SUSTAINABLE STORMWATER MANAGEMENT IN ISRAEL

A STUDY OF POLICY AND BEST MANAGEMENT PRACTICES IN URBAN OPEN SPACES

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with

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An Executive Summary in Hebrew is available
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INSIGHTS AND RECOMMENDATIONS, INCLUDING A TOOLBOX

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EXECUTIVE SUMMARY

The concepts of 'stormwater as a resource' and Water-Sensitive Planning (WSP) have gained popularity among scholars, planners and engineers over the past 10-20 years. The development of these concepts in Israel, as well as in other countries in Europe, America and Oceania, followed the introduction of ideas and techniques of sustainability into various fields of decision-making and planning. In most places, this development aimed to enable replacement of conventional drainage by sustainable stormwater management, with benefits for both human beings and nature. However, despite several thousand publications in this field, we are still lacking reliable data-based guides for sustainable stormwater development, as we have for conventional drainage. The overall purpose of the research we conducted over the last several years was to contribute to advancing Green Infrastructure (GI) in Israel by producing an evidence-based list of principles and practices of Sustainable Stormwater Management (SSWM), with a special focus on urban open spaces that combine SSWM with landscape planning and design.

The research was initiated by the KKL (Keren Kayemeth LeIsrael) and JNF (Israel National Fund) Australia. It was conducted within the administrative framework of the Center for Water-Sensitive Cities in Israel, headed by Dr. Yaron Zinger, and the academic framework of the Technion project on Water-Sensitive Planning, at the Center of Urban Studies and Planning in the Technion – Israel Institute of Technology.

The final report hereby submitted encompasses **four research chapters, each with a distinct methodology**, followed by a fifth chapter of conclusions and recommendations. From a methodological point of view, chapter 2 is distinguished by its use of an appropriate theory for analyzing socio-institutional changes in stormwater management, while chapter 4 is based on extensive case studies of urban open spaces using a unique evaluation tool developed by the researchers. A brief presentation of each chapter follows.

Chapter 1 – An analysis of the quantity and quality of stormwater in Israel is presented, based on data collected from former research projects and documents published by senior public officials. The analysis aims to examine the proposal of using stormwater as an additional source of water for the country. The chapter continues with a brief description of the way we - at the Technion - have conceptualized sustainable stormwater management. The analysis and the description serve as an introduction to the other chapters of this research report and can be taken as an introduction to decision-making regarding the management of stormwater in Israel.

Chapter 2 – The purpose of this chapter was to understand the socio-institutional context for implementation of sustainable stormwater management in Israel. The short history of advancement towards SSWM in Israel was surveyed on the basis of multiple sources, including a dozen semi-structured interviews with leading Israeli professionals and officials involved in stormwater management. The policy analysis that follows uses a theory of three pillars for socio-institutional transformations: (a) cultural-cognitive shifts – changes in knowledge, attitudes and beliefs related to water, stormwater and sustainability; (b) normative shifts - changes in professional conduct and professional standards related to stormwater management, and (c) regulative shifts – changes in laws, statutory plans and governing bodies.

Chapter 3 – This chapter consists of a brief report on the status of stormwater management in Israeli cities, including an analysis of the impediments to implementing a sustainable policy and planning approach. The report is based on (a) what we have learnt from interviewing relevant municipal officials and stormwater professionals, as part of our field research reported in chapters 2 and 4; (b) qualitative analysis of summaries of three focus groups and of a questionnaire completed by their participants, in the framework of a special workshop organized as part of the research.

Chapter 4 is an evaluation of nine landscape projects that integrate SSWM practices. It used an original evaluation tool developed within the framework of this research to assess landscape projects based on four bundles of goals/benefits: hydrological, ecological-environmental, social and economic. This assessment was performed for the stormwater practices used in the selected landscape projects. An appendix to this chapter presents the detailed field work conducted in one of the case studies. A few additional presentations of case studies are combined into a Hebrew appendix of chapter 4.

Chapter 5 is a collection of insights, conclusions and recommendations regarding stormwater management in Israel, based on the findings of the former chapters and, to a degree, on our extensive experience with the subject matter. Below is an abstract of the main insights and recommendations, arranged by the subtitles of chapter 5.

Evidence-based insights regarding stormwater in Israel and its management

- The total **quantity of stormwater in Israel is 200M m^3** (million cubic meters) (annual average, ~30 year measurements), of which 80% is derived from river basin stormwater and the remaining 20% from urban areas. **In contrast to river basin stormwater that is an additional natural water source for the country, the low quantity of urban stormwater is marginal from the point of view of the national water economy**. This conclusion is highlighted by the fact that if all the urban stormwater was infiltrated into groundwater (which is far from being possible), it would add just 3% to the average annual recharge of aquifers in Israel.

- **Urban stormwater is highly significant from the point of view of the cities in which it flows**, because of both its potential damage and potential benefits. Proper valuation of the benefits for city residents and municipal governments (costs are usually calculated but not the variety of benefits) would illuminate the above-mentioned significance.

- According to a survey of Israeli field studies, **the quality of urban stormwater, especially from residential areas, is good enough for any usage except drinking water**. There are doubts regarding the first flushes (of which there may be several during one rainy season), mainly because many studies provide annual averages of quality indicators instead of detailed distributions. Yet, there are researchers who argue that the blend of varying levels of water quality (in puddles on the ground as well as in the groundwater) overcomes the problems related to just a few rainstorms each year.

- There are no established standards for stormwater quality in Israel. The recommended rule here is to **fit the required quality to the intended usage**; there are good reasons to require different qualities from stormwater that is intended to flow into a winter pool compared to stormwater for irrigation.

Policy recommendations for decision-makers at the national and local levels

- **Encourage but do not enforce** Israel's residents to implement stormwater management practices in residential yards.

- **Give preference to managing stormwater in publicly controlled areas,** from the small scale of a single public building or city block to the larger scales of a whole city or catchment basin.

- **Promote awareness** of the variety of potential benefits of SSWM among relevant decision-makers and professionals as well as the wider public.

- **Increase the knowledge base of SSWM** as a precondition for its wide implementation. Knowledge from abroad is often irrelevant, because of different rainfall regimes, and because frequently the sewage system and the drainage system are connected in cities abroad, unlike in Israel. **Examples** of insufficient knowledge and disagreements among professionals regarding basic hydrological and drainage calculations include: appropriate **return periods** for different spatial scales, **infiltration rates for various soils**, models for calculating **evaporation** and stormwater system **design**.

- **Require interdisciplinary work** as a necessary prerequisite for implementation.

- **Determine the value of benefits versus the costs** of projects, especially landscape projects that integrate SSWM practices. Environmental economists should do this work.

- **Subsidize implementation** of SSWM in urban areas, at least in its initial stages.

- **Promote partnerships** with all the main stakeholders.

- **Enact a new law** of stormwater management to replace the obsolete 1957 Drainage and Flood Control Law.

- **Publish national policy statements** and practical **guidebooks** of evidence-based principles and practices for SSWM.

- Regulate the relationships between the **Drainage Authorities and the municipalities** in their areas.

- **Revise TAMA 34/B**, especially TAMA 34/B4.

- Replace the statutory 'Drainage Appendix' with **'Stormwater Management Appendix**'.

- **Assign local governments or local Water Corporations the authority to manage the implementation of SSWM in their areas**. This should be subject to national regulation, cooperation with the relevant Drainage Authority, and publication of a local SSWM policy statement, which incorporates planning principles and evidence-based practices, such as those detailed below.

Recommended toolbox for professionals in SSWM – Sustainable Stormwater Management

- **The recommended goals of SSWM** are the three foundations of sustainable development: **environmental-ecological** goals**, social** goals and **economic** goals, plus one that is particular to SSWM: **hydrological** goals. Each of the four consists of a bundle of recommended sub-goals/potential benefits expected from educated implementation of SSWM. This list of sub-goals form the recommended criteria with which to evaluate the level of achievement/performance of SSWM projects and practices. To the extent possible, **all of these sub-goals should be pursued simultaneously and synergistically.**

- **Twelve planning principles are recommended, based on the groundwork conducted by the Technion research group for WSP – Water-Sensitive Planning:** 5 principles that are good for any sustainable development project and 7 specific principles for sustainable stormwater management. Among them: select multi-purpose projects and practices; adjust each project to local conditions; work with nature (not against it); slow down the flow of stormwater instead of rushing it out of the urban area; data and management of both stormwater volume and discharge are critical in SSWM.

- **Special design principles are recommended, particularly for designing urban open spaces that integrate SSWM.** Examples of such design principles are: prefer NBS - Nature Based Solutions; use local natural resources, both biotic and abiotic; endeavor to reduce impervious areas and increase the pervious and green areas in each project.

- **Special 'best management practices' – BMPs – are recommended, particularly for designing open spaces that integrate SSWM; the practices are related to three spatial scales: macro, mezzo and micro**. BMPs for the macro and mezzo scales can be divided into two types: planning-related practices and constructed practices. Examples of the first type are: use an ecological survey as a basis for planning; use a hydrological survey as a basis for determining urban land uses; the layout of open spaces and roads should follow the hydro-geographical structure and should be set before the location of housing and employment areas is determined; preserve and rehabilitate streams and channels. Constructed BMPs for the macro and mezzo scales include: detention, retention and infiltration ponds, urban forests, winter pools and vegetated swales. In the same way, BMPs at the micro scale include a combination of planning practices, such as: leave permeable areas in the yard and connect impervious areas (including roofs) to the pervious areas in the yard, with constructed practices (that can be either engineered or planted) such as: rainwater tanks, dry wells, green/brown roofs, and rainwater gardens.

Recommendations for KKL-JNF

- **Support New Sources of Water for Israel, as part of the present JNF strategy** A ONE BILLION DOLLAR ROADMAP FOR THE NEXT DECADE. In addition to stormwater, there are other existing and potential 'new sources' such as greywater and production of water from air that can greatly benefit from innovative technologies as well as innovative methods of delivery and appropriate regulation. New sources of water are needed for the sake of Israel itself, for its security and resilience, and can also be exported to other countries that are crying out for clean and inexpensive water.

- **Integrate Green Infrastructure for Communities into the KKL plan of ISRAEL 2040**. The term Green Infrastructure directs the wide field of various infrastructures to the principles of sustainable development. It may relate to energy and transportation as well as to the sectors that this research touches upon – water, soil, open spaces and landscape. Our recommendation deals with the latter, which encompass stormwater management, soil and biodiversity conservation and all the greenery in urban areas and outside the cities – forests, parks and gardens of all sizes. Moreover, the recommendation calls for Green Infrastructure for Communities. Supporting community life is an established goal of KKL, first in rural areas and more recently also in towns and cities. Taking into consideration the lack of resources to cover the whole country, as well as concerns of inequality and social justice in Israel, we recommend directing the KKL activities to communities in the North and in the South of Israel, and thus, to integrate 'Green Infrastructure for Communities' into ISRAEL 2040. Even if only part of the grand plan can be implemented, it is recommended that 'Green Infrastructure for Communities' be included within it.

- **Support a center of excellence for applied research on Green and Innovative Infrastructure for Communities.** This is a necessary condition for implementing many of the above-mentioned recommendations. Our experience suggests avoiding the construction of new research campuses (as was originally suggested by ISRAEL 2040) and **preferring the selection of one (or up to three) of the existing regional centers** as a base/bases for the recommended applied research center. Most appropriate for this task seems to be MIGAL – Galilee Research Institute

LTD; it sits next to Kiryat Shmona and works in cooperation with Tel Hai College which recently set up a new graduate program in Water Science. Our recommendation to KKL is to join hands with MIGAL and administer together a center of excellence as part of the ISRAEL 2040 (or 2050) plan, a center that may be named **GREENOVATION ISRAEL**.

Final remarks

In parallel to the work presented in this executive summary, our research group executed the **following activities**:

Delivery of the first ever course at the Technion on 'Water-Sensitive Planning'. It was attended by undergraduate students from landscape architecture (Faculty of Architecture and Town Planning) and environmental engineering (Faculty of Civil and Environmental Engineering), together with Master's students in urban and regional planning.

Organization and teaching of a course in urban stormwater management at the Technion Continuing Education campus in Tel Aviv, attended by local authority engineers and planners.

Organization of a workshop for researchers and stormwater management professionals in local authorities, including six lectures on SSWM and three roundtables for discussion and identification of barriers to implementation.

Publication of an article in a scientific journal:

- **From Conventional Drainage to Sustainable Stormwater Management: Beyond the Technical Challenges**
  Goulden, S., Portman, M., Carmon, N. and Alon Mozes T.
  Journal of Environmental Management, No. 219, 2018, pp. 37-45.

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CHAPTER 1

URBAN STORMWATER AS A WATER RESOURCE FOR THE STATE OF ISRAEL: ISSUES OF QUANTITY AND QUALITY

Naomi Carmon

Israel consumes approximately 2,500M m³ of water annually. The annual report of the Water Authority (2017) reveals that some 2,000M m³ of freshwater are produced from natural and artificial sources each year; about one half of which – close to 1,000M m³, are produced through drilling into eight groundwater basins[1]; approximately 400M m³ from surface water sources, including springs, streams and the Sea of Galilee; and an additional volume of some 600M m³ from seawater desalination plants. In addition, about 350M m³ of purified wastewater are consumed annually.

Natural water is a renewable resource. It is renewed each year through precipitation, which in Israel is comprised almost entirely of rain. Rain falling on the ground continues in three alternative tracks: approximately 70% returns to the atmosphere through direct evaporation or transpiration from plants; about 25% infiltrates to the groundwater and some 5% becomes stormwater which flows upon the ground and in streams. These are average values that represent all the regions in the country, which vary greatly one from another. Nearly 100% of the rainwater returns to the atmosphere in forested and agricultural areas, due to the intensive activity of the plants and their roots. In the sand dunes along the beach, which are unable to retain water, most of the water infiltrates to the groundwater (Gvirtzman, 2002, pg. 21).

1.1 The Quantity of Stormwater in Israel

Several attempts have been made to assess the total quantity of surface stormwater in Israel. These focused on the Western drainage, which flows to the Mediterranean Sea. Gvirtzman calculated and assessed that the average annual rain volume in Israel amounts to approximately 7,000M m³; of which about 200M m³ flows to the sea and are "lost" in it (Gvirtzman, 2002, pg. 21-23). It is interesting to note that this rough estimation by Gvirtzman – 200M m³ that flows in the streams to the Mediterranean Sea – is also the figure indicated by the professionals who published an updated Hydrological Service document (Givati[2] et al., 2019), which relied on measurements conducted over an extended period of time (1986-2010). This quantity – **an annual average of 200M m³** – serves in this chapter as **an estimate of the total volume of stormwater, which can potentially be considered**

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[1] Data from active production wells, by the eight groundwater basins (in 100K m³): Yarkon-Taninim – 274; Coast – 257; Negev and Arava – 108; Eastern mountain – 98; Kinneret (Sea of Galilee) – 90; Western Galilee – 67; Carmel – 45; the mountain rim – 2 (Water Authority, 2018).

[2] Amir Givati served for 14 year (until 2019) as Head of surface water and Hydrometeorology department, in Israel Hydrological Service

as part of Israel's water resources[3]**.** This is the average quantity; whoever will manage this quantity must take into consideration the extreme variance between different years: in the winter of 1991-92 the quantity of stormwater reached 967M m³, while in 1993-94, 1998-99 and 2000-01 it amounted to only 20-39M m³ a year.

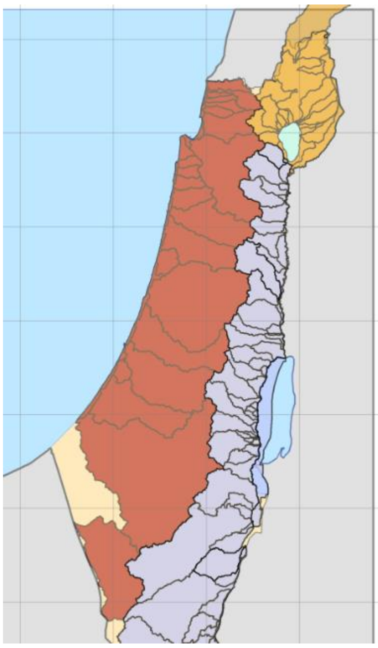

Fig 1.1: Map of drainage basins between the Jordan River and the Mediterranean Sea. The Western drainage flows to the Mediterranean Sea (Source: Givati, 2018)

The annual average of 200M m³ of stormwater comprises a significant amount of water in terms of the water resources in Israel. It amounts to nearly 10% of the country's annual consumption, and is greater than the amount of water produced by any of the desalination plants currently operating in Israel; each plant's annual production capacity amounts to 90-150M m³ (Water Authority website, 2019). However, of the total quantity of 200M m³/year, it is important to distinguish between two main parts: the surface stormwater that flows in rivers outside cities and towns that reaches an annual average of 160M m³ – 80% of the total quantity, and the stormwater that is created in urban areas, which amounts to an average of only 40M m³ a year, or 20% (Givati & al, 2019).

Do 40M m³ of urban stormwater – the annual average – comprise a significant amount of water in terms of the water resources in Israel? A relevant comparison for replying to this question is to consider the quantity of the urban stormwater in relation to the total quantity of "recharge" in the country, which is the total amount of water that infiltrates to the aquifers. The average annual volume

[3] Although this is the official figure of the Water Authority, it likely underestimates the total volume of stormwater that could potentially be exploited in Israel, for two reasons. Firstly, the figure only relates to the western drainage basins and does not take into account the Kinneret (Sea of Galilee) drainage basin, the Golan Heights, the Negev and the Gulf of Eilat. Secondly, the figure is based on water measured by the Hydrological Service downstream near the Mediterranean so does not account for stormwater 'lost' through evaporation. Under a scenario of efficient stormwater management, more stormwater would be captured upstream, as close as possible to where it fell, and in this case the volume of measured stormwater would be higher. Nonetheless, since this report focuses on urban stormwater (as opposed to all the stormwater in Israel), and the western drainage basins include almost all of the significant urban areas in the country with the exception of Jerusalem, we will use the official datum of the Hydrological Service in this document.

of recharge is 1,300M m³ (idem), i.e., **if all the urban stormwater would be added to the recharge of the aquifers (which is, of course, impossible, as detailed below), the supplement would amount to only 3%.** Considering these data, Givati et al. (2019) concluded that "managing urban stormwater holds great importance… primarily in the urban space", while "the contribution [of urban stormwater] to Israel's water economy is secondary."

Hence, the conclusions with regard to stormwater in river drainage basins are different from those related to urban stormwater, as follows:

(a) **The quantity of stormwater from river drainage basins is quite large in relation to the volume of water resources in Israel** – the stormwater which flows in Israel's rivers amounts to an annual average of 160M m³ in the Western drainage (the Western drainage covers most of the populated area in the country, including a sizable part of the Northern Negev, as seen in the above map). Consequently, **it is important to manage this large amount of river basin stormwater to benefit the national water economy,** allocating much of the water to nature and to conserving and rehabilitating rivers and streams (for information about the importance of streams in Israel see: Kaplan, 2004). This, without neglecting the traditional roles of stormwater management, i.e., mitigation of damaging floods and soil preservation. It appears that at the Ministry of Agriculture and Rural Development, which operates via 11 drainage authorities, there is professional momentum toward well-advised management of river-basin stormwater, influenced by an in-depth study of the principles of the European Water Directive (EU 2000) and its supplement dealing with flood management (EU 2007) (Neuman and Gutman, 2019).

(b) T**he quantity of urban stormwater (historical average of 40M m³) is marginal from the point of view of Israel's national water economy.** This corresponds the above assertion of Dr. Givati (who served as the Head of the Surface Water Department at the Hydrological Service), and is opposed to what is commonly presented by the authorities of urban planning and water resource management. This quantity **is certainly insignificant in terms of the quantity added to the recharging of aquifers** (which, as stated above, amounts to an average supplement of 3%). To clarify: we do not regard 40M m³ lightly, as elaborated further in section (c) below; however, from the perspective of the water economy, which can allegedly benefit mainly from infiltration into the ground of the urban stormwater, we are dealing with the potential of only a small quantity that is difficult-to-impossible to realize. It is legally challenging to enforce infiltration in lots on which private homes were built years ago, and therefore enforcement is not worthwhile, but infiltration can and should be encouraged. Theoretically, one can try to obligate infiltration of stormwater in urban renewal sites, but taking into consideration the tall and dense construction that characterizes these sites, with many buildings required to build underground parking areas under the entire lot, the possibility of actually achieving full infiltration is limited. As for new construction, the assumption is that within the next 30 years the built area will double its present size, and obligating infiltration in these areas will be possible. However, local authority officials, who wish to be reelected, will probably prefer not to enter into conflicts with their residents over the infiltration of water, whose main benefit is the national water economy and not the local one. Furthermore, structural engineers express concern about building foundations (there is insufficient knowledge on this matter in Israel), and infiltration facilities tend to become clogged in the absence of routine maintenance, which Israelis do not excel at. Considering all the above factors leads us to conclude that **from the perspective of the benefit to the national water economy, the financial, professional and regulatory efforts required to enforce infiltration of urban stormwater in cities along the coastal plain cannot be justified.**

(c) **In contrast, urban stormwater has great significance for the local authorities** in whose territory it was created, in two ways:

- In terms of the potential benefits that cities – their residents and urban nature - may gain from well-advised urban stormwater management.
- In terms of the damage that urban stormwater causes to cities, which is expected to grow in the future with the increase in the total built area and the number of extreme rainfall events due to climate change.

This dual significance has economic, environmental and social implications for local authorities. Therefore, **it is only proper that the task of urban stormwater management and its conservation will be assigned to municipalities, and that these efforts will be steered toward improving the welfare of their residents.** We will discuss some of the ways to achieve that later in this report.

The above discussion and its conclusions are related to stormwater quantity. However, decisions concerning beneficial and efficient management of stormwater must also address its quality.

1.2 The Quality of Stormwater in Israel

Measuring the quality of urban stormwater is controversial. There is disagreement on what is more important and what is less important to measure, on how to measure and how to present the measurement results (for example, hourly pollutographs, as opposed to annual and even multi-annual rainstorm averages). While research in Israel deals rather extensively with the quantities of stormwater (and with floods), relatively few studies have examined its quality. Comparisons with findings from other countries are usually irrelevant, mainly because **in most of the older countries and cities in the Western world, the drainage and sewage systems are unified** and are, of course, contaminated. **In Israel, the Water and Sewage Law prohibits any connection between drainage and sewage systems**. Indeed, illegal connections can be found and there are instances of sewage overflow into drainage systems, especially in heavy rainfall days. Yet, the law is generally obeyed, and the level of contamination does not come close to what is common in combined systems. Another important reason for avoiding conclusions based on findings from abroad is Israel’s special rain regime. It is characterized by rain storms that are concentrated in only a few months of the year, and are often particularly intense; the intervals between storms, the quantities and intensities affect the concentrations of the substances that are measured in order to determine quality and the level of compliance with standards.

Israel has not set a standard for stormwater quality. In the absence of such a standard, researchers often compare their findings to the drinking water standard (Ministry of Health - Israel, 2013), although no one intends to drink stormwater directly. A more relevant comparison refers to the standards for treated wastewater (Ministry of Health – Israel, 2010), which is intended for unlimited irrigation or for release into streams.

An additional important methodological issue is how one relates to lab research, as opposed to field research. According to Prof. Avital Gasith, a leading specialist in aquatic conservation from Tel-Aviv University, actual results that are relevant to the issue at hand behave differently to lab results. In the artificial conditions of the lab, it was observed that substances that are commonly found in road leachates cause deformities in tadpoles and in other small fauna, while real-life personal observations of Prof. Gasith in roadside puddles, from the last 40 years, have not identified harm to invertebrates and to amphibians living in these bodies of water (Marcus, Gasith & Carmon, 2014).

Hence, we will present below testimonies and conclusions from field research only. We will relate to research dealing with basin stormwater combined with urban stormwater, or with the urban stormwater itself, emphasizing quality measurements of stormwater that flowed from urban residential areas (which include roads and parking lots situated between residential buildings).

The first and largest Israeli enterprise for collecting river basin stormwater and infiltrating it into the groundwater is the Shikma reservoir, which was established in 1958. Shikma Stream drains an area of 750 km^2. It collects stormwater from the Oved, Hanun and Shikma Streams, and infiltrates them into the coastal aquifer. A population of approximately 42,700 resides in some 40 settlements in the Shikma Stream drainage basin. The land uses are diverse – urban, agricultural, industrial, commercial and services (Shikma, 2019). The swelling of the stream in winter reaches an average annual volume estimated at 2.7M m^3. The captured flows range from 0 to 11M m^3 a year. They are accumulated in the Shikma Reservoir, which was built near the stream's estuary where it flows to the sea near Kibbutz Zikim. From there, they are pumped from the reservoir and conveyed and infiltrated into the groundwater in sandy infiltration fields south of the city of Ashkelon. Approximately 5.6M m^3 (a multi-year average) are exploited annually thanks to this system. The stormwater that reaches the reservoir and the water produced from the adjacent drilling sites are constantly monitored and periodic reports are published jointly by the Water Authority, the Ministry of Health, Mekorot (the national water company) and the Society for the Protection of Nature. The most important finding, from the viewpoint of this discussion, is that **the quality of the water from the production wells complies with the Public Health Drinking Water Regulations** (Water Authority, Water Quality Division, 2015). This means that the infiltration process through the sandy soil succeeded in purifying the water from contaminants that the stormwater carried from the large basin with its diverse land uses – urban, agricultural and industrial.

Goldschlager et al. (2013) measured the quality of urban stormwater in the cities of Ra'anana and Herzliya in residential, road and industrial basins. They found that the salinity values and metal traces were lower than required by the drinking water standard, but that the level of e-coli and coliforms was higher than the standard permitted (they are attributed to sewage seeping into the drainage pipes from sources that can be identified and treated at source). Their conclusion was that the stormwater in the coastal plain was a wasted water resource; it was particularly suitable for recharging the aquifer, mainly because of its low salinity levels, and was also suitable for various uses, except for drinking.

An especially detailed empirical study was conducted by Assaf, Nativ et al. (2004) in the city of Ashdod. They measured numerous parameters of stormwater quality and associated factors in urban areas, including residential and industrial areas and roads. We are particularly interested in their conclusion concerning stormwater from residential areas: they concluded that stormwater from residential basins can be used directly, following minimal treatment (filtering and chlorination), and in addition, can be infiltrated into the aquifer through the soil, without any treatment. Moreover, the low level of salinity in the stormwater will help dilute the groundwater in the coastal aquifer.

Burmil, Shamir & Carmon (2003) measured the quantity and quality of stormwater from a residential neighborhood in the city Rishon-LeZion. The neighborhood (covering an area of approximately 500 dunams) included lots on which buildings of varying heights had been built, as well as the roads leading to them. Lab tests were conducted on 26 samples of stormwater flowing out of the neighborhood. The results showed that 24 of the 26 met the standard for drinking water in terms of the measured substances. The chlorides and nitrates were lower by significant orders of magnitude than those found in the cells of the coastal aquifer beneath that neighborhood.

The most recent research in this field was conducted by Wollach, Friedler, Zinger & Haft (2018). They examined the quantity and quality of urban stormwater in the city Kfar-Saba over a period of three winters, at the outlet of four types of urban basins: a residential basin, a light industry basin, a road basin and a basin with mixed land uses (the latter includes a sizable agriculture area). We discuss here the part of their research that presents their findings on the quality of the stormwater, as compared with the accepted water standards in Israel. For each of the basins that were examined, they present (Figure 9, idem) average values of eight chemical elements: zinc, aluminum, barium, phosphorous, chrome, manganese, copper and sodium. These were compared with: (a) drinking water quality standard (Ministry of Health, 2013); (b) the quality standard for purified wastewater permitted for unlimited irrigation; and (c) release into streams (Ministry of Health - Israel, 2010). Note that only two of the eight elements – barium and chrome – are considered by the Israeli Ministry of Health (2013) as “elements affecting health”, while the others are listed as “elements with an organoleptic effect”, i.e., do not affect health, but rather the water’s taste, color and odor, which are important for drinking water but less critical in the case of water used for irrigation and for releasing into nature and streams. The same figure 9 in the above-mentioned report also reveals that urban stormwater, as measured in three types of urban basins – residential, roads and light industry basins – meets the Israeli standard for unlimited irrigation, except for a deviation in the concentration of aluminum. Stormwater originating in the residential basin excels in terms of its fulfillment of not only the standard for unlimited irrigation, but also the standard for drinking water, except for the deviation of the aluminum level. This detailed report research included also bacteriological tests (not included in the above comparison to Israeli standards) – tests that detected coliforms and e-coli[4], as was found in some of the **previous research studies. The sources of such bacteriological contaminations can be identified and should be treated at the source.**

[4] The researchers also checked the sources of the contamination and found (after adding tests for caffeine and medicines) that these originated in people and in the sewage that they produce. This test calls for monitoring the different locations where sewage reaches the drainage system – which is prohibited by law – and requires urgent handling of these breaches. This is essential for multiple reasons, including improving the quality and expanding the potential uses of stormwater.

Researchers and policy makers may reach different operative conclusions based on the findings of the above Israeli research. We recommend **adjusting the required quality to the planned use of the stormwater.** The quality required of drinking water is of course different from the quality of water intended for infiltration, and infiltration directly into the groundwater may require water of a different quality than infiltration through soil. We will illustrate the idea of 'adjusting the required quality' to the planned use by relating to the quality required for conserving ecological systems, such as stormwater flowing to a winter pool.

Samples were taken in mid-May 2018 from the winter pool of Herzliya Park, which is fed by urban stormwater, for the purpose of testing the water quality. The results indicated multiple coliforms and high concentrations of nitrogen. Prof. Avital Gasith, an ecologist and zoologist with expert knowledge in aquatic ecology, stated that winter pools are open bodies of water whose energetic basis (the fuel of the sustenance composition) is decaying organic material, mostly from the remains of vegetation from the previous year which have dried up during summer months. The pools are characterized by intensive decomposition by bacteria and fungi that unicellular organisms feed on, which in turn small crustaceans feed on. The concentration of oxygen in winter pools is usually around 70% of the saturation level and below, and near the bottom of the pool (where the concentration of organic material is high) there may even be a total lack of oxygen. The concentration of nutrients is also high – not as a result of contamination but due to the decomposition of the organic plant material (a situation similar to the peat in Israel's Hula Lake). Therefore, the concentrations found in the samples were indeed high, but entirely reasonable for an open body of water with no water flow, and consequently, no flushing of the volume of water. On the contrary, the pools dry out and the concentration of materials (and the bacteria!) continuously rises (characteristic of mid-May). The suitable criterion for evaluating the ecological health of winter pools is the biological diversity of the fauna and flora, which thrive in the pool of Herzliya Park. Numerous fowls frequent the pool and they too contribute to the bacteria, including to e-coli. Their presence in the pool attests to the good quality of its water (according to the criteria of a functioning winter pool). **Without bacteria, biological diversity in winter pools cannot be sustained**[5].

On the background of the above data and evidence regarding the quantity and quality of stormwater in Israel, we move to issues of managing stormwater in Israel.

1.3 Toward Sustainable Management of Stormwater in Israel

In the mid-1990s, we at the Technion – Israel Institute of Technology, began developing a Water-Sensitive Planning (WSP) approach. A simple definition of WSP is: urban and regional planning that takes water resources, their flow and management, into consideration. A broader definition of WSP: a field of research and practice that combines urban and regional planning of the built and open

[5] Taken from an exchange of emails (October 15, 2018) with Prof. Gasith and quoted with his permission. Prof. Gasith added: "My students and I 'waded' in many dozens of winter pools for the purpose of sampling, and we do not appear to have been harmed in any way."

environment with the management of water resources, for the benefit of humans – improving the residents' quality of life – as well as for the benefit of nature – protecting natural resources and ecological conservation. WSP deals with the diverse interfaces between urban and regional planning and considerations pertaining to water. **From the outset, the management of stormwater has played a central role in WSP** (Carmon & Shamir, 1997).

From the early days of WSP in Israel, its defining statement has been: **'Stormwater is a resource, not only a nuisance'**, and its preferred method was exploiting the stormwater close to the site of rainfall. At the beginning of the 21st century, **WSP development was adapted to the principles of sustainability** (Shamir and Carmon, 2007; Carmon and Shamir, 2010).

The WSP approach to sustainable management of urban stormwater gradually became more advanced and sophisticated and more connected to developments in this field in other countries, especially Australia, New Zealand and North America. One approach that we have found especially appropriate to the Israeli situation is **the 'Soft Path' to water** which, in recent years, has captured a central place in the general approach to developing and managing water resources, particularly in North America. As opposed to the engineering approach, which has been dominant throughout most of the 20th century, and the economic approach, which has taken over in so many fields toward the end of the century, the 'Soft Path' to water is a holistic, multi-purpose, multidisciplinary and sustainable avenue (Gleik 2002; 2003; Brandes and Brooks, 2007; Brooks, Brandes and Gutman, 2009).

On the basis of the above foundations we gradually developed a system of 12 planning principles and guidelines for action for Sustainable Stormwater Management[6], which are divided into two main groups: (1) General principles of sustainable development, which apply to sustainable stormwater management as well as to other areas of sustainability (such as sustainable transportation); and (2) Special principles and guidelines for stormwater management according to the WSP approach, which emphasize the differences between our Soft Path and the conventional drainage planning. For the detailed list of Sustainable Stormwater Management (SSWM) principles and guidelines, which are in line with the approach to stormwater management in Water-Sensitive Planning (WSP), the reader is invited to go to the final chapter of recommendations, section 5.3.

[6] The principles and guidelines were formulated over the course of approximately 25 years of research and numerous meetings with professionals, especially water and drainage engineers, landscape architects, ecologists and environmentalists. For information on WSP research and for a list of publications, see: https://naomi-carmon.net.technion.ac.il/research-fields/#Water-Sensitive and the last Appendix of this report.

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CHAPTER 2

ANALYSIS OF POLICY FOR PROMOTING SSWM (Sustainable Stormwater Management) IN ISRAEL

2.1 Background

During the last three decades, non-conventional practices for managing urban stormwater (runoff) have become an important topic among researchers the world over and in Israel as well. Due to water shortages worldwide and the rising importance of cities, there has been growing awareness of the value of runoff as a resource to be factored into urban development. This is evidenced by the emergence in many countries, including Israel, of more sustainable approaches to urban stormwater management including Water-Sensitive Urban Design (WSUD) in Australia, Sustainable Urban Drainage Systems (SUDS) in Britain, and Low-Impact Development (LID) in North America (Fletcher et al., 2015).

Many factors play a part in these developments, including rising populations, urban densities, and increased water demand, increased environmental awareness, and increasing risk of storm damage, exacerbated by climate change, in addition to urban sprawl with its attendant covering of land area by various types of impervious surfaces. The quiddity of conventional drainage approaches is that those applying them treat stormwater as a nuisance to be removed from the urban area as quickly as possible.

Sustainable management approaches see runoff as a multifunctional resource (Mitchell, 2006) with many potential benefits for society and the environment if managed wisely (Carmon and Shamir, 2010; Barbosa et al., 2012; Fletcher et al., 2015; Hering and Ingold, 2012; Makropoulos et al., 2008; Mitchell, 2006; Roy et al., 2008). In this part of the project, we use the term Sustainable Stormwater Management (SSWM) because it is a major component of Water Sensitive Planning (WSP)[7]. We also use the term runoff management which more closely aligns with the Hebrew term used for surface water draining in urban areas either due to storms (rain events) or from irrigation, mostly of landscaped areas. These terms denote approaches that depart from reliance on conventional urban drainage (see Table 1). We also refer to WSP in the latter part of the report since the policy analysis presented here focuses on Israeli cities where this term (in Hebrew) is more commonly used.

[7] SSWM is managed by the principles of WSP; in this chapter both are used interchangeably.

	Conventional urban drainage	Sustainable Stormwater Management (SSWM)
Attitude towards stormwater	control & remove; planning is based on data of extreme events.	a valued resource for humans and nature; living with water; planning is based on data of all stormwater events.
Goals	avoid flooding; avoid sanitation risks, in cases with combined sewage infrastructure; reduce topsoil erosion.	multiple: (i) water-related – increasing quantity & quality, flood mitigation & adaptation. (ii) ecological – protecting water-based ecosystems, reduced topsoil loss (iii) social – improving urban quality of life by supporting urban nature and water-based urban landscapes, reducing urban heat islands and creating recreational and educational opportunities (iv) economic – reducing infrastructure costs, increasing land value due to blue-green landscapes and attracting tourists.
Measures	rapid removal of runoff (in urban areas), mainly by constructed channels.	slowed runoff conveyance, detention, retention and infiltration; biological and mechanical quality treatment; dynamic management of flood plains; integration with conventional drainage as needed.
Professional roles & work process	drainage engineers work alone post land-use planning and architectural design	cooperation from start between various relevant professionals: i.e., urban planners, architects, engineers, landscape architects, ecologists.

Table 1 – Characteristics of conventional drainage and Sustainable Stormwater Management (SSWM) (adapted from Goulden et al., 2018)

In many countries and regions there is evidence of a gradual transition from conventional to sustainable stormwater management practice and various types of WSP (Chouli et al., 2007; Dhakal and Chevalier, 2016; Ellis and Lundy, 2016; Ferguson et al., 2013) as well as good reasons to accelerate this shift. As Karvonen (2011) notes, "Where conventional stormwater management focuses on the symptoms of large stormwater volumes, source control goes to the root of the problem to address development patterns and impervious cover that create these large volumes of polluted water in the first place" (p.18). Connecting between integrated urban water management and spatial planning provides a statutory basis and a means for spatial water management, for overcoming fragmented water governance (Mitchell, 2005) and for shifting the field of water management from a largely technical domain to one with broader professional and social considerations (Wiering and Immink, 2006).

Professors Carmon and Shamir developed the approach of Water-Sensitive Planning in the early 1990s in Israel, emphasizing the multiple objectives of stormwater management and the benefits of integrating water considerations, including the multiple objectives of stormwater management, into urban and regional planning (Carmon and Shamir 1997; 2010). To understand their work and our work, the development and history of water policy in the country should be presented.

As far back as 1959, Israel’s Water Law determined that all water resources are owned by the public (no private ownership of a water resource) and managed by the state. The guaranteed supply of water, first and foremost to agriculture, continued until the end of the 1990s, when water policy and resources were considered to be in "crisis" due to , among other reasons, a major depletion of Israel's underground water sources (Menahem 2001). During the 1990s a shift in water management occurred, influenced by general trends taking place in the country, particularly privatization and massive urban development which both had huge implications for the agricultural sector regarding water and land (Feitelson and Rosenthal 2012). To meet urban needs, significant changes were called for in laws, regulations and institutions to improve water management over time and space (Laster, Almog et al. 2009; Portman 2018). Attempts in the 1990s to reform the institutional structure of the entities administering the different laws led to several changes, including, in 1997, the consolidation of 26 Drainage Authorities who were responsible for 40% of Israel's land area into 11 dedicated Drainage Authorities covering the entire country.

Ten years ago, the Israeli government commissioned a study to identify problems with existing surface runoff management institutions (Sadan, Loventhal et al. 2011). Grave conflicts were identified in relation to the administration of three laws: the Rivers' Authorities Law of 1965, hereafter "the Rivers Law"; the Water Law of 1959, and the Drainage and Flood Law of 1957. Problems stemmed from the often conflicting goals of water management, particularly those promoted by authorities responsible for river "corridors" established by the River Law and by those responsible for stormwater drainage according to the Drainage and Flood Law which refers to "damaging" surface water without distinguishing between various local geographies. These problems highlight spatial conflicts (i.e., riparian municipalities fail to coordinate runoff management with the respective drainage authorities) and conflicting goals sought by mandated actions (i.e. drainage versus river ecosystem health).

Other reorganization efforts impacting the scale and scope of runoff and stormwater management policies and practices include amendments to the National Outline Scheme for the Water Sector (NOS 34). NOS 34 was originally approved only in 2003. The most recent two amendments of the original plan, NOS 34/B/3 and NOS 34/B/4, mandate regulations that promote WSP (Carmon and Shamir 2011). The first amendment, NOS 34/B/3, addresses the protection of rivers and streams with their multi-objective nature, including the drainage of stormwater. The second, NOS 34/B/4, requires that major city and neighborhood plans include "drainage" appendices that encourage storm water infiltration and retention, and prevent groundwater contamination (Portman 2018). Such appendices are required to include "to the extent possible" instructions for the use of surface runoff water (e.g. for irrigation, local landscaping, stream replenishment etc.) and to enable the use of public open space for retention and infiltration of runoff (NOS 34/B/4, Chapter D, §§ 22.1.1 and 22.1.2). In Amendment 4 of NOS34/B, although the term "drainage" was not replaced with "stormwater management" as experts promoting principles of WSP proposed, the definition of "drainage" was at least broadened to include myriad WSP objectives, such as replenishment of underground aquifers and runoff reuse for landscaping.

An influential policy document is the country's Long-Term Master Plan for the Water Sector (hereafter "Water Sector Master Plan"), which includes a special chapter on stormwater management. The chapter calls for the transfer of responsibility for managing runoff and drainage in urban communities to the municipal water and sewage corporations (Israel Water Authority 2012, p. 9). Yet as a non-statutory document, the Water Sector Master Plan lacks implementation authority.

In parallel to these advances, based mainly on the work of Technion researchers and also impacted by what has transpired in other parts of the world, Israeli planning institutions have promoted the idea of runoff harvesting through the publication of design guidelines for planners and developers (Ministry of Environmental Protection, Ministry of Construction and Housing, Ministry of Agriculture, 2004). Various municipalities have published guidelines of their own and new initiatives for standards have been prepared within various regulatory contexts. In practice, various small-scale projects have been proposed by urban planners and landscape architects addressing a variety of goals and relating to stormwater management on different scales.

A suggested new stormwater management law that adopts “non-conventional” objectives and principles has been discussed in the Knesset (Israeli Parliament) since 2010. It has not been approved, mainly because of conflicts of authority between the Ministry of Agriculture and the Water Authority. Meanwhile, several dozen projects that adopted the multi-objective approach has been planned and executed, but no systematic evaluation of their performance has been conducted.

2.2 Policy analysis

2.2.1 Methods

To understand how WSP and SSWM practices can be promoted and become widespread in urban areas of Israel, the policy component of this project analyzed factors influencing current implementation of SSWM.

A main source of data were a dozen semi-structured interviews, face to face or by phone, with leading Israeli professionals involved in stormwater management in various capacities: municipalities, regional drainage authorities, the Water Authority (part of the Ministry of National Infrastructure), researchers, and private professionals in the fields of engineering and planning. In addition, we reviewed national and local plans, laws, policy documents and professional guides (grey literature).

Interviewees were asked about changes in professional approaches to stormwater management; the existence of regulation, policies and other guidelines affecting their work; their perspective on barriers to implementation of these tools; examples of Best Management Practices (BMPs); and suggestions for their further implementation. We also conducted three focus groups on current practice and challenges in urban stormwater management, as part of the workshop attended by local authority officials and planning and engineering consultants (mentioned above).

We analyzed the data collected via interview as well as other sources using thematic analysis (Braun and Clarke, 2006; Joffe and Yardley, 2004; Vaismoradi et al., 2013). We applied deductive themes on the institutional conditions we expected would support SSWM according to existing literature (e.g. language and governance), and complemented these with themes based on topics identified as central to the development of stormwater management in the Israeli literature (e.g. professional collaboration and planning policy) (Laster et al., 2009; Shamir and Carmon, 2007; Water Authority, State of Israel, 2012).

2.2.2 Results

Following Scott (1995), Ferguson et al. (2013) and others, we used socio-institutional "pillars" to understand the transition to better management practices surveyed in the literature. We organized the findings and themes into three inclusive (and sometimes overlapping) groups representing the types of transitions made (see also Table 2): (a) cultural-cognitive shifts: changes in knowledge, attitudes and beliefs related to water, stormwater and sustainability; (b) normative shifts: changes in professional conduct and professional standards related to stormwater management, and (c) regulative shifts: changes in laws, statutory plans and governing bodies. In particular, we looked at the role of the system of urban and regional planning in these changes and its impact on socio-institutional elements that enable or restrict a shift towards WSP. For each group of factors, we present dominant changes found, an assessment of progress and its current limits which signifies the types of impediments and hurdles faced. Other impediments to WSP, not contained in the groups mentioned, include the lack of physical and climatic data that would allow detailed planning and accessible professional training and expertise to support existing national guidelines (Laster, Almog et al. 2009).

Cultural-cognitive	Research and knowledge-generation
	Attitudes to stormwater as a resource; associated policy goals
	Awareness of sustainability and urban sustainability
Normative	Professional guidelines and guides
	Professional training in SSWM
	Professional norms presented in practice
Regulatory	Relevant laws
	National masterplans and statutory outline plans
	Legal responsibility and governing bodies for water management at national and municipal levels

Table 2.1: Categories of socio-institutional "pillars"

The findings are presented below in table form, followed by a detailed narrative by category.

	1990s and before	2000s	Since 2010
Cultural-cognitive	Strong public awareness of water scarcity since early days of the State Growing awareness of sustainable development including government decisions Academic research into new modes of stormwater conservation emphasizing water quantity and infiltration to groundwater	Drought periods (1999-2001, 2004-2011) strengthen interest in new water sources including, among other, stormwater conservation Rising environmental awareness in Israel among decision makers and general public expressed for example by over 100 NGOs under "Life and Environment" umbrella organization Academic research emphasizes environmental, economic and social goals of stormwater management in addition to hydrological goals	Discourse of multi-goal stormwater management reaches wider circles of various professions as well as national and local decision makers; concentrates on infiltration into the ground Research emphasizes ecological and environmental benefits of sustainable stormwater management and the central role of planning and landscape architecture in implementing SSWM Large-scale desalination in Israel reduces policy and professional imperative for investment in alternative freshwater sources
Normative		Landscape architects and a few drainage engineers adopt Sustainable Stormwater Management discourse and several practices, mainly via professional forums. Guidelines on water-sensitive planning and stormwater management issued by two of the six regional planning committees. Ministry of Construction & Housing with other ministries published guide for practitioners on "runoff-conserving planning and construction" (2004) with emphasis on infiltration.	Landscape architects carry out projects on neighbourhood and urban scales integrating a range of practices of stormwater management Drainage engineers prepare drainage appendices for large construction plans (as required by the National Outline Plan), beginning to integrate urban planning with stormwater management, but note the lack of professional best practice guidelines
Regulative		Water Corporations Law (2001) regulated and privatized city water & sewage management, making it more efficient, while SW remained a part of municipal responsibility. National Outline Plans – the highest level of the planning system – adopted (2006&7): 34/B/3 on streams and drainage; 34/B/4 on water retention and infiltration for groundwater enrichment and protection.	National Masterplan for the Water Sector (2010) adopts some basic principles of SSWM Proposed revision to Drainage Law submitted to Parliament (2013); still under discussion; recognizes stormwater as a resource and its multiple goals

Table 2.2: Summary of socio-institutional changes in stormwater management in Israel over time and by socio-institutional 'pillar'

2.2.2.1 Group One Factors: Cultural-Cognitive Changes

These include growing ***awareness and knowledge*** of runoff issues and sustainable management of runoff within urban areas and ***changes in stormwater management definition and priorities*.** Frequent droughts and water scarcity awareness (Menachem, 1998) make it impossible to prescind water management from national consciousness. In 2010, a special government investigative committee was created for the management of the water sector and gave clear recommendations for the exploitation of alternative sources, including building and planning practices to encourage infiltration of runoff. The committee's work made use of research published earlier (in the 1990s as mentioned) which highlighted the relationship between stormwater quality and quantity in Israel and development practices (Asaf et al., 2004; Goldshleger et al., 2015; Kronaveter et al., 2001). The recommendations included proposed goals for water-sensitive planning and policy, and planning recommendations in the context of Israel (Carmon and Shamir, 1997; Meiron-Pistiner et al., 1996).

In parallel there has been growing awareness of environmental degradation and sustainability issues in Israel over the past two to three decades which has led to significant government decisions and to rapid growth in the size and diversity of environmental non-governmental organizations (Tal et al., 2013). Some of these activities, and pressure from environmental activist groups, led to the creation of government-backed voluntary 'green building' and 'green neighborhood' standards which include some criteria for runoff conservation. Some major cities have also become more active in establishing environmental policy commitments (Goulden et al, 2016) and integrating nature into the urban domain. These changes provide a supportive context for raising awareness of runoff management as a component of urban sustainability; however, such changes vary widely between municipalities. While this is evidence of cultural-cognitive change, some local officials reported that the public is not always on board with experts. As an example, some members of the public see projects involving retention of water as unnecessarily risky due to the likelihood of standing water which serves as a breeding ground for mosquitoes and could cause drowning accidents.

We based our findings of changes in ***runoff management definition and priorities*** mostly on accounts from local authority officials. They determined that professional practices mostly focus on infiltration at the micro (plot-scale) level. At the same time, landscape-based stormwater projects are being developed in several cities and are driven by the landscape and ecological value derived from water-based parks and increased flood resilience. According to one municipal landscape architect, the national outline plan requirement for permeable surface area wasn't considered relevant to their local environment or geological conditions, but they used the requirement, in the absence of any other, to require greater use of vegetation in local planning proposals. This suggests that there is an interest in implementing WSP practices but a discrepancy between current planning requirements and municipal understanding of stormwater management priorities.

Another impact on the priorities for implementation of WSP is the increased dependence on desalination. A succession of ten government decisions from 1999 to 2008 approved the establishment of desalination plants, rising from a single tender for 50M m^3 capacity in 2000, to a decision in 2008 to produce 750M m^3 by the year 2020. Desalinated water now accounts for approximately 50% of freshwater supply in the country (Water Authority, n.d.). This change, and those mentioned above, supports the finding that while a cultural-cognitive shift towards sustainable stormwater management would imply a taken-for-granted plan of action, the goals associated with WSP are still shifting.

2.2.2.2 Group Two: Normative changes

The first of these involves ***professional standards with regard to planning and runoff management practices*** which occurred mostly from 2010 onwards, with guidelines adopted within the planning system. The Regional Planning Committee of the country's Central Region adopted guidelines on water-sensitive planning in 2000, having witnessed conflicts between the Planning and Building Law and the Drainage Law (O. Cafri, pers. comm., 22.3.17), as did the Tel Aviv Regional Planning Committee in 2004. Recommendations from the Ministry of Environmental Protection and from an inter-ministerial committee for "stormwater-conserving construction", established in the year 2000, led to the development of stormwater guidelines in other regional and local planning committees, with a particular focus on encouraging infiltration to replenish the coastal aquifer (Shamir and Carmon, 2007). In 2004, the Ministry of Construction and Housing together with the Ministries of Environmental Protection and of Agriculture published a professional guide to runoff-conserving construction, even though little budgetary emphasis was placed on its dissemination.

A change in the professional approach ***(i.e., professional "conduct")*** taken towards runoff management also occurred. For example, a training workshop for drainage authority employees (established following the redrawing of drainage authority boundaries in 1996) emphasized the connection between stream restoration programs and runoff management. From around the year 2000, after dissemination of the workshop program, there was a gradual change in terminology among participants from "drainage" to "runoff management", and incorporation of sustainability terminology that made WSP hard to ignore. The workshop created a broad informal professional network and shaped wider discourse.

Some interviewees emphasized the role of individual professionals, e.g. engineers, landscape architects or municipal officials, who subscribe to WSP. These professionals recalled their insistence that runoff management be integrated into design. They also recalled their unwillingness to take part in projects where drainage solutions would simply be calculated and added post-design. A notable example of this integration in practice is a runoff management plan prepared in 2013 as an appendix to the Tel Aviv-Jaffa drainage masterplan, proposing landscape-based alternatives to additional drainage infrastructure.

Websites of landscape architects and drainage professionals also offer consultations regarding SSWM, indicating its entry into more general professional conduct, yet mostly with an emphasis on infiltration. Finally, an emphasis on WSP from a normative perspective is not widely found in academic education programs in planning and engineering. Thus, integration of WSP, while occurring, is taking place at a slow rate and in the next decade may still be limited. This highlights the importance of the Water Sensitive Planning class taught for the first time at the Technion in Spring 2017.

2.2.2.3 Group Three: Regulatory Changes

As mentioned, the key regulative tool relating to runoff management is the 1957 ***Drainage and Flood Protection Law*** wherein "drainage" is the managing of runoff defined as: “water that endangers or may endanger agriculture, public health, development of the country and the functioning of necessary services”. In the law, streams are drainage conduits without ecological or landscape significance. A proposed amendment, which has been under public and formal consideration for close to 20 years, includes a change in terminology from ‘drainage’ to ‘stormwater management’ which would acknowledge the rich potential benefits of runoff. The proposed amendment would also clarify the division of responsibility and funding between specific relevant authorities. An advanced revision has been on the table of a Knesset committee since 2013, stalled by disagreements over the responsibilities of different authorities. As reported in grey literature and confirmed from the in-depth interviews and comments collected during the workshop, significant decision-making power is still in the hands of the agrarian sector which results in the highly entrenched and problematic division of responsibility between regional drainage authorities and the municipalities (Sadan, Loventhal et al. 2011; Becker and Ward 2015).

National Outline Plans and Masterplans have the potential to promote WSP practices in urban areas. As described above, two new National Outline Plans (NOPs), related respectively to stormwater and to rivers, incorporated a change in approach. The Outline Plan on “streams and drainage” (NOP 34/B/3) guides planning in the proximity of streams to maintain viable drainage routes and landscape and ecological functions. A second one, Outline Plan (NOP 34/B/4), sets out to create a planning framework for enriching and protecting groundwater, while reducing flood damage, via water retention and infiltration to aid the conservation and use of surface runoff. Its specific requirements focus mainly on infiltration of stormwater into the ground in order to enrich groundwater, at the individual plot level (requiring 15% penetrable surface area on every plot) and at larger drainage installations outside the city. The plan also requires large development plans to include a drainage addendum approved by the relevant regional drainage authority.

NOPs 34B/3 and 34B/4 were described by practitioners and public officials interviewed as a significant change because they created the first formal connection between the Planning and Building Law and runoff management, supporting both infiltration and stream restoration. Respondents noted positively the steadily increasing numbers of plans sent to drainage authorities for approval as stipulated by the NOPs. However, previous evaluations have shown that the implementation of the NOP lags behind expectation, because of a lack of enforcement and professional expertise required for successful evaluation and also because planning committees can opt to exempt certain plans of this requirement (Laster et al., 2009; Geldman, 2012). A further limitation (indicated by review of the plans and other documents, such as the guidelines published by the Ministry of Construction and Housing (2004)), is a focus on infiltration of water into the ground as the sole practice with a parallel lack of capacity of planning committee members to monitor compliance. Limited training and education of professional staff contributes to this problem.

The chapter on stormwater in the Israel Masterplan for the National Water Sector, written by Carmon and Shamir and submitted to the Planning Division of the Water Authority at the Ministry of National Infrastructure, is the first formal document to introduce the ensemble of water-related environmental, social and economic goals as crucial to WSP. The chapter (Water Authority, 2012; Carmon and Shamir, 2011) calls for multi-disciplinary work from the initial stage of each development plan, alternative professional training, and coordination of urban and basin-level runoff management via watershed-level master plans. It also includes a series of administrative recommendations regarding the division of labor between the relevant authorities. Yet, unlike the NOP's mentioned above, this masterplan is not statutory. Although categorized as a regulative tool, its main impacts are on awareness of the paradigm change (the cultural-cognitive component) and on pushing towards changes in professional conduct and professional standards (normative component).

The Israel Water Law determines ***public ownership and national and municipal responsibility for managing all the water in the country*****,** above as well as below ground, and it establishes water as a public resource. Centralized control has enabled national management of water resources (Rubin et al., 2006), including construction of the national water carrier for distribution to arid areas in the 1960s and county-wide desalination infrastructure in the early 2000s (Tal, 2006). Yet this public ownership of all water in the country is a barrier for local entities wishing implement WSP practices, such as infiltration. Implementation of localized management priorities would require substantial changes to this situation (Rubin et al., 2006).

The requirement in NOP 34B to submit drainage appendices to drainage authorities for approval, for large new urban development plans, attempts to overcome this urban/rural fragmentation. The proposed amendments to the Drainage Law also allocate broader responsibilities to the drainage authorities and require preparation of basin-based masterplans to coordinate runoff management between municipal and rural authorities. Informants noted that the drainage authorities could be a significant actor in promoting WSP practices, but several of them currently lack the professional leadership and resources needed to fulfil this role.

Runoff management is also less organized than other water resources. In 2001, the_***Water and Sewage Corporations Law*** was passed with the goal of increasing efficiency of water supply and wastewater management. It established a closed financial loop so that revenues from water provision would increase investment in water infrastructure (Water Authority site, undated; OECD, 2011). In all but two municipalities in the country, drainage was not included in the remit of the new corporations and it has continued to be handled by the municipality. Interviewees noted that in many cases there is no clear stormwater policy, nor a department with the oversight and budget to bring about a change in policy.[8]

Finally, at the regional level, interviewees articulated jurisdictional problems that create barriers to integrated management and impediments to implementation of WSP, including the disconnect between urban runoff management goals and those of the 11 river basin authorities created in 1996. Furthermore, municipal handling of drainage is disconnected from the national authorities responsible for research and policy, such as the Ministry of Agriculture and Rural Development and the Water Authority.

2.3 Discussion and conclusions

The aim of this section of the research and this chapter of the report was to map and then analyze the socio-institutional changes over time affecting the implementation and adoption of WSP and SSWM practices in Israeli cities. Using the analytical framework, we explored changes that have taken place, emphasizing the role of urban and regional planning.

The socio-institutional context for implementation of WSP (Water-Sensitive Planning) and SSWM (Sustainable Stormwater Management) in Israel has changed substantially over the past twenty years. The main change is in awareness and discourse among relevant decision-makers and professionals, especially among landscape architects and also water engineers, with acceptance of the idea that stormwater is a resource and not only a hazard. However, the 1957 Drainage and Flood Prevention Law, which defined stormwater as harmful water, and is aligned with an agriculturally dominated approach (Feitelson, 2005; Menahem, 1998), is still in effect. The revision to this law proposes to replace the term 'drainage' with 'stormwater management', and to exchange the negative definition of stormwater with recognition of its benefit to people and nature. Moreover, the urban and regional planning system has adopted the basic idea that stormwater is a valuable resource and it has assisted the transition towards SSWM by including stormwater management stipulations at certain stages of the planning process. However, the transition is far from complete. Attitudes in favor of SSWM are common in only certain policy and professional circles and are limited by administrative barriers and low public awareness. Furthermore, in both new regulation and in practice, infiltration of stormwater for groundwater enrichment is the dominant approach, while adoption of broader goals and practices of SSWM are advancing far more slowly.

What prevents SSWM practices from entering mainstream planning and development practice? International experience has shown that for sustainable runoff/stormwater management to be widely accepted, advances in professional and academic knowledge need to be complemented by a range of social and administrative changes. This coincides with water management and policy literature that suggests that to understand the factors influencing water management on the

[8] A unique case is Rishon Letzion's runoff management handled by the local Water and Sewage Corporation. This corporation manages artificial stormwater-fed lakes in the city, to enrich groundwater and provide a source of pumped irrigation water for neighborhoods, with the lake serving as a popular recreation area.

ground it is necessary to go beyond analysis of policy to look at broader institutional elements such as professional expertise and cooperation, discourse and administrative changes (e.g. Brown and Farrelly, 2009; Ferguson et al., 2013; Rogers et al., 2015).

Generally, **there is a lack of public awareness of the potential role of stormwater management for achieving sustainability**. In many cases, surface runoff water is still seen as a hazard within cities. As Morison and Brown (2011) contend, local-level policy commitment to stormwater management may be a phenomenon of “policies without publics” (p.84) where **there is no direct interest in the issue, unless related directly to personal harm**. Yet there is a strong interest in water conservation in many cities, especially in arid environments, like Israel, west Australia and the southeastern US. The emphasis on groundwater replenishment research, carried out in the 1990s in response to concerns over groundwater shortages (e.g., Kronaveter et al., 2011; Katz et al., 2001), reflects this concern. The recommendations and policies developed emphasized infiltration (for example, the permeable surfaces requirement within the national outline plan on water management). This leads to one of our findings regarding impediments, indicating **overemphasis on one particular WSP practice – infiltration into the ground** .

In the 2000's, Israel experienced rapid development of desalinated water as a major water source. This change has reduced concerns over enough drinking water, which previously dominated national policy (Teschner et al., 2013), leading to less interest in alternative water sources that WSP could provide. As a result, the promotion of WSP needs to rely on other societal and environmental goals and consensus around them. In other words, **the time has come for what Mitchell (2006) describes as a “multifunctional” strormwater management that is directed to economic, ecological, social and hydrological goals**.

Different professional groups who are expected to work together may understand new water management paradigms in different terms, as found by Wiering and Immink (2006) in relation to new discourses on ‘accommodating water’ in Dutch spatial planning. In our case, **landscape architects serve as examples of those driving SSWM projects**. While this trend may lead to a greater number of landscape-based BMPs, **drainage engineers and city planners need to be involved to bring about systemic changes**.

While the redrawing of river-basin authorities in 1996 was a positive step, **the strict division between these regional drainage authorities and ‘islands’ of local authorities and municipalities responsible for urban drainage** (as described in Laster, 2012) **is a barrier** to the implementation of coordinated SSWM, because it relies on goodwill cooperation between different authorities with myriad interests. **Stormwater management in planning and development lacks a "parent authority"**. **Changes in policy, approach and discourse evident at the national and regional levels**, as already described here, **have hardly extended to the local level, where initiatives are – in most cases - piecemeal and not nationally driven**.

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CHAPTER 3

STORMWATER MANAGEMENT IN CITIES OF ISRAEL: STATUS REPORT

3.1 Introduction

This Status Report is based on two main sources of information. First, on what we learned from interviewing relevant municipal officials and stormwater professionals, as part of our field work reported in the previous chapter and the next chapter. Second, on analysis of three focus groups and questionnaires completed by their participants, as part of a special workshop organized by the research team in March 2017 at the Center for Urban and Regional Studies in the Technion.

The goals of the special workshop were: (a) to disseminate existing knowledge of stormwater management among Israeli professionals, mainly those who work for municipalities, and (b) to collect information about the status of stormwater management in the cities of Israel. . Invitations were sent to a few dozen city engineers and architects, to those responsible for stormwater management in the municipalities and to selected researchers and practitioners.

The first part of the workshop consisted of introductory lectures by Prof. Tal Alon Mozes and Dr. Yaron Zinger and a series of six lecture presentations. Prof. Naomi Carmon presented the concept of SSWM - Sustainable Stormwater Management within the framework of WSP - Water-Sensitive Planning, as developed by Technion researchers since the 1990s. Nadav Shapira, an MSc student, presented the evaluation model for urban parks that include stormwater management practices developed in his thesis; landscape architect Rachelle Wiener reviewed three cases of WSUD designed by her office at various scales and in different geographical regions. Architect Naomi Angel, former Chief Planner of the Tel Aviv district, presented five urban schemes that integrate SSWM, emphasizing a number of principles based on her many years of experience. Engineer Dov Bogyesky discussed the unique example of the Rishon-LeZion stormwater lakes which include a retention pond, a pond for infiltration and pumping from ground into a public irrigation system. Keynote speaker Prof. Liat Margolis, Head of The Green Roof Innovation and Testing Laboratory at Toronto University, presented three case studies from Greater Toronto; these studies integrate green-blue infrastructure into urban planning and regeneration projects, and simultaneously, achieve ecological, social, and economic goals.

In the second part of the workshop, the participants were divided into three roundtable focus groups. Each group discussed both the status of SSWM in the Israeli cities they were familiar with, and the barriers to advancing its implementation. First, each participant was asked to complete a questionnaire that dealt with both subjects, and then a general discussion was conducted, summarized by graduate students. The summaries and the answers to the questionnaire were analyzed and added to the other sources to create the following report.

3.2 Status Report: Stormwater Management in Israeli Cities

This concise summary of what we learned about the current state of stormwater management in Israeli cities is organized in two sections, by the two main subjects of the workshop and the questionnaires. First, how stormwater is managed in the city, including awareness and implementation of principles and guidelines of Sustainable Management of Stormwater (SSWM) in urban planning and development; and second, the main impediments to implementing it.

3.2.1 Municipal stormwater management

- Most cities have not developed clear policy and written guidelines on stormwater management – the representatives of only one participating municipality reported having a written policy and guidelines. Three municipalities reported that they are working on issuing written guidelines, and the other municipalities do not have a clear policy nor written guidelines.
- Usually, cities do not have master plans for urban stormwater management.
- The Drainage Authorities (regional authorities with professional workforce) have been identified as a central actor, which may potentially be able to influence the sustainable management of urban stormwater, but they do not actually influence what is happening in the cities within their basins.
- Municipalities situated at the lower section of a river often suffer from flows arriving from the higher sections, due to deficient planning and/or lack of basin coordination.
- In many cases, municipalities have not appointed a single entity with the authority to deal with all aspects of stormwater management. As opposed to water and sewage, which are presently managed by the Water and Sewage Corporations, stormwater management is handled by different bodies in different cities. Moreover, at times it is split between several departments within the same municipality, including the infrastructure department, the channeling or drainage department (teul in Hebrew), and the department responsible for enhancing the city’s appearance (Shefa- - Shipur Pnei HaIr).
- Fear of flooding is still the main, and frequently the only, reason that municipal authorities engage with stormwater management.
- For the few cities that engage with stormwater management beyond flood mitigation, with the aim of turning stormwater from a hazard into a resource, in most cases this is limited to the practice of infiltrating stormwater into the ground. .

3.2.2 Impediments to implementing a sustainable policy and planning approach

- **Lack of familiarity with the principles of the sustainable approach to stormwater management** – The idea that “stormwater is a resource, not a nuisance" has been recognized by many of the relevant officials, and certainly by most professionals in the field, as has the goal to replenish groundwater by infiltrating stormwater into the ground. Yet the potential of SSWM to advance social and environmental-ecological goals as well as the possibility of reducing drainage costs through green infrastructures, is either not well known or considered impossible to achieve.

- **TAMA (National Outline Plan) 34 B/4 presently comprises a barrier to sustainable management of urban stormwater** – The National Outline Plan has delivered a message that stormwater is a resource and that it must be used to replenish groundwater. However, its emphasis on infiltrating stormwater into the ground has attracted so much attention that its brief mention of the wider goals of stormwater management, directed by the principles and proponents of Water-Sensitive Planning, are largely ignored.
- **There is no clear division of responsibility or coordination between the Drainage Authorities and the managers of stormwater within cities.**
- **Lack of awareness of the general public about the potential for stormwater to be a resource with benefits for individuals and the general population** – this results in frequent public objection to projects involving water retention.
- **Shortage of professionals with the proper training** – training in sustainable stormwater management is lacking, particularly among water and drainage engineers; it is more widespread among landscape architects.
- **Lack of economic/financial incentives to those willing to invest in conserving and utilizing urban stormwater** – no incentives are given by the central authorities to the municipalities, nor by the municipalities to residents, to provide a beneficial solution for stormwater in their jurisdictions; no charge is imposed on projects that burden the existing drainage system.
- **Finally, to address the one SSWM goal that has been widely recognized – replenishing the aquifer by means of stormwater infiltration – the main impediments reported by the participants of the workshop and field work are:**
    - Lack of clear planning guidelines, particularly for the appropriate flood return periods for various types of land use: 5, 20 or 100 years.
    - Public complaints in winter due to concern about mosquitos and risks of drowning in retained water, and in summer because of the dry appearance of stormwater-fed landscapes.
    - Lack of hydrological consulting on which locations are suitable for infiltrating stormwater, and which are not.
    - No consideration of the difference in quality of stormwater flowing from different land uses: residential, roads, industrial and agricultural.
    - Gaps between what is planned and what is executed.
    - Infiltration pits frequently become blocked or clogged; maintenance work is required yet there is no awareness of the need and/or no budget allocated for such maintenance.
    - No enforcement – commonly a lack of verification that the work being executed is compatible with approved plans, and no enforcement over time.

CHAPTER 4

EVALUATION OF URBAN OPEN SPACES THAT INTEGRATE PRACTICES OF SUSTAINABLE STORMWATER MANAGEMENT (SSWM)

This chapter focuses on green-blue projects: projects involving urban open spaces that integrate elements and practices of stormwater management. Theoretically and practically, it relates to the emerging field of Green Infrastructure (Benedict and McMahon, 2002; Gill et al., 2007) and to the Soft Path to water and water management (Gleik 2002; 2003; Brooks, Brandes and Gutman, 2009).

The first part of the chapter presents an evaluation tool developed within the framework of this research, while the second part presents the findings of applying the evaluation tool to selected cases.

4.1 An Innovative Tool for Performance Evaluation of Green-Blue Projects:

We decided to develop a new performance evaluation tool that enables: (a) evidence-based and integrated evaluation of practices of landscape design and those of stormwater management; (b) measurement that is user-friendly, is not lengthy nor costly; (c) effective communication with various stakeholders, including non-professionals.

The development of the tool is based mainly on Sustainable Development goals (see below). The tool emphasizes benefits to human beings and nature, although dis-benefits/costs are also considered.

The methodology for the evaluation stage of the research included the following steps:

- ***Selecting bundles of goals for evaluating the performance*** - Adopting the principle of sustainable development led us to start with the three basic bundles of goals, the three "core elements" of sustainable development accepted by the UN (UN resolution 2018): environmental-ecological goals, social goals and economic goals. Our focus on SSWM caused us to add to the 'classic' three a fourth bundle: hydrological goals.
- ***Selecting goals/potential benefits*** – three to five goals/potential benefits were selected for each bundle, based on 25 years of research into WSP (Water-Sensitive Planning) and SSWM (Sustainable stormwater Management) at the Technion (see above section 1.3 and the list of publications below, in the appendix to chapter 5), with a few recent additions (Shapira 2018). The result of this selection is presented in the table below.

Hydrological goals/ benefits	Ecological-environmental goals/benefits
• Stormwater harvesting for various uses • Aquifer recharge • Mitigating urban floods	• Improving stormwater quality before it reaches receiving water (aquifer, river, lake, sea) • Biodiversity support • Rehabilitating/conserving wet ecosystems • Soil conservation
Social goals/benefits • Making places for leisure time and recreation • Enhancing nature in the city • Enhancing aesthetics and visual landscape qualities • Education for sustainability and good citizenship • Social involvement and community development	**Economic goals/benefits** • Financial benefits for the municipality • Increased value of proximate real estate • Economic opportunities in proximity of blue-green landscape

Table 4.1: Four bundles of goals/benefits for evaluation of green-blue projects: urban parks with stormwater management practices

- ***Selecting green-blue cases/projects*** – We selected the projects for evaluation from a group of green-blue projects, defined for the purpose of this research as landscape urban projects that include elements of stormwater management. We opted to focus on **projects in cities along the coastal plain in the center of the country** – Netanya, Kfar Saba, Herzliya, Tel Aviv, Holon and Rishon leZion, plus one from Jerusalem. This choice was driven by the decision to reduce variability within the basic conditions of the selected projects and the dominance of the coastal aquifer in the Israeli discourse on urban stormwater management. We selected **projects with different scales**, as expressed by the size of the stormwater catchment areas, **with a variety of stormwater management functions** - stormwater slowed conveyance, detention and retention, harvesting for various uses, infiltration into the ground and purification (by natural soil or artificial mechanisms), **and a variety of stormwater practices** - winter pools, stormwater reservoirs/lakes, limans (depressions in the soil, with trees), terraces, concave lawns, sedimentation basins for purifying stormwater, green channels for conveying stormwater, biofilters, rain gardens, green roofs, infiltration pits, infiltration through sandy soil and permeable ground cover. The green-blue projects selected according to the above typology are presented in Table 4.2.
- ***Data collection*** – Because implementation of the tool is intended to be evidence-based but not lengthy nor expensive, we decided to base the data collection on two main sources: first, available documents that may differ from project to project, such as plans of the various professionals, related internet sites, ecological studies and visitors' surveys; second, semi-structured interviews with project planners, designers, engineers, and ecologists who were involved in the project, relevant municipal officers and maintenance persons. In a few cases we also used brief interviews of on-site visitors.

- ***Data analysis*** – The collected data is organized in text with illustrations. The text presents the project within its urban and geographical context. It briefly tells the story of the project's planning and construction and then describes in words and photos the stormwater practices used and the performance of each of the goals, as extracted from the interviews and the documents mentioned above. This part of the analysis ends with a summary table, organized by goals and potential benefits (see the tables in section 4.3).

- ***Performance evaluation (grading by stakeholders(*** – At the center of the analysis stands a stakeholders' workshop for performance evaluation of each selected green-blue project. The participants in the workshop were professionals (sometimes also students of the relevant professions), decision makers (frequently municipal officials) and public representatives. They received the text with illustrations described above, together with the summary table. They were asked to review the results and use them to grade from 0 to 4 the level of performance of the project for each potential benefit within each of the four main bundles of goals. The final grade is either a number reached by consensus among the participants (preferred) or the average grade rounded to the closest whole number.

- ***Presentation by pie radar chart*** – To present the results of the evaluation process we developed an Excel tool that produces a pie radar chart with the results of the performance evaluation. A radar chart is useful for visualizing performance analysis data, which involves comparing multiple properties – in this case, goals and benefits - side by side.

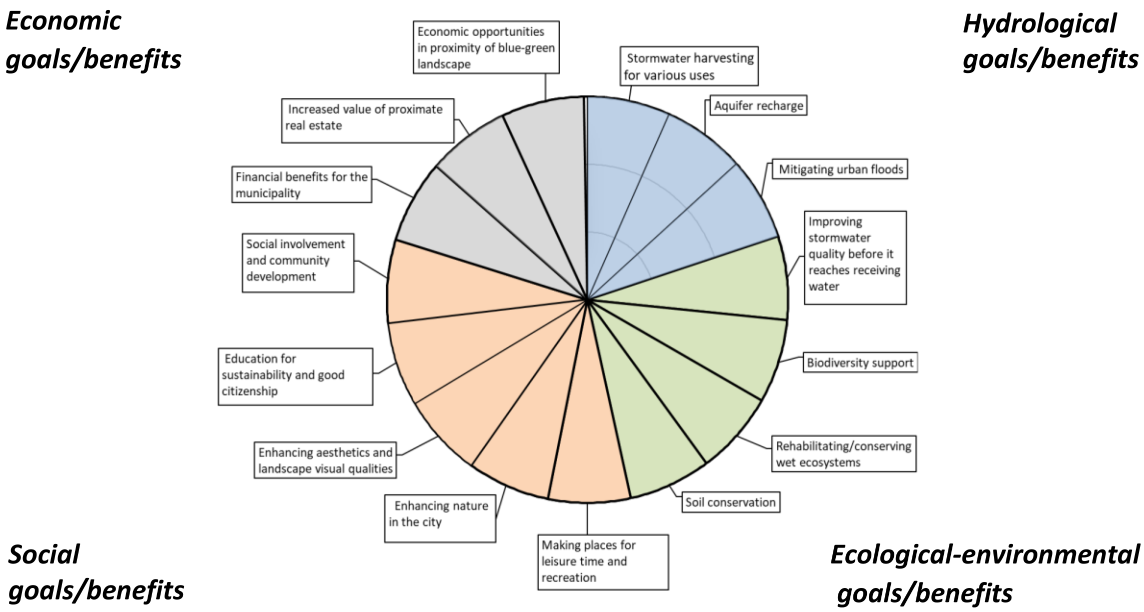

Fig 4.1: The four main bundles of goals (different colors), each with its goals/benefits in one pie chart; no grades, equal weight

- ***Possible weighting*** – The tool enabled participants at the workshop to give a different weight to each bundle of goals or specific goals/benefits, according to the importance they ascribe to each of them. For example, representatives of environmental agencies might prioritize blue or green benefits, while city officials might give precedence to economic or social benefits. The tool multiplies the grade by its weight and provides a new easy-to-perceive picture of the goals achieved in a pie radar chart, a picture that takes into consideration the priorities of the various stakeholders.

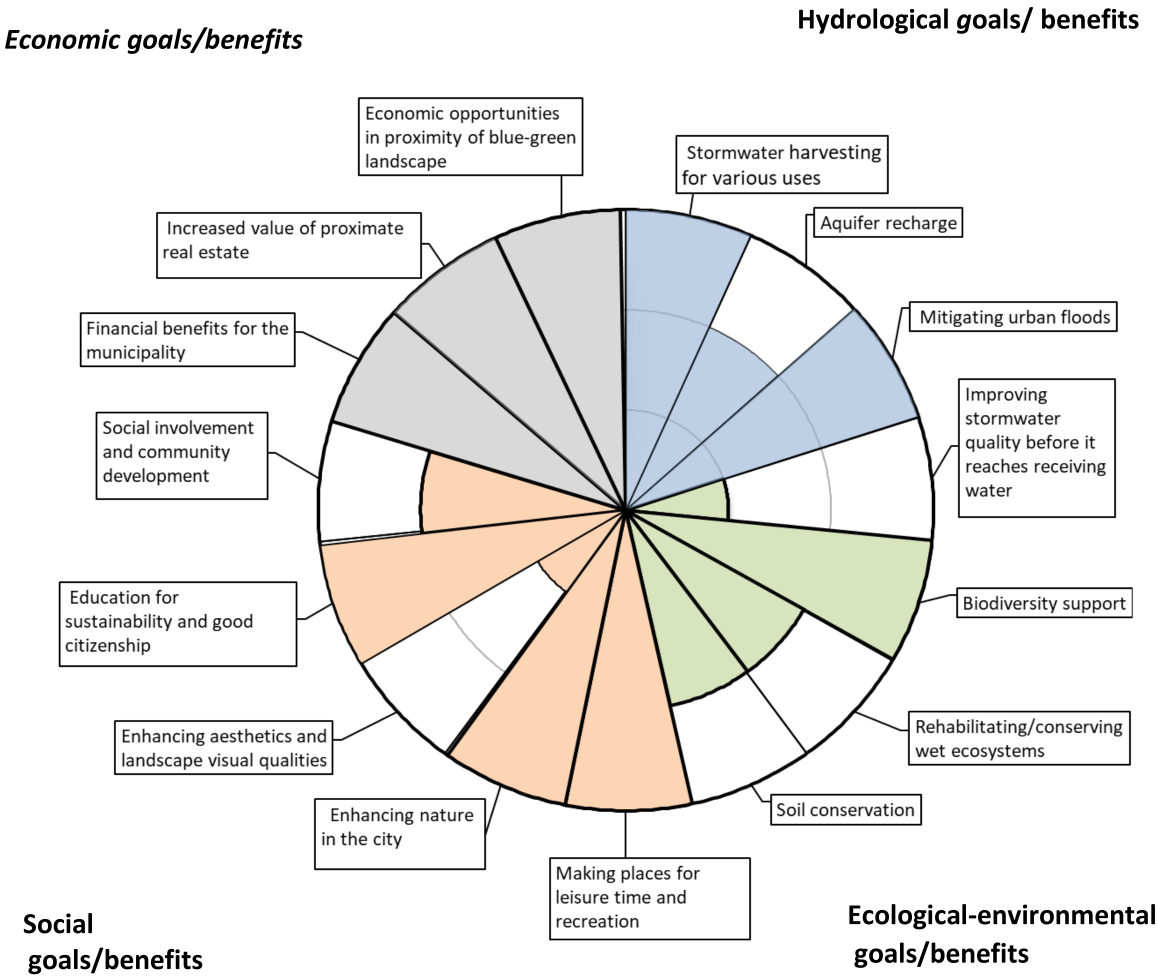

Fig 4.2: The four main bundles of goals (different colors), each with its goals/benefits in one pie chart; different grades and same weight to each goal

4.2 Results of the Performance Evaluation

The results are presented in this chapter case-by-case, summaries of the evaluation of each of the nine selected cases. Eight of the nine are above the coastal aquifer. They differ in their spatial scale and the functions of stormwater management that were found in them, as seen in Table 4.2.

City	Name of Project	Spatial Scale[1]	Retention [2]	Detention[3]	Flow moderation[4]	Quality improvement[5]	Infiltration into the ground[6]	Direct advantage of Stormwater[7]
Rishon-LeZion	Ha'Agamim Park	Multi-city						
Jerusalem	Emek Ha'Zvaim	Several Neighborhoods						
Herzliya	Herzliya Park	Several Neighborhoods						
Kfar-Saba	Kfar-Saba Municipal Park	Several Neighborhoods						
Holon	Neot Shoshanim	Neighborhood						
Netanya	Dora winter pool	Neighborhood						
Kfar-Saba	The Green School	City block						
Tel Aviv	Porter School	Building lot						
Kfar-Saba	Biofilter Kfar-Saba	undefined						

Table 4.2: Nine studied projects by spatial scale and function of stormwater management

1- By size of catchment basin.
2- Retention - Holding stormwater without release.
3- Detention – Temporarily storing stormwater.
4- Flow Moderation - Slowing stormwater flow.
5- Quality improvement - Reducing stormwater pollution by natural or man-made means.
6- Infiltration into the ground - Deliberate infiltration, dispersed or concentrated.
7- Direct advantage of stormwater - Using stormwater for various human and ecological purposes.

4.2.1 HaAgamim (The Lakes) Park, Rishon-LeZion (1999 and onwards)[9]

Park HaAgamim is situated in the western part of the city Rishon-LeZion. The project is integrated into the western metropolitan recreation area of the central district. The metropolitan recreation area is 1,970 dunams (approximately 487 acres), and the area of the park is 1,440 dunams (approximately 356 acres), which includes the lake inside the Superland complex and HaNakik Lake. In recent years, commercial and leisure activities have been taking place in the park, and it also boasts landscape attractions.

The total area of the park's drainage basin is 23,000 dunams (approximately 5,683 acres). It drains the cities Rishon-LeZion, Bat-Yam and Holon through a drainage system. The lakes are situated on impermeable clay soil, with the exception of part of HaNakik Lake, which is situated on permeable kurkar (eolianite). The water that collects in the Superland lake is pumped into HaNakik Lake where it infiltrates the soil and is repumped from a shallow well to irrigate the parks in the western part of Rishon-LeZion. The park was planned by the H. Cahanovich and Miller & Blum landscape architecture firms.

Fig. 4.2.1.1: Scheme of the Superland park, Landscape architect H. Cahanovitz.

Fig. 4.2.1.2: Superland lake, (photographed by N. Shapira)

[9] For a detailed analysis of the project, see Shapira, N., annotation 1

Goals/benefits		SSWM practices contributing to the achievement of goals / benefits	Assessment	Score (0-4)
Hydrological	Mitigating flooding	The lake at Superland and HaNakik Lake	The project does not include practices for mitigating flooding.	0
	Recharging the aquifer	HaNakik Lake	Urban stormwater management in the project recharges the groundwater at approximately 2M m^3/year. Approx. 1.3M m^3/year remains as groundwater after pumping stormwater for irrigation and can be used by the city to meet emergency needs.	4
	Harvesting stormwater for various uses	HaNakik Lake	All the open public spaces in western Rishon-LeZion are irrigated with 600-700K m^3/year of urban stormwater. A "fourth system", which includes 16 km of irrigation pipes, was installed for this purpose.	4
Ecological - environmental	Improving stormwater quality before it reaches receiving water	Grille-covered cell, infiltration through sandy soil	A grille-covered cell prevents coarse waste from reaching the lake. The stormwater infiltrates through the sandy soil, thus improving its quality before it reaches the aquifer. The project prevents polluted stormwater from reaching the sea.	3
	Supporting biodiversity	Stormwater lakes	The lakes attract 100 different species of birds and fowl, 39 of which were observed nesting, or for which evidence of nesting was found. Large numbers of the species associated with wet habitats, such as cormorants, ducks, coots, herons and others were observed.	4
	Conserving wet ecological systems	Stormwater lakes	The project combines significant bodies of water, which allow fauna and flora that are characteristic of wet habitats to thrive. The plan of the southern part creates numerous ecological niches, and a natural shoreline appearance.	4
Social	Venue for leisure, recreation	All the practices	A municipal park that combines extensive and intensive areas	3
	Experiencing nature in the city	Stormwater lakes	The planning of the floating promenade enriches the experience of nature in the park. The promenade, which includes bird observation points, allows visitors to get close to the lake and feel as though one is visiting nature.	3
	Aesthetics and landscape quality	All the practices		3
	Education promoting sustainability and good citizenship	Signs, tours	Signs in the park provide explanations about the winter pool	2
	Promoting a community spirit and social engagement		The park provides a setting for educational and community activities that strengthen the ties between the residents and their environment. Signs at the entrance to HaNakik Lake provide explanations about the nature values at the site, but do not sufficiently address the manner in which stormwater is managed as part of the project.	3
Economic	Savings from direct use of stormwater		670K m^3/year are exploited within the framework of the project; these provide the municipality with cost savings at a scope of NIS 2,211,000 a year.	4
	Savings from lower drainage infrastructure costs		The project utilizes the drainage ducts and serves as an end point solution, and therefore does not provide cost savings on drainage infrastructure	0
	Lever for economic opportunities near the site		The lakes in the project play a significant role in attracting commercial and employment uses, which greatly contribute to increasing revenues from taxation	3

Table 4.2.1 Evaluation of HaAgamim (The Lakes) Park, Rishon-LeZion

4.2.2 Emek HaZvaim (Valley of the Gazelles), Jerusalem (2010 and onwards)

Emek HaZvaim is a natural open area of approximately 240 dunams (approx. 59 acres), which is located in the southwestern part of Jerusalem, and drains about 8 sq.km. For years the area served as a plantation with a population of deer. The 1959 blueprint outlined most of the area as open public space. Despite objections filed by building entrepreneurs, its plan was approved in 2010, and the park, which was planned by Landscape Architect Rachel Weiner and Architects Gil Veadya and Shay Weinstein, was opened for visitors in 2015. The park includes an area that is natural and intended for conservation, a second area for cultivating ancient agriculture, and a third area intended for intensive recreation. A stormwater conveyance system feeds several pools that are mainly intended for recreational use.

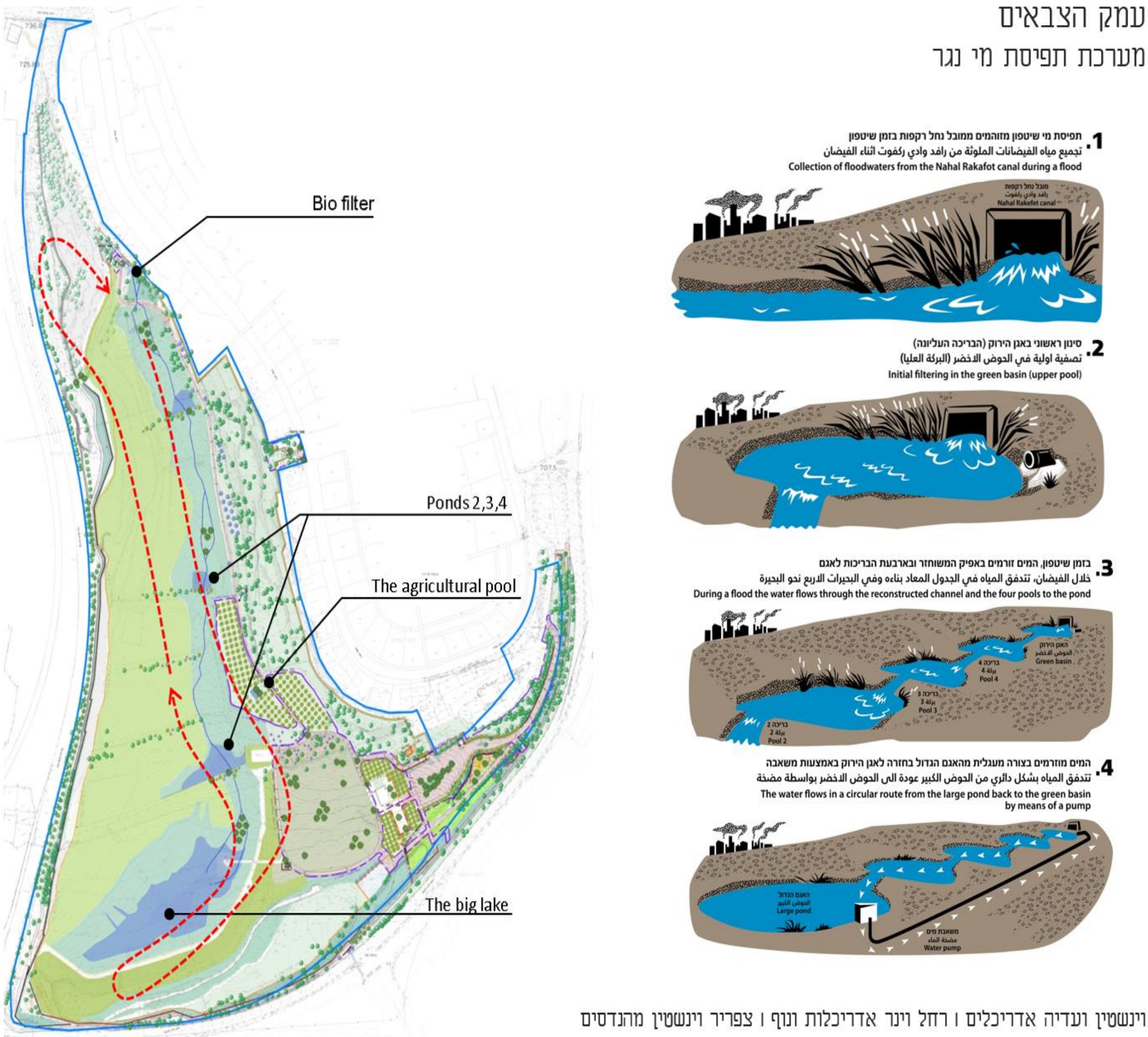

Fig. 4.2.2.1: Scheme and illustrations of the stormwater system of Emek HaZvaim, R. Weiner, S. Weinstein & G. Vaadia and Z. Weinstein.

	Goals/benefits	SSWM practices contributing to the achievement of goals / benefits	Assessment	Score (0-4)
Hydrological	Mitigating flooding	A series of built pools, local depressions, a green roof	The pools receive the stormwater from the adjacent neighborhoods, winter puddles in the local depressions and the green roof mitigates the flow	4
	Recharging the aquifer	-------	The project is not intended for the infiltration of stormwater; the bottom of the pools has been made impermeable	2
	Harvesting stormwater for various uses	Pools, a green roof	The stormwater supports the park's natural systems, as well as recreational activities. The roof vegetation is irrigated only with stormwater.	3
Ecological - environmental	Improving stormwater quality before it reaches receiving water	Pools	The upper pool treats the water using vegetation and filters the stormwater through gravel. The next pools operate via sedimentation and oxygenation. The water flows in a spiral system and undergoes "repeat purification." The water quality has not been tested.	3
	Supporting biodiversity	Pools, a green roof, agricultural terraces and fallow land	The diverse habitats in the park attract many species of fauna and flora, along with the renewing flock of gazelles. According to the park's ecologist Amir Balaban, their number and diversity have grown.	4
	Conserving wet ecological systems	Pools	Conservation of the pools throughout the year allows the wet ecological systems to thrive. Additionally, fencing parts of the park allows "nature" to thrive without human intervention.	4
Social	Venue for leisure, recreation	All the practices	A municipal park that combines extensive and intensive areas, " a municipal attraction"	4
	Experiencing nature in the city	All the practices	Intensifying the experience of nature and encouraging observation of the fauna.	4
	Aesthetics and landscape quality	All the practices	A unique park that combines natural areas and landscape elements with much attention to aesthetic details.	4
	Education promoting sustainability and good citizenship	Signs, tours, orientation center	The park includes many activities for children, youths and various communities. The signs are clear and enlightening, the visitors can rent binoculars for observation. Stormwater is included in the explanations provided in the park.	4
	Promoting a community spirit and social engagement	All the practices	The park was established thanks to the efforts of the local residents. It is used today for educational and community activities. A group of volunteers operates in the park.	4
Economic	Savings from direct use of stormwater		The use of stormwater allows savings as pools do not need to be filled with freshwater. The green roof is irrigated with stormwater only.	3
	Savings from lower drainage infrastructure costs		The conveyance of water to the park provides savings in draining the stormwater from the neighborhoods	2
	Lever for economic opportunities near the site		At this stage, this has not yet been implemented. There is a possibility of commercial areas in the future, in combination with the light rail that will pass through the southern part of the park.	2

Table 4.2.2 Evaluation of Emek HaZvaim (Valley of the Gazelles), Jerusalem

4.2.3 Herzliya Park, Herzliya (2004) [10]

The park covers a total area of 700 dunams (173 acres), of which 256 dunams (approximately 63 acres) are presently developed. The park includes three phases:

Phase 1: 115 dunams as an intensive park, whose primary goal is to create a quality venue for leisure activities for the benefit of the city's residents.

Phase 2: 65 extensively developed dunams, and a winter pool covering approximately 120 dunams. The winter pool is being restored on the basis of environmental values.

Phase 3: 40 dunams with a variety of gathering areas for visitors, a continuum of systems connecting this part to previously developed areas and allowing movement between them, and practices for stormwater management.

The park integrates a number of stormwater management practices: a winter pool and a sedimentation basin, eucalyptus groves, stream-like open ducts and concave lawns.

The park was planned by Landscape Architect Barbara Aronson.

Fig. 4.2.3.1: Winter Pool, Herzliya, (photographed S. Amir)

[10] For a detailed analysis of this project, see appendix of this chapter

Goals/benefits		SSWM practices contributing to the achievement of goals / benefits	Assessment	Sco-re (0-4)
Hydrological	Mitigating flooding	Winter pools, stream-like open ducts, concave lawns, eucalyptus groves	All four practices delay stormwater flow from the eastern part of the city to its western part in each rain event; the winter pool, in addition to the above, serves as a floodplain in extreme rain events.	3
	Recharging the aquifer	-----------------	Due to the clay soil, there is hardly any infiltration in the area of the winter pools. Infiltration pits are planned in the southern area.	0
	Harvesting stormwater for various uses	Winter pool	Stormwater harvesting is used to sustain the fauna and flora of the winter pool. The stormwater serves as "water for nature."	3
Ecological - environmental	Improving stormwater quality before it reaches receiving water	Winter pool Stream-like open ducts	The stormwater reaching the winter pool passes through the sedimentation basin. A grid on the pipe prevents large objects from entering it, and others settle in the basin, which is dried and cleaned once a year. According to Prof. Gasith, the water quality is good, and suitable for sustaining life in the pool.	3
	Supporting biodiversity	All the means	A survey conducted by Prof. Gasith and the Society for the Protection of Nature identified a rich variety of species, including rare ones: Lepidurus apus (invertebrate), Pelobates syriacus (amphibian), approx. 40 species of rare plants, approx. 64 species of fowl, and more.	4
	Conserving wet ecological systems	Winter pool	Wet ecological systems are becoming extinct in Israel. The park is planned to conserve and nurture these systems with minimal disruption of human activity.	4
Social	Venue for leisure, recreation	All the means and also other park areas	The park serves the residents of Herzliya and its surroundings throughout the day and year. The various activities respond to the needs of different users. There is easy access to the park from the area of the train station, as well as from the eastern and western parts of the city (a pedestrian overpass will be built in the future).	4
	Experiencing nature in the city	Winter pool Eucalyptus groves	The winter pool is a display of urban nature, as are the other parts of the park which include little cultured vegetation. There is hardly any commercial activity in the park, and illumination is limited, to avoid light pollution.	4
	sthetics and ndscape quality	The entire park	The aesthetic qualities of the park have been recognized by a number of prizes: The Design Award 2010, the Landscape Architecture Award 2013, and the Karavan Prize 2015.	4
	Education promoting sustainability and good citizenship	The entire park, and particularly the winter pool	Many activities take place in the park, with the participation of the city's students, in collaboration with Keinan House, which is a municipal center for sustainability	4
	Promoting a community spirit and social engagement	The entire park	The residents' engagement in protecting the winter pool helped reject a legal claim to build inside the park. A telephone survey conducted among the residents, as well as meetings they attended, led to the consolidation of a program for the park. The residents' engagement intensified after the park was established.	3
Economic	Savings from direct use of stormwater	The winter pool	Savings in the establishment and maintenance of the winter pool, as compared with the establishment and maintenance costs of the intensive park	3
	Savings from lower drainage infrastructure costs.	The entire park	Since most of the land uses around the park are public, the value of the assets in the area has barely increased as a result of the park's establishment and the stormwater management	1
	Lever for economic opp.	The entire park	There is no economic activity around the park.	0

Table 4.2.3 Evaluation of Herzliya Park, Herzliya

4.2.4 Municipal Park, Kfar-Saba (2006)

An extensive municipal park situated at the northeastern part of the city Kfar-Saba. The park covers an area of 270 dunams (approximately 67 acres), 83 dunams (20.5 acres) of which are drained through topographic depressions with infiltration pits at their center. The soil is alluvial red loam which allows infiltration. The park was planned by Zur Wolf Landscape Architects. In 2016, a winter pool was planned at the center of the park by Landscape Architect Liav Shalem. The pool covers an area of approximately 1.2 dunam (0.3 acres), and its maximum depth is 1.5 meters. The water reaches a sedimentation pool with a red loam sand bottom, and from there flows to a larger pool, whose bottom part has been coated with clay to prevent infiltration. The water is retained in the pool for about four months, and flows to a sandy area where it infiltrates. The vegetation at the pool’s perimeter is characteristic of winter pools, with vegetation characteristic of red clay sand in its upper parts.

Fig. 4.2.4.1: Scheme of the park, L. Wolf.

Fig. 4.2.4.2: Aerial view of the park

	Goals/benefits	SSWM practices contributing to the achievement of the goals / benefits	Assessment	Score (0-4)
Hydrological	Mitigating floods	Topographic depressions and infiltration pits, Winter pool	The northern part of the park drains into infiltration pits, and mainly into topographic depressions. Water from the southern part of the park and from its perimeter reaches the winter pool. There is hardly any stormwater flow from the neighborhood to the park.	2
	Recharging the aquifer	Topographic depressions, infiltration pits and a winter pool	Due to poor maintenance, the infiltration pits have become clogged. Stormwater infiltrates into the concave lawns, and from the winter pool, mainly from its outlet to the sandy area.	2
	Harvesting stormwater for various uses		Stormwater detention contributes to the soil's moisture for an extended period of time, reducing the need for irrigation	2
Ecological – environmental	Improving stormwater quality before it reaches receiving water	Grass-covered surfaces, sedimentation pits and infiltration pits	The water flows on the grass-covered surfaces to the sedimentation pits, and from there to the infiltration pits through the gravel bed, which improves the quality of the water before it reaches the aquifer.	3
	Supporting biodiversity		Natural vegetation around the winter pool and throughout the park	2
	Conserving wet ecological systems	Winter pool	Construction of a winter pool	3
Social	Venue for leisure, recreation	Lawns, winter pool	An intensive municipal park that attracts many visitors, except when flooded	4
	Experiencing nature in the city	Winter pool	Mainly at the winter pool	3
	Aesthetics and landscape quality	All the means	Received the Israeli Association of Landscape Architects prize (2014)	4
	Education promoting sustainability and good citizenship	Signs	Signs in the park provide explanations about the infiltration pits	2
	Promoting community spirit and social engagement		Unknown	0
Economic	Savings from direct use of stormwater		Some saving on irrigation costs	1
	Savings from lower drainage infrastructure costs	No drainage systems in the park	Some saving, at least because no need to drain the area of the park.	1
	Lever for economic opportunities near the site	Development around a quality green area	The park attracts visitors from adjacent neighborhoods	2

Table 4.2.4 Evaluation of municipal Park, Kfar-Saba

4.2.5 Neot Shoshanim Park, Holon (2007)

The park consists of a grove, and is one of several urban stormwater management projects in the city of Holon (Plan H/5353). The purpose of the project was to prevent flooding in the adjacent residential complexes, while creating a “liman” landscape pattern and planting eucalyptus trees that will effectively consume the stormwater. The grove is situated on clay-sand and kurkar (eolianite); therefore, the extent of infiltration across the site varies. The grove was planned by Landscape Architect Bruce Levin.

Fig. 4.2.5.1: Drainage pipe at the edge of the park

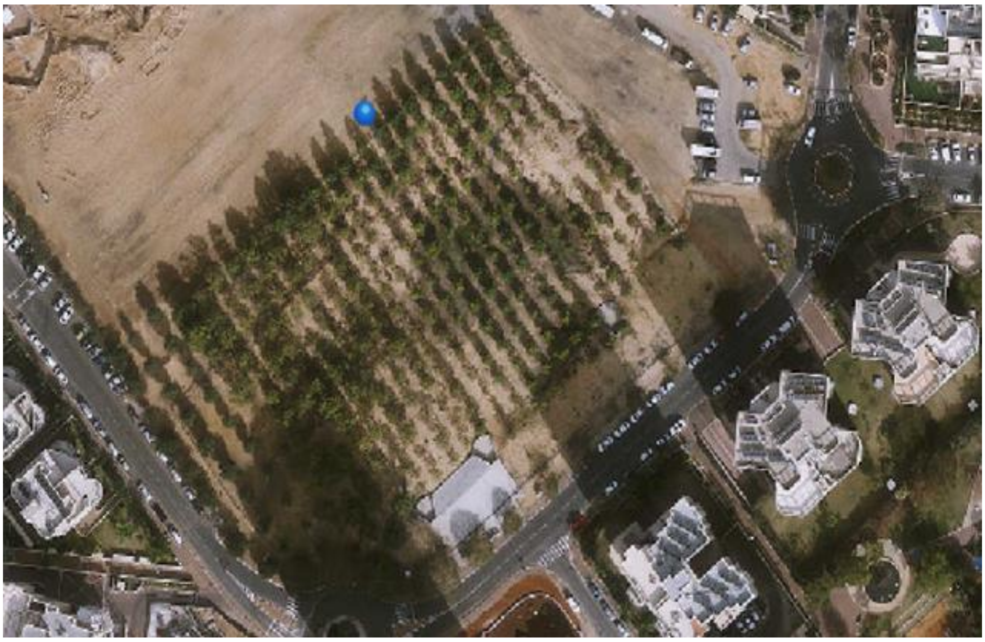

Fig. 4.2.5.2: Aerial view of the park

	Goals/benefits	SSWM practices contributing to the achievement of the goals / benefits	Assessment	Score (0-4)
Hydrological	Mitigating flooding	Topographic depression, infiltration pits and planting of eucalyptus trees (water consumers)	Water from the neighborhood flows to the park through drainage ducts	3
	Recharging the aquifer	Infiltrating soil and infiltration pits	Clay lenses limit infiltration	3
	Harvesting stormwater for various uses		Planned irrigation with greywater, and not with stormwater. Stormwater retention contributes to soil moisture for extended periods of time.	1
Ecological - environmental	Improving stormwater quality before it reaches receiving water	Infiltration through sandy soil	The water passes through the sandy soil, which adsorbs pollutants	2
	Supporting biodiversity	Eucalyptus grove	Monoculture of eucalyptus trees. Attracts birds, but not more.	2
	Conserving wet ecological systems			0
Social	Venue for leisure, recreation	Eucalyptus grove	Extensive municipal park, part of which is fenced and does not attract visitors, with a dog park at its perimeter	1
	Experiencing nature in the city		Limited, eucalyptus trees planted in a grid	1
	Aesthetics and landscape quality	Planting	Very limited, no diversity, few components	1
	Education promoting sustainability and good citizenship			0
	Promoting a community spirit and social engagement		Unknown	0
Economic	Savings from direct use of stormwater	Stormwater retention in the park	The contribution of the stormwater to the condition of the eucalyptus grove has not been measured	2
	Savings from lower drainage infrastructure costs	Lack of drainage systems in the park	Some savings	1
	Lever for economic opportunities near the site	Development around a quality green area	Has not been checked	1

Table 4.2.5 Evaluation of Neot Shoshanim Park, Holon

4.2.6 Dora Park, Netanya (2005)

Dura Park is situated in the southern part of the city of Netanya. It was established around a winter pool that comprises a part of the many winter pools that were previously common along the coastal plain, and whose number is dwindling with the development of the urbanization process.[11] The pool's flooded area during the winter months ranges from 80-120 dunams (approximately 20-30 acres), and the soil in this area is alluvial-clay, which becomes impermeable when it comes into contact with water. The pool collects stormwater from the park area surrounding it. In 2005, Plan NT/ 16/537 / A was approved; the plan designates residential areas and public areas, as well as areas for institutions and for new roads. The plan defined the area of the pool (53 dunams – approximately 13 acres), and an open public area around it, with guidelines provided for conserving the pool and handling drainage. The park around the pool was planned by Landscape Architect Gideon Sarig.

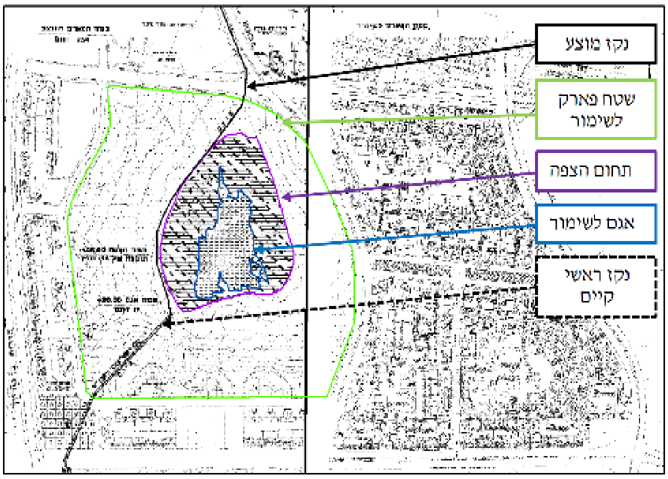

Fig. 4.2.6.1: Drainage report of Plan NT/ 16/537 / A. Source: The plan documents.

Fig. 4.2.6.2: Winter pool, Dora Park.

[11] Levin N, Eldad E, Gasith A, (2009), "Decline of wetland ecosystems in the coastal plain of Israel during the 20th century: Implications for wetland conservation and management" Landscape and Urban Planning 92 (2009) 220-232, Available online 13 June 2009.

Goals/benefits		SSWM practices contributing to the achievement of the goals / benefits	Assessment	Score 0-4)
Hydrological	Mitigating flooding	Winter pool; large trees that absorb great amount of water	The winter pool was not intended to mitigate flooding. In the original plan, the stormwater circumvented the pool, but due to the small quantity available for sustaining the natural system in the pool, a decision was made to direct some of the stormwater into it	2
	Recharging the aquifer		The winter pool is situated on clay infrastructure; consequently, there is no infiltration	0
	Harvesting stormwater for various uses	Winter pool	The stormwater meets the need for "water for nature" and sustains the rich wet ecosystem that is at risk of extinction	3
Ecological - environmental	Improving stormwater quality before it reaches receiving water	A retention basin at the entrance of the duct that reaches the winter pool, and vegetation at the entrance of the channel conveying the water to the pool	The retention basin collects coarse pollutants. According to Prof. Gasith, the vegetation in the channel serves as a green basin. Prof. Gafni's report from 2009 states that the water quality is good enough to allow various species in the pool to thrive.[12]	2
	Supporting biodiversity	Winter pool	A unique ecosystem has survived in the pool, including a variety of algae, erect water plants, and plants characteristic of the perimeter of water bodies, including rare species. There are many invertebrates in the pool, and it attracts waterfowl, reptiles and amphibians (including Pelobates syriacus, which is at risk of extinction).	4
	Conserving wet ecological systems	Winter pool		4
Social	Venue for leisure, recreation	All the practices	A municipal park combining extensive and intensive areas	3
	Experiencing nature in the city	Winter pool	No-touch areas that provide the experience of nature in the city	4
	Aesthetics and landscape quality	All the practices	A unique aesthetic landscape element, combining a no-touch area and a municipal park	4
	Education promoting sustainability and good citizenship	Signs, tours	Signs in the park provide explanations about the winter pool	2
	Promoting a community spirit and social engagement		The pool was conserved thanks to the efforts of the community members and the Society for the Protection of Nature	2
Economic	Savings from direct use of stormwater		Unknown	0
	Savings from lower drainage infrastructure costs	Unknown	Unknown	0
	Lever for economic opportunities near the site		Has not been checked, but the pool attracts residents of adjacent neighborhoods	2

Table 4.2.6 Evaluation of Dora Park, Netanya

[12] Gafni, Sh., 2010. Winter Pool in Netanya – Ecological State Report for 2009, Michmoret School of Marine Sciences, Ruppin Academic Center, the Society for the Protection of Nature. The report is available to readers on the municipality's website, uploaded on 01.08.2016. http://www.netanya.muni.il/?CategoryID=2573&ArticleID=6642

4.2.7 The Green School, haZemer haIvri Neighborhood, Kfar-Saba (2012)

The school includes 18 classrooms, administration buildings, a sports hall and a central yard that comprises its “green lobby”, and includes playing fields, an amphitheater and a winter pool. The complex, which was designed by the Architect Tagit Knafo-Klimor and Landscape Architect Lior Wolf, was certified by the American green building rating system LEED (Leadership in Energy and Environmental Design) and awarded a Gold rating level. Stormwater management at the school is intended to recharge the coastal aquifer, to mitigate flooding and to reduce the amount of stormwater flowing out of the site, in accordance with the municipality’s guidelines.

Fig. 4.2.7.1: School yard and the penetrating lawn

Fig. 4.2.7.2: Plan of the school

	Goals/benefits	SSWM practices contributing to the achievement of the goals / benefits	Assessment	Score (0-4)
Hydrological	Mitigating flooding	Winter pool, infiltration pits	The yard drains to the winter pool and from it through the infiltration pits	2
	Recharging the aquifer	Infiltration pits	A small amount. A quantitative assessment was not performed	1
	Harvesting stormwater for various uses		Stormwater from the roof irrigates the lawn. Stormwater fills up the winter pool.	3
Ecological - environmental	Improving stormwater quality before it reaches receiving water	Infiltration pits	No treatment of the water, except for flow on surfaces – some of which are covered with grass Stormwater is used or infiltrates so that almost no water leaves the yard, thus saving contamination.	3
	Supporting biodiversity	Extensive planting areas	A relatively high percentage of tree cover, mostly local Israeli trees. Planting bulbs and sowing wildflowers. Adding nesting boxes.	3
	Conserving wet ecological systems	None in the area		0
Social	Venue for leisure, recreation	All the practices	The schoolyard encourages active learning and offers a sports strip for the community's benefit	2
	Experiencing nature in the city	Grove & sowing herbaceous plants	The grove, with all its components, creates a natural look	4
	Aesthetics and landscape quality	All the practices	A yard at a high level of development	3
	Education promoting sustainability and good citizenship		Part of the school's agenda	4
	Promoting a community spirit and social engagement		A sports strip that is open to the community for its use	2
Economic	Savings from direct use of stormwater		Irrigation with stormwater collected from the roofs	2
	Savings from lower drainage infrastructure costs	Less drainage infrastructure	Partial	1
	Lever for economic opportunities near the site			0

Table 4.2.7 Evaluation of the Green School, HaZemer HaIvri Neighborhood, Kfar-Saba

4.2.8 Stormwater Management System, Porter School of Environmental Studies, Tel-Aviv University Campus (2014)

The Porter School building was the first in Israel to be awarded the highest rating of the American green building rating system LEED (Leadership in Energy and Environmental Design). The building serves as an education center that also promotes multidisciplinary research on ecology, the environment and sustainability. It excels in the integration of various systems that enhance energy efficiency, including infrastructure and structural elements, extensive use of recycled materials, sustainable landscape development, computerized control mechanisms, and transportation accessibility aspects. Water management in the building is achieved at three main levels: reduced use of freshwater for ongoing consumption and for irrigation, including the development of an economic landscape; drainage of stormwater, based on water sensitive planning principles; and recycling of water for irrigation purposes. Landscape development was carried out by Braudo Maoz Landscape Architecture.

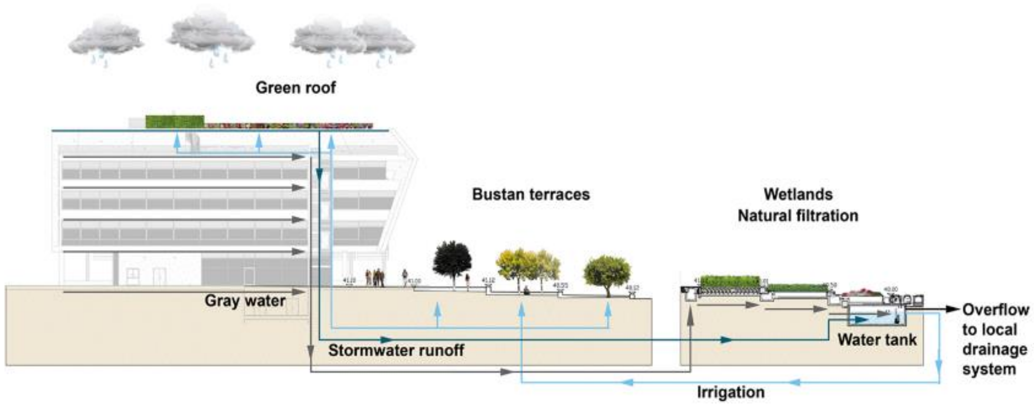

Fig. 4.2.8.1: Stormwater Management System scheme (Braudo-Maoz)

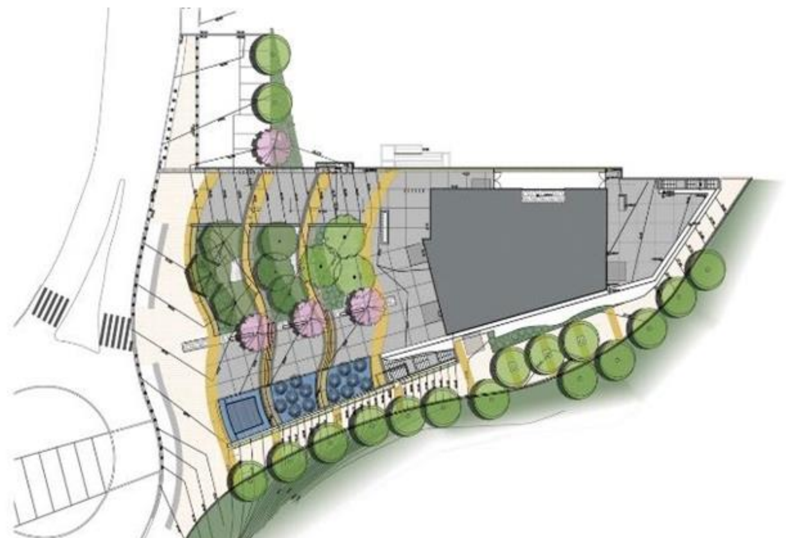

Fig. 4.2.8.2: Porter entrance garden scheme (Braudo-Maoz)

Goals/benefits		Stormwater management practices contributing to the achievement of the goals / benefits	Assessment	Score (0-4)
Hydrological	Mitigating flooding	Green roof, terraces	The rainwater is absorbed in the terraces for 40 minutes, no overflow to the road was observed.	1
	Recharging the aquifer	Terraces	The infiltrating area is smaller than required by National Outline Plan 34 B/4 (15%), proper angles in the terraces. (No infiltration from the purifying pool).	1
	Harvesting stormwater for various uses	Planned, shared use of stormwater and greywater for irrigation	The stormwater reaching the purifying pools is used for irrigation. The greywater system has been out of operation since mid-2016.	1
Ecological - environmental	Improving stormwater quality before it reaches receiving water	In terraces with two main strata: A thicker bottom stratum with tuff or gravel filling (varying) & a thinner upper layer of wood shavings. Purifying pool at the lower terrace.	The quality of the water infiltrating from the terraces has not been tested. The quality of the water intended for irrigation from the purifying pool has been tested and is now at a murkiness level lower than 5 NTU, and the conductivity level is higher than the standard for irrigation and drinking. The unreliability of the testing systems and the lack of proper supervision of the system are unequivocally responsible for the results.	1
	Supporting biodiversity	Diverse vegetation, preference for local vegetation		2
	Conserving wet ecological systems	None in the area		0
Social	Venue for leisure, recreation	All the practices	The building is located at the campus perimeter, far from residences	1
	Experiencing nature in the city	Biofilter	Not more than any urban "garden"	1
	Aesthetics and landscape quality	All the practices	High level development, attention to details.	4
	Education promoting sustainability and good citizenship	Signs, website, tours	In 2017 the School held 17 events for the public at large, 35 academic events focusing on the environment. The website enables visitors to track the building's operation, but without placing an emphasis on stormwater.	4
	Promoting a community spirit and social engagement	Nonexistent		0
Economic	Savings from direct use of stormwater	Savings in irrigation	Limited, particularly as the greywater treatment system is not operating.	1
	Savings from lower drainage infrastructure costs	Less drainage infrastructure	Very limited, in view of the different systems (see cross-section above)	0
	Lever for economic opportunities near the site			0

Table 4.2.8 Evaluation of Stormwater Management System, Porter School of Environmental Studies, Tel-Aviv University Campus

4.2.9 Biofilter, Kfar-Saba (2010 and onwards)

An experimental project that is intended to examine the possibility of purifying urban stormwater before it is infiltrated into the groundwater. Additionally, the project examined the possibility of purifying contaminated groundwater and returning it to the aquifer, while creating a demonstration park. The project was initiated by Dr. Yaron Zinger, Jewish National Fund (KKL) and Landscape Architect Ruth Kolodny. The area of the biofilter is 87 sqm. It is constructed as a detached surface using an impermeable layer and is composed of five layers of filtering and purification beds at a total depth of 1.2 meters. The bottom layer is intended to be permanently saturated, and includes an additive of a cellulose carbon source in order to optimally remove nitrates. The upper layer is composed of drained sand-soil, which supports the unique vegetation and enables oxygen-dependent decomposition processes to take place. The biofilter system includes 12 different species of plants, some of which are Australian species that have been proven to be highly effective in removing contaminants/pollutants while preserving a high level of filtering of the system.

Fig. 4.2.9.1: Bio filter, Kfar Saba (Yaron Zinger)

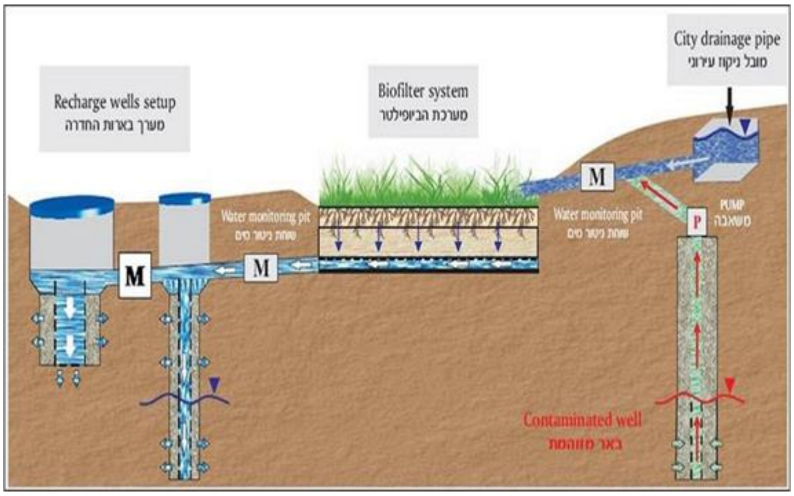

Fig. 4.2.9.2: Water system scheme, Kfar Saba (Yaron Zinger)

Goals/benefits		Stormwater management practices contributing to the achievement of the goals / benefits	Assessment	Score (0-4)
Hydrological	Mitigating flooding	The biofilter basin	The biofilter basin can absorb 350 m³/hr of stormwater. The duct close to it transfers stormwater at a quantity of up to 70,000 m³/hr.	1
	Recharging the aquifer	-------	The project recharges the aquifer with purified water. The quantity of water is limited, reaching approximately 5,000 m³/year.	2
	Harvesting stormwater for various uses	Biofilter	The stormwater's only use is recharging the groundwater.	0
Ecological - environmental	Improving stormwater quality before it reaches receiving water	Biofilter	Intensive treatment of stormwater using vegetation and various layers. The quality of the water being infiltrated is suitable for irrigation	4
	Supporting biological diversity	Biofilter	Limited, sporadic observations, no organized survey. Planting the biofilter with Australian species is inconsistent with the desire to promote local diversity.	1
	Conserving wet ecological systems	Biofilter	None at the site	0
Social	Venue for leisure, recreation	Biofilter	The biofilter was designed as an amphitheater to supports various uses; however, as revealed by a poll among some 50 of the neighborhood's residents, they have never participated in any activity there.	0
	Experiencing nature in the city	Biofilter	Water as a natural display during only a short period of time.	1
	Aesthetics and landscape quality	Biofilter	Lack of shading, design of moderate quality	1
	Education promoting sustainability and good citizenship	Signs, tours	Tours take place at the site, mainly for professional groups and KKL's delegations. Signs describe the biofilter's activity, but most of the near-by residents – according to a poll – are not familiar with the biofilter's goals.	2
	Promoting a community spirit and social engagement		There is no evidence of the biofilter supporting the local community or any form of social activity	0
Economic	Savings from direct use of stormwater		There is no use of stormwater for various uses	0
	Savings from lower drainage infrastructure costs		At this experimental stage, there are no savings in for infrastructure	0
	Lever for economic opportunities near the site		Unclear	0

Table 4.2.9 Evaluation of Biofilter, Kfar-Saba

4.3 Summary: Evaluation of BMP's

There are several dozen landscape projects in Israel that include stormwater management practices. Most of these are found in the coastal plain, and mainly in its central region, but some are located in the northern part of the country, in the Jerusalem area, and also in the south. In the 20th century, most of these projects relied mainly on floodwater from non-urbanized areas. However, in the 21st century, subsequent to research conducted in Israel and trends in the USA, Australia and Europe, there has been growing awareness among landscape architects (and a smaller number of engineers) of the possibilities of integrating stormwater practices in their projects. Consequently, the number of landscape projects handling urban stormwater has grown as well.

Common urban stormwater management practices/measures implemented in landscape projects in Israel include:

a. **Winter pools that fill up with stormwater over a period of several months a year,** such as in Herzliya Park, Kfar-Saba Park, and Dora Park in Netanya.

b. **Stormwater reservoirs/lakes that play also an aesthetic landscape role, often suitable for sailing but not for bathing,** such as Park Ha'Agamim in Rishon-LeZion.

c. **Limans (depressions in the soil, with trees),** as in Herzliya Park and in Neot Shoshanim Park in Holon.

d. **Terraces,** such as those in Emek HaZvaim in Jerusalem, and in Anabe Stream in Modiin.

e. **Concave lawns,** such as in Herzliya Park and in Kfar-Saba Park.

f. **Sedimentation basins for cleansing stormwater,** such as where the stormwater enters the winter pools in Herzliya Park and in Kfar-Saba Park. In some cases, measures such as metal grilles and/or a bed of coarse gravel have been installed at the entrance to the sedimentation basin to prevent the entry of large floating objects.

g. **Green channels for slowly conveying stormwater**, as in Herzliya Park.

h. **Biofilters,** such as in Kfar-Saba, Ramla and Bat-Yam.

i. **Rain gardens,** such as the one that has lately been constructed in Ramat-Aviv.

j. **Green roofs, such** as at the Porter School, Tel-Aviv University and urban agricultural farm on the roof of Dizengoff Center**.**

k. **Infiltration pits,** as at the park in Kfar-Saba, and in Neot Shoshanim Park in Holon.

l. **Infiltration through sandy soil to remove pollutants,** as in Park HaAgamim in Rishon-LeZion.

m. **Pervious/rain-penetrable ground cover,** as common in many yards in residential areas and requested by NOP 34/B/4.

The following table summarizes the level of achievement/performance of the BMPs, by goals.

Goals / BMPs in the research	Hydrological goals			Ecological-environmental goals				Social goals					Economic goal
	Stormwater harvesting for various uses	Aquifer recharge	Mitigating urban floods	Improving stormwater quality before it reaches	Biodiversity support	Rehabilitating/conserving wet ecosystems	Soil conservation	Making places for leisure time and recreation	Enhancing nature in the city	Enhancing aesthetics and landscape visual qualities	Education for sustainability and good	Social involvement and community development	Inexpensive Maintenance
Winter pools	++		+		+++	+++	+	++	+++	++	+++	+	+++
Stormwater lakes	++	+	++	+	++	++	+	++	++	++	++		++
Limans	+	++	++	++	+		+	+	+	+	+		+++
Terraces in sloped areas	++	++	++	+	+	+	+++	+	+	+			++
Sedimentation basins for purifying stormwater				++			++						+
Green channels for conveying stormwater	+	+	++	++			++	++		++			++
Biofilters	++	+		+++	+			+	+	+	+		++
Rain gardens	++	+	++	+	+	+	+	+	+	++	+	+	++
Green roofs	++		+	+	+	+			+	++	+	+	+
Infiltration pits	++	+++	++	+							+		++
Infiltration through sandy soil	++	+++	+++	++									+++

Scale: Not at all - Empty cell / Low + / Medium ++ / High +++

Table 4.3: Performance of BMPs by goals

Below are several conclusions derived from the analysis of BMP's:

Multi-goals BMPs: all the studied stormwater management practices were implemented so that **a single practice simultaneously achieves several goals from different bundles of goals. In addition, the practices frequently worked synergistically to amplify the benefits of the project to a level that would not occur if each goal was tackled individually.**
We can cite several examples:

a. The winter pool is intended primarily to serve ecological purposes, to conserve aquatic environments and increase biological diversity. The urban water site and seasonally-specific fauna and flora, as well as unique landscape design, attract many visitors to experience nature in the city while simultaneously being educated on sustainability. The site thus also achieves social goals. The same practice of constructing winter pools also retains stormwater and contributes to the hydrological goal of mitigating floods.

b. Concave lawns detain the stormwater during large storms, and thus contribute to mitigating flow, while most of the year they serve recreational purposes and also protect the soil from erosion.

c. Stormwater lakes/reservoirs mitigate flooding, enable stormwater harvesting for diverse uses, create sites for leisure activities and recreation, and serve as a lever for economic opportunities in their vicinity.

In many of the projects studied, the planners utilized 2-4 stormwater management practices in sequence, so that together they would amplify the benefits of stormwater management:

d. In some parks the concave lawns connect to an open stream-like channel with vegetation, which detains and conveys stormwater through the park during large storms to where the drainage duct removes the water from the park.

e. In another park, the stormwater arriving from the city first flows to a container filled with gravel, in which a metal grille has been installed at its opening, and from there to a sedimentation pool located on the other side of the grille, and onwards to a lake or winter pool.

f. In some cases the different measures are installed in pools at different heights, and the water passes from the upper pool, which purifies it through use of gravel and vegetation, to lower pools, where it is treated through sedimentation and oxygenation. Examples are in Emek HaZvaim in Jerusalem, and similarly, the three pools at the Porter School at Tel-Aviv University.

There is a fundamental difference between large projects, which receive and treat stormwater from a large area, such as Herzliya Park or HaAgamim Park, **and small projects** such as the Porter School building and the biofilter in Kfar-Saba. The former creates significant benefits for the city and its residents, while the latter are important for demonstration and educational purposes. Practical benefit will be derived from them only if they are duplicated hundreds and thousands of times.

To summarize chapter 4:

- **Most of the projects that were studied succeeded in meeting diverse stormwater management goals, and are therefore worthy of being referred to as sustainable projects** due to their simultaneous and synergetic contribution to environmental-ecological, social and economic goals;
- **Most of the practices that were evaluated** provide added value in terms of the residents' quality of life as well as environmental protection and nature conservation; **hence they are worthy of being referred to as BMPs – Best Management Practices.**

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APPENDIX TO CHAPTER 4: example of a full case study

Herzliya Park and its Stormwater Management Practices: Description and Evaluation[13]

1 The City of Herzliya and Herzliya Park

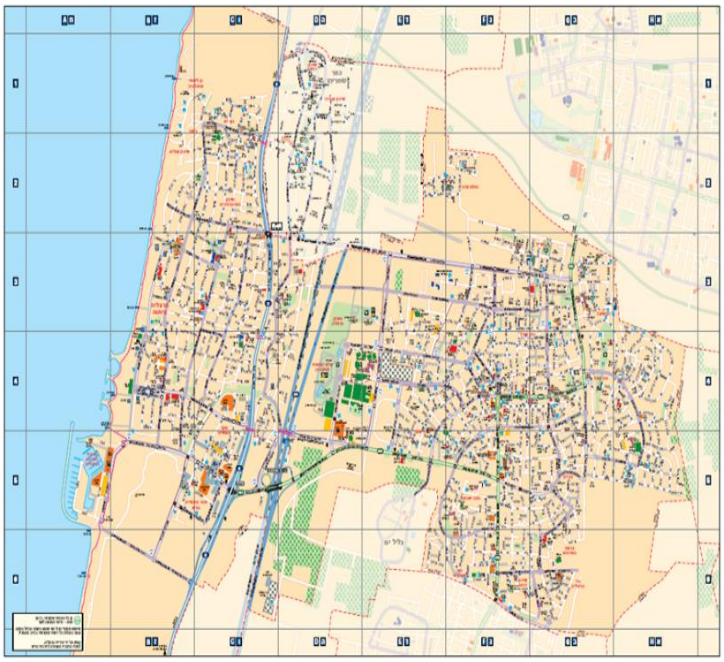
Herzliya is a seaside city located in the southern Sharon region of Israel, approximately 10 km north of Tel-Aviv. It was established in 1924 as a rural agricultural community with land allocated for agriculture, recreation and urban residential areas. In 1960 it was formally declared a city. Its population today numbers approximately 95,000 inhabitants, and it is ranked high – 8 on a scale of 1-10 – on Israel's socio-economic scale for communities.

The city's geographic distribution is clear: its western section is spread along the coast of the Mediterranean Sea and borders the Ayalon highway, where Israel's railway passes as well. Most of Herzliya's residential areas are located on the eastern side of Ayalon highway. A wide strip of public spaces is situated between the western and eastern parts of the city – these include the local soccer field, the outdoor sports compound ("Sportek"), the IDC - Interdisciplinary College, several schools, and also the large municipal park, which is the object of our research.

Herzliya has a long coastline, and its altitude ranges from 0 to 66 meters above sea level. The multi-annual average rainfall in the area (the measurement station is located in the adjacent Hakfar Hayarok) is 583 mm. The city suffers from frequent flooding. We have found reports of flooding in the daily newspapers from the years 2013, 2015, 2017 and 2018; these frequently occur in the central strip, inundating main streets as well as residential buildings. However, there were no reports of fatalities resulting from these floods.

The area upon which the park was built is an historical flood plain. The flood plain was created due to drainage confined by the eolianite ("kurkar") range to its west, which prevents streams from draining to the sea, and also because of the heavy clay soil, which impedes the infiltration of water. Already in the Roman period, attempts were made to drain the swamp to the sea using a tunnel dug in the eolianite range, in order to utilize the fertile swamplands for agriculture. Over the years the tunnel became blocked and the swamp was restored to its original size – approximately 1.5 kms long and about 0.5 km wide.

[13] Thanks are due to planner Smadar Amir for excellent work in collecting the case data, taking photos and writing a professional report in Hebrew.

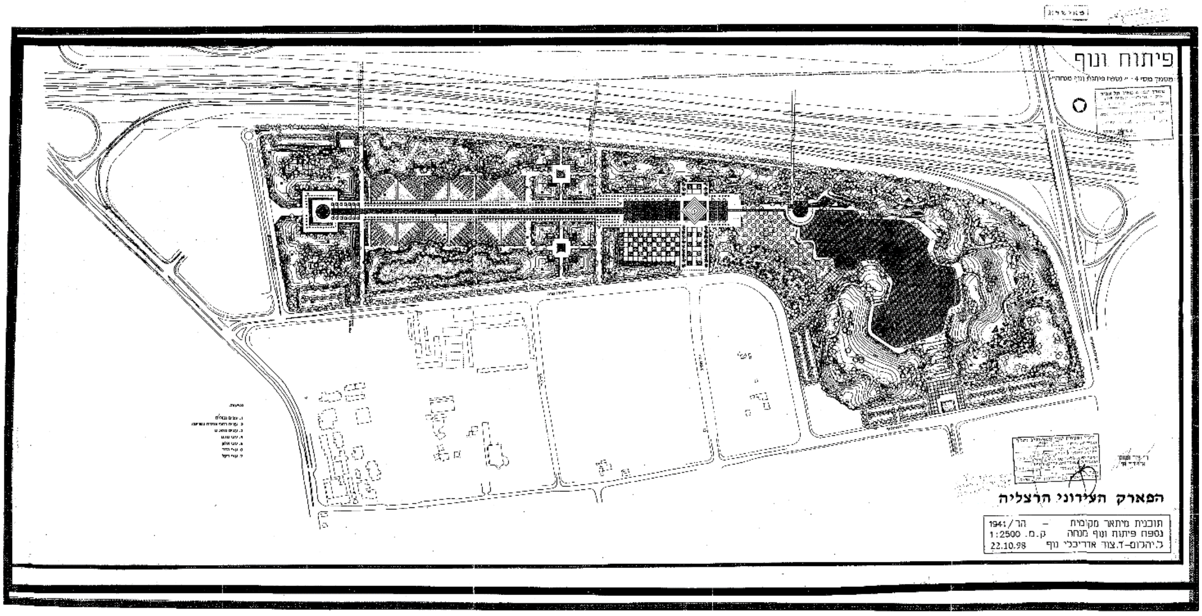


The city of Herzliya, with the broad strip of public services at its center, including the municipal park

During periods when the groundwater level was high, the swamp was a constant presence in the area (Mendelsohn, 2016). At other times it was a seasonal pool that dried up in the summer. With the establishment of Herzliya and the opening of the Roman tunnel, the permanent swamp disappeared. The land became agricultural fields, some of which were abandoned in the 1980s, with a few areas becoming sites where building waste was dumped. Most of the area remained a seasonal pool that drains over half of the city's stormwater (Aronson, 2014), filling up with rainwater in winter and drying up in summer.

The decision to establish a park in the swamp area was met with strong opposition from the private landowners who owned some of the land. They wanted to convert it into a residential area, and even submitted a plan for 1,400 residential units. After their appeals to the planning authorities were turned down, they took legal action. Following many years in the court system, their claims were heard by the Supreme Court, which rejected them and ruled that construction in the park area would not be permitted. However, the standing of the park as a seasonal pool was not statutorily defined.

In the 1990s a decision was made to change the land designation in the area from agricultural land to open public land, and to establish a municipal park. The plan for the park was prepared by the office of landscape architects Lippa Yahalom and Dan Zur. It suggested a formal design, including a hard edged decorative pool, a linear stream of water and a boulevard of four rows of palm trees. The plan was rejected by the municipality, which approached landscape architect Shlomo Aronson for a new proposal.



Yahalom Zur proposal for the park (Retrieved from Herzliya municipality, department of Engineering, May 2018)

At the beginning of the millennium (Carmel, 2016), Prof. Avital Gasith of Tel-Aviv University invited Herzliya's then mayor Yael German and the city council members to visit the area, intending to show them "a gem of nature", a most important natural site within their city limits. Later on, Prof. Gasith (2005) conducted an ecological survey of the swampland and the Society for Protection of Nature in Israel (2008) published a position paper supporting the resolution to conserve it. Additionally, a poll was conducted among the city's inhabitants who supported conserving the winter pool in the park. Concurrently, in 2004, the firm Shlomo Aronson Architects was hired by the municipality of Herzliya to design a municipal park on the area of the historic swampland. At first, Aronson intended to include a permanent lake in the park; however, following the intervention of Prof. Gasith, and later of the mayor and others, the landscape architects realized the importance and uniqueness of leaving a significant part of the area as a seasonal pool and incorporating it into the planned park. The total area of the park is 700 Dunams, situated between Road No. 20 (Ayalon) in the west, through Menachem Begin Road in the north, Jabotinsky and Yosef Nevo Streets in the east and Shivat Hakochavim Street in the south. The developed area today - including the three first phases of development - covers less than half of the 700 Dunams. The remaining areas that have not been developed are owned partly by the municipality and partly by private owners.

The park with the winter pool is located inside the city, which can be seen on its outskirts (Photograph: Carmel Merhav)

Phase 1 of the park, which covers approximately 115 dunams, was opened to the public in 2009 as an intensive park with the primary goal of creating a quality space for leisure activities for the city's inhabitants. Large lawns were planned and planted; an artificial lake with goldfish and ducks was established with an adjacent coffee shop, as well as walking and jogging trails, bicycle paths, a shaded playground for toddlers, an "extreme sports" play area for children, with rope bridges, a zip-line, climbing walls, slides, nets and more (Mendelsohn, 2016). The design was based on a motif simulating a tree that extends its branches toward the future directions of the park and simulates a "natural flow", which is associated with the site's natural history as a drainage basin (Aronson, 2016). In this phase, two practices for managing stormwater were included in the park: open stormwaer channels that simulate flowing streams and large concave lawns.

The public success of Phase 1 and the court ruling allowed implementation of Phase 2: the restoration of the winter pool, which was guided by environmental values. The planners' goal was to conserve and cultivate the natural activity already taking place in the pool with minimal intervention. They carefully kept a balance between the desire to expose the abundant natural phenomena to the public and the need to conserve the ecological systems that autonomously exist in the area (Aronson, 2014). This phase included 65 dunams of cautious development; the approximately 120 dunams of the winter pool were left as an extensive, undeveloped area.

The third and last phase, which has since been executed, covers some 40 dunams south of the area developed in Phase 1 (see the map below). It conserves the values guiding the previous phases, and particularly the movement continuum and the connection to water elements. It includes two spacious concave lawns for short-term stormwater retention, with the water accumulated in it flowing in an open channel to the channel developed in Phase 1. The area includes diverse intimate gathering spaces, catering structures and new services.

The design of the park is considered highly successful and it has won several excellence awards (see below 3.2.5.4). In addition to the items mentioned above, the park includes a bird-watching center, a forested picnic area, a plant shelter, two coffee shops, an area set aside for outdoor grills (barbecue), an open amphitheater, diverse installations for children, a train for children and more.

Various activities, for both children and adults, take place in the park. A group of volunteers, inhabitants of Herzliya, operate in the park and in the adjacent Keinan House Community Center. A footbridge connecting the park with the neighborhood Herzliya B, which lies west of Ayalon highway, is presently being built.

Execution phases

- Phase 1 – 2008 (approx. 115 dunams)
- Phase 2 – 2011 (approx. 65 dunams)
- Phase 3 – 2014 (approx. 40 dunams)
- Extensive area, undeveloped – winter pool (approx. 120 dunams)
- Future phase

The three-phase plan of Herzliya Park (Source: Power Point presentation by landscape architect Barbara Aronson)

2 Stormwater Management Practices in Herzliya Park and their Evaluation

Herzliya Park is a green-blue project, i.e. a landscape project that includes stormwater management practices. The most prominent of these practices is the winter pool, with an adjacent sedimentation basin. Additional practices include small eucalyptus forests in topographical depressions (similar to limans), large concave lawns and stream-like open channels. All of these will be presented below.

2.1 The Winter Pool and the Sedimentation Basin

A winter pool is a seasonal body of water that is usually fed by stormwater (and at times, by shallow groundwater as well). Such pools exist along the Israeli coastal plain in areas with depressions in clay soil, where there is little, if any, water infiltration, and most of the water loss is caused by evaporation (Shalem & Gasith, 2018). Winter pools in Israel remain wet throughout the winter, as well as during part of springtime, and dry up in the summer, as dictated by the Mediterranean climate of the country. Thanks to their seasonal regime, winter pools are populated by unique flora and fauna. The organisms populating the winter pools utilize distinctive life strategies to enable a complete life cycle within a wet period lasting only several months, after which they must survive throughout the long dry season, until the next winter (Rothschild & Perlman, 2010).

The northern part of the winter pool (photograph: Smadar Amir, April 2018)

The winter pool in Herzliya Park receives stormwater from the drainage pipe of Yosef Nevo Street, which flows to a sedimentation basin. The basin is used for coarse cleansing of the stormwater arriving from the city's neighborhoods. The water goes through a grated barrier at the pipe's opening; when the water arrives in the sedimentation basin the heavy particles settle. The slope between the pipe's opening and the canal through which water flows out of the sedimentation basin enables additional retention and the settling. In the dry season, water from excess irrigation, car washing, etc. arrives in the sedimentation basin.Therefore, in contrast to the winter pool, it remains wet throughout the year. In recent years, a decision was made to dry up the sedimentation basin at the end of summer in order to avoid the transfer of polluted sediment that has accumulated in it into the winter pool, when the basin fills up and overflows.

The canal from the sedimentation basin to the winter pool (photograph: Smadar Amir, April 2018)

The opening of the channel leading to the sedimentation basin (photograph: Smadar Amir, April 2018)

The water flows from the sedimentation basin westward in an open channel that is full of vegetation, and splits into two at the end: one side reaches the southwestern part of the pool, and the other continues to the northwestern part. The pool fills with water after the first significant rain (usually in October-November) and dries up completely in the summer months (starting May-June). The pool is home to an abundant ecological variety of flora and fauna, as detailed later in this report. During the dry period, some of the flora and fauna survive, thanks to special survival strategies, including winter hibernation, sustainable eggs, sustainable seeds, etc. In order to avoid disrupting these processes, human interference in the pool area must be avoided, also in the dry season.

The plans for the winter pool (Phase 2 of the park's development) were designed to enable it to exist as a natural area in which human activity is highly restricted and the interference with local nature is minimized. The plans enable the public to access the pool and witness the wealth of natural phenomena by means of a floating deck that connects the sedimentation basin with the southwestern winter pool. The path is closed off with gates at night and has no nighttime illumination. Along the path, there are concealed birdwatching points that allow quiet, non-invasive observation of the water birds.

Entrance to the wooden path, with a sign providing information about the winter pool and the activities forbidden in it (photograph: Smadar Amir, April 2018)

The area of the winter pool is divided into three sections: the southwestern pool, the northwestern pool and the eastern pool (see above the map of the three phases of the park). The “main path”, which is located between the northwestern and eastern sections, includes jogging, walking and bicycle trails, and reaches the small forests of Phase 2. Tall reeds separate the path and the pool; these were planted to avoid disrupting the activity of the fauna in the pool. The northwestern section of the pool covers a large area (including the area of the future park) and at present is actually an open area, a continuation of the natural winter pool.

The “main path”, including jogging, walking and bicycle trails (photograph: Smadar Amir, April 2018)

2.2 Eucalyptus Groves

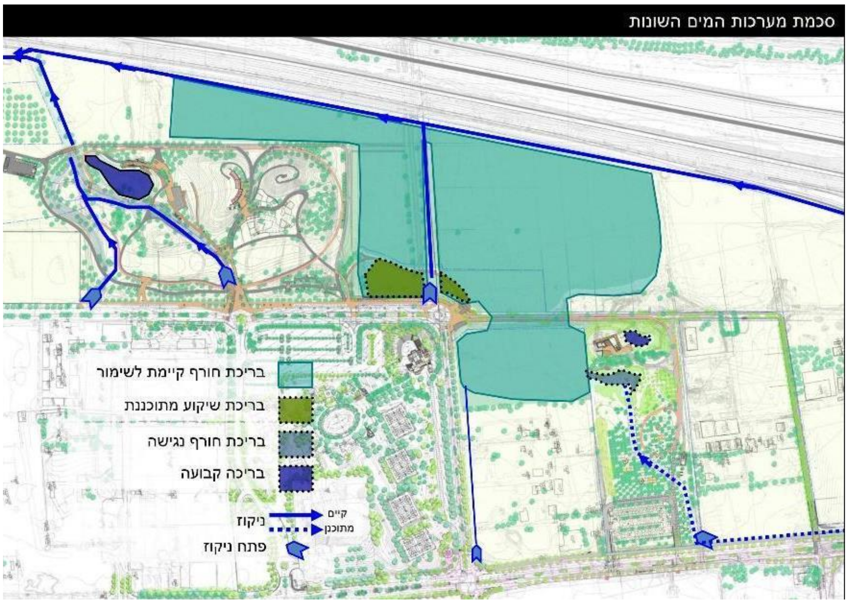
There are a number of small eucalyptus groves in the park. These small forests and their surrounding area were left in the natural state they were found in before the park’s development. They do not require irrigation; rainfall and surface runoff is sufficient to sustain them. They function similarly to the limans found in Israel's Negev desert in that most of them are situated in areas that are topographically lower than their surroundings., Therefore the runoff is captured and detained for a short period of time, sustaining the trees and contributing to stormwater management..

Part of a small Eucalyptus grove in the park, on a rainy day (photograph: Smadar Amir, April 2018*)*

2.3 Stream-like Open Channels

Four drainage pipes lead runoff from eastern Herzliya to the park. The northern pipe arrives directly to the northern section of the winter pool. The second pipe leads runoff into the sedimentation basin, which then flows into the winter pool. The two channels further to the south reach the park area (the part that was planned in Phase 1) and have been designed to simulate two stream-like open channels with low vegetation. The two connect and drain into a channel in the western part of the park, and from there, the water flows to the large drainage tunnel near the train station, which drains the excess water westward.

The storwmater management role of the open channels is to direct the water and produce short-term retention. The two channels were designed at a slope of 0.5% from the entry threshold of the city's pipes to the western drainage tunnel. Yet at the time of the park's planning, the person in charge of drainage was not certain that the channels would be able to drain the water, and therefore, he added a closed drainage pipe (40") that passes underneath one of the channels and drains the summer flows and some of the runoff during major storms.



Drainage scheme (Source: Aronson's Power Point presntation, 2014)

The meeting point of the open channels, on a summer day and after significant rainfall (photograph: Smadar Amir, April 2018)

2.4 Concave Lawns

Four expansive lawns are found in the areas of the park developed in Phases 1 and 3. They were planned as concave lawns so that runoff from broad areas of the park would flow to them and accumulate for a short period of time. The lawns serve as an area for leisure activities, with a large playground at their center.The slopes of the lawns in Phase 1 are planned so that when they fill with runoff during significant rainfall events, the runoff flows from them to the open channels.

Playground at the heart of a concave lawn (*photograph: Smadar Amir, April 2018*)

3 Evaluation of Herzliya Park and Practices of Stormwater Management in the Park

This section of the research uses the evaluation tool that was presented in part 2 of this report. The evaluation is based on a list of goals that was developed within a series of studies into Water-Sensitive Planning that were conducted at the Technion over the past 25 years (Carmon 2015). The goals are divided into four groups: hydrological, ecological-environmental, social, and economic. Following a presentation of the sources of data used for evaluating Herzliya park, our findings regarding the level of achievement of each goup of goals will be detailed.

3.1 Sources of information for the evaluation of Herzliya park

In order to asses the extent to which the park, and the stormwater management practices in it, achieve the diverse goals of this green-blue project, the study used three categories of information: (1) Relevant scientific-professional literature; (2) Available documents relating to the seasonal pool in Herzliya and to the municipal park; and (3) Interviews with relevant informants.

The scientific-professional literature that we used in our work deals with Water-Sensitive Planning (WSP) and its objectives, as well as with the appropriate practices for managing runoff based on the WSP approach (Carmon & Shamir, 1997; Shamir & Carmon, 2007; USEPA, 2010; Carmon & Shamir, 2010; WSUD,2013; Marcus, Gasith & Carmon, 2014). A key document that we based our work on was a seminar paper dealing with Herzliya Park, written by a landscape architecture student (Merhav, 2016), within the framework of the course “Water-sensitive Planning”, which was developed and delivered for the first time at the Technion in 2016 by the authors of this report. Several documents provided information on the winter pool as a central element of Herzliya Park (Gasith, 2006; The Society for the Protection of Nature in Israel, 2008; Rothschild & Perlman, 2010). We also drew information from the site of Herzliya city engineer and from articles about Herzliya Park which were published online (for example, Mendelsohn, 2016).

Interviews, conversations and e-mail communication with “relevant informants” – those who were, and still are involved in the park’s planning and maintenance - comprise a source of information of primary importance. The interviews were conducted face to face, aided by a semi-structured questionnaire and an assessment table with scores indicating the extent to which the defined goals were achieved (0 – not at all; 1 – somewhat; 2 – moderately; 3 – fairly well; and 4 – very well) . The main interviewees were Prof. Avital Gasith of Tel-Aviv University, who initiated the conservation of the winter pool to leverage the establishment of a municipal park at the site, provided valuable input during the planning process and continues to be involved through his students; Drainage Engineer Shmuel Bedolah of the firm H.G.M Civil, Water and Environmental Engineering and two of the engineers of the Union of Water Engineers - who handled, and continue to handle the issues pertaining to the stormwater and drainage at the site; Landscape Architect Barbara Aronson from Shlomo Aronson Architects, the firm responsible for planning the park in all of its phases; Rachel Ben Gom, who was responsible for environmental issues at the office of Herzliya’s City Engineer; Landscape Architect Vered Osher, the manager of Herzliya Park; and Koby Azulay, director of water and environment at the park.

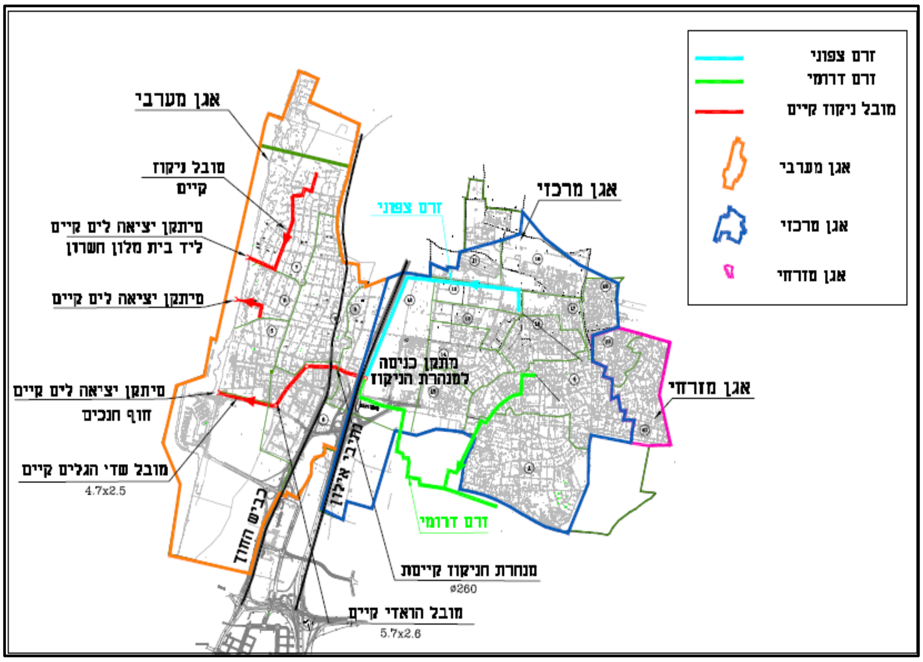
3.2. Results

Below we present findings concerning the level of achievement of each of the goals in the four groups which were examined –hydrological, ecological-environmental, social, and economic. Finally, a comprehensive evaluation of the entire park will be presented in a table and in a pie assessment chart, as described in part 2 above.

3.2.1 Hydrological goals

Mitigating Urban Floods

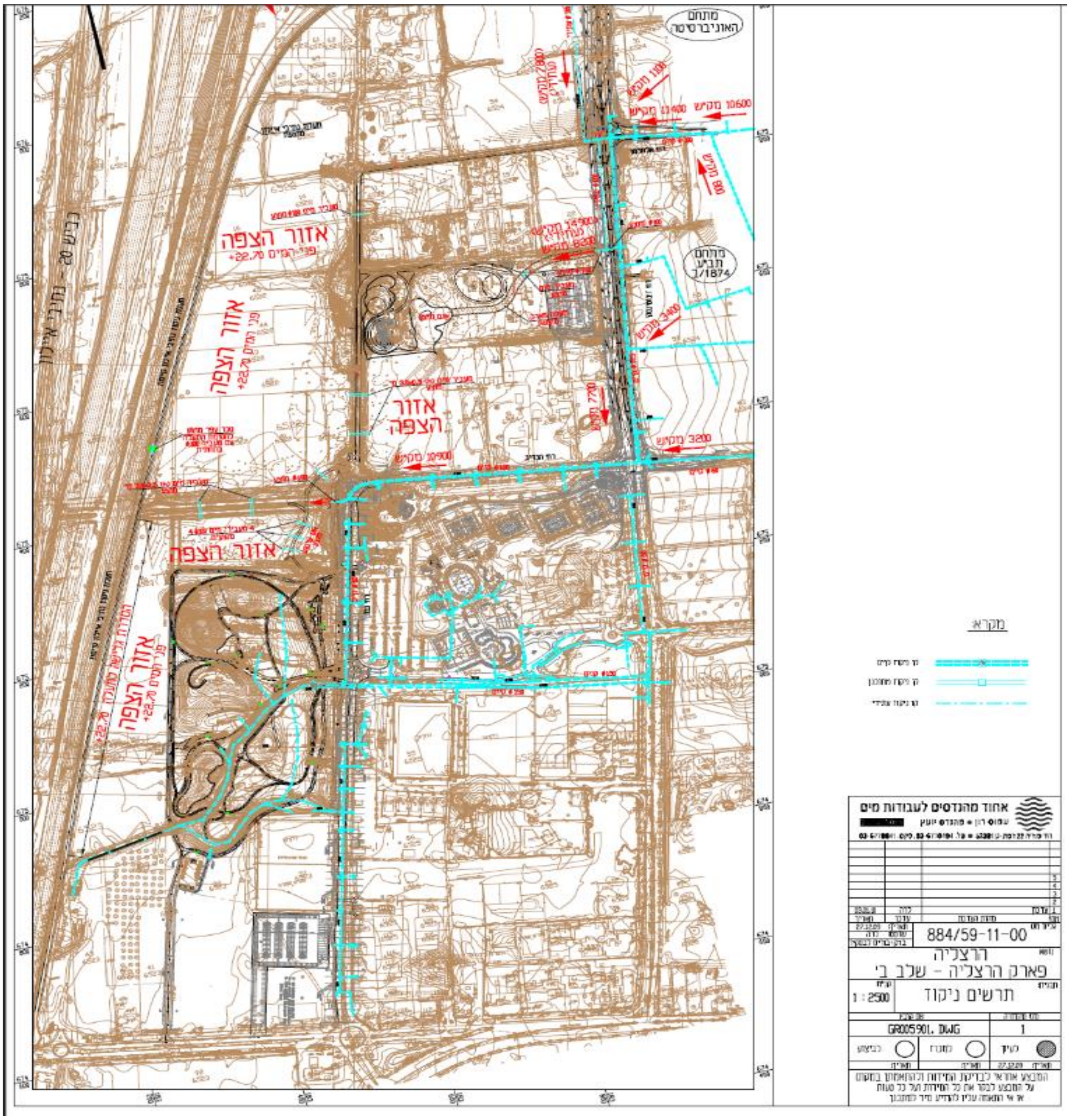
The swampland upon which Herzliya Park was established served as a floodplain throughout thousands of years of settlement on land that is now the State of Israel. It is located in the geographic center of the city of Herzliya. In the Drainage and Channeling Master Plan of Herzliya (Bdolah, 2011), the park is shown at the western edge of the city’s central drainage basin. This basin covers almost the entire built side on the eastern side of Ayalon highway. Most of the basin is covered by residential buildings with several public buildings.



Catchment areas in the City of Herzliya (source: Bdolah 2011)

In order to understand the role of the park and stormwater management practices for the municipal drainage system, which is responsible for protecting the city from flooding, we collected numerous documents and conducted interviews with the drainage engineers and landscape architects who had been involved in these issues over the last 15 years. Based on our findings, during Phase 1 of the park's planning there was limited collaboration between the landscape architects and the engineers. We were informed that a hydrological survey had been carried out at the site; however, we were unable to locate it. In Phase 1, landscape architects included two stream-like open channels to convey the stormwater. On the eastern side of the park these connect with two drainage pipes arriving from the city to form one sloped channel inside the park which connects to the drainage pipe system carrying stormwater to the Mediterranean Sea to the west. However, Landscape Architect Barbara Aronson advised us that the engineers did not have confidence in the function of the open channels and installed a conventional drainage pipe underneath them.

During Phase 2, which included the planning of the winter pool, there was some degree of collaboration between the engineers responsible for the drainage (in this phase only) – th Union of Water Engineers, and the park's planners – Aronson Architects. This is evidenced in the figure below.



Drainage plan of Phaze 2 in Herzliya partk (source: the Union of Water Engineers, 2000)

Figure 4.4.15 shows the drainage pipe system (in light blue) entering the park (on the right), and indicates in words (in red) the role of the winter pool as a floodplain. The drainage engineer Boris Levskyr shared that each significant rain event results in stormwater flowing into the park. To deal with extreme rain events, the engineers were instructed by the municipality to create a spillway throughout the areas of the winter pool at a height of 22.70 meters above sea level (the areas in the figure indicated in large red font as "floodplain"), allowing water to collect to a height of 22.90 meters. This possibility is realized only in extreme storms (we were unable to find out their probability of occurrence), and is intended to delay the flow of the stormwater from the floodplain to the municipal drainage system which directs the flow to the sea, thus mitigating flooding and partly reducing the need to significantly expand the drainage system.

Our conclusion, therefore, is that the park and the winter pool are integrated into the municipal drainage system and contribute greatly to mitigating flooding, and to some extent also to lowering the cost of the drainage system. That said, broader collaboration between the drainage engineers and the landscape architects could have increased the use of other stormwater management practices in the park (in addition to the winter pool), and further increased the hydrological and economic benefits derived from it.

<u>Recharging the aquifer</u>

The soil under the park is clay, which does not allow infiltration of water and thus renders spontaneous infiltration to the coastal aquifer impossible. Infiltration pits could have been included in the park, as they will be in the area that will extend the park southward. However this idea was not raised when the park was initially planned during the first decade of the millennium.

<u>Harvesting stormwater for diverse uses</u>

Harvesting stormwater means directly using rainwater and runoff before they infiltrate into the ground or reach "receiving water" (the sea, a stream, etc.). The principles of Water-Sensitive Planning determine that wherever possible, direct usage is preferable to infiltrating stormwater. One of the possible uses is "water for nature." The Israeli Water Authority's master plan (2012) formally states that the State of Israel is required to allocate a certain quantity of water each year for "water for nature". The winter pool captures the stormwater from each significant rainfall event and uses it to sustain the pool and its flora and fauna. The goal of runoff harvesting for diverse needs is thus achieved.

3.3.2 Ecological-environmental goals

<u>Improving the quality of the stormwater before it reaches the "receiving water"</u>

The stormwater that reaches the park and the winter pool originates in residential neighborhoods. Koby Azulay, who is responsible for water in the park, reported that according to tests conducted on the stormwater, it does not flow from the adjacent airport. Rough waste that is swept by the stormwater (such as plastic bags) is blocked by a grate installed at the opening of the pipe through which the runoff flows from eastern Herzliya. The runoff from this channel first flows down a sloped channel and then arrives at the sedimentation basin where the heavy particles settle. The quality of the water, which goes through these relatively simple practices of cleansing, is good enough to enable the fauna and flora in the winter pool to flourish.

The flow of water in the channel that connects the drainage pipe with the sedimentation basin continues during the summer; this is water from excess irrigation, car washing, emptying of aquariums and garden pools, etc. – water that is of lesser quality than that of winter stormwater. In contrast to the winter pool that is dry during the summer months, this water causes the sedimentation basin to remain wet and rich with vegetation throughout the year.

The maintenance of the pool and the sedimentation basin is carried out under the guidance of an ecologist. Following his professional recommendation, a decision was made in recent years to pump out the water in the sedimentation basin in the month of August to allow it to dry and be cleaned of organic waste that had accumulated at its bottom. Probably as a result of emptying aquariums, this waste includes water snakes, eels and gambusia, little fish that are beneficial as they eat mosquitos but also harm amphibia, and are therefore undesirable in the winter pool.

Support for biological diversity

The Society for the Protection of Nature in Israel was one of the organizations that fought to conserve the winter pool, arguing that it held great significance from an ecological viewpoint as it supports rich biological diversity and also some highly endangered species (Rothschild & Perlman, 2010). In a survey conducted at the initiative of the Municipality of Herzliya by Prof. Avital Gasith (2005), close to the time of the park's planning, the following species were detected in the swampland:

- Numerous invertebrates, including the rare species *Lepidurus apus.*
- Three species of amphibians, including indications of the presence of the rare species *syriacus Pelobates.*
- Approximately 40 species of rare flora, first and foremost the impressive species *Botomus umbellatus*, which comprises the most southern population in the world; and the species *Rumex martimus*, which was considered extinct in Israel's coastal plain.
- Approximately 64 types of birds, including a surprisingly rich population of waterfowl, some of which nest in the area. When the area is flooded, it is characterized by an abundance and high diversity of birds.

An ecological survey has not been conducted since the park's development; however, Prof. Gasith has stated (2018) that he believes that the system today is similar to the one that existed when the above survey was carried out. The birdwatchers, Shlomit Lifshitz and Amir Balaban, collected information about the birds that can be observed in the pool at present, and reported about 20 waterfowl and 30 lawn birds (Municipality of Herzliya website). The following species are also mentioned in the same website, as inhabitants of the park's pool:

- *Syrian spadefoot* – an amphibian with no tail that is similar to a frog. The tadpoles develop in winter puddles; during the summer, the adults bury themselves in the ground in shallow vertical tunnels (up to 20 cm deep) in the proximity of winter puddles.
- *Lepidurus apus* – this crab disappeared from the territory of the State of Israel in the 1980s; since it is considered extinct, the Israel Nature and Parks Authority has initiated its restoration to a number of winter pools.
- Ilanit - *savignyi Hyla*– spends most of its time on trees, descends to the winter pond mainly for reproduction purposes.
- Other invertebrates that were observed in the winter pool: *Bulinus trancatus, Gerridae, Dafnia, similes Arctodiaptomus, Ostracoda, Hydrophilidae*

In addition to the winter pool's important contribution to biological diversity, a garden shelter for endangered plant species was established in the park. Its purpose is to conserve the rare species that grow in this area, as well as to serve as a source for seeds and seedlings that may be restored to nature, to rehabilitate habitats and populate them. The garden shelter includes a variety of plants, including *Lotus creticus L., Satureja thymbra L., Coridothymus capitatus, Globularia arabica Jaub, Scilla hyacinthoides, Salvia fruticosa Mill* and more (Municipality of Herzliya website).

Conservation of wet ecosystems

The conservation of the winter pool – a wet ecosystem of primary importance – comprises a main element in the park's planning and reputation. The conservation of wet ecosystems was included in discussions about the park from the outset, not only by the ecologist and by the Society for the Protection of Nature, who were intensely involved in the early stages of the planning process, but also by the city's mayor, and subsequently, by the city council and by activist inhabitants. The planners of the park wrote (Aronson, 2014) that the planning intervention in the pool area was kept to a minimum consciously and intentionally, in order to conserve its natural balance. Concealed birdwatching points were established in order to avoid disrupting the waterfowl; tall reeds were planted along the central path so that those using it would not disrupt the fauna in the pool; special hidden observation points were established to allow visitors to view the birds and the pool with minimal human interference; there is no illumination along the floating path at the southern end of the winter pool, and only low illumination poles at its northern end.

Interviews with Vered Osher, the park's manager, and with Koby Azulay, who is responsible for water in the park, revealed that the pool's maintenance is minimal and follows the instructions of the ecologist who accompanys the activities in the park.

Soil conservation

Soil conservation is of cardinal importance in Israel. The country is lacking in soil in general, and in fertile soil in particular, and is also suffering significant losses of soil due to a lack of awareness and insufficient allocation of resources. A central cause of soil loss is erosion, which is mainly caused by runoff, and also by wind. The means for preventing erosion and conserving soil can be classified into two types – agronomic and engineering (Halperin, 1996, p. 585).

In our conversations with the professionals responsible for the planning, execution and maintenance of Herzliya Park, the term "soil conservation" was not mentioned. However, observation of what is taking place on the ground reveals that the park contributes greatly to this worthy cause. Soil conservation regulations (1960) stipulate that each canal, channel, strip of grass, avenue of trees, pool, etc., can be considered as a "soil conservation enterprise" (Yaacobi, 2009). Herzliya Park was planned and built in a floodplain, with a high level of awareness of the flow of water within it, and with the intention of mitigating the flow. The winter pool stores a considerable amount of stormwater until it evaporates, and thus prevents strong water flow. There is abundant vegetation in the area of the pool; leaving uncultivated areas with local vegetation is considered a major means of soil conservation. Moderate slopes were planned throughout the park and these slow the stormwater flow, and consequently, lower the potential of soil erosion. Retention areas are scattered in the park, including the small eucalyptus groves and the concave lawns. Fissures in the ground became stream-like open channels housing grass and other vegetation. All of these components reflect the significant contribution of Herzliya Park to soil conservation.

3.4.3 Social goals

<u>Place making for leisure time and recreation</u>

A visitors survey has not been conducted in the park, but based on the testimony of its manager, Vered Osher, the park is visited by people of all ages, both individuals and families, on all days of the week and at all hours of the day. A decision was made at the outset that entry would be free of charge; this undoubtedly encourages visits.

The park offers soft rubber jogging trails, attracting joggers – both individuals and jogging groups – from around the country, who arrive to train in it. Soccer and other teams also train in the park. Private sports activities with personal trainers, including TRX (Total Body Resistence), are also seen.

In addition to Herzliya's inhabitants who come to spend time in the park throughout the week, visitors arrive from the entire region on weekends and holidays – some use their private vehicles, while others take the train. Lately, Israel Railways launched a campaign encouraging train usage, which lists attractive sites near train stations. The park is located a short walking distance from Herzliya train station, and is also mentioned in this campaign. Vered Osher added that during the week-long holiday of Passover, many families came to the park by train. Many youths also visit the park in the evening, arriving on their bicycles. It seems that they are requested to leave the municipal gardens at night by the police and find Herzliya Park an attractive alternative.

<u>"Nature in the city" enhancement</u>

"Urban nature" is a natural system located within the territory of a local authority (The Society for the Protection of Nature in Israel, 2017). The concept of urban nature includes conservation of biological diversity and unique nature values, while allowing the general public to access a high quality natural environment and supporting community and educational activities, as well as the local economy, by helping generate revenues from tourism (ibid.).

The winter pool in Herzliya Park certainly meets the definition of urban nature. Much effort has been invested in its planning, and continues to be invested in its daily cultivation, in order to conserve the natural processes taking place in the pool and to minimize the impact of development, as well as the impact of the maintenance team and the park visitors. One can witness the annual display of the pool filling up during the winter and drying up in summer, as well as the cyclic blooming and wilting; and observe water fowl, and also birds nesting and raising their chicks from the concealed birdwatching points, without disrupting them.

According to the park's planners (Aronson 2014) and its manager, Vered Osher, it is not only the winter pool but the entire park that offers the experience of "nature in the city". The small eucalyptus groves have been conserved in their original state in different parts of the park. Cultured plants have not been planted– neither roses nor seasonal flowers; only local plants and stream vegetation, which provide a sense of nature. The plants that were chosen were those that do not require intense irrigation. Once successfully planted, they required minimal irrigation, almost like the wild vegetation that is not irrigated at all. Vered added that with the exception of the coffee shops operating in the park, there is no commercial activity in the form of peddlers, open-air markets, etc., with the intention of preserving the sense of nature.

Aaesthetics and landscape quality

Herzliya Park provides unique landscape aesthetics, as can be seen in the images below.

Figure 16: Deck along the winter pool (photograph: Smadar Amir, April 2018)

Figure 17: General view of the park

The functioning and aesthetics of the park gained professional recognition among the landscape architects' and designers' community:

- The park won the Israeli Design Excellence Award for 2010.
- The park won the Israeli Association of Landscape Architect's award for 2013. The judges declared, as part of their statement, that: "The creative and innovative design derives from the site's characteristics, and based on them succeeds to generate added value from both the

ecological and architectural viewpoints. The park serves the general public in a wonderful way, and constitutes an example of planning that takes into account both the needs of the community and of the environment." (http://www.land-arch.org.il/images/inc/files_magazines/792.pdf)

- The park was awarded the Karavan prize in 2015. Aliza Braudo, chair of the landscape architects association stated: "it has both artistic and aesthetic values." (https://www.haaretz.co.il/gallery/architecture/1.2714525)

Education for sustainability and good citizenship

Herzliya Park promotes education for sustainability among children and youth, as well as among adults. This is expressed in the following:

- The park pamphlet, which enables visitors to conduct an active tour of the park, familiarize themselves with its different areas and learn about its flora and fauna.
- "Edible forest" – a small orchard was planted in the park, containing a variety of fruit and nut trees: strawberry, pomegranate, walnut, almond, guava, feijoa, cherry, sweetsop (sugar apple), wampi (Clausena lansium), persimmon and mango. Local inhabitants cultivate this orchard.
- Keinan House – built in 1936 as a lone house at the heart of the orchards. Efraim Keinan renovated it in 1946, and his family lived there for the next 60 years. The ownership of the house was transferred to the Municipality of Herzliya in 2007, and was declared a "house of nature, the environment and the community", and is considered a part of Herzliya Park. Based on this declaration, the house was designed in line with the values of sustainability. The illumination system was designed through use of the poterium bushes, the benches were made of natural wood, the sculpture was built using Israel Electric Corporation waste, etc. The garden surrounding the house was upgraded in accordance with the city's nature concept. Guided tours take place at the house and continue to the park. Keinan House currently serves as a focal point for local community activity that advance the social-environmental discourse in the city.
- Broad educational activities for children in Herzliya's schools takes place in the park. Activities for all 4^{th} graders take place at the winter pool as part of their curriculum. The one-day tours begin with an explanation at Keinan House and continue with activities in the winter pool area. There are approximately thirty 4^{th} grade classes in the city (some 1,000 children in total). This activity is now in its fourth year.
- Changing awareness of nature among Herzliya's inhabitants – the park's manager reported a change in the residents' perception of the park. At first they were concerned that the park and its winter pool would attract mosquitoes and they voiced their objection. In contrast, today they feel a sense of pride, which is expressed in their efforts to care for the park, and in public reporting to the municipal call center about hazards, litter, vehicles driving in the park, etc.

Social involvement and communality promotion

The park's establishment was a complex process and required much community involvement. Along with the part played by prominent persons and organizations that support the development of urban nature, the political commitment of the mayor and the city council were also required (see Appendix 2). These were supported by caring residents of Herzliya, whose help was needed to advance the process, despite the claims filed by those who owned some of the land and were interested in making a profit by constructing high-rise buildings on it. The inhabitants' support helped during the court proceedings, including at the Supreme Court, which ruled against the land owners and in favor of the public interest of conserving the winter pool and establishing a large municipal park in the area (see Appendix 1).

According to the presentation provided by Landscape architect Barbra Aronson (2014), the planning program of the park was determined following a telephone survey conducted among the city's residents and a brainstorming workshop with local residents (referred to in the image below). Accordingly, it included the following elements: playground facilities, lawns, an amphitheater, picnic grounds, a lake, jogging and bicycle paths, a coffee shop, public toilets and shaded areas.

Brainstorming announcment (Source: Aronson's powerpoint presentation, 2014)

The community involvement in the life of the park continued, and even increased after its establishment. Some of this involvement was bottom-up, especially in the form of volunteers. It was also encouraged from above, through public entertainment and youth activities funded by the municipality. The park's manager mentioned a photography project that she had initiated in recent months, which was inspired by beautiful pictures of the park and life in it, which were sent to her by visitors.

3.5.4 Economic goals

Financial benefits for the municipality

The municipality has gained a successful, particularly well-functioning park, with significant savings in its establishment and maintenance costs. Based on a "position paper" prepared by the Society for the Protection of Nature in Israel (2008), "the conservation of the winter pool as a natural area with minimal development will save the city's residents millions of NIS: the cost of intensive park development (lawns, pergolas, facilities) is estimated at more than NIS 100,000 per dunam; therefore, conserving some 120 dunam of pool saved the Municipality of Herzliya approximately NIS 12 million.

Furthermore, the annual maintenance costs of an intensive park are estimated at thousands of NIS per dunam. The park's manager indicates that the maintenance of the winter pool is minimal – a day or two of mowing periodically, as per the ecologist's instructions. Consequently, the municipality saves hundreds of thousands of NIS annually.

The park generates additional financial savings, though the extent is unknown, due to the fact that a significant amount of stormwater drains into the winter pool each year, a large share of which evaporates and does not reach the drainage system situated to the west of the park. Engineer Borris from the Union of Water Engineers told us that thanks to the calculations of the floodplain in the park, the western drainage system of the city is considerably smaller than it would have been without it. In addition to the above saving, there is stormwater that is directed to the stream-like open channels, where it flows relatively slowly, irrigating and evaporating on its way. If these large amounts of stormwater would not have been detained at the park, the municipal drainage system that conveys the runoff to the sea would need to have been expanded, which would have required significant financial investment.

On the other hand, it is important to remember the municipality's expenses as well: compensating the private landowners whose land was confiscated to establish parts of the park (a process that is ongoing and far from over), and the establishment and maintenance of a large park which is open to the public free of charge. In addition, the municipality initiates cultural events in the park, also free of charge, including guided tours, concerts, dancing, story-telling and more. Even the blue-and-white (paid) parking in the park's vicinity is free of charge for Herzliya residents; visitors from outside the city pay a parking fee, which constitutes revenue for the municipality.

Increased value of proximate real estate

The land uses in the vicinity of the park are mainly commercial or public, including the city's stadium, performing arts hall, country club, Air Force House, the Interdisciplinary College (IDC), event halls and more. No residential areas neighbor the park, whose value would have increased thanks to the green and blue landscape visible from their buildings' windows. The "Western Green Herzliya" neighborhood lies not far from the northern (and as yet undeveloped) part of the park; it is a relatively new neighborhood that mainly attracts young families. A search on the most popular website for information concerning residential neighborhoods and the purchase/rental of apartments in Israel (*MADLAN*), reveals that the proximity to the park is indeed mentioned as one of this neighborhood's attributes. However, it is only one among other attributes, such as spacious apartments and proximity to public transportation, to schools and sports clubs, and also to open areas – of which the only mentioned by name is Herzliya Park. We therefore conclude that the park's impact on real estate prices in the area is small.

Economic opportunities in proximity to blue-green landscape

The park's planners intentionally refrained, and continue to refrain from allowing commercial activity to take place within the park, which in their view would be incompatible with the "nature in the city" experience that they would like the park visitors to enjoy. There are only two coffee shops, one at the southern part of the park and one at its center, near a playground. An additional coffee shop (Phase 3 of the development) is presently closed for renovation.

The main public services offered by the Municipality of Herzliya, mentioned above, operate in proximity to the park. However, is it reasonable to assume that their existence in this location and the activities taking place there are not influenced by the park.

The shopping mall "Shivat HaKochavim" which is situated near the park, is worth mentioning in this context, if only because there is a huge glass wall near its entrance (close to Aroma coffee shop). It is possible that observing the park, or visiting it as well, are part of the shopping experience at the mall, and therefore, positively impact on its level of attractiveness.

We have not found evidence of any plans to expand the economic activity in the park or in its vicinity.

Herzliya Park as a Green-Blue Project:

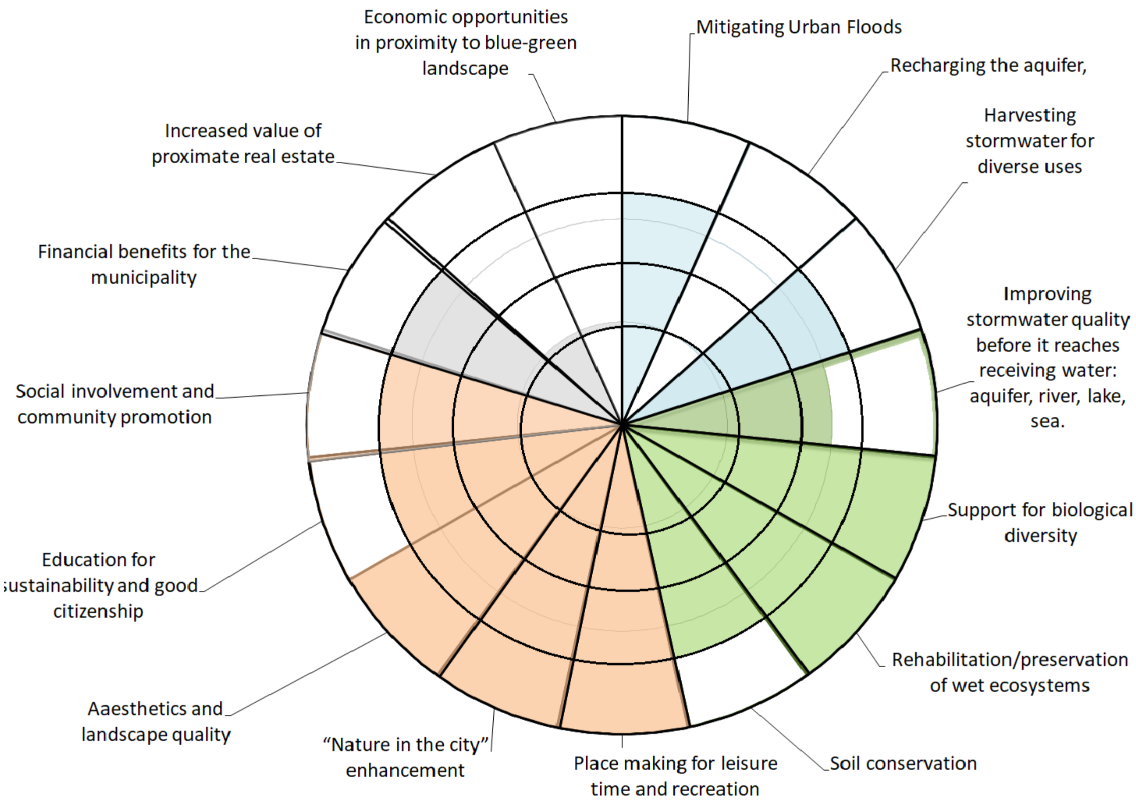
Comprehensive Evaluation of Goals Achievement

Herzliya Park is a green-blue project – a landscape project that integrates practices/means/tools for stormwater management. In this research, it serves as a test case on an urban scale. It demonstrates that integration is possible, and that it supports the achievement of goals related to all four groups that were examined: hydrological, environmental-ecological, social and economic goals.

Herzliya Park as a Green-Blue Project – Overall Assessment of the Achievement of Goals

Goals/Benefits	Relevant stormwater management practices	Information for evaluation (details in former sections)	Grade* (0-4)
Mitigation of urban floods	Winter pool Stream-like channels Small eucalyptus forests Concave lawns	The pool retains stormwater and the others slow down its flow	3
Aquifer recharge	---	Clay soil does not enable infiltration; infiltration pits were not added to the park	0
Stormwater harvesting for various uses	Winter pool	The pool collects "water for nature", which is a formal water use in Israel;	3
Stormwater quality improvement before it reaches "receiving water"	River-like open channels	The sedimentation basin cleans runoff to the extent required for the pool; Slowing down the runoff flow and passing through vegetation contributes to cleansing	2
Biodiversity support	Winter pool The other practices	The natural fauna and flora in the pool and other practices contribute considerably to biodiversity	4
Rehabilitation/conservation of wet ecosystems	Winter pool	Rigorous conservation	4
Soil conservation	All the practices	Each practice and its vegetation slow down runoff flow and conserve soil	3
Place making for leisure time and recreation	Winter pool Concave lawns Eucalyptus forests	Residents of Herzliya and other visitors intensively use the park; The practices increase the park's attractiveness.	4
Nature in the city enhancement	Winter pool The other practices	Extensive careful development nature and using local vegetation	4
Aesthetics and landscape quality enhancement	The practices and the park as a whole	A series of professional awards confirms the unique quality	4
Education for sustainability and good citizenship	Winter pool The other practices	Plenty of educational activities; citizens alert whenever they detect hazards	3
Social involvement enhancement	Winter pool The other practices	Citizen participation in ensuring pool conservation; volunteers are active in the park	3
Financial benefits for the municipality	Winter pool	Cost savings in development and maintenance in comparison to an intensive park; Cost savings due to somewhat smaller drainage system in the western part of the city	3
Increased value of proximate real estate	The park as a whole	No housing in immediate proximity; the park is considered as adding some value by *MADLAN***	1
Economic opportunities in proximity to blue-green landscape	---	---	0

*Grades: 0 – not at all; 1 – little; 2 – moderate; 3 – well; 4 – very well** *MADLAN* is a popular real estate site



The various goals were achieved to varying extents. In two of the groups – environmental-ecological goals and social goals – the park was awarded high evaluation grades: mostly 4's (very well) and a few 3's (well). Economic goals were moderately achieved (0,1,2). The hydrological goals, which deserve particular attention in this research, were achieved to a mixed degree: aquifer recharge – not at all; mitigation of urban floods– well, but not very well; runoff cleansing – again, well, but not very well. Our explanation for the variance in the level of achievement is anchored both in a lack of sufficient awareness of the potential for achieving these goals among the professionals who dealt with the park's planning, and the lack of collaboration between them.

The raison d'être of the park at the location where it is situated is that the site was an historic floodplain. The landscape architects, who are primarily responsible for the park's image, were aware of the 'watery' history, and stated: "The main skeleton of the park and the design of its elements are an interpretation of the basic concept of 'natural flow', a concept directly associated with the site's natural history as a drainage basin" (Aronson, 2014). However, this awareness did not encourage them to communicate with the drainage engineers and to collaborate with them from the very start of the planning process. The idea of collaboration and its potential benefits were even more distant from the point of view of the drainage engineers. Moreover, the drainage plan of Phase 1 of the park reflects a lack of belief in the potential of stormwater management measures to aid drainage; as a result a drainage pump was installed underneath the open channels in Phase 1 of the park's development. The drainage engineers as well as the landscape architects did not think at all about recharging the aquifer, because the soil type in the area is clay, which does not infiltrate water. However, they could have considered infiltration pits, such as those planned in Glil-Yam park across the road, at the southern part of Herzliya Park. Glil-Yam is being designed by the same landscape architects and reflects lessons drawn from the planning and implementation of Herzliya Park.

In contrast to the very little communication between the landscape architects and the drainage engineers, a close connection was maintained between the planners and the ecologists at all stages of the parks's planning, execution and maintenance. Prof. Avital Gasith was responsible for mobilizing Herzliya's mayor and the city council to restore the winter pool as a central focal point in the park, and the Society for the Protection of Nature in Israel assisted by supporting the decision to conserve the natural pool at the size needed to support the natural processes taking place within it. Among other actions, ecologists ensured that the sedimentation basin was situated in an area that had already been damaged by human activity, and prevented the use of heavy machinery in the vicinity of the natural pool. Additionally, maintenance of the the pooland of the park in general takes place in consultation with an ecologist. Landscape Architect Barbara Aronson believes that the establishment of the park opened up new possibilities for similar parks, which were developed in subsequent years, and contributed to promoting a professional dialog between landscape architects and ecologists. The success of this collaboration is very apparent in the high to very high grades that were awarded to the achievement of the environmental-ecological goals and of the social goals, which are closely associated with the planning and design.

The diverse goals were not only achieved simultaneously, but the synergy between them is clearly discernible. The planning and execution of the stormwater management practices contribute greatly to achieving the environmental-ecological goals. These practices include first and foremost the winter pool and the adjoining sedimentation basin, the small eucalyptus groves in shallow depressed areas, the concave lawns and the stream-like open channels, which contribute to reducing floods and to cleansing the flowing runoff. These measures also producefocal points for social interest in the park, while helping to reduce execution and maintenance costs. All of these aspects, as well as the talent and the ability of the designers to communicate with the target audience, led to the success of Herzliya Park. In a newspaper article covering the most recommended parks in central Israel, Herzliya Park was listed first (Sagi Alfasa, 2012).

Finally, we wish to add that the park's success is not guaranteed. Although the court has ruled in favor of protecting the right of this area to serve as a municipal park (and not as a land intended for residential or other uses), this has not yet been finalized statutorily. Some of the land in the park area is still privately owned. Furthermore, the water sources feeding the winter pool are under threat of building and road construction plans. There is hope that these issues will be resolved with time, due to the public and educational success of the park. It is dear to the heart of many of Herzliya's inhabitants and of its public representatives, and it is reasonable to assume that they will fight to preserve and expand it.

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CHAPTER 5

INSIGHTS AND RECOMMENDATIONS, INCLUDING A TOOLBOX

Clear trends of the 21st century have already begun to emerge. A salient one among them is an emphasis on achieving climate change resilience by means of green policies and practices, including green infrastructure and nature-based solutions. Our approach to SSWM – Sustainable Stormwater Management – is in line with these trends and it is briefly characterized below.

SSWM is part of the 'Soft Path' to water management. As opposed to the engineering approach, which was dominant throughout most of the 20th century, and the economic approach, which took over many fields toward the end of the century, the 'Soft Path' is a **holistic, multi-purpose, multidisciplinary and sustainable avenue** (Gleik 2002; 2003; Brandes and Brooks, 2007; Brooks, Brandes and Gutman, 2009). The essence of our approach is presented below in section 5.3.1. Here we emphasize a few points that – at least partly - differentiate SSWM from other current approaches to stormwater in Israel.

- **We recommend encouraging implementation of SSWM - Sustainable Stormwater Management projects**, by means of subsidies as well as a wide educational operation (see below section 5.2); encouraging it wherever possible, in the north, the center and the south, in large and small projects, each according to specific local conditions.
- **ENCOURAGEMENT DOES NOT MEAN ENFORCEMENT; we disagree with those who support immediate enforcement of SSWM throughout Israel. We_believe that evidence-based policy and guidelines should be pre-requisites to general enforcement.**
- **We recommend identifying and generating additional knowledge that is still missing for wider implementation of SSWM projects.** Gathering and analyzing necessary data, and reaching agreements between relevant professionals and institutions, are all necessary conditions for informed decision-making on implementation of SSWM projects. **Knowledge from abroad is often irrelevant, because of different rainfall regimes, and because the sewage and drainage systems are often combined systems in cities abroad, unlike in Israel.**
- **A critical component of the missing knowledge will come from monitoring and evaluating carefully selected examples of SSWM projects,** of which there should be more if they are subsidized and encouraged as above**.** The projects will reflect various regions and river basins in the country. Early examples of such evaluations are presented in chapter 4 above and in the appendices of this report.
- In other words: we support the approach of 'listening first and doing afterwards', over the more common Israeli approach of 'first do and then listen' (in Hebrew: *Na'aseh veNishmah*, Exodus 23:4).

This fifth chapter of the research presents insights, conclusions and recommendations, based on the former chapters as well as on knowledge gathered in more than twenty years of the Technion project of Water-Sensitive Planning in Israel and abroad (see a list of publications in Appendix 1 at the end of this chapter). The chapter is composed of four distinct groups of insights and recommendations: first – a discussion of stormwater as a water resource in the Israeli case, based on data that most professionals seem to ignore; second - policy recommendations for decision makers; third – recommended toolbox for professionals in the field of SSWM, presenting a rich collection of available principles and practices for implementing SSWM; fourth – recommendations for KKL-JNF.

5.1 Insight: Can urban stormwater serve as an additional water resource in Israel?

5.1.1 The answer is negative from the point of view of the State of Israel

According to data from the Hydrological Service of the Water Authority of Israel (2018; see chapter 1.1 above), the annual average volume of stormwater in Israel is 200M m^3. Twenty per cent of this is urban stormwater while the remaining 80% falls in rural areas. The rural stormwater is large enough to serve as an additional water resource for Israel. However, **even if all of the urban stormwater, i.e. an annual average of 40M m^3, recharged the aquifers, this would only increase current natural aquifer recharge by 3%.** This small potential addition does not justify the heavy costs – financial and others - of trying to infiltrate all (or much) of urban stormwater into the ground.[14].

5.1.2 The answer is positive, from the point of view of urban local authorities

Urban stormwater is highly significant from the point of view of municipalities, mainly because of the potential benefits to the municipality and its residents, and also because of stormwater's potential dangers (mainly floods), which the municipality can mitigate. If urban open spaces are planned and developed using the suggested toolbox for SSWM (as detailed below in 5.3), local authorities and their residents have the potential to reap many benefits from stormwater, hydrological as well as environmental-ecological, social and economic (see chapter 4 above). When there is a way to benefit from stormwater above ground, it will almost always be preferable to infiltration. I**n order for the municipality to enjoy the benefits, the stormwater should be of appropriate quality**. We suggest that appropriate in the case of stormwater means that the quality fits the intended use; the quality required for a stormwater pool in which people are allowed to swim will be very different to the quality required for a winter pool. As explained in detail above (section 1.2), findings of available field studies – which for practical recommendations are preferable to laboratory studies – indicate that the quality of urban stormwater, especially from residential areas, is good enough for all non-drinking uses including infiltration. To be on the safe side, it is better to avoid direct infiltration and instead to favor infiltration that goes through appropriate soil, preferably with local plants and stones. It is also recommended that stormwater stored in urban area is at least conveyed through sedimentation basins that collect rough dirt.

[14] There may be other considerations related to infiltrated stormwater, such as diluting contaminated groundwater or mitigating the advancement of the saltwater intrusion, but we miss the relevant data.

5.2 Policy recommendations for decision-makers In response to current impediments to promoting SSWM in Israel

The policy recommendations are organized according to the theoretical framework suggested by the research unit of policy analysis (Chapter 2 and Goulden et al., 2018, ibid), with some additions: **(1)** Cognitive recommendations, such as knowledge, attitudes and beliefs that are related to water, stormwater and sustainability; **(2)** Normative recommendations, such as professional standards and conduct related to stormwater management; **(3)** Regulative recommendations, such as laws, statutory plans and governing bodies. We add to these two more groups: **(4)** Economic recommendations, such as economic incentives and valuations of benefits and costs of projects and practices; **(5)** Social-administrative recommendations, such as promoting partnerships, public-civic and public-private partnerships as well as long-term cooperation with the local community.

5.2.1 Cognitive policy recommendations (related to awareness, perceptions, attitudes and knowledge)

(A) **Promote awareness of the variety of potential benefits of SSWM among relevant decision-makers**, in national as well as in local institutions, **among the relevant professionals and the wider public**.

(B) **Increase the knowledge base for wide implementation of SSWM**. Shortage of knowledge and data in critical issues of stormwater management, and a lack of research and development of solutions based on innovative technology, were found to be outstanding barriers to implementation, especially because so many of the stakeholders seem to ignore the issue of lack of sufficient knowledge. To demonstrate the severity of the problem, we share a few striking examples, firstly regarding **basic hydrological and drainage calculations**: (1) Water and drainage engineers are familiar with calculation methods and tools for flood protection, and therefore address almost exclusively extreme storms that are computed based on runoff discharges. However, considering runoff as a source of water, not merely as a nuisance to be removed, requires consideration of the full range of rainfall events, not only peak storms, and must distinguish clearly between **runoff discharge and volume** and calculate volumes with appropriate methods.[15] (2) Information and/or professional agreement about appropriate standards are absent with regard to the following basic issues: appropriate **return periods** for different spatial scales and sizes,[16] **infiltration capacities for various soils**, models for **evaporation**, and procedures for calculating **design discharge:** as for the latter, should one calculate by the long-used Rational Formula, or the Tachles or NTA

[15] While working on this project we met with engineering consultants who work for the Government and local authorities, who confused between calculating the discharge and the volume of runoff.

[16] We found in our work that a city of 100,000 inhabitants in the Coastal Plain, was planned for a 1:20 storm event, while a new neighborhood close by, also in the Coastal Plain, was planned for a 1:100 storm event, while the burden of drainage cost (which raised the price of housing) and the responsibility for maintaining the stormwater pits rests on the tenants, mostly families with children in multi-story buildings.

or other model?[17] (3) There is not enough data and there are different interpretations of existing data on **urban runoff quality** in Israel in general (see discussion in Section 1.2 of this report), especially when it flows from different land uses (housing areas, roads, employment compounds); there is no agreement on the runoff quality required for various functions: infiltration, versus irrigation, versus detention and storage basins. (4) An example of **a novel technology, which exists in Israel in theory, but has not been tested**: installation of control valves in large drainage pipes, so that the pipes can be used to provide conveyance capacity during extreme storms as well as temporary detention storage following such storms[18].

Ways to overcome these deficits are massive support for **applied research,** alongside R&D - **research and actual development of SSWM technologies, practices and tools, monitoring and evaluating the operation of existing projects with SSWM practices,** especially green infrastructure projects with 'nature-based solutions' under specifically Israeli conditions. (C) **Disseminate knowledge of SSWM principles and practices to overcome the severe scarcity of professionals with appropriate training for SSWM.** This scarcity is particularly notable among engineers and urban planners, less so among landscape architects.

5.2.2 Normative policy recommendations (Professional standards and behavior)

(A) **Require interdisciplinary work**. Every medium- and large-scale urban spatial plan necessitates the involvement of various professionals. A common Israeli procedure is to work in sequence, one after the other. Usually the architect or urban planner starts with locating land uses, where to place housing, roads, public open spaces etc., and oftentimes, the architect - possibly under instructions from the developer - also makes decisions regarding the type of buildings (low-rise, high-rise) and more. Only afterwards, other professionals, including drainage and sewage engineers and landscape architects, are called upon to add their contributions. All of these professionals, frequently with a few others such as ecologists, have to cooperate from the very beginning of each project of a significant size. From the point of view of stormwater management, cooperation is essential in order to effectively and efficiently prevent future damages, especially frequent floods, and to draw the many benefits that SSWM can provide.

(B) **Publish national policy statements, and in addition, practical guidebooks for stormwater management**. Start with a participatory process at the national level to develop and consolidate a policy statement regarding stormwater management, based on knowledge that currently exists among highly experienced professionals and other stakeholders, as well as public representatives. Remember that policies are collections of justified principles of

[17] According the Shmuel Bdolach, one of the best and most experienced drainage engineers in the country, authorities require results of a few models. They tend to employ the strictest results (whose cost is much higher), in the absence of an agreed criterion to select among the models.
[18] See work by Lior Assaf.

conduct, not detailed guidelines. We recommend that policy makers follow at least part of the relevant recommendations in this report, especially in section 5.3. In parallel, recruit highly experienced professionals from the relevant fields to work together to develop guidebooks with professional standards that apply to the various urban and regional areas of the country. These policy statements and guidebooks should be reviewed and revised every few years, in accordance with new knowledge, new technologies and lessons taken from monitored operation of implemented projects and practices. Once these documents have integrated the lessons from actual implementation of projects and technology in Israeli conditions, these policies and guidelines may join the official standards of green construction in Israel and other such formal guides, as well as gradually enter laws and regulations that require enforcement.

(C) **Publish local policy statements for stormwater management**. Each municipality should prepare its own policy document for SSWM that follows its principles and guidelines, including an emphasis on slowing down the flow of stormwater in its area (i.e. not only infiltration into the ground); nature-based solutions and other planning principles of SSWM (see sections 5.2.1 and 5.2.2); and adapting them to the local context including local natural conditions (precipitation, soil et.), socio-economic characteristics, and regulatory and statutory conditions.

5.2.3 Regulative policy recommendations (Laws, governing bodies, regulations, outline plans)

(A) **An appropriate legal framework is a necessity. The first recommended step towards this is to enact a new law of stormwater management to replace the obsolete 1957 Drainage Law.** The 1957 law defines stormwater as "damaging water" that has to be removed as soon as possible from the urban area in order not to disturb human activity. A draft of a new proposed law, which was put on the agenda of the Knesset (Israeli Parliament) in 2013, starts by saying that wherever the old law says 'drainage' it should be replaced by 'stormwater management', recognizing both the terms and many of the conclusions of the Technion studies of Water-Sensitive Planning. Yet, the proposed new law has been under discussion in the Knesset for seven years; no conclusion has been reached, due to differences of opinion regarding official responsibilities and funding. It seems that professional mediation could assist in reducing or even solving the issues under controversy between the Water Authority and the Ministry of Agriculture and Rural Development as well as between the latter and the local authorities, and thus, pave the way to enacting a new law.

(B) **Regulate the relationships between the 11 Drainage Authorities spread throughout the country and the municipalities that are located within each basin**. Water does not recognize municipal boundaries. National regulation is necessary as well as local coordination and cooperation between the authorities within each river basin.

(C) **Revise TAMA** (=National Outline Plan**) 34/B, especially TAMA 34/B4, which turned out to be an impediment from the point of view of implementing SSWM**. Indeed, these National Outline plans (approved by the Israeli government in 2006-7) were highly impacted by the early Water-Sensitive Planning work at the Technion, and thus include the basic ideas that stormwater is a resource and its management should be directed to a variety of goals. Yet, in fact, **TAMA 34/B led to an over-emphasis on only one sub-goal and one practice: recharging the aquifers by infiltration of stormwater into the ground** (see chapter 3 above).

(D) **Replace the statutory 'Drainage Appendix' with 'Stormwater Management Appendix', built in accordance with the goals, principles and guidelines of SSWM.** The idea to submit a drainage appendix with each medium and large spatial plan is a good one. Yet, a survey of recent drainage appendices submitted to various municipalities shows that in all cases the appendices were prepared solely by drainage engineers, and in most cases – as said above – they included only one sub-goal and one practice of SSWM: recharging the aquifers by infiltration of stormwater into the ground. Hence, it is essential to at least update, and as far as possible replace, the current guidelines for preparing these appendices. First, the title should be changed to Stormwater Management Appendix, and second, multidisciplinary teams should be required to prepare it (at least a drainage engineer and a landscape architect). Third, the appendix should use the range of potential benefits, principles and practices that are available for SSWM.

5.2.4 Economic policy recommendations (Valuation of benefits and costs, incentives)

(A) **Determine the value of the benefits versus the costs of landscape projects that integrate SSWM practices.** The professionals responsible for this must be familiar not only with economic cost-benefit analysis but also with water systems, and especially, with valuation of ecological and social factors. There are several methods for making those calculations, but whatever method is selected, we include a few recommendations: (1) The calculations should be **based on real data from the field**, not on a hypothesized set of data or data taken from abroad. (2) The valuation should encompass **not only factors that are monetary, and not only factors that can be quantified to create a continuous variable**, but also factors whose worth can be ranked (such as +, ++, +++). (3) **Where there is no real data regarding the value of an important factor, a substitute should be carefully selected and be as close as possible to the real case**. For example, economists and others often select the price of desalinated water as representative of the value of water infiltrated into the ground (see for instance Rosenthal, 2010). Infiltrated water is different from ready-to-drink water in several ways however; only a part (sometimes not a large part) of the infiltrated water reaches the groundwater, there is an additional cost to pumping it from the groundwater, and there are significant differences in quality characteristics. A preferable substitute in this case may be the price that *Mekorot* charges municipalities for water used to irrigate open urban areas. A recent alternative approach to the valuation of the multiple benefits of stormwater has been published by Driniger et al. [19]

(B) **Allocate governmental budget to support and subsidize implementation of SSWM in urban areas**. The requested support is expected to meet two goals: first, to overcome the impediments of lack of awareness and lack of knowledge required for implementation, by distribution of well-prepared information to different publics, in addition to short training programs for relevant professionals (see above 5.2.). Second, grants to local authorities, by number of SSWM projects and their size, normalized by number of city residents. The assumption is that when there is strong Israeli evidence regarding SSWM's benefits for the quality of life of city residents, for moderating urban floods, and for reducing expenditure on irrigation etc., the municipalities will create economic incentives for private developers, possibly also for private landlords and all those who integrate practices of SSWM into their projects. Employing 'carrot incentives' such as waiving extraction levies are recommended, but there may also be relevant 'sticks’ such as a special tax or specific limitations on construction without SSWM practices.

5.2.5 Administrative policy recommendations (Partnerships)

(A) **Develop public-civic partnerships**. Compared to other Western democracies, civic society in Israel is not highly developed. Yet it is very active in the field of environmentalism. The umbrella organization 'Life and Environment' has collected under its flag over a hundred environmental organizations. We recommend recruiting this organization as well as the 'green Lobby' at the Knesset to mobilize national and local public-civic partnerships to push ahead the development of the necessary regulative structure and promote public awareness of the benefits of SSWM and the ways in which ordinary residents can assist in developing and maintaining SSWM systems.

(B) **Develop public-private partnerships**. The spread of privatization of public services has also reached the field of water. A prominent example is water desalination plants. Four of the five plants that currently operate in Israel are projects of BOT - Build, Operate, Transfer; they were initiated by the government and were constructed and are operated by private companies. These companies are monitored by a governmental body and are committed to selling their product to the government and transferring the plants to the government after 25 years.

(C) **Transfer stormwater management from the municipalities to the Water Corporations**. This is an administrative change that is expected to enable more professional, effective and efficient stormwater management. This change may be an opportunity to modify the structure of the 55 Water Corporations in the country and, as far as possible, base the

[19] Diringer S. E., et al. (2020). Economic evaluation of stormwater capture and its multiple benefits in California. PLoS ONE, 15 (3): e0230549. See the interesting term "levelized cost of water in U.S. dollar per acre-foot of water supply".

revised structure on hydro-geographic borders (river basins) more than on municipal borders.

(D) **Develop long-term cooperation between the developers and operators of stormwater projects and the local communities**. In order to advance SSWM projects such as a park, a grass channel along a street or a winter pool, we need the local community on our side. Community support is valuable in the first stages, when public opposition can block a project's implementation, and also in the later stages of maintenance. The case of *Emek HaTsva'im* park in Jerusalem is a good example: a sizable group of local people are very active in supporting the project, and volunteers of the close-by neighborhood take part in maintaining the park, including cleaning up the stormwater pools after every rain storm.

5.3 Toolbox for professionals in SSWM – Sustainable Stormwater Management

5.3.1 WSP (Water-Sensitive Planning) as a base of SSWM

Since the mid-1990's **an interdisciplinary team of Technion researchers established and developed the interdisciplinary field of Water-Sensitive Planning (WSP) in Israel.** Spearheading the field were Naomi Carmon (urban planner and sociologist) and Uri Shamir (water resources management), along with Tal Alon Mozes and Shmuel Burmil (landscape architects), Avital Gasith (ecologist, Tel Aviv University), Avner Kesler (water and drainage engineer) and others. , Their joint work includes 13 empirical studies and 5 books (in Hebrew), 7 papers in Israeli professional magazines, 6 papers in international scientific journals, 9 student MSc theses, research reports and other publications (see Appendix 1 at the end of this chapter).

Initially, WSP focused on the idea of stormwater as a resource (not only a nuisance) and on 'saving' what was then Israel's main source of drinking water – the coastal aquifer – by infiltrating stormwater into the ground. In the early 2000's, influenced by concepts from sustainable development, the nascent field of WSP research and practice developed in two directions: first, **to WSP's initial hydrological goals** the researchers **added** a wide range of ecological-environmental goals together with social and economic goals. Second, in addition to stormwater management, WSP began to include other subjects at the interface of urban and regional planning and water issues such as water conservation and greywater. At present, WSP can be counted as part of a worldwide trend toward Green Infrastructure.

Over the years, WSP researchers continued to develop its list of goals and a series of planning principles and action guidelines. This SSWM research project further developed these goals and principles in order to facilitate their application for the benefit of both the human and natural environment. . Four bundles of goals and twelve planning principles that were used in this research are presented below.

5.3.2 Goals and planning principles

5.3.2.1 Goals for SSWM and for its evaluation

Based on the WSP approach, additional reading of the literature on sustainable development and stormwater management, as well as our experience over the course of the current research, we recommend the following four bundles of goals to guide SSWM plans and its continuous evaluation. Three of the four are the primary goals of sustainable development – ecological-environmental goals, social goals and economic goals, while the fourth one is directly related to water issues. Within each bundle, 3-5 sub-goals (potential benefits) are listed:

(A) Hydrological goals

- Stormwater harvesting for various usages
- Mitigating urban floods
- Recharging the aquifer

(B) Environmental-ecological goals

- Improving stormwater quality before it reaches receiving water (aquifer, river, lake, sea)
- Biodiversity support
- Rehabilitating/conserving rivers and other wet eco-systems
- Soil conservation

(C) Social goals

- Making places for leisure time and recreation
- Enhancing 'nature in the city'
- Enhancing aesthetics and landscape visual qualities
- Education for sustainability and good citizenship
- Social involvement and community development

(D) Economic Goals

- Financial benefits for the municipality
- Increased value of proximate real estates
- Economic opportunities in proximity of blue-green landscape

5.3.2.2 Two groups of principles

The planning principles of SSWM, which follows WSP approach, are divided into two groups: one that is generic for any sustainable development, for sustainable transportation as well as for sustainable stormwater management, and one that is unique to sustainable stormwater management.

First group: planning principles that are expected to guide any project of sustainable development. The examples below were selected to fit stormwater management.

(A) ***Select multi-purpose / multi-benefit policies and practices***

Each policy statement as well as each practice that professionals use should be **aimed at pursuing as many as possible goals from the three bundles of goals of sustainable development:** environmental-ecological goals, social goals and economic goals. In the case of SSWM, we add to these three the hydrological bundle with its goals (see above 5.3.2.1). To the extent possible, **all of these should be pursued simultaneously and synergistically.**

(B) ***Multi-disciplinary collaboration is required from the outset of the planning process***

Collaboration among various professionals in the planning and implementation processes is required, including among urban planners, landscape architects, water and drainage engineers, road engineers, hydrologists, ecologists, structure and geotechnical engineers. All of those and possibly more are required in large projects, while in small ones, coordination between a landscape architect and a water engineer may be sufficient. Collaboration is valuable at every stage, but especially at the outset, when the location of land uses is determined. If multi-disciplinary planning is in operation and **if the location of open spaces and built areas is based on the hydro-geographic structure of the planned area at the very beginning of the project, then serious urban floods are prevented and stormwater management will be far less expensive and much more effective**.

(C) ***Build partnerships with stakeholders, especially with the local community***

Partnerships with all the main stakeholders involved in and impacted by stormwater management is frequently needed to establish SSWM projects and always required to maintain them over time. The role of local civic organizations, formal and informal, is particularly crucial in this respect.

(D) ***Adjust each project according to local conditions***

Even though there should be written policies and general principles for planning and implementing SSWM projects, each project should be adjusted according to its local conditions. These include local natural conditions such as location within the drainage basin, characteristics of soil, groundwater, topography, streams, flora and fauna; socio-cultural and economic conditions of the community and the municipality, as well as organizational and regulatory conditions, for both the current and planned situations, upstream and downstream.

(E) ***Work with nature (not against it*****)**

Planning and design of the built environment should work in harmony with the existing area's geo-topo-hydrography, with special attention to the seashore (if relevant), stream network and flood plains, contrary to the tendency to sculpt the topography artificially. This principle is based on lessons learnt though many painful experiences in which humans built heavy solid obstacles (such as dams) to protect the built environment from flows of water that collapsed when they were needed the most.

Second group: planning principles for stormwater management

These principles emphasize the diversion of SSWM from non-sustainable conventional drainage. They complement the above mentioned five principles of sustainable development.

(F) Stormwater is a resource, not only a nuisance

Stormwater management can be used to achieve a wide variety of goals (see (A) above) and provide multiple benefits, in addition to its traditional role in mitigating flood damages.

(G) Coordinated management of urban stormwater and river basin stormwater

Coordination is necessary for effective, efficient and sustainable management, including conservation and rehabilitation of rivers and streams inside and outside of cities and treatment of stormwater upstream to avoid damages downstream.

(H) What to do with stormwater

Instead of getting rid of stormwater in the built environment as soon as possible, as required by conventional drainage, we recommend slowing the conveyance of stormwater as well as detention (temporarily holding back the water), retention, storage and infiltration into the soil.

(I) Where to manage stormwater in the urban area

Practices to manage stormwater should take place close to where it is generated. To be effective, they should take place where public control is possible, i.e. in public open spaces, roads and roadsides, yards and roofs of public buildings in large employment areas and parking areas. There is no justification to enforce SSWM in private yards (see chapter 1) but there are good reasons to encourage it and to monitor it in private yards as well.

(J) Appropriate quality

While conventional drainage focuses only on stormwater quantity, quality is important for SSWM. Different qualities originate from different land uses; for example, housing areas produce cleaner stormwater than main roads. Different quality levels are required for different usages. For example, irrigation of a public garden requires a different quality of stormwater from a winter pool.

(K) Stormwater volume and discharge

Conventional drainage focuses only on stormwater discharge, while SSWM necessitates considering both stormwater volumes and stormwater discharge.

(L) Large, medium and small rainstorms

For now, SSWM practices in urban areas in Israel are known to be mainly suitable for small and medium rainstorms; more local (Israeli) knowledge is required before recommendations can be made for practices suited to large rainstorms. To this end, it will be important to monitor and evaluate the results of projects that are currently on the drawing board, such as the Glil Yam Park in Herzliya, as well as to monitor the functioning of floodplains for cases of extreme rainstorms in Israel. In addition, it will be useful to examine success stories from abroad, such as the Greenbelt of Staten Island in NYC.

5.3.3. Landscape planning and design that integrates stormwater management: Principles and practices

This section offers professionals, especially landscape architects and stormwater/drainage engineers, a toolkit for integrating stormwater management into landscape projects. The kit is composed of two parts: **a short list of principles and a long list of practices**. **Both are parts of Green (or green-blue) Infrastructure (GI)**, a 21st century approach to infrastructure management, which conserves ecosystems, provides clean water, and delivers a wide array of benefits to people and wildlife. GI is gradually taking over more and more functions that used to be fulfilled by conventional/grey infrastructure, but at least for the time being, we need both grey and green to work for us together.

Green infrastructure solutions can be applied on different scales, from the micro level of a house or building or urban block (the smallest unit in an urban fabric), to the mezzo level of a neighborhood, urban quarter and small town, and the macro level of a city and its region, which may be a metropolitan area or a river basin. We apply this approach to SSWM. Practices at various levels are presented below (after the principles). Indeed, in this research we are interested mainly in the urban, but water does not recognize urban borders, and therefore, acquaintance and coordination with the wider scale are necessary conditions and are a part of this toolkit.

Another necessary condition for Green Infrastructure is multi-disciplinary and inter-disciplinary work of various professionals. For landscape planning and design that are the focus here, experienced landscape architects are the recommended leaders; those who combine the capabilities of landscape architecture with urban and regional planning (there is such a unique study program at the Technion) can take a leading role at the wider macro scale. In any case, water/drainage engineers should also participate in every landscape project that is expected to integrate stormwater management, and depending on the scale of the project, an ecologist, sociologist and economist should also participate.

5.3.3.1 Principles for designing open spaces

In order to maximize the achievement of the various goals of SSWM, hydrological, ecological, social and economic (see 5.3.2), we present several principles that are especially important for landscape planning and design. Please note that **the following 10 principles are recommended in addition to the 12 principles listed in 5.3.1 for implementation of SSWM, which included the realization of multi-purpose practices, multi-disciplinary** collaboration, partnership with stakeholders, adjustment to local conditions and the other above-mentioned principles.

(A) **Prefer NBS - Nature-Based Solutions**. NBS are solutions to societal challenges that are inspired and supported by nature. In our case, the societal challenge is to reform stormwater management by turning as much as possible grey infrastructure of stormwater to green infrastructure.

(B) **Use local natural resources**. As far as possible, use local soil, local stones and local vegetation; avoid using invasive species.

(C) **Endeavour to reduce impervious areas and increase the pervious and green areas** in each project.

(D) **Create connectivity between impervious and pervious areas.** This will slow down the flow of stormwater and allow infiltration (after it is partly purified by the vegetation), while simultaneously and synergistically benefitting animals that can pass from place to place, and also human beings who take advantage of the connectivity for walking trails, bicycling and more.

(E) As far as possible, **use practices above the ground**, as they contribute much more to the quality of life of the city residents; only the remaining stormwater should be directed to infiltrate into the ground.

(F) Use water-efficient vegetation.

(G) As far as possible, **use stormwater and recycled water for irrigation**.

(H) **"Roughening" the surface of the ground** by creating obstacles to the flowing stormwater, usually with local stones and/or local vegetation, slows down the flow of stormwater to mitigate floods, contributes to the aesthetics of the place and is especially effective in creating niches for small animals for the benefit of biodiversity.

(I) **Maintenance awareness** should guide the selection of practices to be implemented. Simple and low-cost maintenance are sub-goals in and of themselves.

(J) **Adoption of practices implemented abroad requires careful adaptation to the local conditions**, preferably in combination with experimentation.

5.3.3.2 Practices for designing open spaces

Contemporary landscape planning and design often integrate SSWM practices. This section presents a selection of diverse planning and design practices to be used by landscape architects, drainage engineers and all those who deal with open space planning and stormwater management. All the practices fall under the category of SSWM – Sustainable Stormwater Management, as they can achieve multipurpose goals. In our research we found a dozen SSWM practices, which were implemented in the various projects we studied (see ch. 4). Here we will add also practices that we have found in contemporary updated guidelines,[20] and other

[20] Main sources: UBC - University of British Columbia, MLWS Program (2014) **Innovative Stormwater Management**

publications recommended by professionals in the field of stormwater management. Our list does not purport to encompass the vast diversity of international literature but merely to give a taste. The interested reader can find many more suggestions in the publication of the ASLA - American Association of Landscape Architects, which examined and presented more than 450 projects that integrate SSWM (https://www.asla.org/ContentDetail.aspx?id=35068).

The list below, partly illustrated, is sorted according to two criteria: first by scale – the size of area that the project serves, divided by macro, mezzo, micro (they are presented in two rather than three sections because many of the measures are suited to more than one scale; see below). The second criterion distinguishes between planning practices and constructed practices, as detailed below.

(A) The macro and mezzo scales – The macro scale relates to a city and its region that could be a metropolitan area or river basin; the mezzo scale relates to a small town, urban quarter or neighborhoods. The two scales are presented below together, because a large share of the practices is relevant to both.

A1 Planning Practices

For the **macro scale** in Israel, it is important to base the planning process on a ***hydrological-ecological survey*** which will determine the goals of the project and will be the basis for ***master plans on the scale of the river basin***. Such a plan, in addition to its other purposes, will **identify large parcels of land to retain and detain the stormwater**. Special attention will be given to streams and to the protection of water resources. Furthermore, ***municipal planning policy*** will set the goals for the stormwater within the city. As with the countryside, it is important to allocate a big parcel of land for treating stormwater, preferably along urban streams. For the **mezzo scale** it is important to base planning on a ***local planning policy document,*** *to set* ***urban open spaces***

At the property scale https://www.youtube.com/watch?v=bVAOOjRoEB4
At the neighborhood scale https://www.youtube.com/watch?v=emQ8p6LGByU&t=510
At the watershed scale https://www.youtube.com/watch?v=qIsDAewDgT8&t=306s
כרמון (2018) https://naomi-carmon.net.technion.ac.il/files/2018/07/תרם-קורס-משותף-למהנדסים-ומתכננים-ותיקים-22.5.2018
Carmon and Shamir (2010). **Water-Sensitive Planning: Integrating Water Considerations into Urban and Regional Planning.** *Water and Environment Journal*, 24:3, 2010, pp. 181-191.
Shamir and Carmon (2007). **Water-Sensitive Planning: Integrating Water Considerations into Urban and Regional Planning** (Hebrew). Haifa: Technion, Center for Urban and Regional Studies.
-*City of Melbourne WSUD Guidelines Applying the Model WSUD Guidelines. An Initiative of the Inner Melbourne Action Plan* (parts of the report are on the net)

-http://water.lecture.ub.ac.id/files/2015/11/wusud-guidelines-part1.pdf

-https://www.clearwatervic.com.au/user-data/resource-files/Strategic-Approach-to-WSUD-Implementation-Guidelines.pdf

-https://www.melbournewater.com.au/sites/default/files/South-Eastern-councils-WSUD-guidelines.pdf

- http://www.portphillip.vic.gov.au/default/Part_4.pdf

-https://www1.nyc.gov/assets/dep/downloads/pdf/water/stormwater/green-infrastructure/nyc-green-infrastructure-onsite-design-manual-v1.pdf

according to hydro-geographical features of the neighbourhood/town, to preserve local streams and their floodplains, and to integrate the road system with the stormwater system in order to absorb surplus stormwater in peak events. In addition, it is recommended to use parks and open spaces next to public institutions as detention areas. In general, it is important to perceive stormwater as contributing to the experience of nature in the town. Detailed planning practices are listed below.

- **Create river basin master plans** - the boundaries of stream basins are determined by natural hydrology. Their spatial structure provides a basis for master plans and district and municipal outline plans, and of course for the management appendices required under the plans. A river basin masterplan must be adapted to the local natural and human conditions to determine the location of housing quarters and 'large land uses' such as: metropolitan parks, power plants, large water reservoirs and more. Geopolitical, economic and social factors all play a central role in preparing master plans. However, SSWM requires special attention in order to protect built-up areas from flooding, while simultaneously and synergistically to enhance stream conservation, conservation of the quantity and quality of water in the region and protected areas for water sources.
- **Prepare an ecological survey as a basis for urban planning** - in order to prevent severe damage to biodiversity, it is crucial to identify and preserve ecological hot spots and ecological corridors in cities. This planning principle also serves urban residents who may benefit from 'nature in the city'.[21]
- **Prepare a hydrological survey as a basis for urban land uses** - This is the most basic and important planning practice of all. It ensures that the first planning scheme of a new site - whether it is a river catchment, city or neighborhood - will be based on hydrological principles. This is a tangible expression of the planning principle mentioned above: work with nature and not against it [see (E) in 5.3.2.2]. Using a hydrological survey is the gold standard for mitigating severe flood damage, which frequently occurs – for example - when a housing project or a road is constructed in the path of stormwater flow or in a hydrological depression.
- **Set the layout of open spaces according to hydro-geographical structure** - this is recommended as a first step in the layout of any large city as well as a small neighborhood. Protecting and fostering the city's natural waterways, while assigning a safe margin between them and the city's buildings for rare large flows, will also allow for open spaces that attract population and business.
- **Coordinate the layout of roads with stormwater planning** – roads should back up the urban drainage system in times of medium and large storms. It is desirable to design winding roads to slow the flow of stormwater.

[21] See a working example in https://www.tel-aviv.gov.il/Residents/Environment/Pages/UrbanNature.aspx

- **Preserve and rehabilitate urban streams and flow channels** – this will enhance their double role in stormwater management and as a location for urban boulevards and parks.
- **Integrate SSWM practices with the open spaces surrounding large public amenities** – in order to detain or retain stormwater, especially in areas that are at risk of flooding.
- **Include multiple public open spaces of various sizes in the city,** from small gardens in urban blocks to urban and metropolitan parks. Integrating SSWM practices into these open spaces will combine hydrological goals to the social and environmental-ecological goals, which usually guide the planning of such open spaces.
- Use natural slopes wherever possible.

A2 Constructed practices - engineered or planted

The following list is not arranged in any order of preference. Any practice has to be selected according to the goals of the project and local conditions.

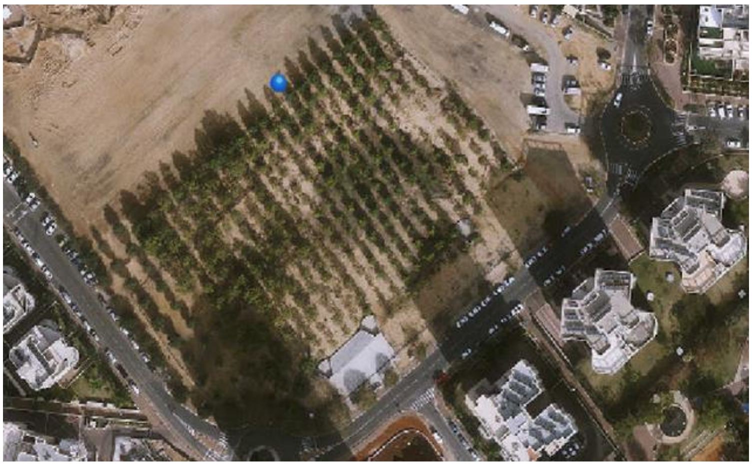
- **Urban forests / street trees / raingarden tree pits** (יער עירוני)

Street trees can be planted to incorporate raingarden stormwater treatment where street runoff is diverted to a street tree pit. The street tree is lowered to allow stormwater runoff to enter the tree pit and filter through the vegetated media before being discharged into the stormwater system.

(http://www.portphillip.vic.gov.au/default/Part_4.pdf p. 140).

- **Groves in topographic depressions** (לימנים)

Permanent or temporary groves in areas that are lower than street level can serve as retention basins and/or infiltration basins. They may be permanent or temporary.



Neot Shoshanim Park, Holon

- **Winter pools** (בריכת חורף)

Winter pools fill with rainwater for 4-5 months in the winter and gradually dry up for the summer. In the past, winter pools were common along Israel’s coastal plain and were part of the natural ecology of the country. They constitute a habitat which maintains a rich and unique biological diversity. Some creatures cannot exist without the winter pool while others (poultry, reptiles, etc.) are attracted by the abundance of water and food. Rehabilitating winter pools has great significance not just from an ecological perspective but also for the social benefits of the pools as sites that bring nature closer to city residents and as a way to moderate urban floods. In comparison to other open spaces, a winter pool requires little maintenance.

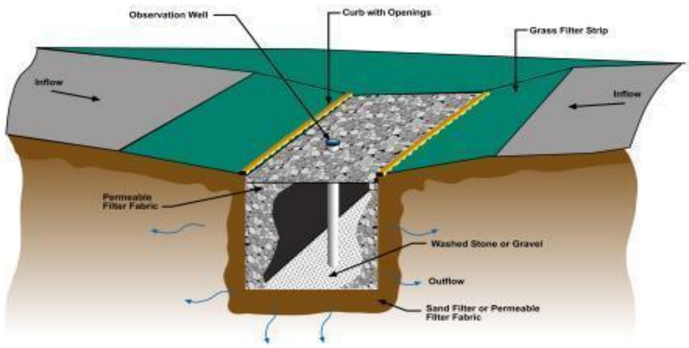
Winter pool in Horashim (photo: Sara Ohaion)

- **Vegetated swales, grass swales** (תעלת פתוחה – תעלת עשב, סינון והחדרה)

Vegetated swales slow the conveyance of stormwater and removes coarse and medium sediment. They are commonly used in conjunction with areas of vegetation through which runoff passes, known as buffer strips. Open channels covered with grass/stones and gravel help to drain areas and improve water quality. They are constructed in urban parks and along roads and paved areas, including parking lots. They can enhance biodiversity.


https://www.whittlesea.vic.gov.au/media/1932/f-design-construction-and-maintenance-of-wsud-guideline-includes-city-of-whittlesea-addendum.pdf p. 25

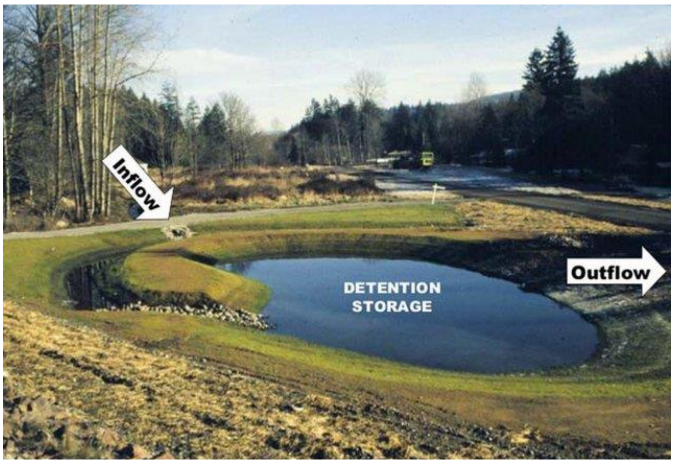
Frequently, infiltration trenches are integrated into the swales.



INFILTRATION TRENCH

- **Detention pond/basin** (מאגר השהייה)

A detention basin or pond is designed to capture and temporarily store runoff from the adjacent rural or residential area before releasing the water to the downstream channel. It can decrease downstream peak flow rates and help improve water quality by allowing suspended solids to settle over a period of time.



https://www.researchgate.net/publication/226149021_Streams_and_Urbanization/figures?lo=1

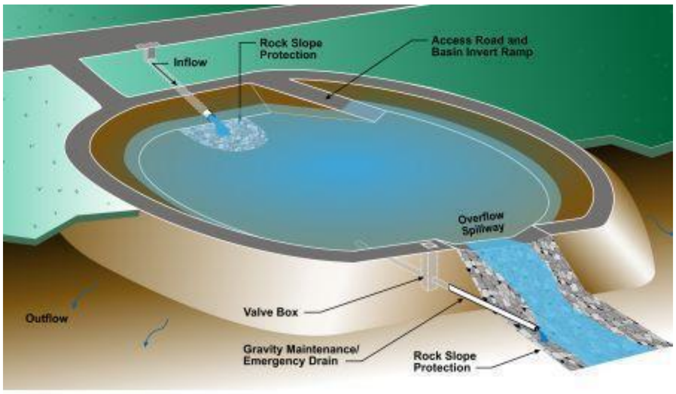
- **Retention pond/basin** (מאגר השהייה)

A retention basin/pool pond is an artificial pond with vegetation around the perimeter and is a permanent pool into which stormwater is directed. Water in the basin infiltrates and evaporates and can be used for irrigation. Retention ponds mitigate stormwater floods, have aesthetic value that tends to raise the price of houses nearby and also provide water quality benefits by removing soluble nutrients.

https://www.manuelbuilders.com/blog/retention-pond-vs-detention-pond

- **Infiltration basin/pond** (מאגר החדרה)

An infiltration basin is a shallow impoundment designed to infiltrate stormwater into the ground.



INFILTRATION BASIN

http://extensionpublications.unl.edu/assets/pdf/ec701.pdf p. 7

- **Constructed wetlands** (אגנים ירוקים)

Constructed wetlands are shallow, extensively vegetated water bodies that remove pollutants through enhanced sedimentation, fine filtration and pollutant uptake processes. Stormwater runoff passes slowly through the vegetated areas, which filter sediments and pollutants; biofilms form on the plants which absorb nutrients and other contaminants. Wetlands are well suited to treating large volumes of stormwater runoff and have the advantage of improving local amenities and providing habitat diversity (https://www.whittlesea.vic.gov.au/media/1932/f-design-construction-and-maintenance-of-wsud-guideline-includes-city-of-whittlesea-addendum.pdf p. 28)

https://globalprojectengineering.ch/constructed-wetlands-unlocking-water-treatment-technology-at-shell/

(B) The micro scale – the single building and its yard

For the smallest urban planning scale –the single building, either privately or publicly owned, and the urban block which is the smallest urban planning unit - the same SSWM objectives (5.3.2) and the same planning principles (5.3.1, 5.3.3.1) are recommended. Here we will present some of the practices discussed in the relevant BMP literature divided into planning practices and built practices.

B1 Planning Practices

The term "yard" below means the area left vacant in the single lot or municipal block, after a building or buildings have been built on it; it is usually used by neighbors but is sometimes intended for public use.

- **Leave a permeable area in the yard** (at least 15%) in the lower part of the yard and not close to the building's foundations.
- **Connect impervious areas in the yard to the pervious area**; the roof will be connected with gutter/s and paved areas in the yard with slight gradients.
- **Maintain the permeability of the natural soil in place**; avoid dispersing building materials in the permeable section and tightening the soil.
- **Use flooring materials** that allow infiltration for paths and the parking area.
- **Ensure that the roof is cleaned and sloped towards the gutters**; roof cleaning is needed to preserve the quality of stormwater flowing from the roof, and to prevent blocked gutters.

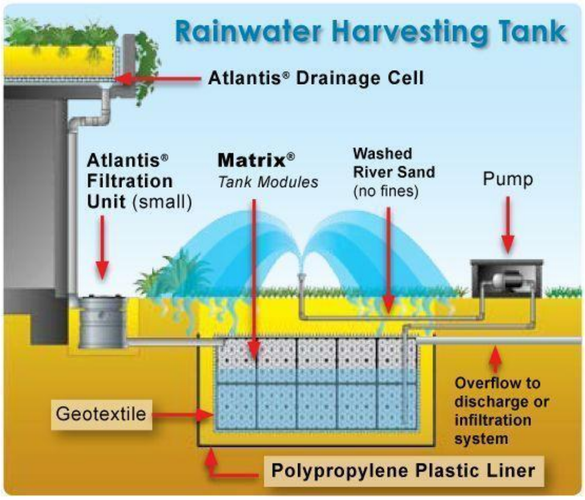
B2 Constructed practices - engineered or planted

- **Rainwater tanks**(מיכלים לאגירת נגר)

Rainwater tanks collect roof runoff for subsequent reuse, sometimes as potable water and other times for irrigation. Rainwater tanks reduce the volumes of stormwater runoff and pollutants that reach downstream waterways. Tanks may be constructed underground and may include modular units or a plastic liner to prevent infiltration.

Figure B-8: Rainwater tank Source: Melbourne Water.

ov.au/media/1932/f-design-construction-and-maintenance-of-wsud-guideline-includes-city-of-
esea-addendum.pdf



https://www.rainharvest.com/blog/?p=349

- **Dry well** (בור החדרה)

A dry well is a pit filled with gravel, sand and stones, sometimes covered with grass. The well is designed to retain and infiltrate stormwater into the ground, thereby reducing the intensity of flow after a rain event. The well can be constructed in the courtyard of a house and can be connected to the gutter descending from the roof. It can also be integrated at the block level, in public gardens and parks. This facility does not handle water quality well, so it is advisable to implement it in residential areas where the runoff is less polluted.

The following image is a typical dry well design with pretreatment features. Arrows indicate the flow of stormwater through the dry well system and into the surrounding sediment and rock.

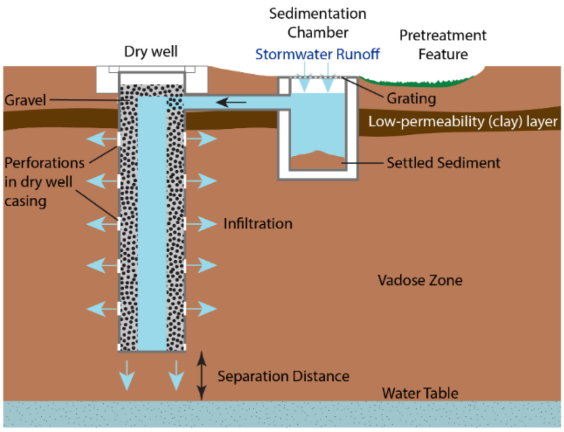


Image Credit: E. Edwards and B. Mandler

- **Green / Brown roofs** (גגות ירוקים וגגות חומים)

A green roof is partly or completely covered with vegetation. It commonly contains native or adapted plants, soil media, a root barrier, a drainage system, and a waterproof membrane. Green roofs detain stormwater in addition to their other environmental benefits. For a detailed discussion on green roofs by the American Association of Landscape Architects see https://www.asla.org/greenroof/index.html.

Brown roofs are not irrigated like green roofs and during summertime they remain dry. Both green and brown roofs can slow stormwater flow, clean the stormwater and support biodiversity.

- **Rainwater gardens** (גינות גשם)

A rain garden/swale/bioretention basin is a shallow landscape depression designed to retain and treat stormwater. Gravels, soil and plants facilitate infiltration and pollutant removal. Rain gardens are typically applied at a property level or neighborhood level and close to buildings (http://www.portphillip.vic.gov.au/default/Part_4.pdf).

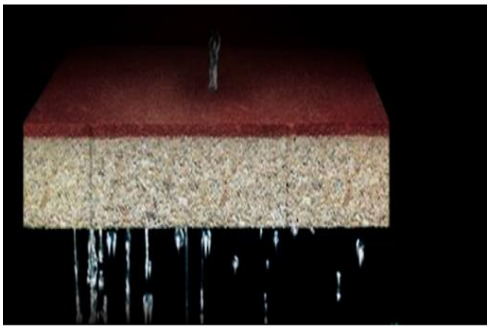
http://nwrm.eu/measure/rain-gardens

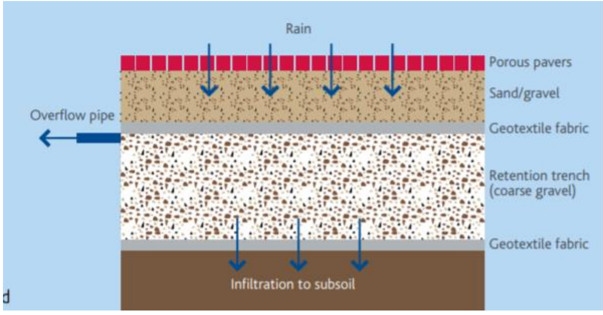
- **Organic and inorganic garden paving** (חיפוי גינה אורגני ואי-אורגני)

Garden paving retains soil moisture for a long time, purifies runoff and helps infiltration to the soil. Organic cover can be compost and wood chips; inorganic cover can be tuff, pebbles and gravel.

- **Porous surfaces and paving** (משטחים חדירים, ריצוף חדיר)

There are a few types of porous surfaces and paving, among them: permeable paving material such as kurkar that is usually designed for access paths, and paving units with openings in between that are spaced apart in combination with thick grass or thin gravel, and are often used for parking areas. By using porous paving that allows rainwater to soak through to the soil instead of standard concrete or block pavers, the design can reduce the amount of 'impervious' surfaces, increase groundwater recharge, improve stormwater quality and reduce pollutant loads, as well as reduce high flows entering the waterway from urban areas, which may5.4.1 cause stream erosion and habitat scouring (126 http://www.portphillip.vic.gov.au/default/Part_4.pdf 126





5.4 Recommendations for KKL- JNF

5.4.1 Support New Sources of Water for Israel, as part of the present JNF strategy: A ONE BILLION DOLLAR ROADMAP FOR THE NEXT DECADE

In actual fact, the current **JNF strategy, A ONE BILLION DOLLAR ROADMAP FOR THE NEXT DECADE**, has already internalized issues of water, sustainability and innovation, and also community, as expressed by its vision and **Proposed Allocation** (https://www.jnf.org/menu-2/our-vision). From the one-billion-dollar total, 35% is due to go to *Infrastructure for Ecology, Special Needs and Heritage Preservation*. Under this title, the following items are relevant to our present research and recommendations: **Water Solutions** - $50 Million; Forestry and **Green Innovations** - $100 Million; **Research and Development -** $50 Million. From the same total of one billion dollars, 40% will be allocated to *Community Building in Israel,* where **Community Building and Park Recreation Space is a prominent component**. Hence, our recommendation to KKL seems to be perfectly in line with JNF intentions and may assist the old organization to renew itself and fulfill its goal of raising a billion dollars in a decade. In the fundraising arena, water is known to be the second in its attractiveness to donors after health issues, providing that the campaign is well organized to fit its target population.

5.4.2 Green infrastructure for communities as a leading theme of KKL

Since it was established, KKL has worked on building infrastructure for the country of Israel. In recent years, KKL has paid more attention than in the past to environmental and ecological considerations and describes itself as "the largest green organization in Israel". It supports and operates activities for sustainable development (see the KKL's internet site[22]), and about a year ago even appointed an expert on sustainability as its Chief Scientist. Our recommendation is to take a big step in the same direction, combined with the goal of working with communities, to **adopt 'Green Infrastructure for Communities' as a leading theme, with a significant allocation of KKL time and resources.** In this way, the theme will work in harmony with the above-mentioned current strategy of JNF.

There are various definitions of the term 'green infrastructure'. A broad definition which we favor is: "Green Infrastructure (GI) is based on the principle that protecting and enhancing nature and natural processes […] is consciously integrated into spatial planning and territorial development … a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services in both rural and urban settings (EC, 2013a[23]). This definition encompasses all kinds of infrastructures including, for example, energy supply systems. For the purposes of this research, focused on water infrastructure, we recommend using a narrower definition suggested by the American Rivers Organization: "Green infrastructure is an approach to water management that protects, restores, or mimics the natural water cycle. Green infrastructure is effective, economical, and enhances community safety and quality of life. It means planting trees and restoring wetlands, rather than building a costly new water treatment plant. **Green infrastructure incorporates both the natural environment and engineered systems to provide clean water, conserve ecosystem values and functions, and provide a wide array of benefits to people and wildlife**" (American Rivers, undated[24]).

The above recommended definition, exactly like the WSP (Water-Sensitive Planning) approach we have been developing for the last 25 years at the Technion, **is related to all of the interfaces between water and spatial planning.** Stormwater infrastructure in the form of SSWM – Sustainable Stormwater Management – which applies to both urban and river basin stormwater[25], is an important component of Green Infrastructure, but not the only one. Another challenging component is sustainable wastewater management. Soil conservation is also a part of Green Infrastructure, along with all the greenery in urban areas and outside the cities – forests, parks

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[22] KKL's internet site: https://www.kkl.org.il/afforestation-and-environment/environmental-quality/

[23] EU – European Community (2013a), Green Infrastructure (GI) — Enhancing Europe's Natural Capital. https://www.eea.europa.eu/themes/sustainability-transitions/urban-environment/urban-green-infrastructure/what-is-green-infrastructure

[24] American Rivers Organization's internet site: https://www.americanrivers.org/threats-solutions/clean-water/green-infrastructure/what-is-green-infrastructure/

[25] Reminder: Out of an average annual quantity of stormwater of 200 M m^3 (flowing to the Mediterranean Sea), river basin stormwater constitutes the majority of 160 M m3, while the rest is urban stormwater (see chapter 1.1).

and gardens of all sizes. KKL has been involved in almost all of these fields. Our recommendation calls for **a common roof for all of these and other related components of green infrastructure, a roof that paints each of them green and brings them much closer to the principles of sustainable development**. Consideration of resilience in the face of natural and human-made hazards is an integral part of this effort.

Moreover, the recommendation calls not only for green infrastructure but for Green Infrastructure for Communities. Supporting community life is an established goal of KKL, first in rural areas and more recently also in towns and cities (see, for example, KKL's tours for families and the Community Forest enterprise). Taking into consideration a lack of resources to cover the whole country, as well as concerns of inequality and social justice in Israel, we recommend directing KKL activities toward communities in the North and South of Israel, and thus **integrating 'Green Infrastructure for Communities' into ISRAEL 2040**.

Israel 2040 is a national effort announced recently by KKL that anticipates attracting 1.5 million new residents to the Galilee and Negev. JNF intends to extensively support this initiative, as expressed by an allocation of 40% of its one-billion-dollar campaign to 'Community Building in Israel'. The goal is expected to be achieved by means of quality housing, hi-tech employment, good education and rich community life. The term sustainability is not mentioned in this grand plan. Yet developing Israel 2040 with green infrastructure makes a "natural" addition to the great plan. **Even if only part of the grand_plan can be implemented, it is recommended to include 'Green Infrastructure for Communities' in it.**

An especially promising example of what we are suggesting is a project that is still in the planning process: restoration of part of the Kinneret catchment area that focuses on **Kiryat Shmona – City of Streams**[26,27]. The partners are the Kinneret Drainage Authority, the municipality of Kiryat Shmona, Tel Hai College, community organizations and a highly professional planning team. They have planned an eco-hydrological restoration of streams which includes stopping the conveyance of urban stormwater through drainage canals that take the water far from the city, and replacing them with well-connected above-ground streams which flow across the city from north to south, with several stormwater retention and detention areas along the way. Using their language, **they refer to 'streams as infrastructure' and streams as a major leverage for urban regeneration**[28]. The vision of these planners is exactly in line with our recommendations: "**synergy between human and environmental well-being**".

[26] Kiryat Shmona: City of Streams (2020). Presentation of a plan in a process of planning.

[27] A few years ago, KKL-JNF constructed the first park that is based on a neighborhood stream in Kiryat Shmona, HaZahav Park

[28] Central components of the urban regeneration are the creation of a downtown water-front district, in addition to parks and gardens along the streams that are accessible to various communities/neighborhoods; a regional academia (Tel-Hai College) and food-tech hub that create "a sustainable industrial eco-system" stands at a northern area of the restoration plan, and another regional hub on the southern edge of the plan with advanced industry next to a leisure area that takes advantage of the blue-green development. All that is intended to turn Kiryat Shmonah into "the beating heart of the Upper Galilee".

5.4.3 Support GREENOVATION ISRAEL - excellence center for applied research of Green and Innovative Infrastructure for Communities

Throughout this research report we have pointed to the need for more evidence-based and practice-based knowledge[29] as a necessary condition for wide implementation of SSWM and the green solutions we recommend. Especially important are monitoring, evaluating and lesson-learning from the implemented projects of green infrastructure in Israeli conditions. Hence, the recommendation to KKL is **to extensively support an excellence center for applied research of Green and Innovative Infrastructure for Communities, which we suggest naming GREENOVATION ISREAL, as part of the Israel 2040 plan.**

However, we also wish to offer an early warning. On the KKL website it states that the grand plan of ISRAEL 2040 includes the construction of 30 new campuses for research and development in the periphery of Israel.[30] Based on deep acquaintance with research institutions in Israel, we claim that it is neither desirable nor reasonable to promote such a proposal. Indeed, there are thousands of Israeli scientists abroad whom we would love to attract back to their homeland. Nonetheless, the Technion, with its high national and international reputation and with readiness to invest half a million dollars or more in constructing a new laboratory for each new faculty member, has not succeeded in recent years to fill all the faculty openings in many of its departments with members that meet its standards. The seven regional centers for applied research that the Ministry of Science and Technology supports[31] have difficulties in recruiting research staff and research money. They depend on more established institutions of higher education in the sense that most of their academic staff have a joint appointment with other institutions and their academic advancement is subject to decisions made in those institutions.

Hence, in light of the many needs and limited resources of money and scientists, **the recommendation is not to build new campuses but to select one and no more than 2-3 of the existing regional centers and use them as a base for the recommended excellence center for applied research.** In our view, the first to be considered – due to their mission and quality as well as the areas they serve - are: MIGAL – Galilee Research Institute LTD that sits next to Kiryat Shmona and cooperates with Tel Hai College (http://www.migal.org.il/About-MIGAL), the Arava Institute for Environmental Studies that sits in Kibbutz Ketura in the far south of the country and works in partnership with Ben Gurion University (JNF is already involved there (https://arava.org/about-our-community/partners/), and perhaps, also the new program for TZAFON YAROK (green north)

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[29] For inspiration see the list of publications of EKLIPSE, an EU extensive applied research **https://www.eklipse-mechanism.eu/eklipse_outputs_reports** , especially Nature-based Solutions to Promote Climate Resilience in Urban Area. See also EPA (2015). Tools, Strategies and Lessons Learned from EPA Green Infrastructure Technical Assistance Projects. Publication # EPA 832-R-15-016. **https://www.epa.gov/sites/production/files/2016-01/documents/gi_tech_asst_summary_508final010515_3.pdf**; World Bank (2019). Nature-based Solutions: a Cost-effective Approach for Disaster Risk and Water Resource Management. **https://www.worldbank.org/en/topic/disasterriskmanagement/brief/nature-based-solutions-cost-effective-approach-for-disaster-risk-and-water-resource-management**

[30] See the bottom of https://www.kkl.org.il/kkl-jnf-and-the-community/community/2040/

[31] See https://www.gov.il/he/departments/general/most_regional_mop

at the medical school in Zefat, which aims to combine medicine with community. The first two have been working for years on environmental research and development. **Each of these existing institutions can serve as an appropriate base for the recommended excellence center/s for applied research on Green and Innovative Infrastructure for Communities, which we suggest should be a part of the ISRAEL 2040 plan of KKL-JNF and named GREENOVATION ISRAEL**.

5.5 Concluding comment

This research report is being completed under the shadow of the Coronavirus (COVID-19) world pandemic. It is forecasted that international travel will be reduced in the coming days, while open-space recreation will rise in Israel, in urban and non-urban areas. At the same time (with no known connection between the phenomena), climate change threatens our planet and requires us to try and reduce the hazard of urban flooding, caused mainly by above-ground stormwater, while improving the livability of cities. This research combines planning and design of open spaces with sustainable management of above-ground stormwater. Current circumstances make this research and its recommendations especially relevant.

נספח לפרק 5

פרסומים של מחקרי תר"מ- תכנון רגיש למים

הטכניון – מכון טכנולוגי לישראל

נעמי כרמון
המרכז לחקר העיר והאזור

אורי שמיר
מכון למחקר המים ע"ש גרנד

בשיתוף עם אדריכלי הנוף פרופ' טל אלון מוזס, דר' שמואל בורמיל; מהנדס מים וניקוז דר' אבנר קסלר; אקולוג פרופ' אביטל גזית, סטודנטים לתארים גבוהים וחוקרים נוספים

רוב הפרסומים שלהלן ניתנים להורדה מן האתר האישי של נעמי כרמון*Naomi Carmon homepage*–

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