk rivers. The immediate effect of the dam was the raising of the Kinneret water levels from 210 meters below sea level to 208.8' (Mekorot 2012).

Although the power plant was destroyed by Jordanian forces during Israel's 1948 War of Independence, the Degania dam was left in place, to allow for maximal utilization of waters in the lake. As the years went by, the opportunities to release water to the Jordan became fewer and fewer. In fact to maximize water in the National Carrier, the dams were only opened to allow the natural drainage system when there was an imminent threat of flooding – which typically involved reaching the 208.8 m mark is reached. But the past two decades have seen significantly lower levels of rainfall in the Galilee and moderate upstream diversions that have reduced the flow into the Kinneret (Rinat 2012). Accordingly, the dam was last opened, and a meaningful quantity of water released to the lower Jordan, in 1995 (Kalman 2012). In practice, the only waters that consistently reach the lower Jordan River were saline streams (diverted from the lake because of their poor quality), irrigation return flow and effluents.

Not all of the pollution in Israel's stream originates in Israel. There are 15 streams that cross the Palestinian/Israeli border. Twelve of these are major streams that flow year-round in a westward direction towards the Mediterranean Sea, carrying sewage and other pollutants from the Palestinian Authority, or from lands that will probably be outside Israeli jurisdiction. (These include: the Na'aman, Zipori, Kishon, Taninim, Hadera, Alexander, Yarkon, Ayalon, Soreq, Lachish, Besor, and Beer Sheva Streams.) Despite considerable efforts to improve water quality in the Yarkon Stream, progress is undermined by sewage that originates in the Palestinian City of Qalqiliyah, in the upper reaches of the Yarkon watershed where treatment is minimal. Indeed, only 30% of the Palestinian population in the West Bank is connected to a sewage network, with the remainder relying on cesspools. Only 6% of the population enjoys the service of treatment plants (EMWATER Project 2004). Similarly, there are three major streams with easterly flow to the Dead Sea or Jordan River that originate in Israel and cross into the Palestinian Authority (the Harod, the Southern Jordan and the Og Stream) and many more minor ones. At least part of each of these streams can be defined as highly polluted, posing a health hazard to users, endangering flora and fauna and unfit for recreational or consumptive uses.

In sum, during the past 60 plus years, Israel's streams have been dramatically altered. Streams have been denuded, waters polluted, channels straightened, floodplains and wetlands lost and banks eroded. Predictably, the environmental impacts of the country's aggressive water management policies have been substantial.

3 Environmental impacts

Environmental conditions in ephemeral or low-flowing streams tend to be particularly poor. To begin with, the endemic ecosystems are naturally under stress due to the short rainy season and the high-annual losses due to evapotranspiration during the dry summer months (Gasith and Hershkovitz 2010). Much of the biological systems did not survive the 1950s and 1960s when most of Israel's streams were transformed into conduits for municipal sewage or garbage dumps. What little fresh water that was available was tapped for purposes of irrigation (Tal 2002). Moreover, even after domestic sewage treatment improved in Israel, since the effluents discharged into these streams do not get diluted by a cleaner water body, the high concentrations of biological oxygen demand (BOD), nutrients and bacteria frequently have a more direct and severe impact on the ecosystem than in naturally perennial streams. Effluent concentrations produced by municipal waste-water treatment are typically set with the full dilution associated with perennial streams in mind. The flow conditions in ephemeral streams present completely different hydrological and ultimately ecological requirements.

In addition, effluent discharge introduces a continuous input of water into an ecosystem which would otherwise be dry. This shift affects vegetation cover, bank and bed stability, sediment transport and storage. The associated hazards of mosquitoes, odours and of course groundwater contamination can be substantial. The natural vegetation and fauna are often replaced by invasive species that are better adapted to contaminated, wet environments. Opportunistic flora in some areas so thrived on organic loadings, that natural flow became clogged and floods ensued due to impaired drainage during winter rains.

A range of pollutants, including non-point agricultural runoff, urban stormwater and discharge from industrial sites can still be found in most Israeli streams. Conventional wisdom suggests that the predominant component of the pollution profile in Palestinian and Israeli streams involves treated and occasionally untreated municipal wastes (Avnimelech 1999). In fact, the few studies that actually characterize the full profile of stream pollution suggests that nonpoint sources from agriculture and urban runoff are the single greatest source of nutrients and other pollutants to the streams (Tal *et al.* 2010a).

Perhaps of greater concern, Israel's streams historically were repositories for industrial wastes, heavy organic discharges from fish ponds and even trash. The Kishon and the Na'aman are two examples of streams that flow through industrial zones that carried away a broad array of largely untreated toxic residuals from the factories. Today, the beds of Israel's streams still contain chemical residues from this period, including heavy metals and organic chemical compounds leaving a toxic sludge at the river base.

Of course the contamination of Israel's streams does not stop on the surface. From a hydrological perspective, the watersheds that contribute to the streams of Israel overlie the primary aquifers, from which much of the country's drinking water is drawn. The interface between the surface and groundwater is poorly characterized, but unquestionably a factor in the ongoing deterioration in aquifer water quality. For instance, in a recent study of the Besor watershed, it was found that 40% to 90% of the wastewater discharged into the Beer Sheva Stream (8000–11,000 m^3) percolates into ground water during the first 60 km of its flow (Tal *et al.* 2010b).

Finally, and perhaps most importantly, there is also the problem of water quantity or 'natural flow' in the stream. Stream flow is considered by many aquatic ecologists to be a master variable (Poff *et al*. 1997), as its affects not only the size of available habitat, but its temperature, its ability to process nutrients, stream geomorphology and numerous other aspects of ecological functioning. The increased demand for water and Israel's aggressive exploitation of groundwater resources led to overpumping of the available groundwater. This has exacerbated the drying of the headwaters that used to supply streams that have become depleted over time. For example, nature reserves in Israel's northern Galilee region which once enjoyed cool spring flow throughout the year, are frequently 'bone dry' during the summer months.

A recent report by the Society for Preservation of Nature – Israel's largest environmental organization and one which was

founded as a protest to the draining of the Huleh swamps – reported that flow in a full two-thirds of all springs monitored were severely reduced or were actively witnessing a decline (Skutelsky and Pearlmutter 2012). As a result, the stream flow in many water bodies has been reduced to a trickle or ceased completely. Stream flow in the lower portion of the Jordan River – Israel's only true river declined by over 95%, with current flows consisting primarily of agricultural runoff and semi-treated sewage (SPNI 2008). Flow in the Yarkon Stream, which runs through the heart of Tel Aviv, Israel's largest metropolitan area, is less than 2% of historic flows (SPNI 2008). Only the headwaters of the Jordan remained with significant shares of natural flow and functioning natural ecosystems. Several streams that had perennial flow became intermittent streams. Some that had been intermittent or ephemeral ceased to flow altogether. The aquatic ecosystems, already vulnerable due to the high variability of stream flow, were decimated.

Biodiversity trends in Israel remain largely negative in aquatic habitats. There are six indigenous amphibian species in Israel, but none of them enjoy a stable population (Gafny 2002). The green toad is threatened; the tree frog considered vulnerable; two salamander species are endangered, and the Syrian spadefoot toad and the banded newt are defined as 'critically endangered'. Nature lovers rejoiced in November, 2011, when the painted frog, for 50 years thought to be extinct globally as a result of the Huleh drainage miraculously reappeared (Rinat 2011). But their future is not clear, as the wetlands habitat that supported the species has virtually disappeared. The threat to Israel's reptiles is not quite as acute (Bouskila 2002). Nonetheless, one-third of 103 local reptile species are endangered, with 3 on the list of local extinctions. Fish have done worse – almost a quarter of endemic fish are endangered and five are already extinct (Goren 2002).

For some 50 years, the Israeli public was largely indifferent to the massive degradation of the nation's streams. Two events, however, seized national attention and influenced public perceptions about the severity of the stream water quality crisis: The Yarkon gained special notoriety when Australian athletes fell into the water as a result of a bridge collapse during the opening ceremony of a sporting event in 1997 (Tal 2002). Four died from acute poisoning after ingesting polluted water and the toxic sediment. The event was filmed live on national television and remained the top news story for days. The tragedy was discouraging, because Israel had invested enormous energies and funds into rehabilitating the Yarkon Stream that flows through the heart of the greater-Tel Aviv area and it was largely thought to be a success story.

The second event involved a cancer cluster among veterans of the elite 'shayetet' – Israeli seal unit. An expose in the Yedioth Ahranot newspaper alleged that the illness was the result of training dives made years earlier in Haifa Bay at the mouth of the Kishon River, with its toxic cocktail of industrial discharges. Eventually, in 2000, a blue ribbon panel of inquiry was convened by the Department of Defense, but could not conclusively confirm a statistically significant causal relationship between the morbidity and the pollution (Israel Ministry of Defense 2001). (Former Supreme Court Chief Justice, Meir Shemgar, who headed the panel, disagreed with the panel's conclusions and submitted a minority opinion.) Nonetheless, the Ministry of Defense ultimately decided to grant the former divers the benefits of disabled army veterans (Kenon 2003).

In sum, by the 1990s, Israel's streams were polluted and many were desiccated. Nature had long paid the price, but by then people had also died as a result. There was strong support among the Israeli to rehabilitate, if not restore, the country's surface waters.

4 Towards rehabilitation

The combination of increasingly pernicious environmental conditions in Israel's streams, the declining economic and political influence of the agricultural sector in Israel,[2] and increasingly concerned environmental awareness among the public converged to change the government's approach to the matter. In 1993, while serving as Minister of Environment, Yossi Sarid established a Stream Restoration Administration appointing Yoav Sagui as its Chair. Sagui, a lifelong conservation advocate then served as Chairman of the Society for Protection of Nature (Tal 2002). Even before a strategy could be designed to address the considerable scientific and ecological challenges, institutional hurdles were considerable. The number of agencies that needed to coordinate their work was daunting. They included, the Israel Water Commission (now the Water Authority) that is responsible for allocating water to streams; the Israel Nature and Parks Authority that is responsible for monitoring streams and for preserving those that flow within nature reserves; the Jewish National Fund (the 'JNF' – a public company responsible for forestry in Israel and committed to investing in landscaping streams and creating recreational facilities); the Ministry of Agriculture, responsible for Drainage Authorities; Israel's planning agencies working in the Ministry of Interior; and the Ministry of Environment, responsible for keeping pollutants out of the water. And of course little could be accomplished without funding that was controlled by the Ministry of the Treasury. Representatives from all of these institutions along with public interest advocates came together on the Administration steering committee. In retrospect, appointing an NGO leader comfortable in his role as an outside maverick may not have been a particular wise choice for bringing together so many competing agencies.

The new Administration did not succeed in creating a clear national strategy, geographic priorities or clear division of responsibilities. For example, JNF staffers describe the negative reaction of donors who contributed to the construction of a park alongside the Lakhish stream when they came to see about the state of their gift. They found the playground largely unused because it was located alongside a putrid waterway, raising

some consternation. When Sarid was replaced by Rafael Eitan, the Administration lost its political backing and ceased to function effectively.

Statutory authority *per se*, was *not* a meaningful obstacle to stream restoration activities by the Administration and its agencies. As early as 1965, Israel passed the Streams and Springs Authorities Law that empowered the Minister of Interior (now Environment) to create an independent Authority to coordinate the oversight of activities to protect a stream or river. Such authorities are empowered to undertake steps to protect and conserve the stream and its banks as well as abate nuisances and prevent pollution. It took 23 years for the first Authority to be declared in the Yarkon Stream in 1988, with the Kishon Authority (1994) and Besor (2010) following suit. Of equal importance is an amendment passed in 2003 to the Streams and Springs Order that allowed the existing Drainage Authorities (responsible for flood control and drainage under the Drainage and Flood Control Law of 1957) to take responsibility for regulating areas alongside the streams. Soon thereafter, 8 of the 11 Drainage Authorities opted to redefine themselves and expand their mandate to stream management and restoration (Israel Ministry of Environment, Water and Stream Division 2010). Moreover, Israel's Water Law from 1959 was amended in 1971 to offer the Water Commissioner (now director of the Water Authority) almost 'dictatorial powers' to abate environmental hazards and discharges into surface waters. Ultimately, however, laws cannot create the funds and political will that is necessary to upgrade treatment, enforce discharge standards, create environmentally friendly flood control system or provide the recreational resources that will bring the public to the streams. And the Administration had ceased to effectively marshal the potential contributions of the disparate institutional partners into a single effective effort.

The vacuum at the national level was filled by several impressive initiatives by regional agencies that 'thought globally and acted locally'. Numerous drainage basin authorities took their new roles as Stream Authorities seriously and began to coordinate the rehabilitation work. The first was the Yarkon Stream Authority with a 50-million dollar effort over the years, and was soon to be followed in the Kishon, Besor and Lakhish, etc. A critical first step in rehabilitation efforts involves creating a Masterplan that can serve as a blueprint for the myriad activities which need to be part of a restoration programme. Implementation may take decades, yet slowly but surely the plan can become operational.

With plans in various stages of development, the list of restoration initiatives undertaken during this period grew to include Tsipori, Kishon, Taninim, Alexander, Yarkon, Ayalon, Lachish, Besor, Beersheba, Harod streams as well as segments of the southern Jordan River. And yet, the first 20 years of Israeli efforts have been disappointing. None of the streams have shown full revitalization, and swimming and boating is still not encouraged, when not prohibited on most Israeli streams. There are, however, promising signs that this may change.

Today Israel's streams certainly benefit from the steady improvement in Israel's sewage treatment. Since the 1960s, greater Tel Aviv area has enjoyed relatively high levels of treatment, but most of the country's other facilities had only primary treatment. This began to improve due to a massive investment by the Israeli government. In 1995, there were 15 advanced wastewater treatment facilities in Israel. By 2002, the number had jumped to 28. By 2005, 32 plants were fully operational leaving 80% of the total wastewater in Israel being treated at least at a secondary level (Inbar 2006). While much of the wastewater was delivered to farms as recycled effluent, the wastewater that was released into the streams, contained lower organic loadings and pathogens than previously. Between 1990 and 2010, Israel invested nearly $2 billion in wastewater treatment facilities (Israel Ministry of Environment, Water and Stream Division 2010). The investments have produced substantial dividends in terms of environmental quality as measured by several water quality parameters in Israel's major streams. Between 1994 and 2000, levels of organic carbon, total nitrogen, and total phosphorus inputs into major streams all declined by more than 40% (Shapira and Mazor 2001). The improvement was not uniform, however, with some streams continuing to see a decline in water quality.

Ultimately, streams cannot come back to life if they do not have a reliable flow of fresh water. Because water allocation in water-scarce countries is essentially a zero sum game, taking water for stream restoration has traditionally been perceived as taking water away from agriculture. Politically, the aquatic ecosystems could not compete with Israel's farm lobby. But by 2000 agriculture's stature within Israel society had declined. With only 3% of the gross national product (GNP) and an even lower percentage of the country's work force, the farm lobby was no longer as all powerful as it had once been. An urban citizenry living in high-density communities sought recreational outlets and the attraction of the country's streams appeared more compelling. These societal dynamics apparently affected the political calculus. In the year 2000, the cabinet's 'Governmental Decision 18/7/2000' for the first time, specifically approved allocation of 50 mcm of fresh water to nature – essentially an allocation for the restoration of Israel's streams. Over a decade later, authorities had yet to actually allocate all of this water to nature, but at least at the level of proclamations and vision, administrators were beginning to recognize the value in rehabilitated streams.

These were steps in the right direction in terms of improving water quality and the adequacy of stream flow. But they were baby steps.

5 The potential for genuine progress

Recent years have seen several developments which bode well for the long-term prospects of improved surface water quality and stream rehabilitation. The Water Law has been amended to include environmental goals among the list of legitimate uses of

water. And Israel's policy of large-scale desalination should offset at least some of the pressures on natural water supplies. On the water quality side, sewage treatment standards have been significantly improved, requiring tertiary treatment levels for nearly all municipal wastewater facilities. These policy changes have been accompanied by several initial projects designed to restore or rehabilitate streams and wetlands, including the multimillion dollar efforts at reflooding of parts of the Huleh Valley and dredging and removing contaminants from the Kishon River.

5.1 *Policy changes*

5.1.1 *Legal recognition of nature as a water consumer*

When it was passed, Israel's Water Law did not recognize nature as a legally acceptable recipient of water. This essentially meant that any allocation of water to nature by a Water Commissioner was a contravention of statute. Streams and wetlands were essentially left with whatever water, if any, remained after other legally recognized beneficial uses received their shares. This situation persisted for 40 years. As part of a public interest legislation project at the Arava Institute for Environmental Studies, in 2002 a survey was done with experts in the field, eliciting their views about how the Water Law might be upgraded. Formally recognizing the legality of water allocations to nature was among the highest priority amendments recommended (Tal 2007).

A draft amendment revising the Water Law was passed on by the researchers to Knesset member Shalom Simchon, the then chairman of the Economics Committee responsible for overseeing the Water Law. Simchon was a past Minister of Agriculture, lived on a farm and was generally considered a pillar of the agricultural lobby. Yet, he embraced the proposal and submitted it as a private bill. The original draft not only added 'nature preservation/stream restoration' as an additional use for water that could be allocated. It also required Israel's Water Commissioner to provide water to natural assets 'if the Minister of Environment or the Director of the Nature and Parks Authority requested it in order to maintain the ecological health of natural assets'. In the rough and tumble of committee negotiations, this provision was 'watered down slightly'. The version that passed merely added to the environmental objectives as a legitimate recipient of water and stipulated that the Water Commissioner (now Director of the Water Authority) submit a report about allocations to nature each year to the Knesset (2003). The law did, however, remove a significant statutory obstacle to stream rehabilitation and changed the orientation of Israel's Water Authority. The Authority has since committed to finding water for stream restoration, called for proposals for determining water needs for environmental purposes, and included stream restoration in its long-term masterplan (Israel Water Authority 2011).

5.1.2 *Desalination*

Israel's current commitment to desalination on a massive scale may reduce pressure on natural water resources, allowing water tables to rise and springs to flow again. As of 2011, 300 mcm of water were desalinated, accounting for over half of all the water supplied for domestic uses and nearly a third of all freshwater consumption for all uses. This amount is expected to increase to over 550 mcm by 2015, and to 750–1000 mcm by 2020 according to various plans laid out by the Water Authority. Moreover, because currently over 80% of wastewater is treated and reused, each cubic metre desalinated actually adds 1.7 m^3 of water to the overall water supply. And given plans to increase the share of wastewater reused, these quantities can be expected to increase even further.

As a result, Israel's dependence on natural (rain-fed) sources of water should significantly decline in the future. Current policy is to recharge aquifer levels in order to build a strategic reserve for future needs. While this will not raise water tables high enough for most springs to flow naturally again, it may help in isolated cases and should at least stunt the current trend of declining flows from springs (Skutelsky and Pearlmutter 2012).

5.1.3 *The Inbar standard for effluent discharges*

As Israel's sewage treatment improved, it became clear that meeting the existing standards would not be sufficient to bring its moribund springs back to life. The Ministry of Environment spearheaded an initiative to upgrade the existing '20–20' standard – which relied on a requirement of 20 mg/l BOD and 30 mg/l total suspended solids (TSS). The Ministry's deputy director Yossi Inbar chaired a committee that brought together representatives from the agricultural and finance ministries as well as the agricultural lobby. After protracted negotiations in 2002, a compromise was reached and a new standard for waste-water reuse was proposed which has since been known as the 'Inbar standard'.

The standard is the first waste-water treatment standard in the world that establishes a two tiered criteria for sewage treatment. Effluents that are discharged into streams have one set of standards as opposed to another set of standards for water delivered to agriculture. With agricultural interests challenging the need to invest in treatment to meet the requirements of low-flow streams, the standards are designed to ensure efficiency. One set of standards is designed to allow for unrestricted irrigation with each parameter driven by considerations of soil, flora, hydrological and public health. Ecological carrying capacity constitutes the rationale for the parallel stream discharge standards.

In 2005, the new treatment guidelines were formally approved although, a long phase-in period was allowed, so that the necessary investment in sewage treatment infrastructure could be upgraded (Lawhon and Schwartz 2006). The standard replaces the 20/30 standard with a uniform 10/10 BOD/TSS requirement. It also contains standards for boron and salinity. But many standards are bifurcated. Faecal coliform requirements are more stringent for irrigation (10 per 100 ml) than for streams (200 per100 ml), which presumably can benefit from dilution dynamics. At the same time, the standard for total nitrogen and

phosphorus is tougher in effluent bound for streams (10 mg/l and 1 mg/l) than it is for irrigation (25 mg/l and 10 mg/l) to reduce the risk of eutrophication.

As it turned out, despite the years of haggling in negotiations, waste-water treatment facilities typically discharge both to streams and to irrigation and so the 'efficiency efforts' were largely symbolic. No sewage treatment plant specifically designs its facilities for irrigation or stream release. But the very fact that special standards were designed to improve in-stream ecological integrity sent an important policy message about the seriousness with which Israel views stream restoration.

5.2 *Rehabilitation projects*

In addition to the above-mentioned policy changes, Israel has also embarked on several projects designed to rehabilitate aquatic ecosystems. Such actions range in scale. Among the small projects is securing agreements to supply modest amounts of water to individual springs in Galilee and an agreement that resolved a high publicized controversy regarding water from the Ein Gedi springs – a small, but ecologically and historically significant desert oasis. The bulk of the waters were being captured directly from the springs for use by a bottled water company as well as for agricultural and domestic purposes in a nearby settlement. Today the waters are now captured downstream after flowing through a protected nature reserve. Larger projects include the reflooding of portions of the Huleh Valley and dredging of the Kishon River, as described in more detail below.

5.2.1 *The return of the Huleh*

The first major land reclamation project undertaken after Israel received independence was also its largest. The Huleh wetlands and the contiguous 14 km^2 Huleh lake lay at the northern tip of Israel were seen as a source of malaria and an impediment to agricultural production. With the JNF responsible for the massive reclamation project, by 1958, the Huleh valley was entirely drained. A small 310 ha area was reflooded as a reserve and reminder of the original landscape. Agriculture in the Huleh valley was dramatically expanded. Regrettably, in the southern and central parts of the valley, the agricultural dividend that the project was supposed to create never materialized.

As the groundwater table dropped, the peat soil began to degrade due to the penetration of air and microbial decomposition of the organic matter. Subsurface fires became a problem, resulting in the formation of underground caverns. The peat became black dust which was basically infertile. In some areas, soil surface dropped by as much as 3 m which led to flooding, making lands impassable during the winter. And in the dry summer months, dust storms became a problem. Voles, a mouse-like rodent became a nuisance. The farmers in the area stopped cultivating the soils and sought alternative livelihoods (Hambright and Zohary 1998).

In addition, the draining of the Huleh swamps and channelization of the Jordan River that ran through them, resulted in a decline in water quality in the Sea of Galilee (which, despite the moniker 'Sea', is actually Israel's only lake and one of its major sources of freshwater). The wetlands slowed the flow of water from the upper Jordan River, allowing nutrients to settle and be adsorbed and processed. With their removal, these nutrients flowed directly into the lake. Furthermore, channelization of the river increased the speed of flow, which in turn, increased erosion of the river's banks, further degrading lake water quality (Hambright and Zohary 1998, Nishri 2011).

After a feasibility study, it was decided to reflood part of the old lake. The work was completed in 1994. The JNF agreed to take on the project as something of a penance for its ecological folly 40 years earlier. The 'Agmon' or mini-lake is only 1 km^2 and, on average of half a metre deep, far shallower than the original lake. Yet, the new 'novel' ecosystem quickly became a major tourist venue with an astonishing array of birds and other wildlife. Tens of thousands of migrating cranes winter on the site and scores of pelicans fill the air. The Agmon offers an excellent example of surface water rehabilitation, which although very far from a 'restored' original resource, constitutes an extremely valuable ecological asset (Laskin 2010). It is healthy enough to be a candidate for a UNESCO heritage site. The project offered a 'proof of concept' for advocates of stream restoration who could demonstrate clear environmental benefits and with 400,000 annual visits, meaningful economic values.

5.2.2 *Dredging of the Kishon*

The Kishon flows through Israel's most industrialized area. It has served for decades as the drainage canal for industrial effluents from large chemical industries, oil refineries and other heavy manufacturers. Its waters have long been toxic and rancid. Beginning in the mid- to late-1990s, tighter regulations on effluent discharges and upgrading of the local sewage treatment plant, as well as concerted action by the Kishon Stream Authority, resulted in significant reductions in inflows of major pollutants, including organic loads, ammonia, oils and suspended solids (Nissim and Gutman 2011). However, reduction in pollution inputs has not been sufficient to compensate for decades of accumulated stocks of pollution in the streambed sediments, and current conditions in the stream are still extremely toxic.

In an attempt to actually rehabilitate the Kishon, a masterplan was developed, debated and approved. The centrepiece of the project is plan to dredge and treat the contaminated soil along the streambed in Haifa. In order to accomplish this, the course of the stream will be altered, adding a large meander downstream. Once in place, the contaminated land will be treated biologically and the soil used to create an urban park along the stream's new banks. This project is expected to be completed by 2015. Other elements of the masterplan include acquiring additional water allocations for the stream as well as reintroduction of native flora and fauna. The masterplan's price-tag of

nearly $60 million makes it the most expensive effort to date to streamline rehabilitation in Israel. Roughly 60% of the funding for the rehabilitation project is to be paid by the oil refinery and chemical companies that are responsible for much of the historic pollution, with the national government footing the bill for another 30% and the local authorities taking care of the remainder (Darel 2011). The cost-sharing agreement was hotly contested, as the companies disputed the relative share of the cleanup costs they should be forced to pay. With many of the facilities recently privatized, the plants argued that most of the serious pollution had been released when they had been government-owned companies. The Kishon rehabilitation project was officially endorsed as a project of national interest by the government in 2011 with the Prime Minister himself coming to the site to officially launch the programme. The amount of effort and money that is now being dedicated to rehabilitating the nation's most toxic stream may indicate a true turning point as to how streams are valued in the country.

6 Challenges and the road ahead

While significant progress has been made to improve water quality and develop rehabilitation plans for the nation's streams, significant challenges remain. In a 2011 report on the state of stream restoration policy in Israel, the nation's State Comptroller office noted that nearly 20 years after the establishment of the national Stream Restoration Administration, not one stream had actually been restored (State Comptroller, Israel 2011). The report cited numerous policy obstacles that remain to effectively implement the rehabilitation policy. Among these are overlapping policy mandates across government agencies, conflicts of interests within government agencies responsible for rehabilitation and insufficient funding.

Over a dozen government agencies are responsible for some aspect of stream rehabilitation, including national ministries, local authorities and specific agencies tied to the streams, such as drainage basins or stream authorities. The Stream Rehabilitation Authority – an interagency body – acts in the advisory capacity only, and has no statutory authority. Among those with genuine operational powers, it is often unclear who is responsible for coordinating the policy and what the hierarchy of decision-making is when agencies do not see eye to eye, as is often the case.

The Comptroller's report also criticized government policy for not taking a watershed basin approach to stream rehabilitation, even though it is widely recognized that such an approach is necessary for effective implementation. While the Ministry of Environment is authorized under the Streams and Springs Authority Law to establish stream basin authorities, it has been reluctant to do so, in most cases, conferring the responsibility for developing and implementing a rehabilitation plan to the local Drainage Authorities. Its rationale for doing so has been not to create redundant bureaucracies. Yet, it raises both conflicts of interests and conflicts of perspectives.

The primary responsibility – and legally binding obligation – of drainage basin authorities, which operate under the auspices of the Ministry of Agriculture, is to prevent damage from flooding. To this effect, they tend to focus their efforts on channelizing streams and ensuring that the water flows quickly through them. However, floods are a necessary element in freshwater aquatic ecosystems, fulfilling numerous ecological functions such as replenishing wetlands and dispersing seeds. While the drainage basins can be held liable for failing to prevent flood damage, they have no such obligation to implement specific rehabilitation projects. This creates clear prioritization of incentives with water quality and ecosystem rehabilitation lower on the hierarchy. In addition to the conflict of interests, there is also a conflict of cultures, as Drainage Authorities have tended to seek engineering fixes to stream issues, rather than taking more ecologically based watershed approaches (State Comptroller, Israel 2011). Efforts to place the Drainage Authorities under the mandate of the Ministry of Environment, in order to change both the conflicts of culture and of interests, have been met with significant resistance (Darel 2010).

According to estimates by the Ministry of Environment, rehabilitation of the nation's streams will demand over $1 billion dollars, including an additional half billion dollars for upgrading sewage treatment facilities and another half billion for actual projects in and along the streams (Israel Ministry of Environment, Water and Stream Division 2010, State Comptroller, Israel 2011). The average amount of funding allocated by the government for rehabilitation projects between 1998 and 2010, however, was only roughly $2.5 million, leading the Comptroller's office to declare that at the current pace, rehabilitation efforts would take a century to complete (State Comptroller, Israel 2011).

Many economic assessments have found the economic value of stream rehabilitation in Israel is quite high, often outweighing the costs (Yarkon Stream Authority 2002, Barak 2010). Yet, much of the benefits are in the form of public goods, and therefore, do not necessarily generate revenues that can be used to fund the rehabilitation projects. As additional cases such as the Kishon, in which large industries with deep pockets can be coerced to foot the bill, are not foreseen, this leaves the government to appropriate the necessary funds. For streams in urban areas, some of the revenues can be raised through property taxes on areas expected to see an increase in property value, however, this is not likely to raise sufficient funds for all rehabilitation needs. Other economic policies to generate revenue, such as a dedicated tax on water consumption, have been resisted by various parties who maintain that water prices are already high, and that such a tax would be regressive in nature.

A small abstraction levy which charges more for users to pump upstream than downstream, in an effort to incentivize letting water flow in natural channels, has been implemented

by the Water Authority on a small scale. However, such a policy is effective primarily in areas such as the tributaries to the upper Jordan River, in which water still flows naturally from springs. Potential to utilize this policy in coastal streams is limited, however, as water tables are often so low that springs no longer flow.

Even if policy-makers were to sort out regulatory and financial issues, several other challenges stand in the way of stream restoration in Israel. First and foremost, perhaps, are the scientific questions of what is needed to restore or rehabilitate rivers. Under pressure from the Water Commission (now the Water Authority) to detail the water needs of streams, an interagency team led by the Nature and Parks Authority and the Ministry of Environment, produced a policy brief entitled 'Nature's Right to Water', detailing the minimum amounts of water necessary for ecologically functioning streams (Nature and Parks Authority and Ministry of Environment 2003). The report cited a need for over 600 mcm per year for nature reserves and coastal streams, and an additional 200 mcm per year for restoration of the Jordan River. These amounts were above and beyond the amount of water flowing in the streams at the time. It comes to a considerable quantity of water, amounting to more than half of the annual renewable freshwater resources of the country. This translates into a significant societal investment. Taking desalination costs as a shadow price, a 'back of the envelope' calculation puts the annual expense of supplying such amounts at roughly half a billion dollars. Knowing that such a request would be summarily dismissed, the authors specified that, because water could be captured downstream, net water needs (i.e. losses to evaporation and unrecoverable seepage) could be satisfied with only about 50 mcm for the reserves and coastal streams, and focused on this quantity as a realistic goal.

While the policy document played an important role in pushing forward the debate on the water needs for nature, it was deeply problematic. First of all the policy of encouraging capture of the stream flow downstream while certainly better from an ecological perspective than capturing upstream, and may be politically necessary to be taken seriously, inherently sacrifices flows into estuaries – the deltas where fresh and seawater mix. Estuaries can be important habitats in and of themselves, and often play an important role in ecological functioning upstream as well.

Second, the quantities were calculated based on a dated methodology that failed to take into consideration important nuances in flow regimes that are vital to ecosystem health, such as the timing, duration and rate of change of flows (Poff *et al*. 1997). The methodology is widely used because it is inexpensive and easy to implement (Katz 2006). Yet, it reflects the state of the art 40 years ago. The present criteria were proposed as a rule of thumb in the 1970s by Donald Tennet, an American hydrologist who examined rivers in the western USA, and who himself has stated that many better, more sophisticated methods have been developed since then (Instream Flow Council 2002). Furthermore, that method, like most other methods for determining ecological needs for streams, was based on how much water must be left in streams to avoid irreparable damage. It assumes a reasonable existing ecological integrity. Much less is known about how much flow must be returned to the streams in order to overcome damage already inflicted by decades of dewatering and toxic discharges, as is the case in Israel. This is especially challenging in Israel, as no coastal stream is in good enough ecological health to serve as reference and basis for restoration plans.

While the exact quantities needed to rehabilitate streams are still unknown, it is clear that they are significant. As stated above, in 2000, the government had already committed to allocating 50 mcm of water for nature preservation and rehabilitation. However, as of 2011, only 10 mcm was actually been allocated for such purposes, almost exclusively to the Yarkon Stream. Policy-makers still struggle to find the needed waters. As Israel presently uses 100% of its renewable precipitation, until the country's desalination network grows appreciably, water for streams will have to come at the expense of other uses. Agriculture, which for decades had been the primary consumer of natural freshwater, has seen its allocations cut by half since the mid-1990s, and fiercely resists further reductions. Domestic consumption, which now accounts for the bulk of consumption of freshwater, is not allocated, and thus, reductions can be accomplished only by policies such as awareness-raising campaigns, pricing increases or improved technologies. Even though all of these measures are being implemented, domestic consumption is still predicted to grow significantly over the coming decades, in line with the expected population growth (Israel Water Authority 2011). Various government proposals call for treated wastewater – treated to the Inbar Standards – to account for much of the future allocations for stream flows. Yet, ecologists and environmental organizations argue that the standards are insufficient to bring about actual ecological restoration, and that water at these standards may cause more harm than good (Gasith and Hershkovitz 2010, Skutelsky and Pearlmutter 2012).

Additional improvements in water quality are still needed as well. The Inbar Standards have already decreased the amount of pollutants and improved water quality in streams, from effluents, the primary point source of contamination. But many streams still suffer significant loadings from non-point source pollution from agricultural, urban storm water or other non-discrete sources. Moreover, periodic treatment plant 'failures' or accidents along the stream are not unknown, and can cause considerable damage even when they occur far away from the stream but within the basin. Several such accidents have occurred in recent years resulting in massive fish kills and other water quality damage that literally wiped out years of rehabilitation efforts.

Changes in land-use within stream basins also complicate rehabilitation efforts. Development, especially in floodplains, decreases recharge areas and increases runoff, exacerbating floods and increasing the need for flood prevention, which, as

stated can contradict restoration goals. Furthermore, such development can prevent projects such as the reintroduction of meanders, which may be necessary for the restoration of ecological functioning in streams. Proposals to establish funds to purchase land for purposes of stream restoration, including open spaces to preserve floodplains, have been put forward, but, to date, have not been implemented (State Comptroller, Israel 2011).

Despite important shifts in policy that reflect a new appreciation of streams' value, evident over the past two decades, significant rehabilitation will still require additional change in public opinion, both among policy-makers and the public at large. Given national water shortages, many citizens still view water left in-stream as a luxury or a waste of precious resources. Editorials and declarations of politicians bemoaning the 'wasted' water left to flow unexploited to the sea are still commonplace, as are calls for development of additional reservoirs to capture surface water flows.

In theory, the production of large quantities of desalinated water should reduce pressure on natural water resources; nonetheless, because of the high cost of desalination, many people object to desalinating seawater, for the 'frivolous' purpose of allowing additional freshwater to run in streams. Theoretically, increasing standards for wastewater treatment can produce more water for in-stream flows. However, once sewage is treated to a high level, local authorities and utilities tend to see it as an economic resource that can be sold to farmers, and are reluctant to release it without payment to streams. Indeed, for many years, the Water Authority expected Nature Reserves to 'pay' for water – though the reserves had little ability of producing income to compete in a national market. Thus, both desalination and high-quality wastewater standards, that should literally lubricate future stream rehabilitation efforts, may work both for and against water allocation to nature.

In numerous contexts, the Israeli public has expressed a desire for stream restoration, especially, in urban areas. Still, it lacks the associated recreational culture. After living through decades of putrid conditions, stream-based recreation activities are minimal. Whole generations have grown up viewing streams as an environmental hazard, not a resource to be enjoyed. A recent study on public willingness to pay for stream-based recreation found that it was divided roughly equally between in-stream activities such as fishing and swimming and off-stream activities, such as bike trails along the banks and picnic areas (Barak 2010). Cosmetic projects, such as bike trails and park benches, seem to satisfy much of the public demand, and are much easier and cheaper to implement. As they do not necessitate additional allocations of water, reductions in pollution loads or a watershed basin management approach, they have been the primary focus of many stream masterplans.

One of the more developed rehabilitated stream projects is for the Alexander stream, located along the Mediterranean coast, half-way between Tel Aviv and Haifa. Its 'restoration plan' won an international prize and the parks along its banks and the rare and iconic soft-back, giant turtles (*Trionychoidea*) who live in its estuarial sections attract thousands of tourists each. And yet the Alexander Stream is still a toxic canal having experienced little meaningful improvement in terms of biological and chemical indicators (Tal *et al.* 2010a). It may be economically rational to begin with the inexpensive 'low hanging fruit' of development of recreation along stream banks. Yet there is concern that many rehabilitation efforts will end there, and not continue on towards comprehensive ecological rehabilitation of the streams and their ecosystems (State Comptroller, Israel 2011).

It is not only policy and public opinion in Israel that needs to change in order to restore or rehabilitate Israel's streams. Given that twelve streams originate in the West Bank, and that the Jordan River system is shared with Jordan, Lebanon, Syria and the West Bank, the ultimate success of restoration efforts is dependent on policies outside Israel's boundaries, as well as on international policy and diplomacy. In terms of water quantity, the challenge is to convince those upstream to forego water so that it can flow downstream – a considerable hurdle given regional water scarcity issues and attitudes that tend to see ecological goals as luxury items. But there is an empirical basis for optimism regarding cooperation in transboundary restoration efforts. For example, in a recent public opinion survey, Palestinians reported a higher willingness to pay for restored streams than did the far richer Israeli public (Abramson *et al*. 2010) and several Jordanian policy-makers, including members of parliament, have come out publicly in favour of rehabilitation of the lower Jordan River.

In terms of quality, the most immediate challenges needed to improve water quality in Israel's streams involve improved treatment of wastewater and policies to abate non-point discharges, especially from agricultural sources, upstream. Given the costs of building and operating high quality wastewater treatment facilities, the new Palestinian plants are unlikely to be built without assistance from international donors. While commitments for construction of some such facilities have been made, much more is needed. In addition, given the poor state of utilities in West Bank, the facilities are unlikely to succeed without additional funds for operation and maintenance. Several academics and policy-makers have outlined potentially win–win situations, whereby, for instance, Israel funds Palestinian projects in the West Bank (see, for instance, Fisher and Huber-Lee 2005, Katz and Fischhendler 2011). To date, some small scale cooperative efforts have been implemented by NGOs or local authorities; however, actual cooperation between parties in this area remains limited.

Finally, the cloud of climate change casts additional shadows over the potential efficacy of any rehabilitation efforts. Already facing chronic water scarcity,[3] the region is experiencing a measurable negative trend in precipitation. This includes longer periods between rainfall events, increasing storm intensity and more extended droughts, trends that are expected to continue into the future (Alpert *et al*. 2008). Various models predict

decreases in precipitation of between 10–30% by the mid-century and by up to 50% by 2080.[4] Moreover, projected temperature increases of 2–4°C, mean that evaporation rates can be expected to reduce available water even further. These trends threaten the health of even currently functioning stream ecosystems, let alone those undergoing rehabilitation efforts (Palmer *et al*. 2009).

7 Conclusions

Stream rehabilitation is a prolonged process that requires considerable stamina on the part of society and decision-makers. The complex web of interactions within biological systems is extremely sensitive, frequently poorly understood and may take decades to reach a healthy equilibrium. Undoubtedly after more than half-a-century of contamination and neglect, under ideal circumstances, rehabilitation requires a considerable investment in removing pollution sources, landscaping and infrastructure. But efforts are particularly vexing in drylands, where fully restored systems will still lack some of the attractive navigational, recreational and ecological benefits that provide motivation in temperate areas. At the same time, Israel is home to streams that literally flow through the heritage and traditions of four major religions, providing both spiritual and economic (touristic) reasons to pursue a new deal for its streams. Offering pilgrims from around the world, the opportunity to hold Baptism ceremonies in the River Jordan as Jesus did in days of old is not just good business; it also constitutes an ethical responsibility that goes along with being a steward of a holy land.

In water scarce regions, a surfeit of water must become available to release anew to the nature reserves and parks as part of a process that meets the competing demands for agricultural irrigation and rising consumer consumption. Hence, one can argue that Israel's streams' time has finally come. The advent of massive desalination is changing the perspectives of the general Israeli public as well as the country's robust environmental movement about water resources. This may explain why the massive investment in desalination capacity on the Mediterranean has largely been welcomed, notwithstanding the implications for energy consumption and greenhouse gasses (Tal 2011). Surely, for Israel's beleaguered surface waters, it offers an opportunity and a fresh lease on life.

In sum, Israel's attitudes towards its streams have changed significantly over the course of the country's 64-year history. Once viewed primarily as a convenient means for evacuating sewage, with little inherent value, streams are now increasingly recognized as a beneficial asset to local communities and the nation as a whole. For an increasingly urban country, they can provide 'green ways' and parks that allow crowded citizens and visitors to enjoy some direct connection with nature and the historic countryside. Laws have been amended, rehabilitation plans developed, and some preliminary projects initiated. The challenges to meaningful rehabilitation of the country's streams are numerous and formidable. The pervasiveness of past neglect, makes it a long-term, expensive prospect. But it appears that the country has turned a corner and that lip service has finally begun to be replaced by actual commitments. If the country can stay the course and implement the many rehabilitation masterplans, the outlook for the future of Israel's streams is hopeful.

Notes

1. Although there are is no single classification that is universally accepted among experts, one popular definition classifies streams as ephemeral if they lie in watersheds where the channel is hydrologically active for less than 2% of the time or about seven days per year (Reid *et al*. 1998).
2. According to Israel's Central Bureau of Statistics, agriculture now accounts for only 1% of the national Gross Domestic Product (Central Bureau of Statistics 2012).
3. Chronic water scarcity is commonly defined by water managers as renewable water supplies of less than 500 mcm per capita per year (based on the Falkenmark Index. For a comparison of water poverty indices, see Lawrence *et al*. 2002). Between 1990 and 2010, Israel's renewable rate was less than 200 mcm/cap/year (Weinberger *et al*. 2012). Even with massive desalination and waste-water reuse included, this amount was less than 300 mcm/cap/year.
4. See, for instance, projections at http://www.climatewizard.org/

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