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ISRAELI WATER SYSTEM

A Circular Economy Business Model Case

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Acknowledgements

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Executive Summary

In 2017, the European Union launched a major initiative under its Horizon 2020 program to understand and promote circular business models in a variety of sectors. The initiative involves the creation of the R2Pi project comprised of fifteen international organizations from nine countries involved in business planning, environmental sustainability, finance, and regulation to develop eighteen case studies in textiles, electronics, building, food, and water. Because of Israel's success with the water sector and the sector's important within the EU based on it being a strategic and significant economic asset, the research team has described how it works and how it encompasses features of a "circular" business model, as well as what lessons can be applied to others, globally.

Israel's water system is composed of multiple private and public organizations along a circular value chain that extends from natural water sources to water storage and collection to waste treatment to reuse. Using a systemic, value chain approach, we describe it as a largely organic, centralized system that mimics the natural water cycle, maximizing efficiency and rewarding performance. Multiple stakeholders in Israel are guided in their efforts by environmental need, government policy, as well as technological drivers which encourage cooperation and innovation. As part of the EU's Horizon 2020 project, R2Pi, we have classified these relationships as a case study based on circular business models that illustrate the efficient, continuous use of resources.

Combining the key elements of circular business models, the team found that Israel's water sector has created a value proposition that provides clean, ready-water on demand, reliable infrastructure, and management and measurements systems that reward efficient, service-delivery.

Building on the business models R2PI project has developed, the team is able to share how the water system works and how the water system illustrates various aspects of circular business models. The following is a short summary of applicable conceptual business models and how the water sector can be understood through this lens:

- Re-condition and reuse - water is used and reused at the technical and biological level in a closed system
- Co-product recovery – recovering waste materials such as sludge from the water to be used as fertilizer and energy stock
- Access – all water is owned by the public, it is used subject to a fee per quantity paid to a regulated public authority

The case study research found that these approaches are driven by a series of environmental, economic, and technological conditions including overuse and damage to the natural aquifers, expensive and fragmented wastewater treatment, less regional rainfall, and growing population and water use intensity. In response the national government maintains public ownership of water resources, consolidates water authorities, builds national water infrastructure systems, commits public support for new water technologies and solution, including sea water and brackish water desalination, as well as transparent water measurement system, monitoring, security, and management systems. This public system translates the environmental and economic externalities into public unit costs and corresponding tariffs, and, at the same time, encourages constant innovations and improvements to improve services and lower water usage (and cost).

In its strategies on pricing, Israel has successfully reduced water demand. Market mechanisms include: block pricing, extraction levies and water markets permitting trading (for the agricultural sector). Non-market mechanisms include water quotas, non-quota use restrictions, infrastructure means of demand management, and public awareness raising campaigns.

In its strategies on continuous innovation, the government actively supports such innovation through direct and leveraged investments in research and development in both public and private firms. Importantly, public facilities serve as beta sites for testing and providing "proof of concept" for new technology. The result: over 300 companies involved in water sector technology, 120 of which are seven years old or younger and an estimated $2.5 billion in water technology and equipment exports annually. Moreover, Israel produces about twenty percent more water than it consumes itself annually, allowing it to export water to countries in its region.

Concurrently, Israel's universities and research facilities focus on energy, water, and agriculture to create solutions that are more efficient, effective, scalable, and sustainable. They are also responsible for training a highly skilled workforce of engineers and scientists who have contributed to Israel's leadership position in water technologies and innovation, opening a path forward for the sector within Israel and offering a benchmark for smart practices that can be transferred to other sectors, and other markets.

1 Introduction

1.1 Background and context

R2π – Transition from Linear to Circular is a European Union Horizon 2020 project focused on enabling organisations and their value chains to transition towards a more viable, sustainable and competitive economic model to support the European Union's strategy on sustainability and competitiveness.

R2π examines the shift from the broad concept of a Circular Economy (CE) to one of Circular Economy Business Models (CEBM) by tackling market opportunities and failures (businesses, consumers) as well as policy opportunities and failures (assumptions, unintended consequences). Its innovation lies in having a strong business-model focus (including designing transition guidelines) as well as in the role of policy development (including designing policy packages).

The ultimate objective of the R2π project is to accelerate widespread implementation of a circular economy based on successful business models and effective policies:

- to ensure sustained economic development,
- to minimize environmental impact, and
- to maximize social welfare.

The mission of the project is therefore to identify and develop sustainable business models and guidelines that will facilitate the circular economy, and to propose policy packages that will support the implementation of these sustainable models.

A core part of this project is to work with organisations who are on the journey towards developing circular economy business models, as well as those who have the ambition to do so but have not yet begun. The project has conducted case studies of eighteen selected organisations.

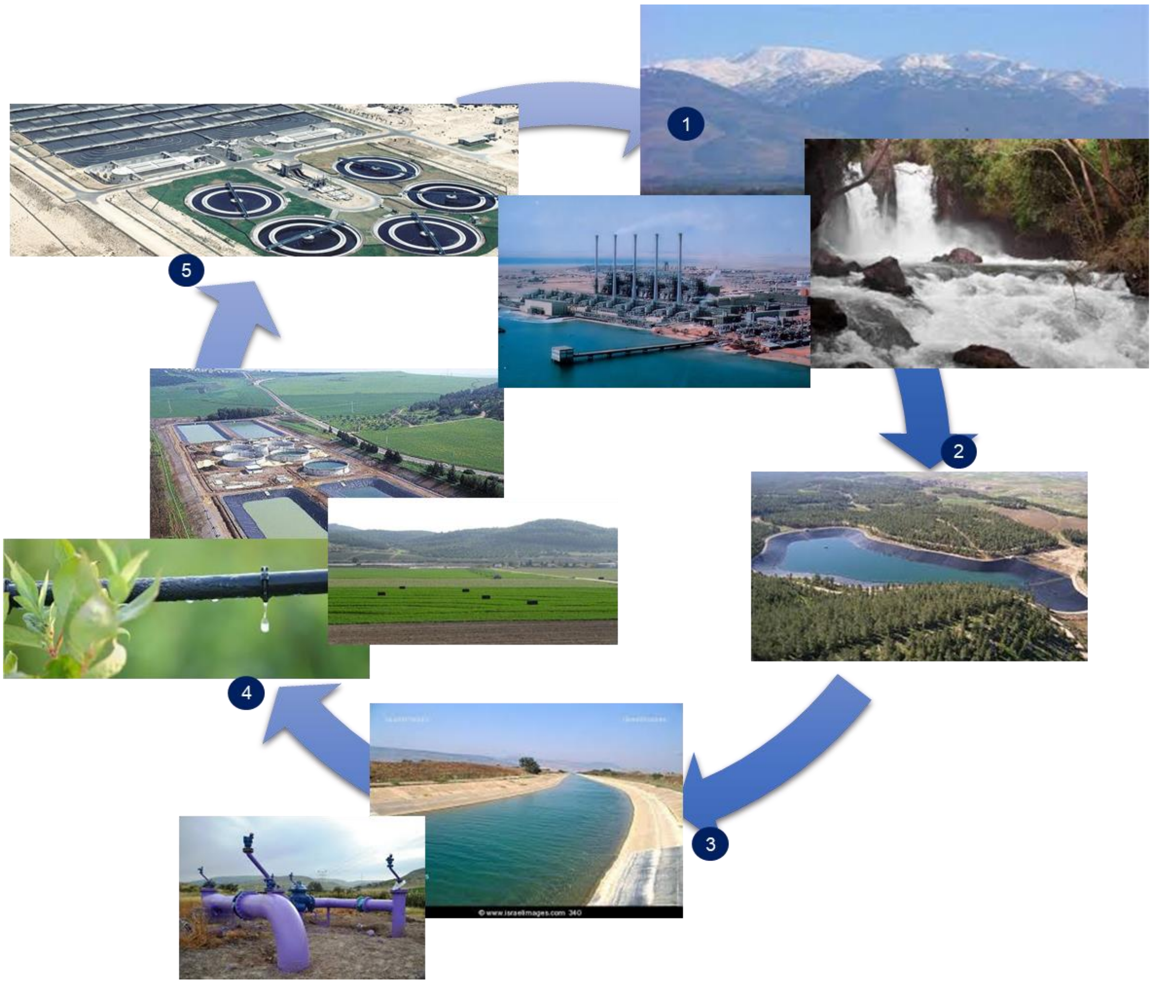
The eighteen chosen cases covered all five priority areas highlighted in the EU Action Plan on the Circular Economy: plastics, food waste, biomass/bio-based, important raw materials, and construction and demolition. Additionally, the cases were selected to ensure learning in each of the seven business model patterns defined by the R2Pi project: re-make, re-condition, circular sourcing, co-product recovery, access, performance and resource recovery, and these will be discussed in more detail in this report. To gather wide-ranging lessons from differing company sizes and maturities, the following were selected: seven large corporations, eight small, medium enterprises, one public entity, one entire value chain with both public and private organisations and one ongoing social project.

This report presents the case of the Israeli water sector. The Israeli water industry, since the founding of the state and more intensively over the last decade, is a good example of water circularity – with the goal of keeping water in the system through efficient use, improved and effective "production," reduction, reuse, and recycling, while lowering the carbon footprint of the sector.[1] In the natural world, water in its various forms—rain, ice and snow, steam, and cloud condensate—cycles through a closed system, with gains and losses in the form of water exchanges between watersheds and between land and air. In the industrial world, the water cycle is more complex. In fact, a (second) "hidden water cycle" exists if one considers the food and other water-dependent commodities exported from one place to another. The Israeli water sector is composed of many government, quasi-government, and private sector businesses. Each actor is either a supplier of water services or customer and user of water as it moves through the cycle. Because this cycle forms a natural circle, where the water resource is used by the next step in the cycle, it is circular. Therefore, this case study examines several of the key actors in this natural cycle, including collectors, conveyors, users, treatment providers, and measurement and management providers. Together, these key actors form the basis of the case study, combining several businesses and public actors instead a single business.

1.2 Business overview

The water cycle begins with natural water sources (1) which include rainfall, snowmelt, rivers, aquifers, and lakes. These may be found within the watershed in which the water is used, or beyond its "borders." In general, each of these natural sources must be protected before they lose their resilience and natural renewability. Aquifers are an important intermediary in this water cycle. They are a natural subsurface collection of water, usually in rock or other porous geological structures. They act as a holding area, naturally cleaning the water through filtration. However, these natural aquifers are overused and often damaged, and thus difficult to restore. From each of the primary sources, water flows naturally and sometimes into reservoirs, which are natural or man-made surface facilities.

FIGURE 1: THE ISRAELI WATER SYSTEM



Source: Jerusalem Institute for Policy Research

Often, the man-made reservoirs require infrastructure for transporting water over long distances. (2) After the water is collected, it must be distributed to users, which involves the collection, preparation, and transportation of stored water, including filtration and may include municipal or other regional water district facilities.

Sources of water in Israel include:

TABLE 1: SOURCES OF WATER

SOURCES	MCM/year
Net water balance and "lost" water from prior period	298
New natural water sources	902
Desal from saltwater	741
Desal from brackish water	60
Waste water treated for reuse in Agriculture (Ag)	395
Gross sources	**2,396**

Source: Jerusalem Institute for Policy Research

Water users include all individual consumers, municipalities, industry, and agriculture. (3) From each of these users, the cycle continues with the recovery, treatment of wastewater and residual waste streams from all users. Clean-up may be done at a variety of levels, depending on the technologies and the uses of treated waste, and the market for reusing water.

Uses of water include:

TABLE 2 USES OF WATER

USES	MCM/year
Agriculture	1,044
Residential	764
Industrial	120
Public	60
Export to other countries	143
Total Uses	**2,131**

Source: Jerusalem Institute for Policy Research

(4) Cleaned or treated wastewater eventually finds its way back to the ecosystem in the form of evaporation and precipitation. (4) Alternatively, recycling includes the reuse of a portion of the cleaned or treated water for agriculture, municipal uses, gardens, and even direct human consumption.[2] (5)

TABLE 3 WATER RECYCLING AND END OF CYCLE

Recycling and end of life	MCM/year
Losses (NRW)	168
Waste water from uses	470
Net water retained in uses (products and exports)	1,661
Net water balance after uses (Sources minus uses)	97
Net treated water not recycled for specific use	33

Source: Jerusalem Institute for Policy Research

The Israeli water industry is recognized as a global leader, thanks to innovations in desalination, drip irrigation, water recycling, and water network security, among others. (6) Israel's R&D programs, its expertise in advanced technologies, and its traditional strengths in water management and agriculture have resulted in a vibrant export enterprise. Its water industry exports stood at approximately $2.5 billion annually in 2016, with a goal of increasing this four-fold by the year 2030.

FIGURE 2 ISRAELI AGRICULTURE IRRIGATED BY TREATED EFFLUENT

Representative Stakeholders at each stage in the value chain (See Figure 3 below)

Sources, collection, and conveyance

1. Mekorot - Founded in the 1937 as the national water company, Mekorot, which means "sources" in Hebrew, is the central entity responsible for all water, related infrastructure, and related policies in the country.
2. Gihon - Hagihon, Jerusalem's municipal water authority, has a service areas of 1 million people. It has a reservoir capacity of 360,000 CM with a peak demand of 220,000 CM per day. Its main treatment plan handles 120,000 CM per day with Israel's third largest teritary activity sludge treatment plant. Its biogas generation produces 2 MW of sustainable electricity, effluent for agriculture, and sludge for fertilizer. The GiHon has 250 workers and is partnering with leading European Utilities and Research Institutions. in a new EU research project to Improve Governance and Social Awareness of Water Environmental Challenges. The new project, titled POWER (an acronym for '**P**olitical and s**O**cial awareness on **W**ater **E**nvi**R**onmental challenges') will set up a user-driven Digital Social Platform (DSP) for expansion and governance of political and social awareness on water environmental challenges in existing water networks. POWER, which was officially launched on December 1st 2015 and financed under the Horizon 2020 ("H2020-ICT10c-2015 Call") was implemented over the next 48 months. Hagihon is an 'early adaptor' water utility, serving as a beta testing ground for some of Israel's innovative water tech start-ups. Hagihon recently signed a seven-year contract with Curapipe, a company that snakes patent-pending material into broken pipes to plug leaks. HaGihon has installed about 2,700 acoustic sensors from start-up Aquarius Spectrum on hydrants across the city to listen for leaks during nighttime quiet hours. Monitoring start-up TaKaDu feeds morning reports to system managers of the entire

network." Hagihon has won several grants from the Ministry of Infrastructure,the national Water Authority, Ministry of Environmental Protection, and the Ministry of Economy. They're working as part of the Horizon 2020 POWER consortium and EU's FP7 Safewater consortium, working to produce an "enhanced system for protecting the municipal water system from contamination." HaGihon is one of 30 entities worldwide included in Cisco's Public Sector IOE market analysis.

3. IDE - IDE Technologies - IDE specializes in the development, engineering, construction and operation of enhanced desalination facilities and industrial water treatment plants. The company provides small- and large-scale desalination solutions, and partners with a wide range of customers, including municipalities, oil and gas companies, mining, refineries, and power stations, on all aspects of water projects, and delivers some 3 million cubic meters a day of high-quality water worldwide. IDE's track record includes building 400 plants in 40 countries over the course of more than 4 decades

Users

4. Netafim – Netafim manufactures integrated drip irrigation solutions for farms and urban gardens. With dominant market shares in the US, Africa, and China, its pipes, regulators, pumps, and controls systems focus on watering the plant, not the dirt. In addition to handling recycled water for Israel's agricultural needs, Netafim also developed nutrigation, which combines drip irrigation and the reuse of animal water to distribute nutrients to plant roots efficiently and effectively. Based on Kibbutz Netafim in Israel's Negev region, Netafim also reclaims and recycles plastic pipes from existing installations and produces and installs new pipes, reducing the need for virgin materials. Finally, Netafim is adapting a service model for its integrated water solutions, allowing the company to remain in the supply, maintenance, and repair value chain with its customers.

5. TaKaDu - TaKaDu enables water utilities to manage their networks more efficiently and make smarter decisions by harnessing utility data and translating it into actionable insights. The TaKaDu solution offers a comprehensive decision-making platform that can be integrated across the utility, from the analyst monitoring the network to the executive team considering long-term strategic investment. TaKaDu's patented technology uses raw data from multiple sources, analysing it to manage the full life-cycle of network events, such as leaks, bursts, and faulty assets.[3]

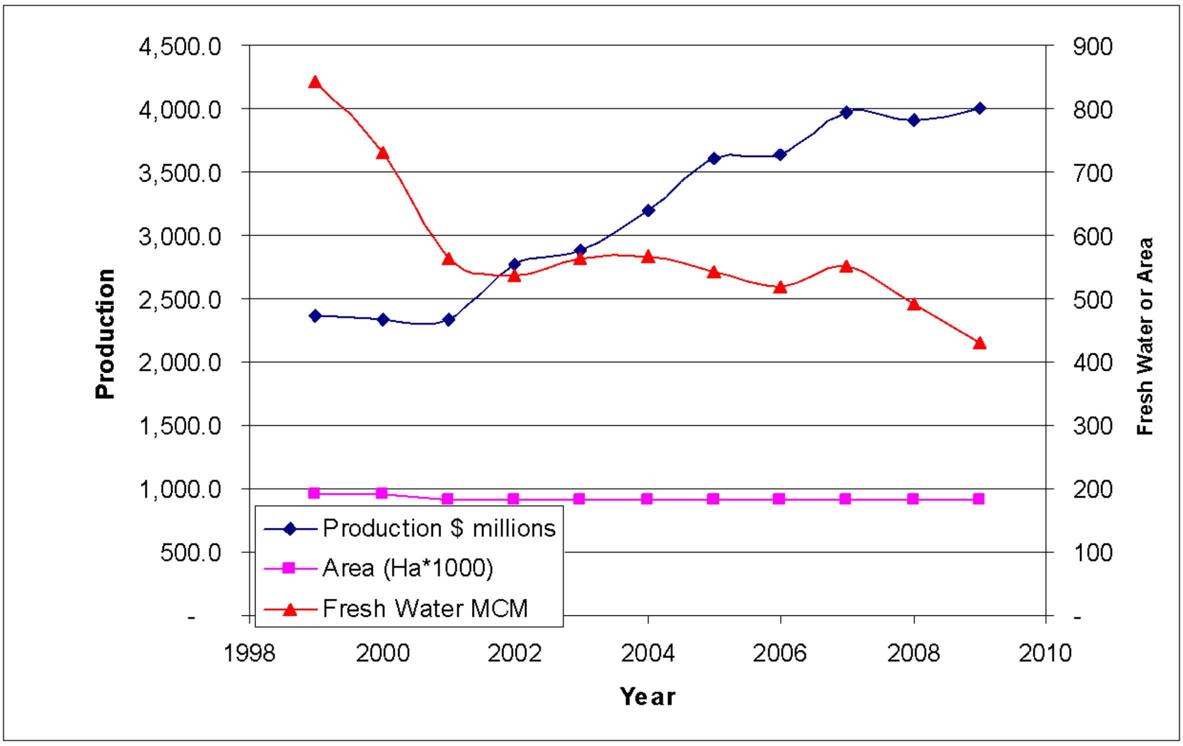
6. Autogronom, Ltd. – sells services that focus on continuous monitoring of the oxygen content in the plant's roots, delivering water and nutrients to each plan based on the plant's needs throughout the growing season. The sustainable precision agriculture business model is based on a leasing model for the equipment and a service contract for the irrigation and fertilization. The results include less water use and less fertilizer use.

Treatment

7. Palgey Ma'im – Palgey Ma'im is a full-service engineering, construction, and operations/maintenance company that provides turnkey wastewater collection, treatment, and recycling distribution systems for industry, municipal water systems and agriculture. Palgey Ma'im integrates multiple technologies and financing methods into efficient and sustainable cycling systems and offers planning and operation of wastewater and water systems, reclaiming effluents, sewage and sludge solutions, manure treatment, supervision and managing of projects.

Figure 3 illustrates the impact of innovation in precision irrigation deployed by companies such as Netafim, and Autogronom, permitting dramatic reductions in fresh water use with corresponding dramatic increases in production (on the same land area).

FIGURE 3 FRESH WATER ALLOCATION TO AGRICULTURE, IRRIGATED AREAS AND PRODUCTION



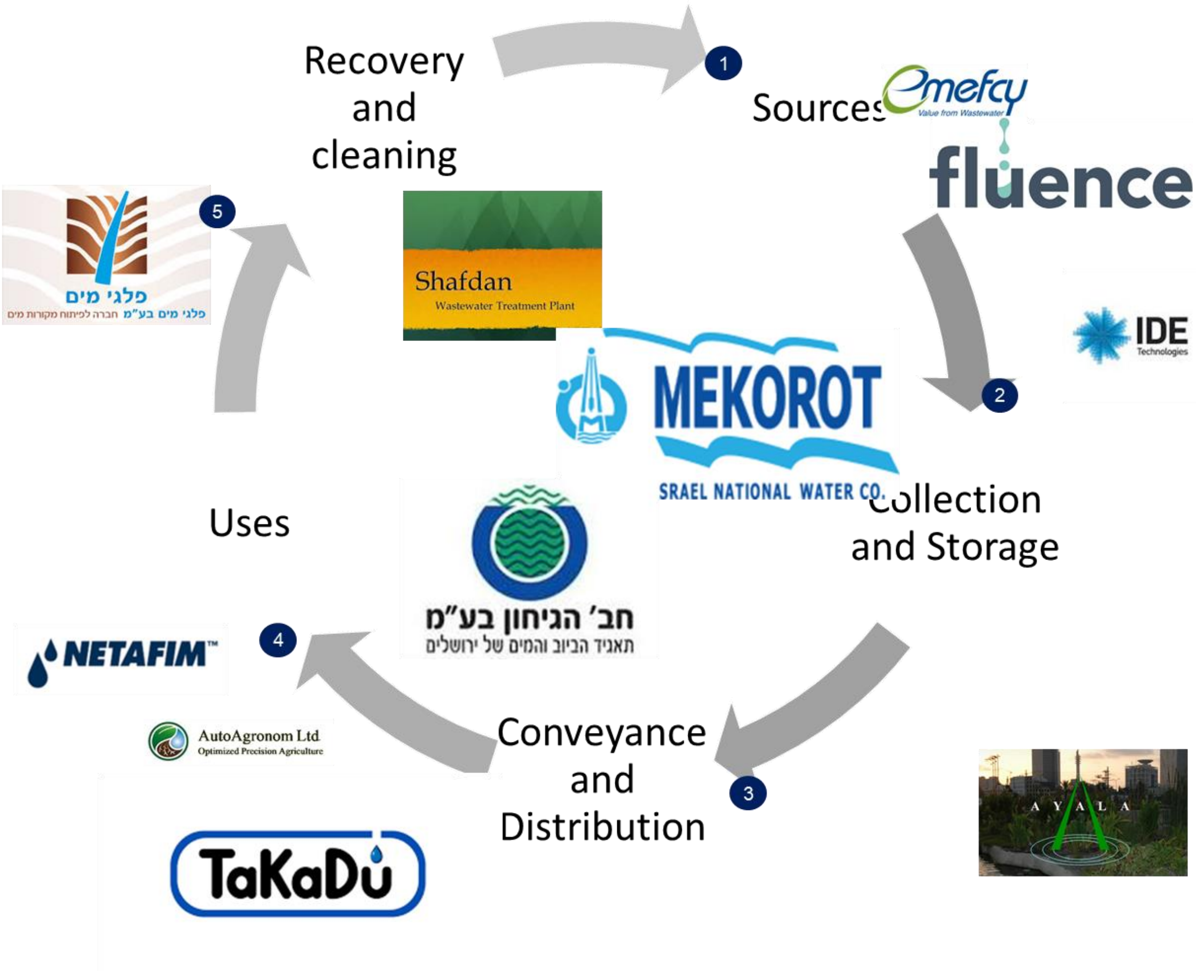
Source: Israel Water Authority

8. Emefcy/Fluence- Founded in 2008, Emefcy provides onsite water recycling solutions to resorts, commercial buildings, and municipalities. These save 90% of the energy used in wastewater treatment and avoid energy-intensive pumping by using the water locally; they can even be solar-powered for a true net-zero solution. Emefcy offers advanced energy-efficient wastewater treatment technologies for municipal and industrial plants. The company's Electrogenic Bioreactor uses electricity-generating bacteria to treat wastewater and produces green electricity as a by-product. Organic contamination in water becomes a fuel source. Its Spiral Aerobic Biofilm Reactor is a self-respiring, prefabricated modular unit for biological wastewater treatment that reduces energy consumption as well as sludge production. Emfcy/Fluence saves about 25 percent of their customer's annual water costs without the need to buy capital equipment. The business model, WATER REUSE AS A SERVICE (RAAS), includes payment and implementation of the plant, operations and maintenance of the plant, with a fixed contract payment; the advantages include: reliable source of water for reuse applications, saving money from day one, and performance-based payments. EMFCY has merged with RWL Water to form a new company, Fluence Corporation.

9. Shafdan – Israel's central waste treatment facility is the largest central treatment facility in the nation. It treats all sewage flowing through Israel's central region, the largest area and population centre in the country. The Shafdan treats 125 MCM per year with a large-scale secondary level treatment facility. It maintains six treatment fields and over 150 production and monitoring wells.

It also maintains 90 KM of pipeline to regional areas in the south and 32 pumping stations, operational storage facilities (.51 MCM) and seasonal storage facilities (17 MCM).

FIGURE 4 PARTICIPANTS IN THE ISRAELI WATER SYSTEM (REPRESENTATIVE)



Source: Jerusalem Institute for Policy Research

Based on interviews with stakeholders, including representatives from HaGihon, Israel's largest municipal water authority, key performance indicators include energy efficiency, lowering water losses, improving customer service, implementing best practices in infrastructures, financial efficiency, and maintaining a quality work environment to attract and retain talent. These performance factors contribute to the success of the Israeli water system.

1.3 The case study analysis process

Based on interviews and research, the case study team mapped the Israeli water system on the Business Model Canvas to illustrate the key components of the sector, their interactions, barriers, enablers. The Canvas is employed to understand each of the components of the underlying relationships among all the components of the business model that create and sustain the value proposition. This analysis included industry conditions and trends, background contextual issues driving the sector, and the policy and market framework within which the sector is operating. Finally, based on interviews with industry stakeholders, the team identified and confirmed the findings and identify key lessons learned and recommendations for others and how the lessons can be applied to other water sectors and other industries.

1.4 Report outline

This case study is organized into the following sections:

- A description of the Israeli water system business context, including an analysis of the factors driving the water sector is included in Section 2.
- A business model assessment of the Israeli water system in Section 3.1.
- An analysis of the circularity of the Israeli water system, including financial and non-financial impacts, and the challenges and opportunities, weaknesses, and threats in Section 3.2.
- A review of the conclusions and lessons learned that may be translated into other water systems and sectors in Section 4.

2 Israeli Water System business context analysis

2.1 Scope of the business context analysis

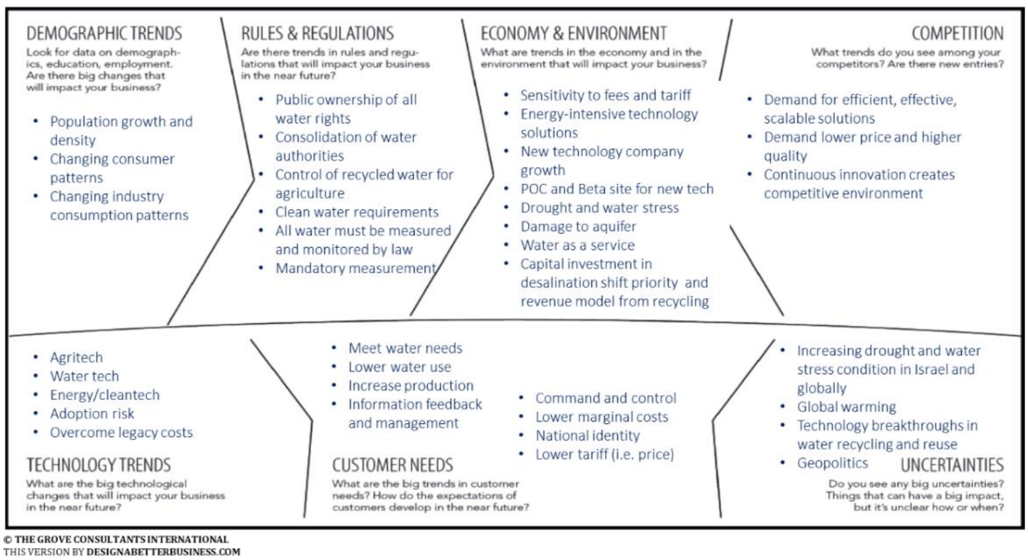
In this case study, the study team conducted a detailed analysis of the economic context of the sector, including global and regional trends, technology break throughs, policies and regulations governing the sector, and business trends in the sector. This contextual analysis included the use of the standardized case study checklist to identify the focus areas for each of the key business stakeholders involved in the sector. These focus areas include demographic trends, rules and regulations, economy and environment, competition, technologies, customer needs and risks and uncertainties in the sector. Once the business context analysis was prepared, the case study team presented the contextual analysis to the key stakeholders in individual meetings and group meetings to confirm and adjust the analysis.

2.2 Contextual factor analysis

The study team analysed the key drivers of the Israeli water system. These include expected population growth (1.5 percent per year) which is expected to drive demand, and the environmental stresses from climate change which will make it even harder to service the demand. This is evident in the recurring and worsening drought conditions in the natural water system, especially within the last five years.

Other environmental and economic drivers include the overuse and pollution damage to the natural water system caused by noxious uses and uncontrolled runoff, and the corresponding cost (financial and environmental) of energy needed to collect, transport, and treat water. Related to this are the business opportunities from new technologies to serve this growth market (in Israel and globally), and financing needs and investment opportunities in the sector. At the same time, behavioural drivers include an increasing awareness by users of the need to conserve water and ensure the quality of the water supply.

FIGURE 5 CONTEXT MAP CANVAS



Source: Jerusalem Institute for Policy Research

The following sections describes each of the components of the Context Map Canvas summarized in Figure 5 and how the Israeli water sector is described with this tool.

Demographic trends

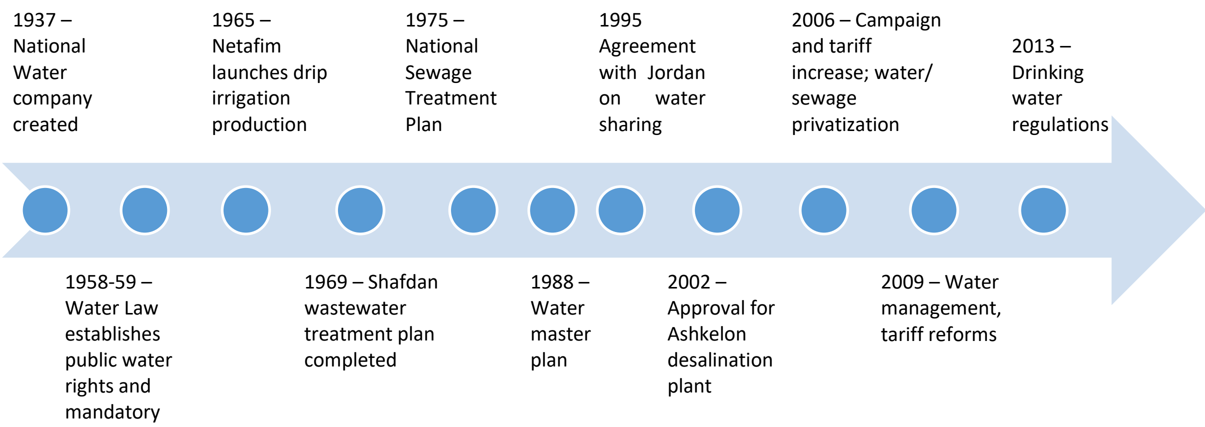
The key demographic drivers for the water sector in Israel are the rapid growth of the population, increasing density of the population in urban centres, and changing consumer and industry consumption patterns, including less water intensive uses and water saving behaviours. Threats to global water security derive from: (1) growing population (8.3 billion people projected in 2030, up from 7 billion today); (2) growth in average consumption of water from natural sources (e.g. 70 percent of freshwater consumed globally taken from rivers, lakes, and aquifers in 2017); and, (3) reduced water resources (1.8 billion people live under water-stressed conditions, projected to rise to 2.8 billion by 2025 (UN)). For 40 percent of the world's population, demand for water exceeds supply.

Rules and regulations

The key regulatory driver in Israel is the unique singular and central ownership of water by the public. This is followed by the consolidation of the water authorities under a single national water authority. Further, the careful regulations for clean water standards and the corresponding encouraging of the use of wastewater for agriculture drives the patterns of water uses in the agriculture sector. Finally, the public requirement for careful monitoring, measuring, and reporting about water consumption and conditions drives the development of technologies and use patterns. In Israel, this existential threat was recognized long before the modern state took form, but the threat materialized into a national emergency in 2005, in the form of a seven-year drought that threatened to exhaust what was left of the country's natural water supplies. Through usage taxes, water rationing, creation of the centralized Water Authority in 2007, and government partnerships with private-sector firms and new water technology providers, Israel opened many fronts in the battle to end chronic water shortages.

Figure 6 below shows the development of Israeli water policy which has led toward a strategy of water saving and innovation.

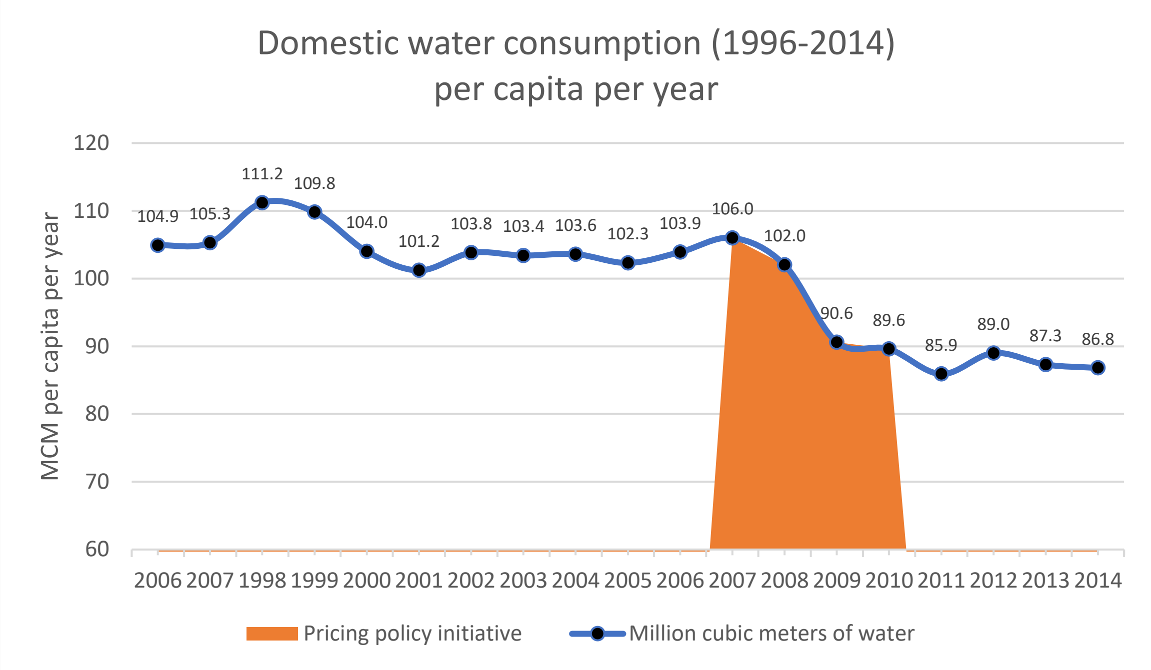
FIGURE 6 POLICY MILESTONES IN ISRAEL'S WATER SECTOR



Source: Jerusalem Institute for Policy Research

Figure 7 illustrates the impact of the water pricing policy initiatives in 2006-8 that resulted in dramatic water use reductions. The initiative includes a two-block system: below 3.5 cubic meters per person per month, the rate was USD$ 2.3 per cubic meter; above 3.5 cubic meters per person per month, the rate was $3.7 per cubic meter. The low rate was maintained at between $2.31 per cubic meter and $2.65 per cubic meter. The high rate rose from $3.41 per cubic meter to $4.26 per cubic meter.

FIGURE 7 DOMESTIC AND PER CAPITA WATER CONSUMPTION



Source: Israel Water Authority

Management of the company explained Israel's tiered pricing for household water usage: the structuring begins with a base rate for each household up to a certain amount. Over that, the price per cubic meter rises substantially. For a period during the drought in 2008, the Water Authority imposed a 30 percent increase on the domestic water prices to further slow consumption. Marketing and public outreach featured prominently in the Water Authority's campaign. In addition to the water rate increase, the water authority's multimedia marketing blitz, which included the "face" of the water shortage, was credited with changing behaviour. The campaign succeeded in many ways. Leak detection and better management reduced losses of "non-revenue water"—water lost through leaks in pipes, valves, and other means—from 15 percent to 7 percent. The Authority's policies also led to increased use of recycled municipal wastewater for agriculture, from about 220 million cubic meters in 2008 to 400 million cubic meters in 2015, an 82 percent increase in only seven years. These initiatives allowed the Authority to reduce the use of freshwater for agriculture while maintaining agriculture production on the same land area at the same level.

Economy and environment

The economic and environmental context for the water sector is driven by market sensitivities to fees and tariffs by both residential and industry consumers. The has led to the drive to build cross-sector subsidies to spread the costs over the largest possible base, especially when deploying energy-intensive solutions and developing new approaches in proof-of-concept and beta sites, which is part of most water treatment and distribution operations. The environmental conditions that drive the water sector including the natural drought and water stress conditions such as limited rainfall, high heat and evaporation, and damaged aquifers.

Treatment and recycling: Israel developed the capacity to completely recycle treated wastewater. At the Shafdan treatment facility, the largest owned and operated by Mekorot (Israel's National Water Company) 86 percent of the wastewater is recycled and deployed to agriculture and municipal gardens. The research and technology department at Mekorot noted that the deployment of desalination techniques for treating wastewater can restore water to drinking-level standards. This becomes more practical as new energy efficient desalination technologies come on online. This technology will also supplement the soil-aquifer treatment system (SAT)—in effect, replenishing the aquifer with treated effluent that is then naturally filtered as groundwater—allowing a more efficient method to treat and recycle the expected increases in demand.

Competition

In Israel, the central management and ownership of water enables continuous managed competition to find innovative, cost-effective solutions. This includes the continuous demand for efficient, effective, and scalable solutions, lower costs, and higher quality.

For large infrastructure projects, to shorten the time required to move from idea, to plan, to approval to implementation, the government instituted new tender and concession models, including Build Own Transfer (BOT) contracts and a fast-track approval process for projects that are expected to meet sustainable water goals.

Adoption, however, is time-consuming and expensive, especially for infrastructure projects with traditional organization and regulatory systems. Paradoxically, while many technologies may lead to the most substantial water savings and long-term economic savings, the technical risk is high. The use of energy services companies, or ESCOs, to attract capital investors, manage project and technology risks, deliver savings, and return capital to investors on a performance basis. This method of performance-based project financing transfers the risk from the water system and user base to private investors.4 This financial solution has been used successfully in California and could be adaptable to member states of the EU which do not and cannot enact, like Israel, a centralized water system in which water is not privately owned.

Technology trends

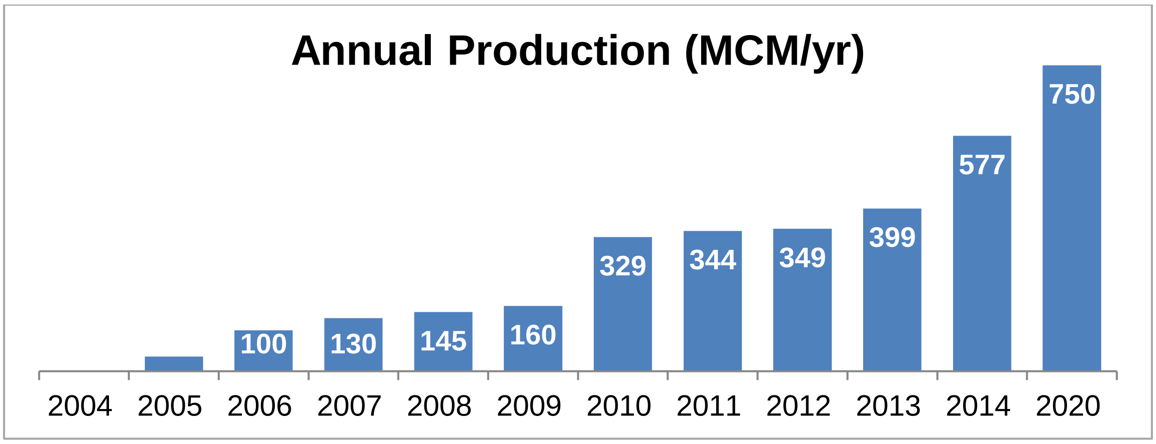
Israel is constantly driving new technologies in the water sector, including conveyance, cleaning, treatment, measurement and monitoring. The use of information technologies in water systems is one of the most significant and important components of the competitive Israeli water sector. This is built on the cross-over from the use of IT solutions in other sectors, including cyber-security, automation, and measurement. These trends are supported by a robust system of government incentives in research and development, new technology start-ups in related sectors such as agritech, water technology, and energy and cleantech. These incentives are important for overcoming adoption risk and compensating for sunk legacy costs in old water systems.

Technologies for water collection, user distribution, and waste infrastructures are rapidly changing. Israel's NewTech program within the Ministry of Economy is the centre for the clean-tech sectors, and works in four areas: (1) investment in future human capital through educational programs in elementary schools and university scholarships; (2) supporting R&D activities through grants for innovative water companies; (3) bridging the commercialization gap by the use of grants for first commercial installations in water utilities; and (4) penetrating international markets through better communication, marketing, and standardization processes.

Desalination plants are another major solution, though not without some controversy.[5] Israel began development in this area in 2001, before the 2006−2008 drought, and today six desalination plants along the Mediterranean Sea yield over 600 million cubic meters of water per year.

Figure 8 shows the rise in the production of water from desalination in Israel in accordance with Israel's master water plan adopted in 1988. As technology improved, there are six desalination plants along Israel's coastline now, with another four scheduled to be built over the next decade.

FIGURE 8 WATER FROM ISRAEL'S DESALINATION PLANTS



Source: Mekorot

Customer needs

Israel has developed water systems to meet the widest definition of customer needs. This definition goes beyond just providing water for consumers. It includes lowering water use, meeting water demand where and when it is need, influencing the use of water through prices and quotas, and providing information feedback and management systems that reinforce and inform consumer behaviours. While lowering the marginal costs of water is beneficial to the consumer, the national priority of water, drives water use behaviour.

Responding to the market, Israel highlights the development, design, and use of technological innovations, including water recycling, smart water systems that predict and detect waste, "nutrigation" (application of plant nutrients through an irrigation system in precise combination and timing for optimal development and best yields) for conventional and new low-water crops, irrigation that reduces water use, and desalination that converts seawater and brackish wastewater into useable, potable water.

Uncertainties

The backdrop of uncertainties in the water sector are always present. Israel is in a region with increasing drought and water stress conditions. With global warming conditions continuing, this is likely to get worse. Simultaneously, geopolitical realities in Israel's region both reflect and increase the stresses on water systems for Israel and its neighbourhoods. According to the US Intelligence Community Assessment of Global Water Security, by 2030, the world's water needs will exceed current sustainable water supplies by 40 percent, which could generate widespread instability and contribute to state failure in certain regions, including in the Middle East. Over the past thirty years, droughts have dramatically increased in number and intensity in the EU and at least 11 percent of the European population and 17 percent of its territory have been affected by water scarcity to date.[6]

3 Business model assessment

3.1 Business Model

The case study team used the Business Model Canvas to analyse the key components and interactions among those components in the water sector.

TABLE 4 BUSINESS MODEL CANVAS FOR THE ISRAELI WATER SYSTEM

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
• Regulators • Technology suppliers • Customers • Operators • Suppliers	• Collection • Storage • Treatment • Monitoring • Maintenance	• Clean, ready water on demand • Management and measurement • Living laboratory for innovation	• Reliable, high quality water • Continuous innovations	• Residences • Municipalities • Industry • Agriculture
	Key Resources		**Channels**	
	• Public ownership of water • Technologically-enhanced systems		• Infrastructure support • Single central water authority	

Cost Structure	Revenue Streams
• Investments in infrastructure • Maintenance, management and operations • Treatment and transport • Security and energy costs	• Regulated fees • Public financing for P3s • Service agreements
Social and environmental -	+
• Not all social and environmental externalities are included	• Environmental industry and employment growth • Reduced and efficient water and energy use; enhanced social and community cohesion and partnership • Economic and financial efficiency

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Adapted by R2Pi

Source: Jerusalem Institute for Policy Research

Key Partners

The water system depends on the coordination and collaboration of regulators, technology suppliers, customers (every water user produces wastewater), and system management. Key components of the system infrastructure are owned and managed by Mekorot and Shafdan, the national water authority and the central recycling and treatment facility in the central region, respectively. Other key partners include large regional authorities, such as Jerusalem's HaGihon. Finally, over 300 technology companies and water specialty companies, such as TaKaDu (providers of leak detection software) and Netafim (a major producer of drip irrigation) provide services and support for the national system.

Key Activities

The water system includes the collection, transport, storage, monitoring, maintenance, recovery, treatment, and redeployment of water.

Key Resources

The central and most important resource is the water in the system. All water is owned by the public. It is controlled, managed, regulated, and recovered by the public. The second most important resource is continuous innovation in the state-of-the art, technologically enhanced systems for all aspects of the water system.

Value Proposition

The value proposition for the water system is to provide a living laboratory for innovation to provide clean, ready water on demand. The system has reliable infrastructure that maximizes reuse and minimizes waste and is managed and measured to ensure efficient and effective delivery. It is enabled by an advanced system of government-technology partnerships.

Customer Relationship

The customer relationship is built on reliable, affordable, high quality water on demand. The responsiveness of the system is based on water as a service.

Channels

The channels that are used to deliver the value is through sustainable infrastructures, responsive services, and transparent, but central control of all assets (waters). This central control consists of the national water authority (the “Reshut” and the national water company (“Mekorot”).

Customer Segments

The customer segments include residents, agriculture (57 percent of managed water), and industry.

Cost structure

The cost structure, including capital costs for infrastructure are paid through tariffs and fees. Technologies are developed in conjunction with the national research and development facilities, the Israel Innovation Authority. Operating costs, including management, maintenance and security systems are covered through user tariffs and fees. The cost structure is competitive through bidding and contracting by the public bodies to private developers and operators. However, the costs are high, in part because of the high costs of energy and environmental externalities (which are included though not fully valued). In addition, the higher costs are used as a mechanism (via pricing) to manage aggressive market demand.[7]

Revenue Streams

The financial sustainability of the system is based on regulated fees for service based on cubic meter of water used, public transfers from taxes and fees, cost-effective public financing for capital improvements that encourage concessions for competitive private-tender BOT operators through service agreements, and payment for performance. All owners, users, and contractors are incentivized to produce an effective and efficient system, and the costs for the whole system, as described in the Financial Performance section below, shows the components of the costs and how the tariff must cover all the costs of the water system, including capital costs, operating costs, energy costs, waste treatment, and desalination.

Social and Environmental

The business model does not include all externalities from the water sector, however, in Israel, the price does include multiple components of the direct and indirect value chain. The business model does include the potential for direct and indirect industry growth (suppliers and users of new technologies and systems) through the constant market and regulatory demands for innovations. Finally, the regulatory control on pricing and water uses involves a high degree cooperation and involvement among various stakeholder groups, including business and communities, which add to the social cohesion and unity of purpose in carrying out the regulation and changing consumer behaviour.

Using the Business Model Canvas tool, the case study team mapped each of these components. The integrated nature of the water system blurs some of the normal business lines, but they all fit within this canvas to show how they create and sustain the value proposition.

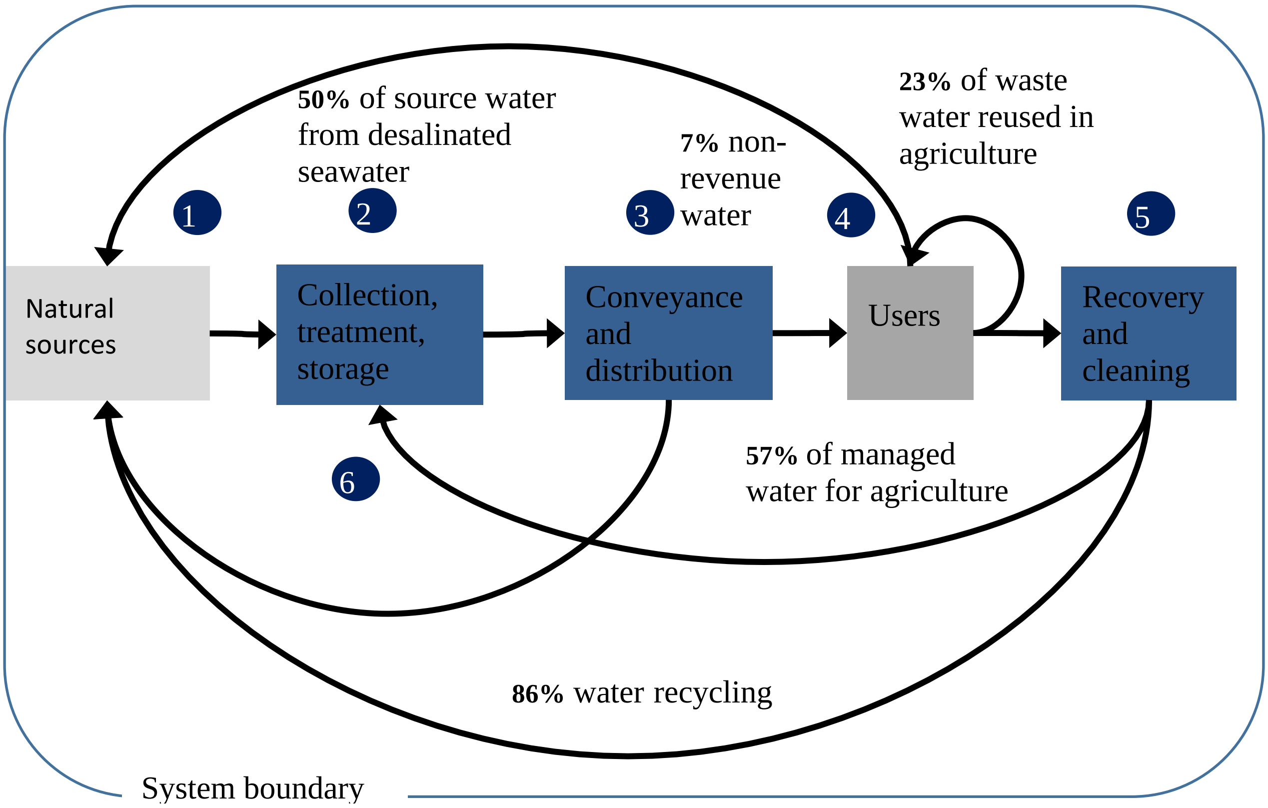
3.2 Value Network

The team identified the volume of water flows through the Israeli water value chain. These volumes are estimates based on published reports about the water sector and estimates based on discussions with stakeholders.

3.2.1 Material Flow

The material flows through the value chain in Figure 9 identifies the key participants in the value chain, including both the businesses (in blue) and suppliers and customers in grey. The black arrows show the direction of the materials flows in the value chain. As shown in this material flow diagram, the water flows through the systems and is returned to various stages in the value chain.

FIGURE 9 ISRAELI WATER SYSTEM PERFORMANCE IMPACTS AND RESULTS



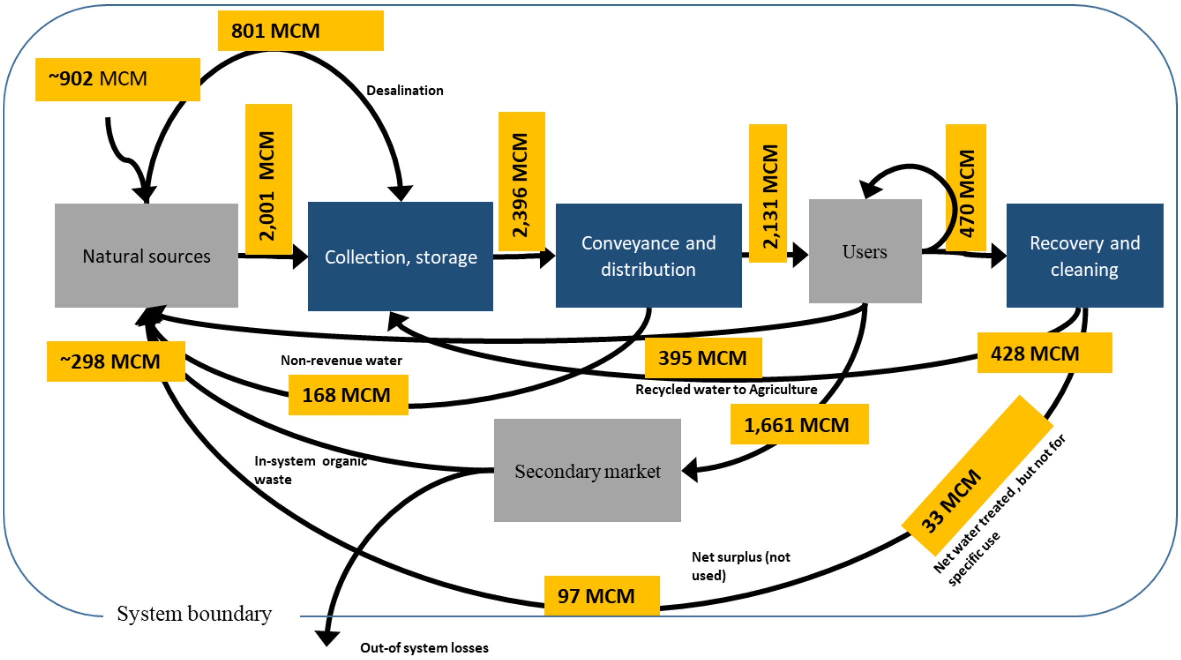
Source: Jerusalem Institute for Policy Research

In the materials flow, it is estimated that 50 percent of the water supply from desalination, adding to the natural sources. Through conveyance and distribution to users, approximately 7 percent of the water is lost (though it eventually returns to the natural source. Among users, an estimated 23 percent of the water is reused in agriculture, reducing the amount of fresh water using in agricultural – which is 57 percent of all managed water in the value chain. And finally, 86 percent of treated water is recycled, which is the highest waste water recycling rate in the world.

3.2.2 Value Flow

Using this conceptual framework for the Israeli water system, the case study team summarized the flows of water within this framework. See Figure 10 below.

FIGURE 10 MATERIAL AND VALUE FLOW MAPPING OF THE ISRAELI WATER SYSTEM



Source: R2Pi Study Team, Israeli Central Bureau of Statistics, Becker, et al. (2012)

This cost per cubic meter of water in Israel translates[8] into the following key valuation metrics for the Israeli water system:

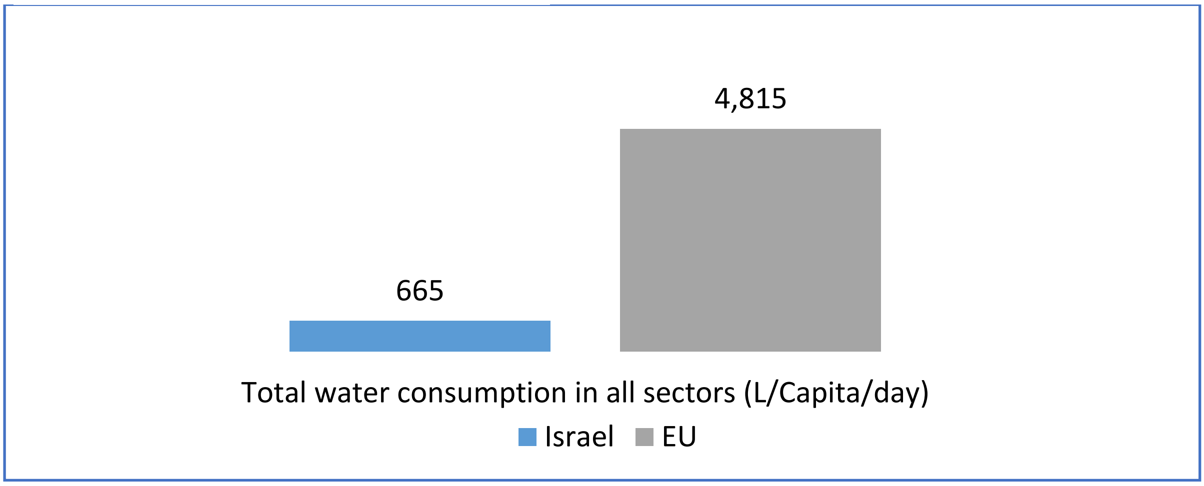
- Integrated value chain consuming about 2.13 billion cubic meters valued at an estimated 4.47 billion Euros annually.
- Desalination production estimated at 801 billion cubic meters with a market value of about 1.6 billion Euros annually.
- Recycled water estimated at 428 million cubic meters valued at 898 million Euros annually.
- Lost water in the system estimated at 168 million cubic meters with a value of 352 million Euros.

Israel's per capita residential water use is one third of the average water use in the EU and represents only a quarter of Israel's total annual water consumption. Eighty-five percent of wastewater in Israel is recycled toward agricultural use, while in the EU that percentage is much lower, around two percent. In fact, more than half of Israel's water—for residential, commercial, and agricultural consumption—is now "artificially produced," via desalination, recycling, and water treatment options. And most new technologies seek to mimic the natural water cycle by engineering the replenishment of aquifers and minimizing groundwater pumping. Additionally, Israel has adopted a host of technologies for saving water at the source and by consumers.

The following figures describe the Israeli water system as compared to the EU for each of several key measures: per capita use, water-recycling rates, and non-revenue water (losses from the conveyance, distribution, and collection systems).

Water consumption per capita includes all managed water sources for households, industrial, and agriculture uses. Per capita consumption in the EU is over seven times higher than Israel, largely due to the much larger water-intensive agricultural (with 89 percent of managed water use in Europe) [9] and industrial uses in the Europe. [10]

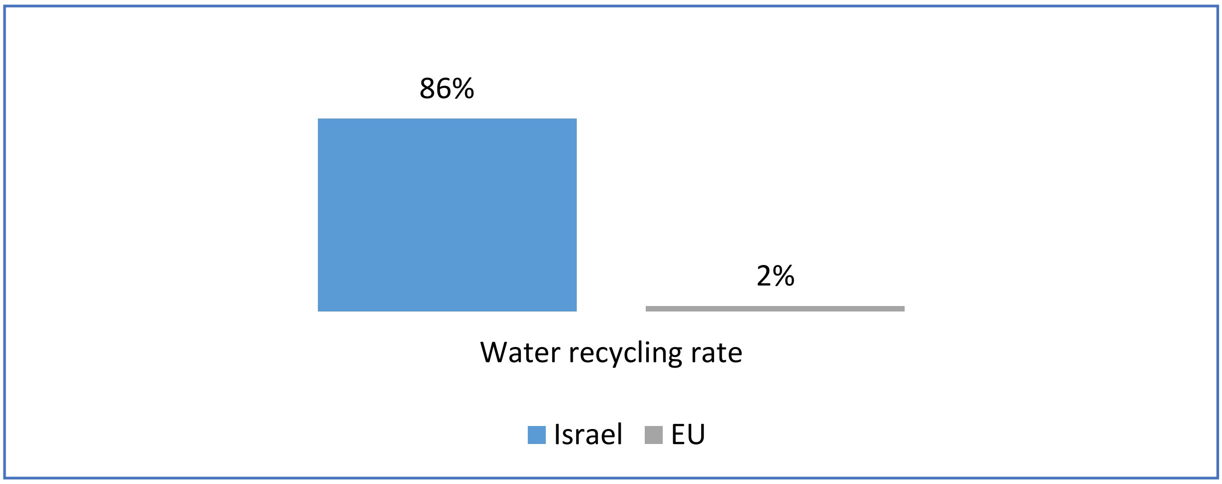
FIGURE 11 TOTAL WATER CONSUMPTION



Source: Jerusalem Institute for Policy Research

Based on the treatment of household wastewater, Israel returns about 86 percent to productive reuses. This about 43 times higher than in Europe.[11]

FIGURE 12 WATER RECYCLING RATE

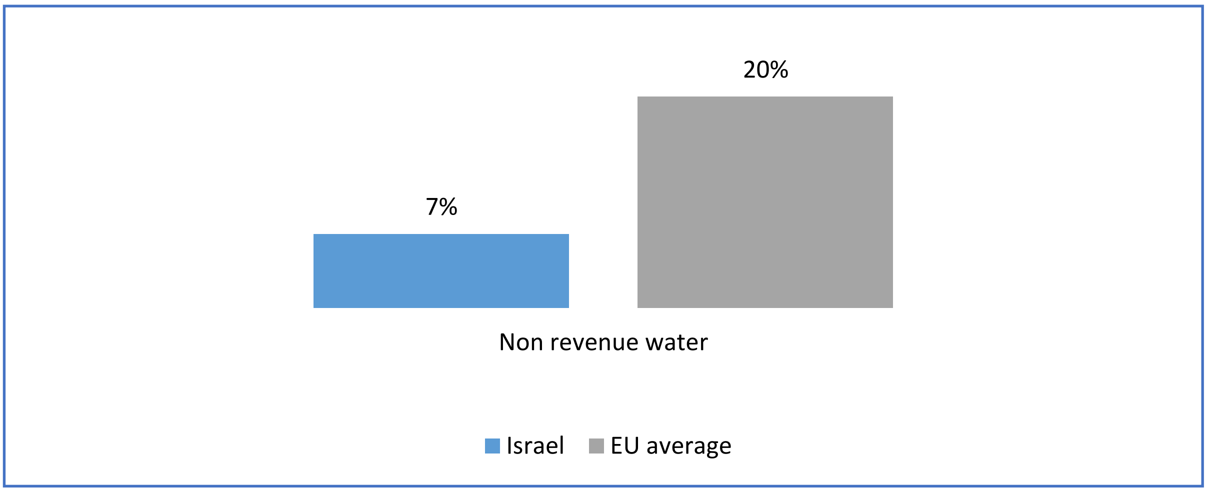


Source: Jerusalem Institute for Policy Research

Non-revenue water [the water that "disappears" from the water distribution system before it reaches the utility's customers], includes lost water attributed to leaks (physical losses) and/or faulty metering or water theft (apparent losses) accounts for an estimated 20 percent of water loss in the EU every year. The full scope of non-revenue water losses cannot be accurately measured or managed and varies widely among older cities, regions and countries.[12]

In the meantime, Israel has cut its non-revenue water in half from 15 percent in 2008 to approximately 7 percent in 2016.

FIGURE 13 PERCENTAGE NON-REVENUE WATER



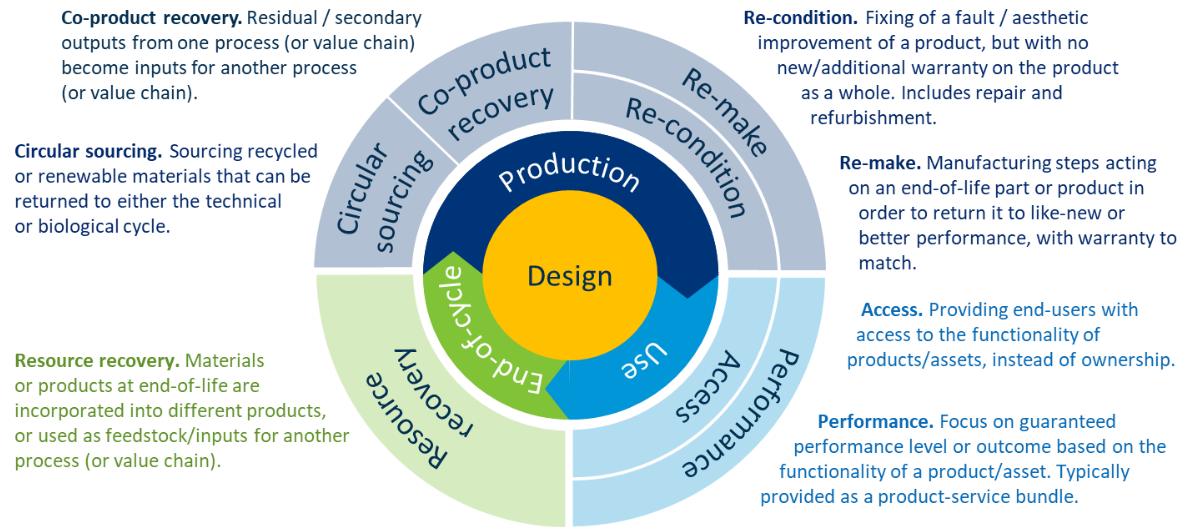
Source: Jerusalem Institute for Policy Research

Over the past decade Israel's large investment in an adaptive, resilient water system through conservation, desalination, recycling, and smart integrated management, has led to the production of about 20 percent more water than it consumes, exporting surpluses to Jordan and the Palestinian Authority. By 2016, the export of Israeli water technology had skyrocketed to $2.5 billion, according to the Israeli Export Institute, and it is expected to continue to rise as it enters water-stressed emerging markets such as China, India and Africa.

3.3 CEBM within the business context

The R2Pi project has defined seven circular business model patterns. Five of these models pertain to the flow of materials. The remained two models describe enabling patterns that describe how the business is structured in terms of ownership and revenues. Table 14 shows defines each of these business model patterns.

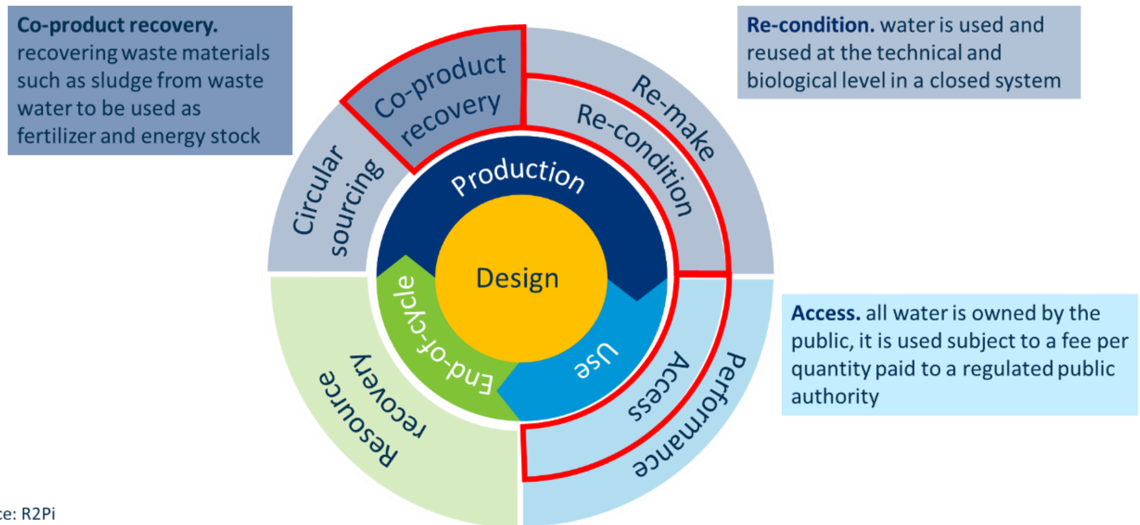
FIGURE 14 CIRCULAR BUSINESS MODEL PATTERNS



Source: R2Pi

The Israeli water system has key characteristics of three Circular Economy Business Models (CEBM) as developed in this project. These patterns are used to highlight the ways in which the water system stakeholders interact to create opportunities for circularity, leveraging their technology, market, ownership for sustainable revenues.

FIGURE 15 APPLICABLE CIRCULAR BUSINESS MODEL PATTERNS



Source: R2Pi

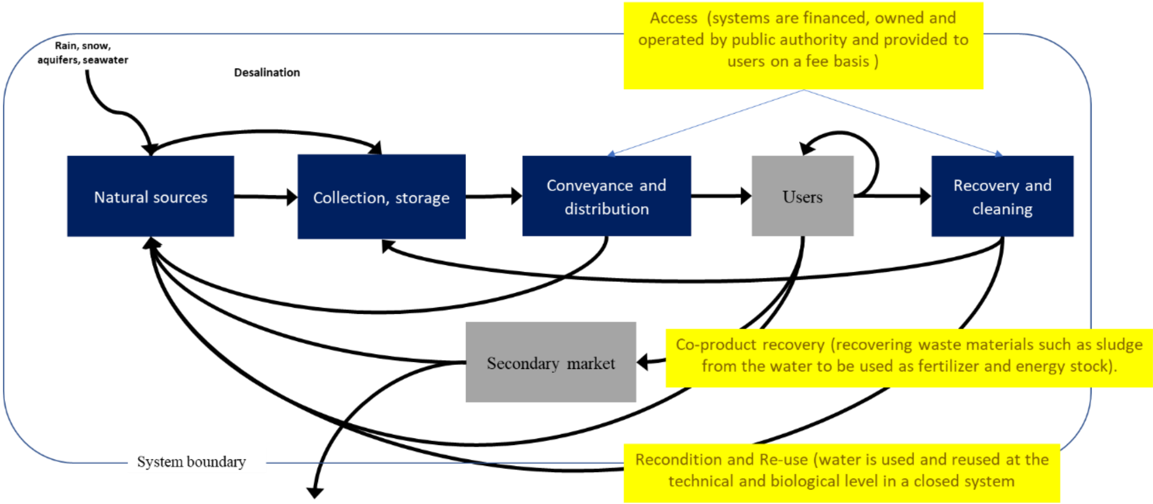
The study team found applicability of other business models to varying degrees, including circular source with selected industry sectors (e.g. food and chip manufacturing). However, the study team concluded that these business models are anecdotal and not representative of the water sector.

3.4 Business model circularity assessment

3.4.1 Circularity assessment

The case study team identified how these business models apply to the water value chain in Israel in Figure 16.

FIGURE 16 USING THE CIRCULAR BUSINESS MODEL PATTERNS IN THE WATER VALUE CHAIN



Source: Jerusalem Institute for Policy Research

For example, the ***access*** circular business model enables new project and capital structures. These capital structures include build-own-transfer arrangements for major water infrastructure that allow a private development to build and own the water treatment facilities on a long-term fee-based agreement with the public authority. This is common with large, capital intensive facilities such as waste treatment and desalination facilities. The private developer may also provide the financing for the equipment and facilities. At a designated time, the facilities may transfer to public ownership. For smaller projects, private developers and service provides are moving to a “water as a service” model where the private owner retains ownership and control of the facilities and sells services to the public authority or private water user. This model is commonly used by Emfcy/Fluence in the provision of low energy, small scale water treatment.

The **co-product recovery** circular business model enables the reuse of waste water without extensive or expensive treatment. This model is used in agriculture applications, for example, where the waste from animal care and feeding is mixed into a slurry or sludge with other waste water and delivered to plants in the field through precision irrigation. This process, pioneered by Netafim, is called nutrigation. Another example of co-product recovery is the sludge separation from agricultural processors (food manufacturing), and other waste producers (residential waste water) through sludge separation and primary treatment and the use of the waste water in precision crop irrigation and composting. These circular engineering solutions are used broadly by Palgay Mayim for their industry clients and by the public waste treatment facility operated by the Shafdan.

The ***reconditioning*** circular business model is used most broadly in the Israeli water system through the recovery of waste water from users, primary treatment of the waste water, and reuse of the waste water for agriculture. The Israel water system has the highest rate of reuse of waste water in the world. The Shafdan is the primary waste treatment facility and it produces treated water for most of Israel’s agriculture.

3.4.2 Business model circularity and strengths/weaknesses assessment

In this part of the case study, the case study team identified the political and legal factors, technology factors, economic and market factors, and sociocultural factors that drive Israel's water systems. The context for this analysis is based on the interviews with the stakeholders in the system about how the system has evolved.

Political and Legal Factors:
The provision of water to all Israeli consumers rests on a series of legal and political measures that permitted the creation of a true, centralized system:

- **Water Drilling Control Law** (1955, 5715-1955, Section 4): prohibits drilling for water anywhere in Israel even by the owner of private land, without first obtaining a licence to do so.
- **Water Measurement Law** (1955, 5715-1955, Section 2(a)): Prohibits any distribution of water unless that supply was done via a meter. This law also required that all utilities install meters to measure the amount of water provided to each home or business.
- **Drainage and Flood Control Law** (1957, 5718-1957, Section 1): This new law addressed surface water, broadly construed. Not only did this place the water found in rivers and streams under government control, but it also took charge of rainwater. It even took ownership of the sewage flowing out of Israelis' homes. The law prohibited diversion of any of these forms of water without first receiving a government permit. It also compelled farmers to obtain a license before herding their own grazing animals on their own property if the animals would cross a waterway in the process.
- **Water Law** (1959, 5719-1959, Section 1): The legislation vested in the government "widespread power to control and restrict the activities of individual water users to further and protect the public interest." All water resources became public property subject to control of the State. Land ownership would confer no rights to water resources on, under, or adjacent to the owner's land. Henceforth, individual or private use would only be permitted if in accordance with the law. The Water Law even stated an expectation that all citizens would use the water they receive "efficiently and sparingly".

Even compared to other countries with public ownership of water, Israel has taken a more absolutist approach than most. In France, for example, a landowner doesn't have unfettered right to use all the water under his/her land to the detriment of others. But the 1964 French water law says s/he can use that water freely provided s/he doesn't deprive his/her community reasonable access. Further, the French Civil Code explicitly gives ownership of rain to the owner of the land where the drop falls.

Economy and Market Forces:
A series of measures have been adopted as drivers towards reducing water demand (Katz, 2010):

- Market mechanisms:
    a. (Block) Pricing
    b. Extraction Levies
    c. Water markets and trading (for agriculture / farmers).
- Non-market mechanisms:
    a. Water quotas
    b. Non-quota use restrictions (such as bans on using water at certain times of the day),
    c. Technical and Infrastructural Means of Demand Management
    d. Standard Setting and Planning as Means of Demand Management
    e. Public Information and Awareness Raising Campaigns

- At the same time political pressures from consumers has prevented the price of water from being raised to a level that reflects its real price (i.e. considering water's value as a goods and service, as well as externalities such as pollution connected to technology use such as desalination).
- The cost of energy is changing rapidly as Israel (and the world) integrates renewable energy sources into its power grid. This will affect Israel's ability to power energy intensive technological solutions to water problems including desalination and wastewater recycling.

Sociocultural factors:

- **Achieving social goals**: Even though water can be thought of as a commodity (either private or public), it also serves as a tool to achieve social goals that cannot be quantified. Those goals have no direct value attached to them, but rather serve as constraints. Examples from Israel are water diverted to the periphery to sustain living conditions to settlers, water to farmers in a minimum amount to sustain heritage, and water as a basic good that every person has the right to get a minimum amount regardless of whether he/she can afford it or not. This indirect value can be defined as the opportunity cost of achieving those pre-set goals. Water policy should consider those costs when defining such goals (as well as the price that is paid for water).
- **Demographics**: 18.1 births/1,000 population (2017 est.) vs 5.2 deaths//1,000 population (2017 est.) result in a growth rate of 1.5 percent. With a small land size area and a relatively high population growth rate (especially compared to EU member states), as well as decreasing annual rainfalls, Israel faces potential annual water shortages that will become more prevalent over time.
- **Social costs of water infrastructure**: The real estate, environmental and social value of the shoreline has pressured the desalination industry (specifically) to build in areas specifically designated for engineering installations to preserve land for tourism and recreation. For example, the Ashkelon facility was built 2 km south of the city, extends over an area of 70 dunam, and sits adjacent to the IEC Rothenberg Power Station.

Technology and system innovation factors

Three factors have contributed to Israel's leadership in water technology innovation:

- Israeli companies are in a constant state of innovation and experimentation to find new solutions to all nodes in the value chain. The water industry comprises more than 300 Israeli companies, 120 of which are seven years old or younger.
- The government supports innovation with R&D support, infrastructure and investment, through agencies such as the New-Tech Department of the Ministry of Economics which focuses on developing technology specifically within the water and (renewable) energy sectors. Additionally, large-scale public (water) companies such as Mekorot provide beta-testing sites providing "proof of concept" for new technology.
- Israel's universities and research facilities, including the Hebrew University (Agricultural Faculty), Weizmann Institute and the Volcani Research Organization (the government-sponsored Agricultural research centre), Ben Gurion University, Arava Institute, Tel Hai College, and others focus on energy, water, and agriculture to create solutions that are more efficient, effective, scalable, and sustainable. They are also responsible for training a highly skilled workforce of engineers and scientists who have contributed to Israel's leadership position in water tech innovation.

There is a strong need for water technologies and there is a strong demand and there is money (both public and private) to support promising technologies. Moreover, the public water system is relatively open to test new solutions whereas the pricing mechanism of the water companies incentivise them to do so.

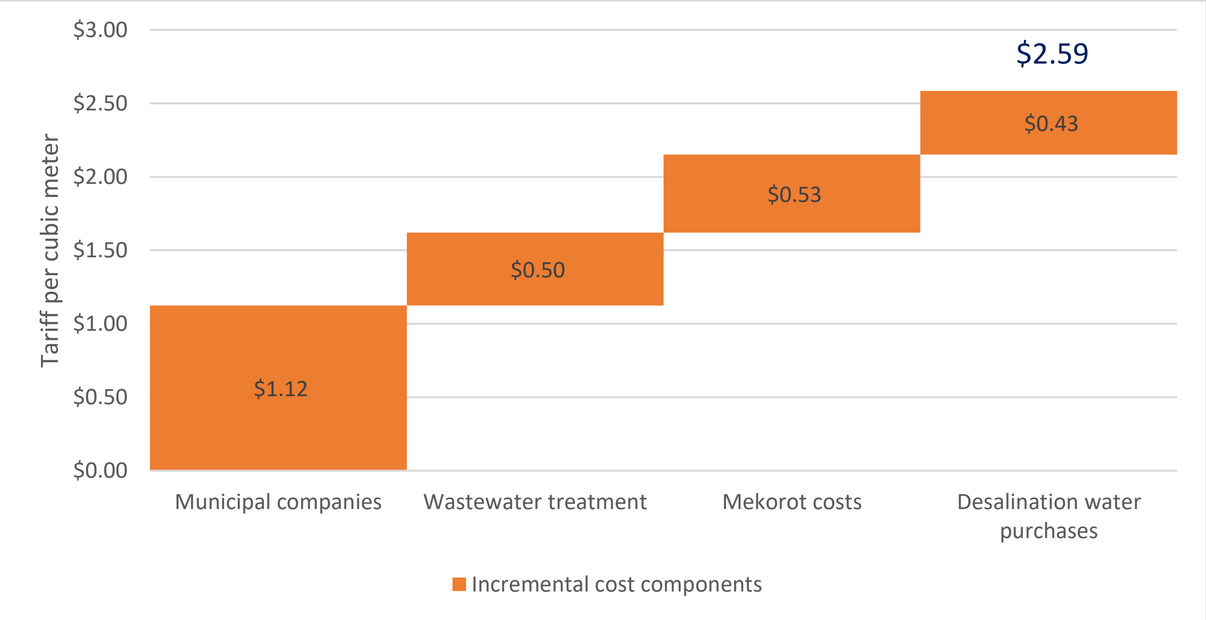
Environmental Factors

- The effects of the Global Climate change are steadily reducing the annual rainfall in Israel, which means that the country will be increasingly dependent on technology to "create" water sources.
- "Creating" water from desalination solves the urgent problem of water scarcity though it requires polluting energy.
- Streams in Israel are no longer viewed as open sewage canals. There is recognition of the importance of streams from both an environmental and economic development perspective. The use of desalination and wastewater treatment has given a new lease on life to streams in Israel.

3.4.3 Financial and non-financial outcomes assessment

The tariff for water is composed of four main components – the municipal operations, wastewater treatment, Mekorot costs, and the costs of desalination. These costs combine to create a tariff with an average price of $2.59 per cubic meter of water.

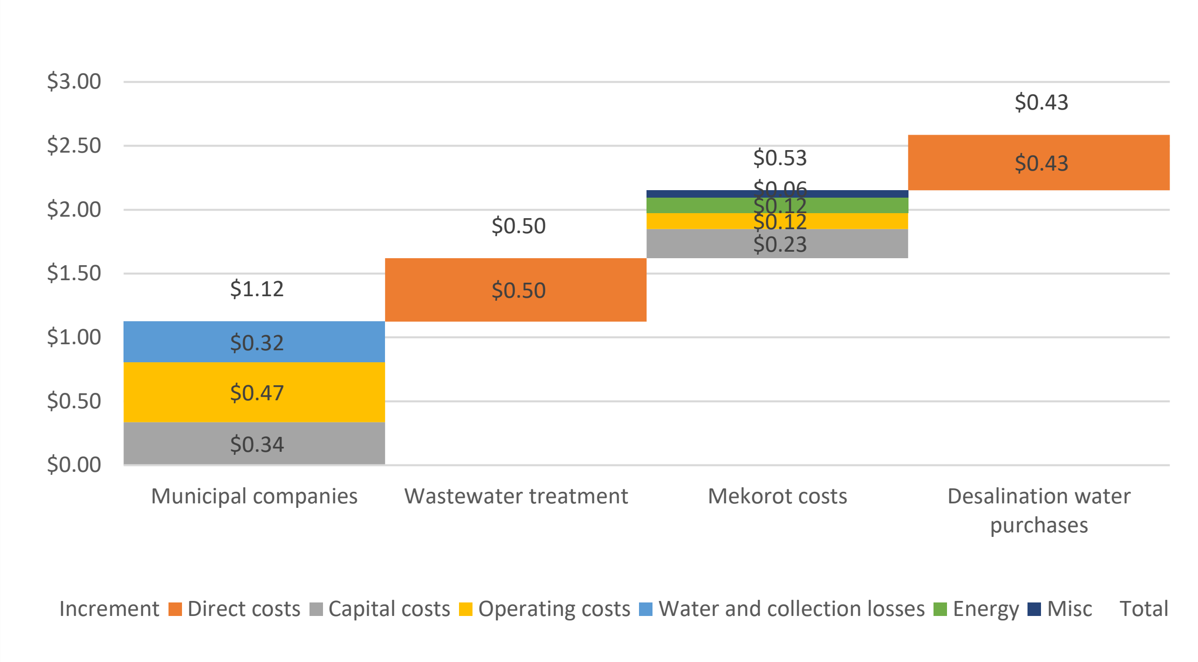
FIGURE 17 MAJOR FINANCIAL COMPONENTS OF THE ISRAEL WATER TARIFF - 2017



Source: Israel Water Authority

The components of each of these costs including operating costs, current payment of long-term debt for capital costs, allowances for water losses, and energy costs.

FIGURE 18 COSTS OF EACH COMPONENT OF THE ISRAEL WATER TARIFF - 2017



Source: Israel Water Authority

Given the integrated pricing and cross subsidization of costs in the tariff for water and the substantial capital investment and long-term payment agreements to system operators (e.g. desalination built and financed through Build-Own-Transfer public private partnerships), the pricing system has mitigated the internal financial motive to move from recycling to desalination. While costs of treatment and desalination differ, the revenues for each are the same in the integrated pricing model.

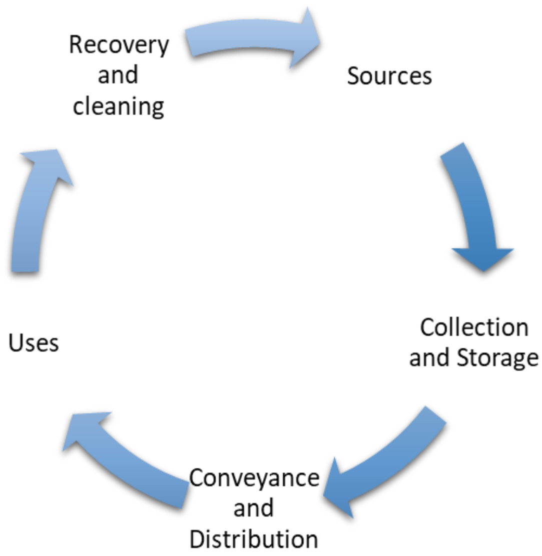
Additionally, stakeholders in the Israeli water system identified several key non-financial outcomes. These outcomes include:

- Community consensus - the water economy is based on consensus among various stakeholders in the community, including residential, commercial, and industrial sectors. In addition, the involvement, support, and leadership by the education, governmental, and NGO communities are integral to the consensus.
- Environment protection – water is an essential element in the environmental balance in the country, including fragile ecosystems, community and economic growth, and biodiversity. As a country in the Middle East, with limited natural water and damaged aquifers, reusing water is a critical component of the nation's environmental protection strategy.

3.4.4 SWOT analysis

The Israel water sector case study included interviews and group meetings with key stakeholders to identify and confirm the features at each stage in the water value chain. This section describes these enablers and barriers and is used to develop an analysis of the strengths, opportunities, weaknesses, and threats at the end of this section. As part of the discussions with stakeholders, the study team presented and confirmed the analysis of barriers and enablers along the water sector value chain.

FIGURE 19 WATER CYCLE



Source: Jerusalem Institute for Policy Research

The Israeli water system has faced several significant challenges. These challenges are described according to each link in the value chain described in Figure 19.

Primary sources: Because of precipitous climate change, the planet is experiencing increased temperatures and higher frequency of extreme weather events. These phenomena significantly affect the natural water supply. These changes, both short- and long term, propel public policy initiatives. In addition, the physical designs of water catchments and treatments in urban and rural areas can have dramatic conservation impacts; flawed and aging infrastructure, or a lack of any infrastructure at all, result in massive run-off and low residual (both sewage and brackish) water quality.[13] Additionally, some new technologies, such as desalination, pose environmental risks and raise considerable opposition to ensure consideration (and mitigation) of environmental damage. Additional work is being done in Israeli research institutions, including Volcani Research Organization, and many private business R&D facilities, to develop non-GMO drought-resistant, and salt-resistant plants, including selective and accelerated breeding based on performance. The regulatory pressure to pursue non-GMO technologies creates added cost and time to introduce new solutions into the market.

Reservoirs and aquifers: The challenges in this phase of the water cycle range from high direct costs (construction and maintenance of reservoirs); protection from encroachment; overuse and contamination from surrounding growth and development; and water loss through evaporation. Another major challenge is the long-established assignment of private water rights, including senior rights that allow for the unlimited use (and depletion) of these assets.

Distribution: This stage of the cycle presents a variety of challenges, including the large capital and operating costs of major infrastructures, such as dams, pipes, and pumps; the large amount of energy used to pump and transport water; the costs to introduce new and expensive technologies, including regulatory compliance; financing limitations of the sponsoring governmental entities; and fragmentation and duplication among ownership, managers, and various levels of government sponsorship.

Users: The three sectors served at in part by municipal systems: domestic, agriculture, and industry. Key among these challenges is the measurement, management, and performance of technologies designed to save water. Also, many of these user systems, may lack scale enough to finance implementation. The lack of scale extends the payback period of technical solutions and lowers the returns for investors and customers. The breakdown of cost components for the tariff include a composite of municipal authority costs, Mekorot costs, waste treatment costs, and desalination costs. Importantly, these costs are shared over the entire service base. The details of these component costs are included in the Financial Section of this case study below. However, the challenges include pressure to reflect the externalities of water, the subsidies available from the public budget, and political pressure to alleviate (or increase) the costs to change market behaviour.

Waste and treatment: The collection of wastewaters from each sector poses challenges, including the cost of infrastructure, the introduction of new processes and technologies, and the costs of regulation and enforcement. These barriers can be exacerbated by ambiguous ownership and responsibility for run-off and non-point sources (leaks or leaching from indefinite or many locations) of wastewater and contamination. Similarly, treatment is expensive: capital costs are high, operating revenues are limited by rate payers, and new technologies are difficult to regulate and implement in old infrastructures (legacy systems).

Recycling: Barriers to recycling wastewater include technical hurdles, regulatory questions, and limitations of the market. While Israel has demonstrated a very high rate of wastewater recycling for certain agriculture uses, a generally high level of resistance exists in the EU market. The main reason identified was the low price of fresh water, against which it is very difficult for treated wastewater to compete. More than that there is a resistance towards the use of wastewater among individual consumers as well as the agriculture community.

In discussion with stakeholders, opportunities or solutions were identified for each stage of the value chain to address the barriers described above:

- Primary sources, reservoirs, and aquifers: A potential solution is the expansion of existing infrastructure financing at the state level to repair and separate storm drains from sanitary sewers, particularly in the coastal urban areas. The separation and capture of storm run-off would allow for the proper retention and diversion to natural or man-made wetlands and recharging the depleted aquifers. At a large scale, however, this solution is, at least in the short term, is costly; nevertheless, smaller-scale and cost-effective storm water capture systems can be implemented.

- Distribution, users, and waste: The fragmentation of ownership, management, and operations of water treatment and waste facilities into hundreds of municipal water districts could be mitigated by regional ownership/operations. Consolidation would allow for coordination and implementation of policy initiatives that encourage efficiencies in management, operations, and financing. This approach was implemented in Israel in 2007 when the Israel Water Authority brought more than 115 separate water authorities and municipal companies under one administrative umbrella. Experiences in most other areas, including regions in the EU and the US markets, are quite different with fragmentation, balkanization, and multiple organizations created to serve the regions.

Based on this analysis of enablers and barriers, the case study team developed the following SWOT analysis. The SWOT analysis is based on the perspective of the Israeli water system.

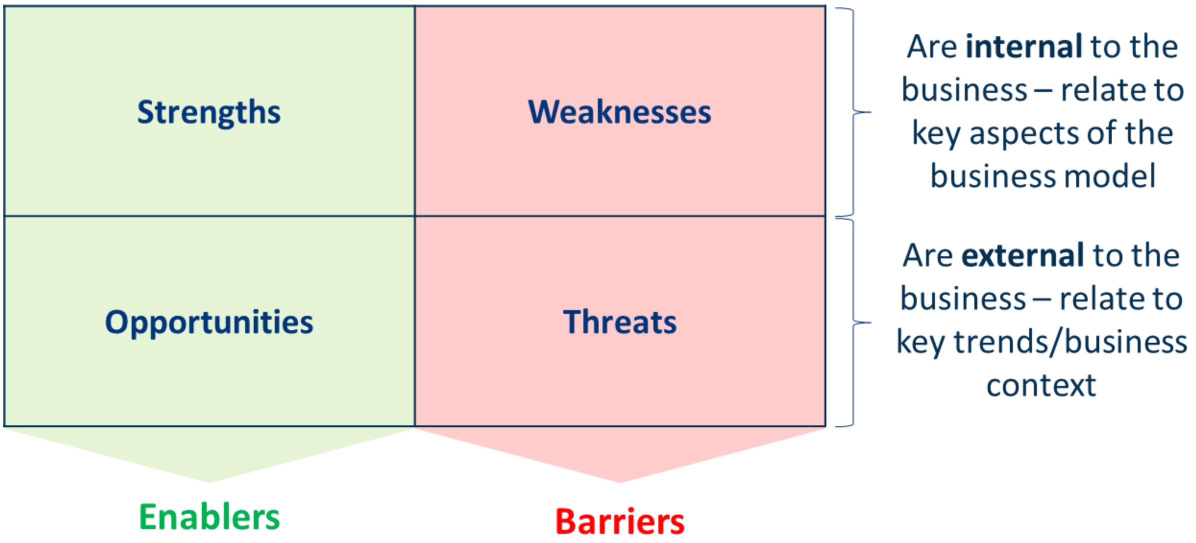
TABLE 5 SWOT ANALYSIS SUMMARY

Strengths ● Public-private Partnerships ● National ownership and governance ● State-of-the art technologies ● Culture of continuous innovation ● Systems financing for whole-system solutions	Weaknesses ● Limited financial returns ● Ownership and governance limitations and complexity ● Adaptation from legacy infrastructures ● New maintenance costs ● New skills for installation and operations
Opportunities ● Cost-effective systems financing ● Full-cost valuation ● User fees based on tiered pricing ● Global credit market for Sustainable Development Goals achievement ● New sector growth in desalination, measurement, detection, management, etc. ● Front-of-the-line regulatory permitting ● Public health monitoring and reporting ● Community and consumer education	Threats ● High energy and capital costs ● Scaling limitations ● Public and market resistance ● Tech, financial, regulatory, and risks ● Regulatory uncertainty ● Environmental needs ● Private water rights ● Gaps in reaching market and adoption ● Public and market resistance

Source: Jerusalem Institute for Policy Research

Using this SWOT analysis, the case study team identified and summarized the enablers from the strengths and opportunities, and the barriers from the weaknesses and threats. These enablers and barriers, both internal to the business model and external to the business (related to drivers and trends) are described in the Final Assessment below.

FIGURE 20 SWOT ANALYSIS LEADS TO THE ENABLERS AND BARRIERS



Source: R2Pi

Following is a summary of the discussion materials used with the stakeholders in individual and group meetings to highlight the enablers and barriers.

The enablers and barriers facing businesses in implementing circular business models vary by the perspective and role of the stakeholder. The team broke down these enablers and barriers by each stakeholder group, including the circular business, customers, suppliers, and partners, the EU, and local communities. In addition, the team identified break through, key lessons learned and key recommendations for making the transition to circular business models:

	Enablers:	Barriers:
Core businesses	● Public ownership of water and central management and pricing ● Legislative mandate for water measurement ● Innovative ecosystem: driven by collaboration between research, business, policy leadership (government)	● High cost of externalities, including energy use, environmental quality, and ecosystem services. ● Pricing model limits market-based innovations ● Regulatory restrictions on the uses of recycled water
Customers, partners and suppliers	● Effective public campaigns to get customers to save water ● Price gap between the National water supplier and the regional (sub-suppliers) creates a permanent pressure for innovation. ● Public ownership and control of water; this leads to central authority and comprehensive, integrated pricing amortizing costs across all parts of the value chain	● Too many small water companies (which doesn't permit economies of scale) ● High Infrastructure costs for water conservation ● High Energy costs for treating and desalinating water
Regional level	● Public requirement to Integrate water reuse in water planning and management.[14] ● Public requirement for water reuse in irrigation and aquifer recharge.[15]	● Diverging national and local adherence to the EU-based Water Framework Directive, which prevents regional stability. ● Insufficient monitoring of water system so that pressures to this system are better understood. ● Landowners free access to water encompassed by land. (Such access prevents centralized monitoring / management of water resources).
Local level	● Public laws required that all utilities install meters to measure the amount of water provided to each home or business. [16] ● Public law to control and restrict the activities of individual water users to further and protect the public interest". All water resources became public property subject to control of the State.[17]	● Financial and operating limitations at small scale ● Legacy system needs to be upgraded and financial plans must allow for these upgrades ● Consumer education must demand circular, efficient systems
Industry Contextual Factors	● Increased water stress due to human induced climate change ● Technological advances that improve conservation, monitoring, and management of water resources ● Demographic growth (and density issues). [In Israeli this is a major issue but may be less so in the EU].	

3.4.5 Final assessments

The case study team summarized the following breakthroughs and recommendations from each stakeholder group described in the SWOT analysis. This summary includes key business practices and policy guidelines.

Core businesses - breakthroughs

- Transparency in public reporting and engagement; public acceptance of regulation
- Entrepreneurial and creative systems financing in the integration and bundling of multiple solutions, including integration of cross-sector IT solutions
- Integrated system pricing to cross subsidize links in the value chain allowing for financial stability and feasibility.[18]
- Use capital structure to shift risk to private sector; use systems financing to pay for services and reward for performance
- Integrate pricing among multiple nodes in the value chain to ensure financial competitiveness of recycling
- Invest in continuous innovation and beta testing in major water facilities as proof of concept

Customers, partners and suppliers - breakthroughs

- Using water companies as "beta-testing" facilities for integrating new technology into water system
- Leverage pivotal roles of key industries (e.g. agriculture) to drive innovations in the mark
- Entrepreneurial and creative systems financing in the integration and bundling of multiple solutions, including integration of cross-sector IT solution19
- Bundle solutions to create financeable scale and service revenue models
- Leverage cross sector linkages (energy, agriculture, and water)

Regional level recommendations

- Improved regional monitoring of water resources across EU member states
- Create financial incentives to reduce the number of National-level water companies to create regional stability
- Create system financing facilities (systems are composed on multiple projects and the financing for multiple projects can be based on whole systems rather than individual projects – this has the advantage of spreading financing costs over a larger base and allowing for cross-subsidies among projects in a complete value chain)
- Design regulation to facilitate market-driven change

Local level recommendations

- Water price as set by National Authorities should reflect externalities
- System financing at the local level should incentivize regional solutions
- Financing should provide for incentive bundled, integrated solutions

Industry drivers

- Increased water stress due to human induced climate change
- Technological advances that improve conservation, monitoring, and management of water resources
- Demographic growth (and density issues).

4 Discussion and Conclusions

Within a decade, global water scarcity may spread to regions holding 60 percent of the world's people. Nearly one-third of the world's 37 largest aquifers are being drained faster than they are being replenished, meaning "groundwater recharge is negative" in eleven of the aquifers. In the final workshop among stakeholders, the team and stakeholders discussed the findings and analysis and discussed the following lessons learned from the circular business models found in the Israeli water system and possible ways to translate those lessons to the others, including the European Union:

- Public responsibility – Water is a public good, which, in Israel, is legally owned by the public. The public sector has the responsibility to ensure that people, including residents and industry, have a safe and sustainable supply of water. As described elsewhere, with the early adoption of national conveyance systems in the 1950 (the Israeli water carrier) through the introduction of new technologies and organization of management and delivery system, the public sector has taken responsibility. However, an equally important point is that the public is also responsible. The ethos of saving water, the preciousness of water resources, and the personal responsibility of each citizen has been a consistent theme in the history of Israel.
- Graduated pricing/shock pricing to change behaviour – The cost of water should reflect the value of water, considering the infrastructure to deliver clean water to consumers, but also considering the ecological system that supports such clean water. The "real" cost of water will shock the public into dramatic changes in consumption and use behaviour as was seen in the measures taken beginning in 2008 that led to "water independence" in 2013.
- Mobilize private sector for rapid deployment of new technologies – Israel has allowed the private sector to innovate through public private partnerships (PPPs) in its infrastructure. Funding support for basic and applied research and financing for the introduction of new technologies across industries (e.g. cybersecurity to leak detection, information technology to smart metering, etc.). Importantly, these public and private investors recognized the importance of direct and indirect financial and public returns on investment.
- Operating facilities as "Laboratories" for managed innovation – Coming up with good solutions to pressing problems is good. Continuous innovation that consistently improves performance and outcomes is better. Israel, through the combination of its well-documented entrepreneurial culture and existential demands, has instituted innovations in key sectors, including defence, energy, agriculture, and water. Public water companies act as beta testing sites for new innovations in water tech.
- Accept and manage risk – New installations carry a variety of risks, including development, financial, political, and technological risks. Each of these categories of risk are recognized and addressed through a variety of mitigation measures, including regulatory reforms, pricing, alignment of stakeholder interests, and performance guarantees by those with the most to gain (and lose). Israel has managed to build a system that addresses each of these risks to the satisfaction of its stakeholders, including the Government, industry, and consumers. For stakeholders, including financial and public sectors, the approach and ability to manage and mitigate risk is most important.
- Integrate IT into infrastructure – Israel has leveraged its world-class achievements in information technologies into water infrastructure, using the Internet of Things model.

> Examples of this are found in the use of Internet connectivity to identify leaks and manage repairs in real time; smart metering that connects real time water usage metering to the home owner or company management; precision irrigation management that customizes the delivery of water and nutrients to each plant according to the conditions and lifecycle of those plants; and information security systems that protect valuable and mission-critical municipal infrastructures against hacking. Many of these IT innovations came from Israel's defence and communications industries and have been adapted and implemented in scalable-installations in Israel and elsewhere.

The Israeli water system has key characteristics of three Circular Economy Business Models (CEBM) as developed in this project. These patterns are used to highlight the ways in which the water system stakeholders interact to create opportunities for circularity, leveraging their technology, market, ownership for sustainable revenues. The Israeli water system highlights how the circular economy business models can be used to move other water systems towards circularity and how other sectors involving precious resources, such as water, can be structured to enhance their own circularity.

Successful translation will involve adoption of circular business models that enable revolutionary technologies, institutional and legislative reforms, and market-based financial and economic mechanisms.

End notes

[1] Israel supplies approximately 10 percent of its electricity production to the collection, conveyance, storage, desalination, and treatment of water (Ministry f Energy, 2013). In comparison, energy use for the same activities in California consume approximately 20% of electricity production (California Energy Commission, 2008)

[2] For this reason water reuse also encompasses significant potential in terms of the creation of green jobs in the water-related industry, and it is estimated that a 1% increase in the rate of growth of the water industry in Europe could create up to 20,000 new jobs. http://ec.europa.eu/environment/water/reuse.htm

[3] See Ofek, Elie, and Matthew Preble. "TaKaDu." Harvard Business School Case 514-011, July 2013. (Revised August 2014.)

[4] This performance-based approach to integrating multiple technologies to lower consumption, lower cost, and increase system productivity is being tested and deployed in California in both municipal systems and farm water systems, where the water rights are privately owned and market-based (similar to the EU systems).

[5] Environmental groups, such as the *Israel Union for Environmental Defence,* have proposed to limit the number and volume of desalination plants, arguing that the large-scale operations disturb fragile coastal ecosystems, increase the use of energy use in the processing and treatment, return high concentrations of minerals and salts into the sea, and may reduce pressure on other conservation measures. Further, the use of desalination plants may be limited in its applicability to landlocked locations or locations with limited access to sea coasts.

[6] http://ec.europa.eu/environment/water/reuse.htm

[7] In 2008, at the height of the drought, Israel increased the tariff on water to retail customers by 30 percent, shocking the market to conserve water.

[8] Based on 2017 prices at NIS 3.5 per dollar and .81 Euro per dollar.

[9] Vanham, D. & Bidoglio, G. (2013). A review on the indicator water footprint for the EU28. Ecological Indicators. 26: 61-75. DOI: 10.1016/j.ecolind.2012.1 0.021. Agricultural products use the majority of water across both measures of water footprint; 89% of the consumption water footprint. http://ec.europa.eu/environment/integration/research/newsalert/pdf/317na6_en.pdf

[10] On average, each EU citizen consumes 4,815 litres of water per day, when the water used to produce all goods and services, including those imported into the EU, is accounted for. http://ec.europa.eu/environment/integration/research/newsalert/pdf/317na6_en.pdf

[11] Both southern Member States such as Spain, Italy, Greece, Malta and Cyprus and northern Member States like Belgium, Germany and the UK already have in place numerous initiatives regarding water reuse for irrigation, industrial uses and aquifer recharge. Cyprus and Malta already reuse more than 90% and 60% of their wastewater respectively, while Greece, Italy and Spain reuse between 5 and 12% of their effluents. http://ec.europa.eu/environment/water/reuse.htm

[12] A key factor driving the market adoption of smart water meters is non-revenue water, which accounts for an average of 20% across European utilities. https://www.metering.com/news/non-revenue-smart-water-meter/

[13] Another barrier at this stage of the cycle is the undervaluation of ecosystem services and their resulting deterioration. This means that the natural terrains, streams, and flora, all of which provide nature's infrastructure for the provisioning of water sources, are not given a representative economic value. Our research shows that when these watersheds work, they are taken for granted. When they don't, it is time to assign an economic value and begin to pay for these services to ensure their sustainability and protection of this valuable natural capital infrastructure. These hidden benefits from natural water sources result in the under valuation of water resources in the entire water value chain, and a "cost" of water far below its real economic value. Our research pointed out the variability of water prices by country and that the price is reflective of its value, not the cost. For example, the cost of water isn't necessarily where it is most expensive to deliver, but rather where it is valued most highly. Importantly, this results in the inability to monetize, leverage, and protect these natural capital resources which make human life possible.

[14] In June 2016, guidelines were issued under the Common Implementation Strategy for the Water Framework Directive with the aim to better integrate water reuse in water planning and management.

[15] On 7 April 2016, the Commission published an Inception Impact Assessment for the upcoming initiative on minimum quality requirements for water reuse in irrigation and aquifer recharge. EU funding for water reuse infrastructure is already available under the European Regional Development Fund (ERDF), the Cohesion Fund (CF) and the European Agricultural Fund for Rural Development (EARDF)

[16] Water Measurement Law (1955, 5715-1955, Section 2(a)): Prohibits any distribution of water unless that supply was done via a meter. This law also required that all utilities install meters to measure the amount of water provided to each home or business.

[17] Water Law (1959, 5719-1959, Section 1): The legislation vested in the government "widespread power to control and restrict the activities of individual water users in order to further and protect the public interest". All water resources became public property subject to control of the State. Land ownership would confer no rights to water resources on, under, or adjacent to the owner's land (Ibid., Section 4). Henceforth, individual or private use would only be permitted if in accordance with the law (Ibid., Section 3). The Water Law even stated an expectation that all citizens would use the water they receive "efficiently and sparingly" (Ibid., Section 9(1)).

[18] We analysed the water sector in terms of the water value chain – meaning the steps from collection from natural sources, processing through desalination, distribution to users, collection from users, treatment and cleaning, and reuse. There are various costs associated with each of these links in the value chain and because some of these links have different costs and revenues in different geographies (mountains, coastal areas, and deserts), among different users (residents, factories, and farms), the costs of some of these links would make parts of the value chain uncompetitive. Therefore, the pricing for water is the integrated system price across all links. This is particularly important for desalination which is expensive and for recycling with extra costs. In both instances, these costs are spread across the total cost for water to users.

[19] One of the key enablers in the Israeli water system is the deployment of creative, entrepreneurial solutions to solve existing and new problems, as they arise or are identified. With expertise in a variety of technologies, especially IT, Israeli entrepreneurs have applied information technology, big data, and artificial intelligence solutions used in cyber security, business intelligence, etc. in predicting, identifying, and plugging leaks in water grids. By using this expertise in one sector and translating it to the water sector, Israeli entrepreneurs have created sustainable business models (with service and performance-based revenues).

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