SMART WATER FOR ARAD (IL)

Smart solutions for a semi-centralized approach in the management of water-food-energy nexus for resource-efficient communities

Introduction

About Arad

Arad has the second largest municipal area in Israel. Located in the Northern Negev desert, the city is home to 31.500 hab. living on 105 square km. Climate change reduced the average rain precipitation from 77 to 42 mm yearly coming in a period December-March and increased average temperature by almost one degree Celsius. For eight months Arad has no natural precipitation. To avoid desertification, the city must irrigate public and private gardens. Despite all the constrains, the city does not apply any smart solution for water shortage and irrigate with tap water at extremely high price and insufficient capacity.
In the energy sector, the city must supply around 183 million kWh per year and it does so by distributing a centralized electricity from the grid produced by Israeli Electric Company. More than 94% of the grid electricity is produced using fossil fuels so the city does not apply any smart managerial solution to diversify the energy supply and to promote a shift towards renewable energy sources.
Demographically-wised, the current governmental-driven practice towards a decentralization of Israeli population brings many new habitants to Negev settlements. Arad is expected to extend its population towards 35,000 habitants in 2030 and to more than 50,000 habitants by 2040. More than 50% of Israeli land is covered by the desert. Sustainability in the desert area with an increased pressure on water resources, biodiversity, and energy is a key for a future development of Arad and the entire area.

Challenges

With desert covering a large part of its surrounding surface, Arad has had to quickly develop solutions for its **lack of arable land** and **potable water**. Factors that cause desertification include urbanization, climate change, overuse of groundwater and practices in agriculture that make soils more vulnerable to wind. In the water and the energy sector two central and interlinked challenges currently are facing Arad as a model city for a modern-style living under desert conditions.

01 : Water

- To pump the effluents back to the city without intensive use of grid electricity.
- Estimation of the amount of effluent needed per a period of time

02: Energy

- Transition towards an affordable decentralized energy solution based on the renewable energy sources

03: Social acceptance and stakeholder involvement

Challenges: Water sector

In the water sector, the adequacy of freshwater resources becomes a critical challenge for a sustainable and growing society. To release tensions and to balance water demand with water availability, the city must enforce a shift towards an irrigation with treated effluents from municipal wastewater treatment plant. The plant is located 4 km to the North-West from city borders in a height gap of almost 200 m. The wastewater is transferred to the plant by gravitation and treated by a sequencing batch reactor SBR to 10/10/5/5 BOD/TSS/P/N level as required by Israeli legislation for secondary effluent standards for unrestricted irrigation. The challenge is to pump the effluents back to the city without intensive use of grid electricity, preferably by applying smart solutions and renewable energy. An alternative solution is a net of decentralized autonomic treatment units fed from a central wastewater discharge line and powered by a renewable energy source such as solar. An additional challenge is to estimate the amount of effluent needed per a period of time. Variations can be quite high depending on the season, temperature, seeded crop, intended land use, initial soil condition. To implement harmonized actions and to construct an integrated infrastructure for a user driven and future proofed water management network, Arad strives for the implementation of a resilient semi-centralized irrigation scheme based on rain water and treated effluents using the tap water only as an ultimate supplement. The challenge is to supply a sufficient amount of water for irrigation at low cost using sustainable solutions, renewable energy sources, and resilient stakeholder-engaging managerial schemes.

·Before a next generation water infrastructure can be operated, it is essential to **demonstrate in real life a future-proofed concept** in terms of operation of diverting available sources and quality of water. A user driven water management system requires joint operations with reliable data exchange between partners.

·Success stories to **engage stakeholders** is highlighted as a critical parameter to support smart water management. Although promising conceptual and technological solutions for water systems are available, further work is required to bring them together in an overarching local water management for Arad.

Challenges: Energy sector

In the energy sector, sustainability must drive Arad away from a centralized electricity supply based on fossil fuels towards a diversified scheme based on solar energy disconnected from a central grid. The potential of solar energy to diversify energy sources and mitigate energy shortages has been discussed in numerous reports and scientific papers. In general, converting only 0.1% of solar energy that reaches the Earth at 10% efficiency would cover the world's needs (3000 GW). More specifically, 320 sunny days, or 2600-3500 sunshine hours per year, would be sufficient to cover Arad entire electricity needs. The whole region is ranked amongst the world's top locations for the construction of solar systems. Driven by the rapid cost decrease (almost 80% over the last five years) and technological advancement of photovoltaic PV systems, the transition to solar energy has become increasingly attractive. Still, in 2020 only 6% of Israeli electricity was produced from renewable sources. That number is surprising given that Israel is a well-known innovator in solar energy and 90% of Israeli homes use solar water heaters developed in the 1950s. To foster a transition toward renewable energy sources, Arad must implement smart managerial solutions, based on digital trading marketplace solutions and engaged stakeholders aiming at increase household income in direct trades. Already existing examples include a Slovakian start-up Fuergy that allows households with solar panels to sell the excess energy they produce to their peers based on a signed contract, a sort of “Airbnb of energy”, and Enel X (owned by the Italian Enel Group) and SunContract that offers a one-time peer-to-peer energy trade, a sort of “the Uber of energy”. A city-driven solution might be an installation of solar panels connected to a secure battery storage unit, called “a basestation”, like in Rwandan start-up MeshPower. The unit is linked, through cables, to power units installed in local houses, giving local people access to electricity. The challenge is to foster a transition towards an affordable decentralized energy solution based on the renewable energy sources.

·Small and large-scale pilot based on development, adjustment, and implementation of digital trading platforms for peer-to-peer trades of excess renewable energy produced by companies or households.

·Release of energy tension through a dissemination of the concept in territories with energy shortage including Jordan, Egypt, Lebanon, Palestinian Authority.

Objectives

Smart water management for Arad leverages on the possibilities of semi-centralized water treatment and a joint operation process. It includes irrigation with e.g. effluent of treated wastewater and optimization of demand/availability (keeping in mind there is a significant elevation between the WWTP and the city that today makes pumping effluents back economically unattractive).

The objective is to secure Arad's water resources by efficiency in a joint operation process embedded in a wide acceptance and market uptake.

The project wants to strengthen the capacities of the water utilities and improve the interest of investors in smart water management built on novel technologies and an innovative business approach. The uptake of digital enabled devices and services allows the integration of multiple waters in a pro-active, resource sustainable and efficient management - and provides operational robustness of scalable water systems.

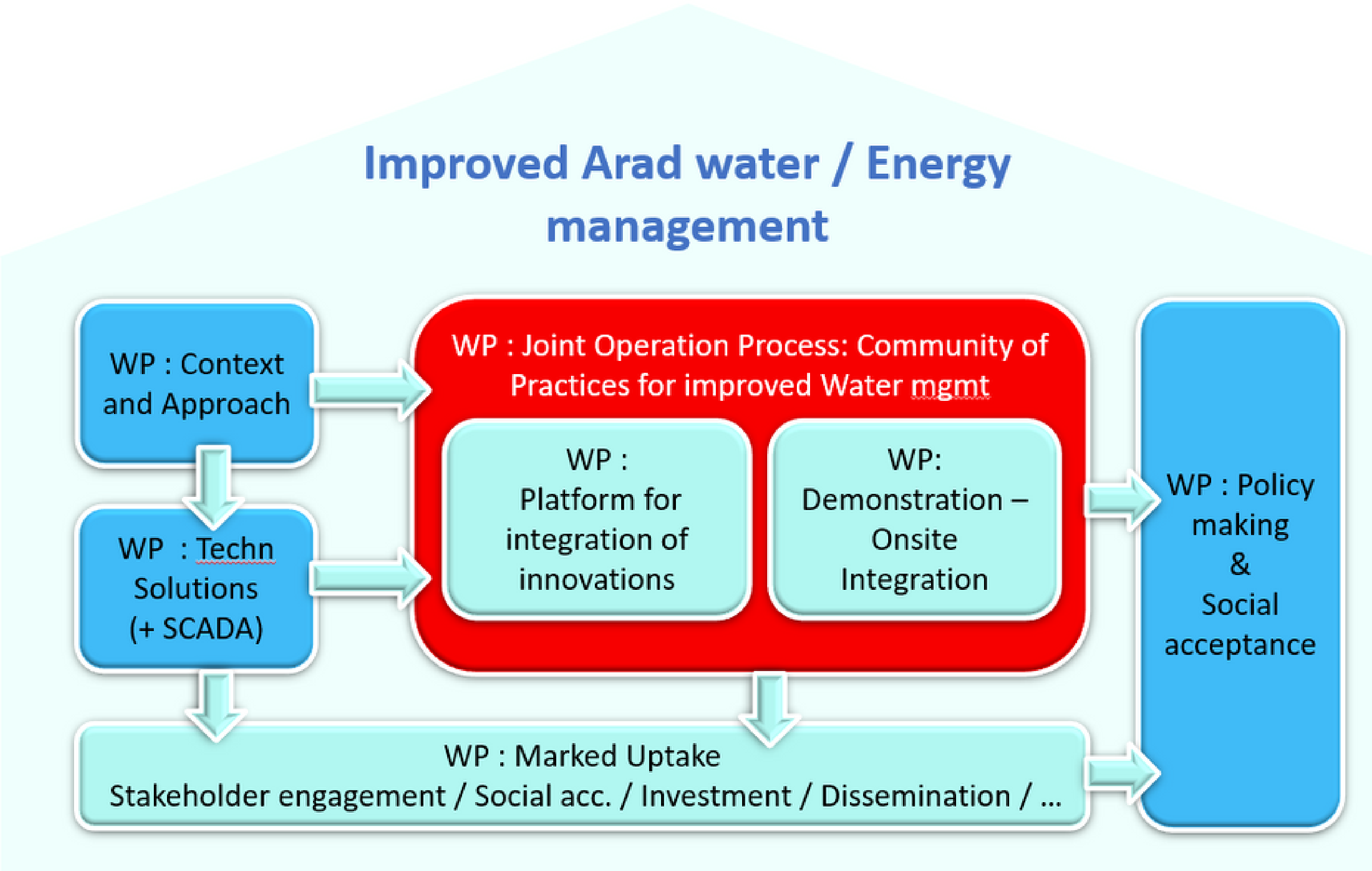
Objective 1: Joint operation process - cooperation

O1.1 Semi-centralized water treatment
O1.2 Forecasting water demand / availability
O1.3 Optimize asset management
O1.4 SCADA
O1.5 Infrastructure and technology fine-tuning
O16 Renewable Energy optimization for the water management

Objective 2: Market uptake (and engagement) of smart water solutions

O2.1 Implementation of the operation process for decentral water mgmt. and irrigation within new business models
O2.2 Exploitation, legal and financial opportunities
O2.3 Social acceptance (and participation) fostering a water-efficient culture

Project Lay-out



Specific technologies to be explored in the project threats

Key enabling technology

In theory, photocatalysis is a good sustainable solution with many practical applications including water and wastewater treatment. The in-situ generated non-selective oxidants such as hydroxyl radical ·OH, superoxide ·O2-, and hydroperoxyl radical HO2·, should oxidize most organic compounds including emerging micropollutants MPs until they are fully mineralized as carbon dioxide and water. In practice, for decades photocatalysis is unable to jump from a lab to the industry. A thorough analysis points on lack of basic understanding of mechanisms of secondary reactive radicals' formation and reaction self-limitation due to recombination. Attempts to mechanically upscale a lab setup produced a widespread of photocatalytic membrane reactors PMRs including ceramic-based cPMRs but did not produce a breakthrough PMR performance.

Introduction of air micronanobubbles MNBs has a potential to minimize organic fouling in PMRs and simultaneously improve the oxidation of emerging MPs. MNB is an abbreviation given to an entire range of micro and nano bubbles in the sizes below 100 mm united on a base of a large total surface area, low rising velocity, extended residence time, and high gas-liquid transfer rate. Preliminary studies showed that the removal of methyl orange in a photocatalytic reactor that contains P25 TiO2 photocatalyst excited by UV-A lamps increased from 58.2 ± 3.5% (N2 aeration) to 71.9 ± 0.6% (O2 aeration).

The key enabling technology in the proposed research is a combination of cPMR with MNBs. Membrane filtration and AOP are often viewed as competitive technologies for MP retention, mainly because polymer membranes are prone to radical degradation. Ceramic membranes, however, behave differently due to the difference in chemical makeup. The proposed research is based on the original idea to use a two-stage approach. In the first stage, an upper separation layer removes up to 95% of the organic matter from secondary effluents (e.g. humic and fulvic acids). Subsequently, those low-molecular weight MPs that manage to squeeze through the membrane encounter a thin photocatalytic layer exposed to the sun. An expected synergetic effect of the combination is in a disintegration of emerging micropollutants in environmental-friendly, sustainable, energy-efficient, and chemical-less way. The idea is to build a net of semi-decentralized treatment units that can work in parallel with no or minimal energy and chemical supply and still provide effluents sufficient for unrestricted irrigation.

Levels of Water management	Required implementation / applications
1. Passive Digital output instruments (meters and sensors)- use of multiple water qualities (cascade)	Rain gauges, flow meters, water quality monitoring and other environmental data
2. Active To process information and remotely operate and optimize systems and processes.	Collect and transmit information in real time, Pump station optimization (E mgmt to reduce pumping costs), Water treatment plant, control Sewage treatment, plant control, Environmental controls, reservoirs, flows, etc., Asset mapping and asset management, Pressure management, Intermittent pumping
3. Smart / Pro-Active Smart applications and Semi-centralized water management Supervisory control and data acquisition (SCADA) systems	Acoustic devices for real-time leakage detection (camera for), asset management, Smart water meters for measuring consumption Pressure monitoring for leakage detection and pump optimization Big data from weather history and forestacts, To store, manage, report, manipulate, and analyze spatial information. Usually integrated with GIS and/or SCADA systems to manage the Arad water network, control pressure, monitor leakage, etc., Improved decision making and risk management, Customer data bases, Smart metering, billing and collections, Hydraulic design and optimization, Water resources and hydrological modelling for water security, Cloud-based data management and hosting options

Impact

- Optimized and transparent operational process control and monitoring

– smart meters, sensors and connectivity significantly improve tracking of all assets, providing real time visibility

- Real-time knowledge of water usage statistics and analytics for smarter and faster decisions
- Business models

Opportunities to quickly explore and experiment business models responding to Servitization, Customized allocation of water, Decentralized water production/treatment and Sustainable considerations.

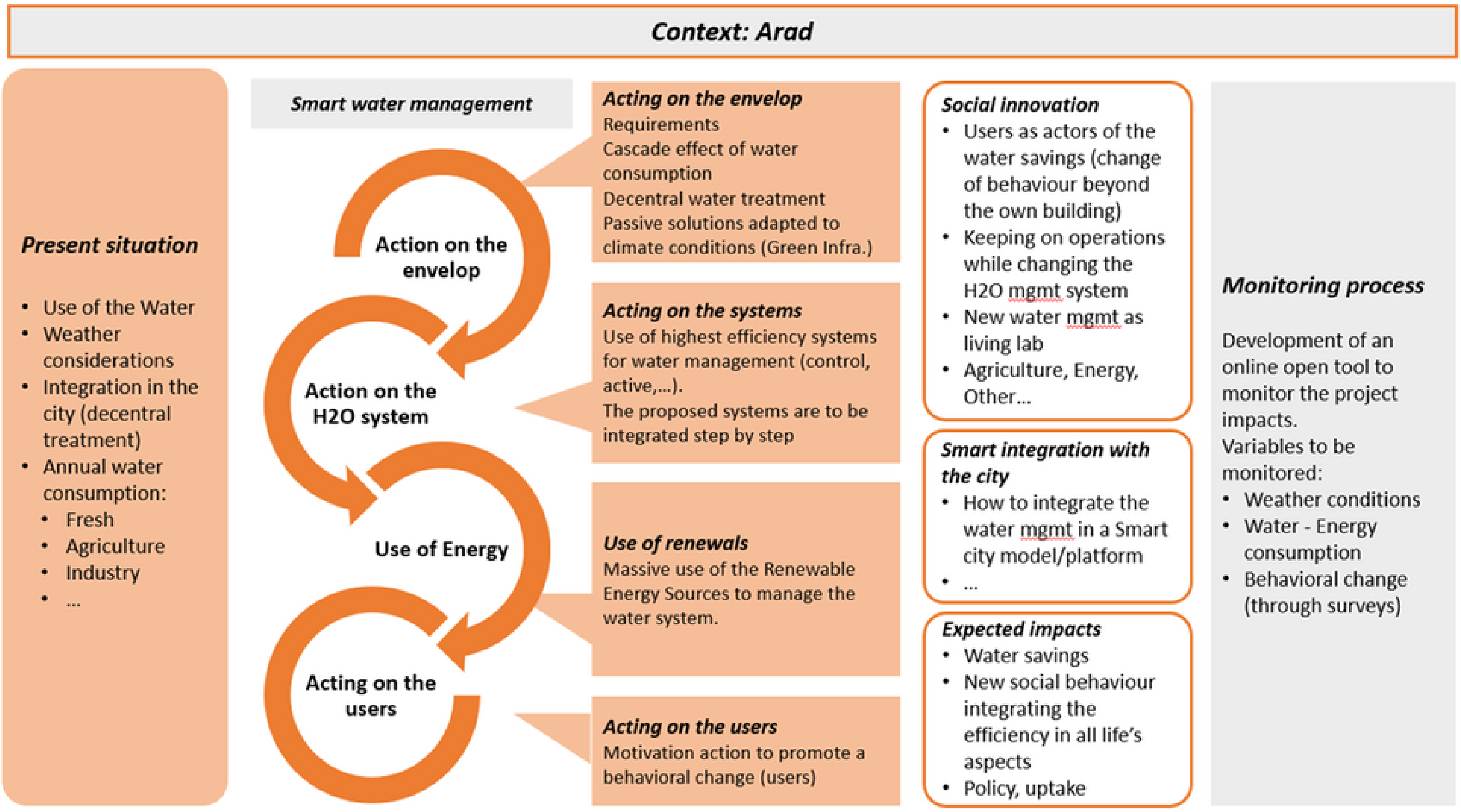
- Citizen participation (social acceptance) of a future approved water management system
- Extra revenues through cost savings

– water management costs can be significantly reduced by real time monitoring of all operations (including leaks, pressure sensors and IoT software analytics), consequently resulting in optimized asset utilization, improved operational processes, and energy costs savings, minimized human intervention, lower maintenance costs and lower infrastructure costs.

Potential consortium

The response to challenges in the water and energy sector demands forward leaning and integrated engagement from a cross section of stakeholders (policy and business priority).

- municipal governments,
- citizen groups
- private sector
- techn & applied sciences


Context: Arad
Present situation
• Use of the Water
• Weather considerations
• Integration in the city (decentral treatment)
• Annual water consumption:
• Fresh
• Agriculture
• Industry
• …
Smart water management
Action on the envelop
Action on the H2O system
Use of Energy
Acting on the users
Acting on the envelop
Requirements
Cascade effect of water consumption
Decentral water treatment
Passive solutions adapted to climate conditions (Green Infra.)
Acting on the systems
Use of highest efficiency systems for water management (control, active,…).
The proposed systems are to be integrated step by step
Use of renewals
Massive use of the Renewable Energy Sources to manage the water system.
Acting on the users
Motivation action to promote a behavioral change (users)
Social innovation
• Users as actors of the water savings (change of behaviour beyond the own building)
• Keeping on operations while changing the H2O mgmt system
• New water mgmt as living lab
• Agriculture, Energy, Other…
Smart integration with the city
• How to integrate the water mgmt in a Smart city model/platform
• …
Expected impacts
• Water savings
• New social behaviour integrating the efficiency in all life's aspects
• Policy, uptake
Monitoring process
Development of an online open tool to monitor the project impacts.
Variables to be monitored:
• Weather conditions
• Water - Energy consumption
• Behavioral change (through surveys)