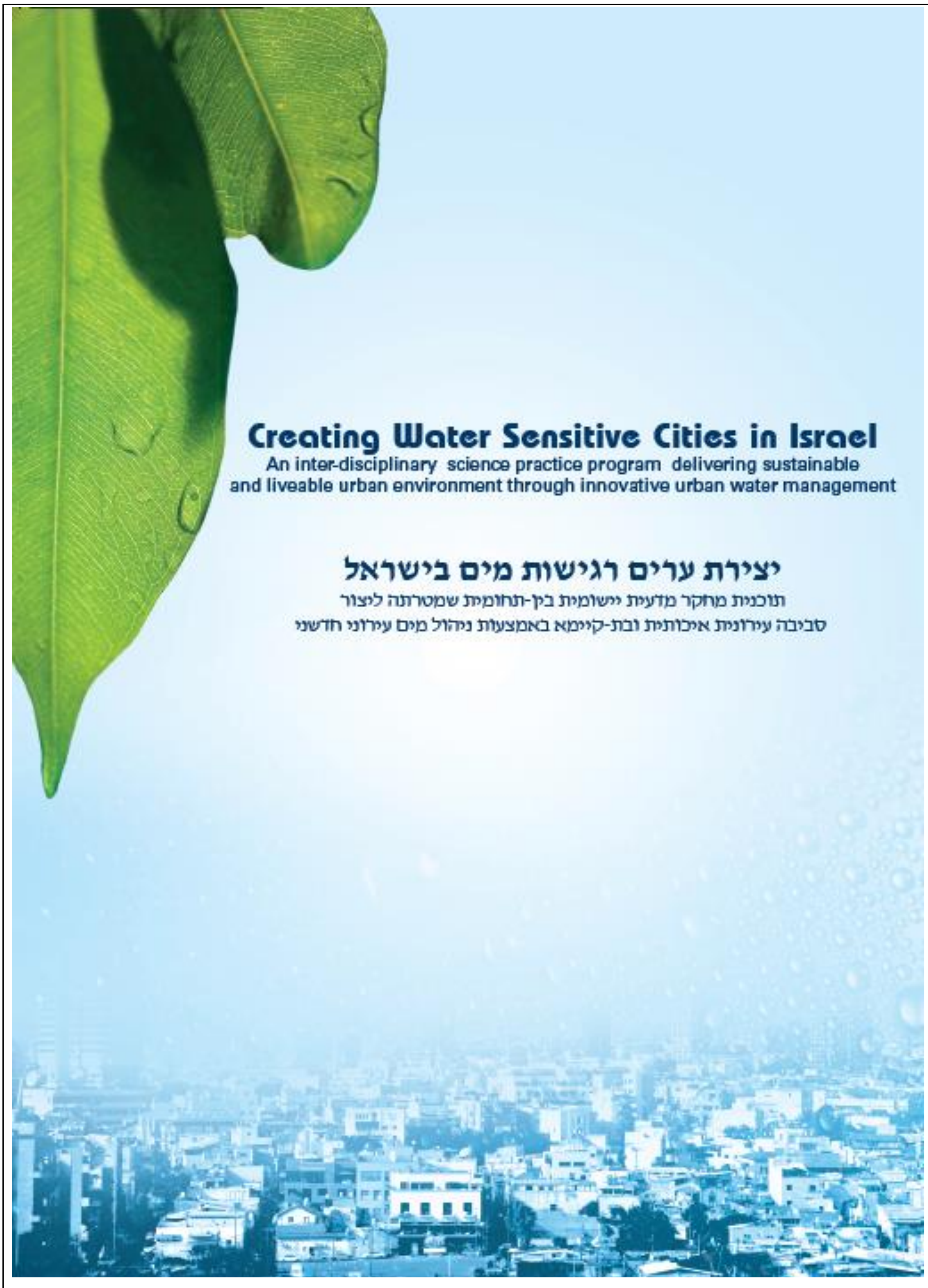

אוניברסיטת בן-גוריון בנגב Ben-Gurion University of the Negev | Technion Israel Institute of Technology | האוניברסיטה העברית בירושלים The Hebrew University of Jerusalem | MONASH University

December 2012

WATER SENSITIVE CITIES IN ISRAEL

An inter-disciplinary science-practice program delivering sustainable and liveable urban environments through innovative water management

THE CHALLENGE FOR ISRAELI CITIES

Israel is facing a range of critical pressures related to water security and urbanisation. Cities are rapidly expanding while experiencing critical water shortages and degradation of their aquifers and waterways. Israel will need to construct 13-15 new desalination plants in the next 40 years if we are to meet the projected urban water needs by 2050 (Fig 1-left). The Coastal aquifer that lies underneath our major cities is under threat from anthropogenic pollution and seawater intrusion (Fig 1-right), and there is a consensus that urgent action is required to assure its long term sustainability. At the same time, public health is further threatened by urban heat island effects, as Israel cities become hotter due to climate change and rapid urbanisation. It is clear from IPCC projections that Israel will become 1-1.5 ^{o}C hotter in the next few decades, which is a significant rise from the current level. The annual rainfall is expected to decrease by 15% of current levels in the North and by 10-15% in the central regions of the country. The coastline areas are an exception in regard to precipitation, where no decrease from the current levels is expected due to proximity to the Mediterranean Sea. Moreover, the distribution of rain events will be less even, and it is expected that there will be lower number of events of higher intensity that may lead to higher risk of flooding. It is therefore clear that ***Israel cities must become resilient to climate and social pressures that confront them, if they are to assure long term economical and environmental sustainability of Israel.***

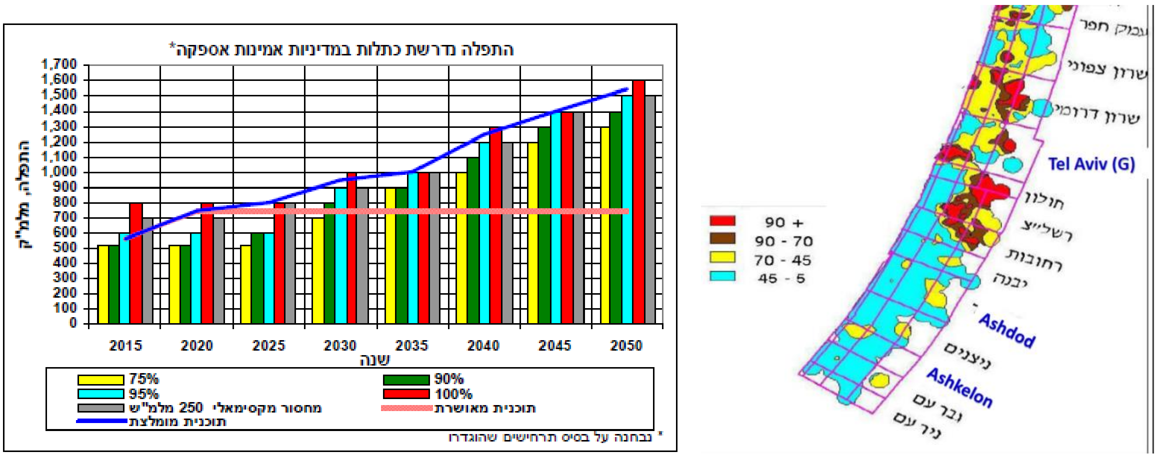

Figure 1: Required desalinated water volumes to meet urban water needs over time (left) and levels of nitrate pollution (in mg/l) of the costal aquifer (right)
Source: left - IWA (2011); right - Israel Water Authority data

Current centralised solutions to urban water management, whilst fundamental to the development of our cities to date, cannot solely provide the multiple benefits required for the future needs of our cities. ***We thus must find new, more integrated solutions that address climate change, urban growth and pollution by delivering simultaneous benefits*** for water security, natural environment, and liveability of our cities.

WATER SENSITIVE CITIES AS THE SOLUTION

The way we manage urban water shapes almost every aspect of our urban environment and quality of life. Water Sensitive Cities adopt and combine decentralised and centralised water management solutions to deliver water security in both water-poor and water-abundant futures, healthy aquifers and urban streams, improvements in urban climates and landscapes, and a reduction in the city's carbon footprint. Three principles underpin a Water Sensitive City (Wong *et al*., 2009):

- ❑ 'Cities as Water Supply Catchments' - meaning access to water through a diversity of sources at a diversity of supply scales;
- ❑ 'Cities Providing Ecosystem Services' - meaning the built environment functions to supplement and support the natural environment; and
- ❑ 'Cities Comprising Water Sensitive Communities' - meaning citizens' decision-making and behaviour underpins environmental sustainability of their cities.

The vision of Water Sensitive Cities is still to be shaped in the contexts of Israeli specific physical, climatic and social needs. Israel, with its unique physical background and even more distinguished history, should develop its own pathways for transitioning towards sustainable urban water futures.

WATER BUDGET OF ISRAEL

Desalination of seawater is an unavoidable pathway that Israel must embrace if it is to meet its rapidly increasing urban water needs stemming from its population growth. As shown in Figure 2, by 2020, Israel will need to double its current desalination capacity to some 700 MCM/y (million cubic meters/y) and by 2050 (less than forty years from now) it will need to more than double that required in 2020 to 1,500 MCM/y. This will entail the construction of some additional fifteen desalination plants along the country's already crowded shoreline, and apart from high construction and operation costs, will also result in negative environmental effects to surrounding marine area, local / regional air pollution and global warming due to high energy input, etc.

However, this future level of required desalination capacity can be reduced, if decentralised systems are employed in parallel with the traditional centralised ones for delivery of safe non-potable water (e.g. water for irrigation of green urban spaces, toilet flushing, cooling, etc.). ***The first suggested alternative is to include urban stormwater harvesting that at present is hardly being practiced in Israel*** (Figure 3-left). Stormwater is defined as the runoff from paved urbanised surfaces, and in that respect it differs from runoff captured from undeveloped land (forested, arable land or grass land). Although far more investigations are needed into volumes of available stormwater, there are some evidence that by 2050, due to the expected increased urbanisation (that means covering of our land with roads, houses and pavements), Israeli cities will be producing some 160 MCM of stormwater each year (Netanyahu *et* al., 2008). If this water source is captured, treated and then used (for example in non-potable uses), it can deliver much needed water that can reduce the annual production of desalinated water by 10% and reduce its consequential negative environmental effects. Furthermore, capturing this "new" alternative resource will also protect our aquifers and improve liveability of our cities. It should be noted that further reduction in new production capacity of desalinated water can be achieved (additional ~140 MCM/y) if onsite greywater reuse is implemented in conjunction with stormwater harvesting (Figure 3-right). ***The first stage of this proposed research will concentrate on urban stormwater harvesting***.

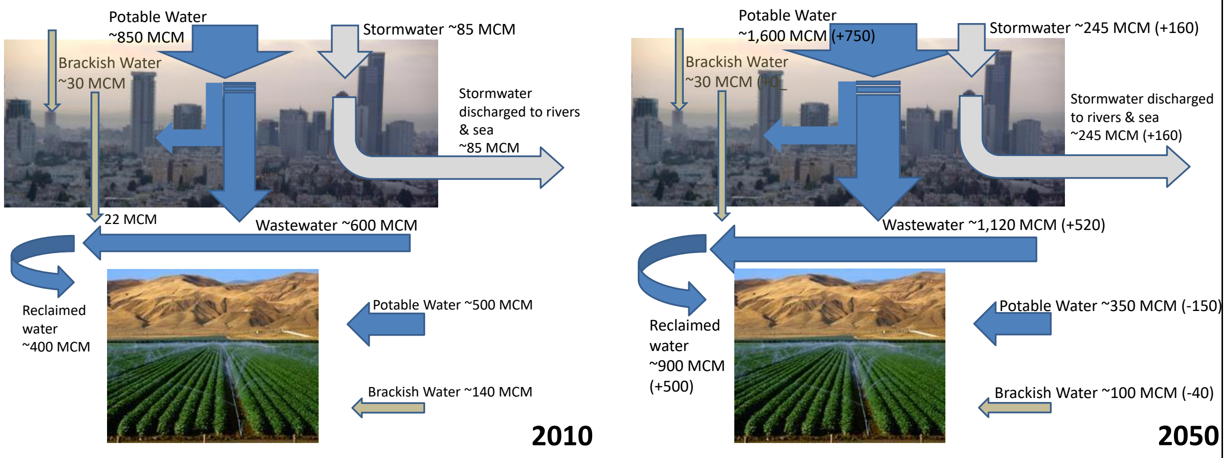

Figure 2: Current and predicted future urban and agricultural water use in Israel – business as usual scenario Numbers in brackets represent change from 2010 to 2050

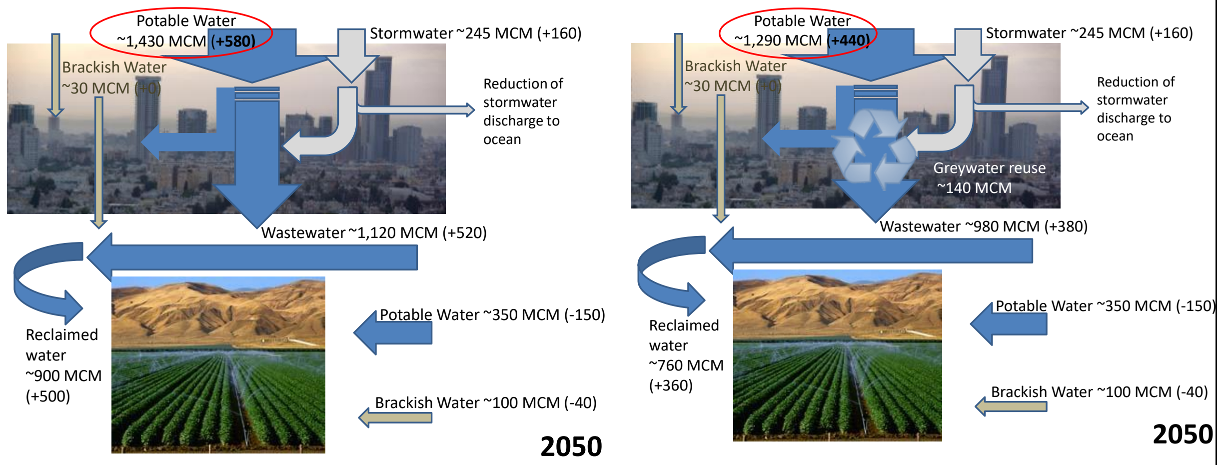

Figure 3: Possible future (2050) urban and agricultural water use in Israel, if decentralised systems are included: stormwater harvesting (left) and stormwater harvesting and greywater reuse (right).
Numbers in brackets represent change from 2010 to 2050; red ellipses emphasise the difference of water production (all desalinated water) the BAU option above (fig 2-right).

Stormwater harvesting is essential to the realisation of Water Sensitive Cities, because:

- ***Urban stormwater is a significant source of water, generated close to where it is needed***. Water consumption in the 25 largest cities in Israel (18 of which reside on top of the coastal aquifer) was 311 MCM/y in 2009 (population 4.1 million) (ICBS, 2010). Based on Netanyahu (2008) the stormwater collection potential in these cities is 55 MCM/y. Thus it can be seen that urban stormwater is a substantial alternative water source, equalling ~18% of the total water use in these urban areas. It should be further noted that stormwater is generally of much better quality than wastewater, and therefore more economical and safer for use.
- ***Uncontrolled stormwater runoff from urban areas pollutes beaches, shallow aquifers and waterways.*** The large amounts of impervious areas in cities results in excessive runoff, causing erosion and pollution of urban streams (Hatt *et al*., 2004), while polluting beaches; e.g. stormwater is the number one pollutant of coastal waters in the USA. Stormwater is a rare fresh water source whose use will ***benefit*** the environment, rather than degrade it (Fletcher *et al*., 2007).
- ***Vegetated stormwater treatment facilities may improve the urban micro-climate, reduce thermal stress and therefore aid public health.*** Stormwater harvesting using natural vegetated systems such as wetlands and rain-gardens known also as biofilters (Figure 4) could have an important role in reducing the urban heat island effect. By maintaining water

in the landscape, local temperatures are decreased, reducing heat extremes (Endreny, 2008); passive cooling is utilised, thus not contributing to greenhouse gas production.

Figure 4: Kfar-Sava pilot biofilter for stormwater harvesting and recharge from Kfar-Sava city into the Coastal Aquifer

- ***Stormwater harvesting using green infrastructure enhances social amenity and is likely to be publicly acceptable.*** Increasing vegetation and "green landscapes" improves the social amenity of cities (Figure 4). Public and institutional acceptance of stormwater harvesting is also much greater than it is for wastewater reuse (Brown and Keath, 2007).

- ***Stormwater harvesting systems is economical and can function with very low energy use***. Stormwater harvesting *via* a range of passive treatment and distribution methods based on bio-mimicry has much lower energy requirements than many other water treatment and supply solutions. As recently demonstrated by a study commissioned by JNF (Kivun, 2010), stormwater harvesting costs NIS 2.95 (AU$ 0.7-0.78), 15% cheaper than traditional stormwater collection schemes, and 17% cheaper than desalinated water (if external costs of desalination are accounted for).

SO WHY AREN'T WE HARVESTING STORMWATER?

Unlike the traditional centralised water supply systems, which have benefited from over two centuries of dedicated research and development, modern urban stormwater harvesting systems are relatively recent inventions (CWSC, 2011). A number of important knowledge gaps are further impeding the widespread adoption of these systems in Israel:

- ***A lack of sustainable technologies.*** There is currently a lack of cost-effective technologies that can harvest stormwater at a range of scales, from household to regional. Some advancements were recently made in Australia with biofiltration technology (Figure 4, FAWB, 2009) showing highly promising results in treatment of nutrients, metals and pathogens (Zinger *et al.*, 2007; Bratieres *et al.*, 2008; Blecken 2010). The first stormwater harvesting biofilter for aquifer recharge was recently successfully implemented in Kfar-Sava (Fig 4, Zinger *et al.*, 2011). However, far more work is needed to further develop these technologies and adopt them for Israeli conditions. Initially, there is a need to understand stormwater quality in Israel cities, since the local data are very scarce. Storage of harvested stormwater is another obvious issue, since urban space comes at a premium. Nevertheless, Managed Recharge Aquifers (also known as Aquifer Storage and Recovery), may be the most feasible and economical for local Israeli conditions.

- ***Human health risks.*** Our knowledge of the public health risks associated with using harvested stormwater is minimal, creating an uncertainty that impedes its adoption. Even in Australia that is further advanced, this is the main obstacle in widespread adoption of stormwater harvesting (CWSC, 2001).

- ***Likely benefits for aquifer recovery.*** Large scale capture, treatment and recharge of stormwater in winter can help recovery of the Coastal aquifer. In summer dry months, the stormwater 'green technologies' could be used to treat the polluted aquifer water. However, such hybrid systems, that treat both stormwater with relatively low pollution levels (e.g. total nitrogen levels in stormwater are typically 2-3 mg/l) in winter and groundwater with high nitrate levels (of over 100 mg/l) in summer, are still to be developed.
- ***Likely benefits on urban micro-climate.*** The landscape benefits of large scale implementation of stormwater harvesting technologies (Figure 2), as well as the benefits of urban irrigation on urban micro-climates, are as-yet unquantified, particularly for Israel climatic conditions. Using hybrid green systems that can produce safe water for landscape irrigation would be ideal for Israel's long hot and dry summers.
- ***Economics.*** The value of stormwater harvesting systems as multi-purpose assets needs to be assessed in the context of climate change and future general economic trends. There needs to be a clear business case made for stormwater harvesting, which considers externalities. Although the JNF study on economics of stormwater harvesting (Kivun, 2010) shows very promising results, it still does not take into account evaluation of environmental benefits, or creation of pleasant and productive urban spaces.
- ***Society and Institutions.*** The role of institutional and social context in facilitating the widespread application of decentralised stormwater harvesting in Israel cities needs to be better understood. It was hypothesised that current institutional regime is the main obstacle in implementation of decentralised systems and that its reform is needed to enable the transformation of urban water sector.

Solving these individual impediments one by one will not be enough; ***an inter-disciplinary approach*** is required if integrated and sustainable solutions are to be delivered.

WHAT WE AIM TO DELIVER

Our research program aims to advance sustainable and liveable cities in Israel through innovative urban water management. This is a highly ambitious and interdisciplinary program that brings together Israeli industry and government with the top Israeli and Australian academic institutions. The Program will have two main stages;

Stage 1: Development of integrated ***stormwater harvesting solutions***, as part of realising Water Sensitive Cities.

Stage 2**:** Delivery of the technologies, strategies, and education and training programs required to create Water Sensitive Cities in Israel that integrate all water streams within urban landscapes and therefore deliver more liveable cities.

Stage 1 can be regarded as the feasibility study of the WSC concept. This document will focus on this stage, which has the following deliverables:

1. ***The blueprint*** on how Water Sensitive Cities (WSC) could be realised through sensitive management of *urban stormwater and integration of these technologies into urban design*.
2. ***Novel multi-functional technologies*** for harvesting of stormwater in winter and treatment of polluted groundwater in summer for aquifer recovery that will also provide amenity to local communities;
3. ***Demonstration sites and capacity building***: community and private and public sector industry engagement to build social and institutional capital for WSC and the launch of key capital works that will demonstrate WSC.

BENEFITS TO ISRAEL

A Water Sensitive City would ensure environmental repair and protection, supply water security, public health and economic sustainability, through Water Sensitive Urban Design (WSUD), enlightened social and institutional capital, and diverse and sustainable technology choices (Brown *et al*., 2007; Wong and Brown, 2008). The envisaged key benefits of the proposed integrated project:

- ***Stormwater harvesting:*** Harnessing the potential of stormwater as an alternative water source will afford cities with an added diversity of water sources in line with the strategy of building resilience through diversity. If widely adopted, stormwater harvesting will contribute to reducing urban water pressure at acceptable costs and with low energy requirements; it is estimated that the potentials are equal to around 160 MCM/y of fresh water to be added to the Israel urban water budget.
- ***Aquifer recovery***: Injection of treated stormwater (that typically has salinity well below 1 mS/cm), as well as widespread treatment of already polluted groundwater may be a step towards protection and recovery of our aquifers. Importance of healthy aquifers for existence of Israel is huge since they are long-term security of fresh water for our people.
- ***City liveability:*** Green technologies incorporated into urban landscapes will improve the surrounding micro-climate, the ecological health of waterways and therefore quality of life in Israel cities. If such systems are not developed and adopted, stormwater will continue to be a key cause of pollution of our streams and beaches, rather than a valuable commodity.
- ***Increasing sustainability:*** If widely adopted, stormwater harvesting can avert the construction of one desalination plant by 2050 with the resultant saved construction and operation costs. Not less important, this will also reduce the negative environmental effects of desalination, help to alleviate the heat-island effect in urban areas and thus enhance the sustainability of our future cities.

PROGRAM OUTLINE

The project will consist of four highly integrated projects, as illustrated in Figure 5. The proposed research program encompasses scientific research from a number of disciplines working collaboratively to integrate their research efforts and research findings throughout the 2-4 years duration of Stage 1 of this research program. The framework for integration of the fundamental research activities of the program is at two levels, i.e., (i) the integrated development and refinement of research perspectives in formulating core research questions; and (ii) the integration of the research insights through the design and implementation of demonstration projects of ecological landscape and urban design at a range of scales.

The projects are briefly outlined below, while a detailed description of the each sub-project of the program is included in Appendix A.

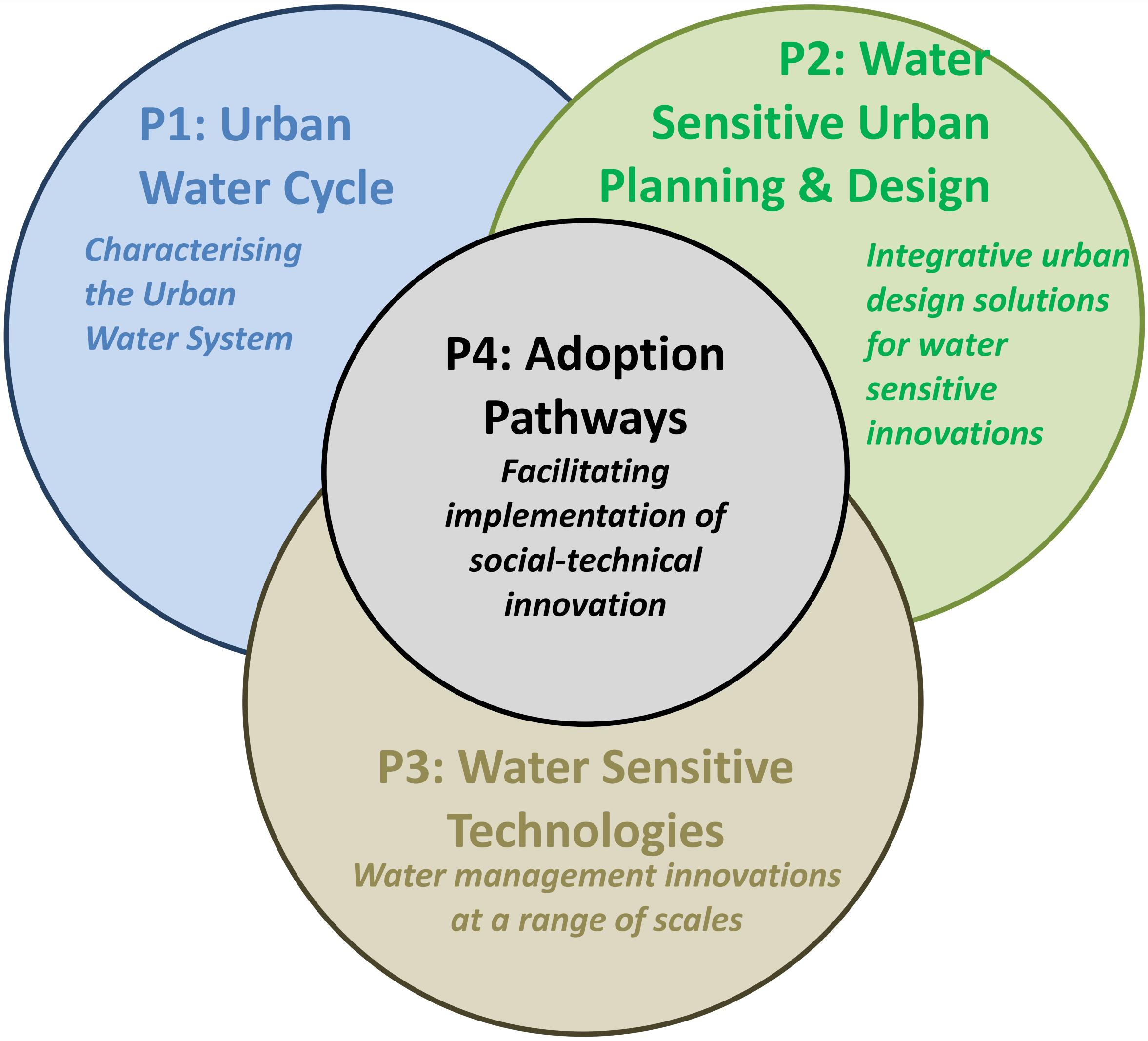

Figure 5: The main projects of the research program

P1: Urban Water Cycle

The aim of this project is to characterise the urban water system in Israeli cities. It will focus on integration of both centralised and decentralised urban water systems to assure water security in rapidly expanding Israeli cities, with the following objectives:

- Quantify available present and future water sources within the urban environment (groundwater, greywater, blackwater, stormwater, recycled water, etc.) and examine the effects of climate change, population and city planning on these water sources.
- Monitor and evaluate quality of water sources that are not currently well quantified, focusing on stormwater in the first instance.
- Develop strategies for local remediation of polluted urban aquifers within the urban landscapes.
- Identify and quantify opportunities for water recycling and stormwater harvesting at a diversity of urban scales (household, cluster of buildings, neighbourhood, city).
- Quantify possible impacts of decentralised infrastructure (e.g. multiple recycling) on existing water supply and wastewater collection infrastructure; in particular, study impacts of reduced flows and elevated concentrations on sewers and wastewater treatment plants.

In Stage 1, this Project will include two activates as outlined below.
Sub-Project P1.1: Visioning of Water Sensitive Cities in Israel.

The goal of this sub-project is to develop a holistic vision for Water Sensitive Cities in Israel encompassing scientific, economic and societal aspects. The research will be a non-statistical meta-analysis study that will review and analyse existing knowledge on specific topics related to the aim of the sub-project. The potential effects of global warming on temperatures and rainfall regimes in Israel on a regional scale will be studied and quantified. Trends of population growth and water demand will be derived. Urbanisation rate and future urban areas textures will be quantified and their effects on stormwater harvesting potential will be analysed. Water sensitive measures such as stormwater harvesting, greywater reuse, local aquifer recovery and green-roofs will be reviewed, their potential implementation within the Israeli context will be assessed, and their overall contribution to Water Sensitive Cities will be evaluated. Aspects of public acceptance and institutional barriers / incentives of alternative urban water sources in the context of Water Sensitive Cities will be studied based on experience reported in the literature, and pathways to encourage acceptance / overcome impediments will be elaborated. Direct and indirect (external) costs and benefits of Water Sensitive Cities in a holistic way covering societal, economic and technical aspects will be quantified. In the last stage of this study, the above specific findings will be integrated and an overall quantitative vision for Water Sensitive Cities in Israel will be developed. Finally, the vision will be examined within case study pilot cities.

Sub-Project P1.2: Characterising Stormwater in Israeli Cities:

Stormwater is a major source of pollution in urban areas, although this is still to be fully recognized in Israel. The latter is because we do not have enough understanding of both quality and quantity of stormwater discharges from Israeli cities. In order to assess the stormwater characteristics associated with different land uses, particle size ranges, and rainfall intensity and duration, it is important to have a clear understanding of the physical and chemical processes that are associated with pollution accumulation during the long dry summers and between storms, and their transport by stormwater. The main aim of this sub-project is to assess pollution levels in stormwater and characterize the impact of various urban land uses on stormwater quantity and quality in the Israeli context. The following specific objectives have been identified: 1) To characterise the quantity and quality of stormwater discharged from a mid-size urban area of Kfar-Sava by monitoring runoff from its three sub-catchments that have different land uses, as well as monitoring discharges from two small (single land-use) urban catchments located in Bat Yam and Ramla; 2) To investigate the integrated effect of different land uses on the quality and quantity at the catchment outlet.

P2: Water Sensitive Urban Planning and Design

This project will deliver integrative urban design solutions for water sensitive innovations. The focus is delivering urban water infrastructure which provides (i) functional urban design, (ii) ecological health of urban streams and beaches, and (iii) the reduction of Urban Heat Island effects. The following objectives have been identified:

- Define optimal building and development (cluster of building) scales and typologies for integrated urban water cycle management for securing urban liveability.
- Develop planning and design approaches that consider water as a resource and public amenity that adds to ecological functionality and supports the public realm.
- Promote thermal comfort in outdoor space through improved microclimate.
- Relate water engineering to urban design by integrating infrastructure and public space.
- Integrate WSUD strategies in order to enhance social amenities of public spaces (urban agriculture, educational landscapes, community gardens, etc.).
- Formulate design language for WSUD.

Sub-Project P2.1: Exploring Urban Design Solutions for Water Sensitive Innovations

To achieve substantial environmental benefits from stormwater runoff in Israeli cities, solutions must be found to adapt the infrastructure of existing urban areas. When new neighbourhoods are planned, a hierarchy of flow paths can be designed to link catchment areas at different physical scales to collection areas where the water may be stored (as groundwater by aquifer recharge or alternatively as above ground storage). In existing built-up areas, such pathways may not be easily discernible, and there may be no suitable collection areas at the appropriate scale. This project will seek to promote water-sensitive planning by developing and demonstrating a methodology that addresses two questions: a) How can an integrated and comprehensive network of water pathways, collection areas and storage be identified and mapped onto an existing urban area, incorporating novel stormwater harvesting and treatment systems (e.g. biofilters, modular systems) and adjacent aquifer recharge measures? b) What are the most effective patterns of implementing water sensitive urban design (WSUD) elements in existing areas in terms of improvement of pedestrian thermal comfort and reduction of energy demand of buildings? These questions will be explored in the context of dense urban development, characterising Israeli cities where exposed land is relatively scarce and green open space is limited. GIS will be used to analyse typical urban typologies in conjunction with existing infrastructure and sub-surface hydrology to demonstrate how stormwater harvesting may be applied to a selected urban location in a city on the coastal plain. The effect on microclimate of different patterns of vegetation associated with stormwater harvesting and treatment elements, as appropriate to the respective urban typologies, will then be studied by means of computer simulation. The outputs of this simulation may then be used to generate detailed data for computer modelling of pedestrian thermal comfort and building energy performance.

P3: Water Sensitive Technologies

The aim of the project is to develop innovative multi-functional water technologies, that can be placed within urban landscapes and where:

- A single technology will be able to treat diverse water sources (e.g. stormwater, groundwater and treated wastewater) within urban areas. e.g., biofiltration systems will be developed to treat stormwater during the wet season and contaminated groundwater/treated wastewater during the dry.
- The technologies will adopt fit-for-purpose treatment principle; e.g. treat water to an appropriate level needed for garden irrigation, aquifer recharge, toilet flushing, etc.
- The technologies will be developed to beautify urban landscapes, increase biodiversity, improve micro-climate, and protect the receiving waters (groundwater, streams and beaches).
- Solutions will be developed for different urban scales ranging from household, neighbourhood and city.
- Technical solutions will be developed for easy integration of new technologies into existing and future infrastructure.
- Management, operation and maintenance procedures for these technologies will be developed as the key priority.

Sub-Project P3.1: Hybrid Biofilters for Dual Stormwater and Groundwater Treatment:

Urban storm-water harvesting biofilters, as developed in Australia, have been successfully introduced to Kfar-Sava (Zinger *et al*., 2011, Zinger and Deletic, in press). During this project it was recognised that Israeli context, such as local climate, urban catchment characteristics (e.g. land use and state of drainage systems), as well as local soil media and plants, requires specific attention if we are to develop effective technologies for local conditions. A major distinction is related to the prolonged hot and dry periods in Israel that last 7-8 months each year that require irrigation of biofilters. At the same time, shallow regions of Costal Aquifer are polluted with high levels of nitrate. Therefore, a modified version of the biofilter design will be developed for harvesting stormwater during wet autumn/winter months and treatment of nitrate contaminated groundwater during dry summer months. This will overcome two identified problems; keeping systems healthy during summer and remediate groundwater aquifer. The main research question is how to accelerate denitrification within the systems via plant selection and optimisation of its submerged zone. We propose to set up a series of laboratory tests to select/develop a fast and reactive electron-donor that will be effectively incorporated within the submerged zone. We will then optimise systems via plant selection and submerged zone design, as well as develop optimal operational regimes for sound implementation of the novel hybrid system. The project will deliver simple adoption guidelines for design, operations and maintenance of the hybrid technology.

P4: Adoption Pathways

The aim of this project is to facilitate implementation of social-technical innovations that will lead to the development of Water Sensitive Cities in Israel. Key objectives of this project are to:

- Facilitate the practical implementation of the concepts, technologies and urban design concepts derived from the program
- Identify institutional and market barriers for adoption of alternative urban water management solutions and develop transition pathways for overcoming these institutional barriers
- Foster evidence-based policy for sustainable water management
- Develop a new economic valuation model for assessing urban water strategies
- Develop design guidelines and software tools

Three main activities of this project will be included in Stage 1 to accelerated adoption, as explained below.

Sub-Project P4.1: Understanding the Water Sensitive Urban Design in Israel Context

Stormwater management practices are an important element of Water Sensitive Cities. This project examines both policy and physical in-the-field implementation of stormwater management practices in Israel through case study research. The objectives are to review and empirically evaluate the implementation of selected stormwater management practices. The evaluation will lead to recommendations for Best Management Practices (BMPs) tailored to various scales of planning (i.e., onsite, cluster, neighbourhood, city, and metropolitan) and to specific geographic regions within the country.

This research will include the following phases: a) selection of the case studies according to chosen criteria; b) development of methodologies for evaluation of the case studies and application of these methodologies; c) presentation and dissemination of recommendations aimed at improving stormwater management practices in Israel. Once the case studies have been chosen according to scale, goals (functions), perceived success, geographic representativeness and data availability, the researchers will devise replicable methods for policy evaluation and for the evaluation of outcomes. The evaluation will draw on indicators derived from relevant literature, management experience and tailored-to-the-case-study characteristics and calculations.

We will start by reviewing and analysing the spatial planning of the cases within the greater urban design context. Next we will review and analyse the implementation process of the selected practices within the Israel planning context (e.g., planning committees and related institutions). Then the research will evaluate the achievement of goals in the various case studies: water-related goals, ecological functionality, social (in terms of public benefits) and economic efficiency.

The outcomes of this sub-project will be (a) recommendations for the improvement of policies that can lead to greater adoption of stormwater BMPs that achieve their goals, including impediments and supports; (b) recommendations for stormwater BMPs at various planning scales suitable to the Israeli context, including improved spatial design of such practices within the urban fabric.

Sub-Project P4.2: Demonstrating Capability for Stormwater Harvesting in Israel

The Kfar–Sava biofilter is an end-of the pipe vegetated system located within a new development. If the concept of stormwater harvesting is to be adopted at a large scale, we need further demonstration of the suite of technologies in different conditions and applications in Israel. The aim of this sub-project is to demonstrate capability of stormwater filtration and biofiltration technologies to harvest stormwater at a source (within upper parts of urban catchments), as well as to showcase the flexibility of biofiltration design for retro-fitting into existing urban areas. The project will, apart from biofiltration technology, also test un-vegetated filtration systems (recently developed in Australia) that are capable of treating higher rates of runoff in space-constrained dense urban environments. The two sites have been selected, one located in Bat Yam and the other in Ramla, where one biofilter and one un-vegetated filter will be retrofitted into existing urban space. The systems will be gravity fed directly from adjacent paved areas (a typical street and a highway), and the treated water directly discharged into the unconfined local aquifer. The systems will be monitored over one wet season for their performance to deliver required water quality for unlimited irrigation, and aquifer recharge. In order to investigate its potential for production of drinking water, the treated stormwater will also be assessed using Israeli drinking water targets.

Sub-Project P4.3: Treated stormwater recharge

In semi-arid conditions surface storage of treated stormwater is less favourable option to groundwater storage that has been tested in Kfar-Sava. In urban regions land area is limited and therefore point infiltration is the preferred solution for large volumes over (relatively) short times. The aim of this project is to investigate the fate and transport of small scale treated stormwater and treated aquifer water artificially recharged into the local aquifer in terms of quantity and quality. The objectives are to (1) compare two different recharge concepts (near surface, and direct groundwater injection) as well as aquifer storage and recovery (ASR), (2) Monitor groundwater quantity and quality underneath the recharge sites, focusing on seasonal water quality dynamics, (3) Track long term changes in recharge well operation and recharge capacity, (4) Develop methodology and priorities for WSUD measures installations. The project spans over three demonstration sites (Kfar-Sava, Bat-Yam, and Ramle). The objectives and approach in each of the sites is determined by the state of the site, with Kfar-Sava already operational, and Bat-Yam in late design stages. In Kfar-Sava the goals addressed will be long term changes in recharge capacity and groundwater fate. Hence only monitoring wells will be installed and water quality at short (meters to 10's of meters) will be tracked by sampling (mostly, budget allowing) downstream. In Bat-Yam a a similar approach will be used, mostly as the vadose zone at the site is very shallow (compared to Kfar-Sava) and the recharge well will deliver the treated waters directly into the groundwater body, In Ramle the specific design will be fixed at later time, but the general intention is to construct a shallow well, allowing relatively long passage in the vadose zone and hence allowing some aerobic processes to affect the recharged water and by that enhance the treatment. Monitoring wells and water content/pressure head sensors will be installed in parallel. Infiltration rates, rate of groundwater recharge (not necessarily the same and at same timing) and groundwater and vadose zone water quality will be monitored regularly. For all sites, vadose zone flow model will be calibrated. The use of geophysical tools to understand the spatial distribution of vadose zone water will be also considered.

PROGRAM TEAM

The research team is gathered from the leading Israeli and Australian Universities:

- Technion - Israel Institute of Technology, Haifa - Tech
- Ben-Gurion University of the Negev, Besheva - BGU
- Hebrew University, Tel-Aviv - HU
- Monash University, Melbourne - MU.

Sub-Projects of Stage 1		**Research Academic Team****	**Student**
P1.1	Visioning of WSC in Isreal	**A/Prof Friedler (Tech) & Prof Wong** (MU), ALL researchers	RF/MSc
P1.2	Characterising stormwater in Israeli cities	**Prof Wallach (HU) & Mr Zinger (MU)**, A/Prof Friedler (Tech), Dr McCarthy (MU), Prof Deletic (MU)	PhD MSc
P2.1	Exploring urban design solutions for water sensitive innovations	**Prof Erell (BGU) & A/Prof Mozes**, Prof Tapper (MU), A/Prof Breen (MU), Mr Allen (MU), Prof Wong (MU)	RF 50% 2 MSc
P3.1	Hybrid biofilters for dual stormwater and groundwater treatment	**Prof Brenner (BGU) & Prof Wallach** (HU), A/Prof Friedler (Tech), Mr Zinger (MU), Prof Deletic (MU), Dr Hatt (MU), Dr McCarthy (MU)	PhD MSc
P4.1	Understanding the water sensitive urban design in Israel context	**A/Prof Mozes (Tech),** A/Prof E. Friedler (Tech), Dr M. Dobson (MU), Mr Allen (MU)	2 MSc
P4.2*	Demonstrating capability for stormwater harvesting in Israel	**Mr Zinger & Prof A Deletic (MU)**, Prof Brenner (BGU), Dr McCarthy (MU) A/Prof Breen (MU)	2 RF 2 MSc

** The sub-project is already fully funded and started in Jan 2012*
*** Sub-project leaders are marked by bold fonts*

The project's team has already started working on P4.2, which includes collaboration between MU, BGU and HU. It should be noted that the Australian researchers are currently involved in a similar $10 mil Research Program (Cities as Water Supply Catchments) that from July 2012 was incorporated in a newly formed CRC for Water Sensitive Cities ($120 mil research centre led by Monash University, http://watersensitivecities.org.au/).

DISSEMINATION OF THE OUTCOMES

One of the key objectives of the proposed programme is to demonstrate the Water Sensitive Cities approach in Israel, and increase awareness of stormwater harvesting as a means of meeting legislative and community expectations in relation to improving the liveability of Israeli cities.

The internal communication strategies will focus on delivering timely and relevant information to partners and key stakeholder representatives. The primary pathways for this will include materials presented directly to the industry and government participants, as well as an email newsletter sent regularly to the wider community.

At the very beginning of the program, a Communication Plan will be developed. The external communication strategy will focus on five key elements that are designed to support awareness, understanding and acceptance, all of which are prerequisites to adoption: (a) technical and issue based articles in industry-focused media, (b) targeted direct mail, (c) a website providing access to background technical and industry reports, conference papers and general promotional materials, (d) seminars, training programs and technical workshops, and (e) site visits and field days.

Public and private value will be created through the application of scientific knowledge to the solution of a series of environmental problems associated with urban developments and roadside verges. One of the main avenues for dissemination will be via Project 4.2, i.e., demonstration sites across major Israeli cities.