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METHODS, TOOLS AND BEST PRACTICES TO INCREASE THE CAPACITY OF URBAN SYSTEMS TO ADAPT TO NATURAL AND MAN-MADE CHANGES

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THE WATER SENSITIVE FUTURE OF LAHIJAN.

PUBLIC SPACES AS INTEGRATED COMPONENTS OF STORMWATER MANAGEMENT INFRASTRUCTURE

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ABSTRACT

The emergence of the modern urban water system in Iran, albeit facilitated access to clean water and accelerated discharge of waste- and stormwater, it left some negative imprints on country's urban and natural environment. Among which larger stress on natural water cycles and pollution of water resources are of great importance. More importantly, such impacts are occurring when cities are going through a changing climate, and are facing higher risks of water shortages and flooded urban surfaces in warm and wet seasons, respectively. The present research is built upon a case study conducted in Lahijan, a small city in northern Iran. Bridging between traditional urban design principles and water management practices, the study aims to find ways to connect place making with urban water infrastructure design in order to reintegrate water into the design of public spaces to create visually pleasant, environmentally sustainable and yet resilient contemporary urban forms. The analysis of the water-state of the traditional city reveals that stormwater has been an integrated into the design of Lahijan's public spaces for centuries, and that the blue and green surfaces were the key components in constructing the porous landscape of Lahijan. As an endeavour to build new techniques upon the old traditions, the paper concludes that after a long period of absence of water in urban settings, water must be reintegrated in the design of public spaces. Accordingly, urban spaces of the future water sensitive Lahijan through various storage, conveyance, infiltration, and evaporation capacities shape the distributed on-site stormwater management infrastructure of the city which can adapt to the impacts of a changing environment while addressing the problems of water scarcity, floods, and pollution.

KEYWORDS:
Urban water infrastructure, Public space, Stormwater, Lahijan, Iran

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水敏型城市 LAHIJAN 的未来。

公共空间作为 LAHIJAN 雨水管理基础设施的综合组成部分

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摘要

虽然伊朗现代城市供水系统的兴起促进了清洁水的获取，同时加速了废水及雨水的排放，但还是给这个国家的城市和自然环境带来了负面影响。自然水循环面临的较大压力以及水资源污染是其中的两大问题。更重要的是，当城市面临气候变化，在温暖潮湿的季节面临更大的水资源不足以及洪水淹没城市地表的风险时，也会产生这些影响。目前正在针对伊朗北部的小城市 Lahijan 进行一项案例研究。为了缩小传统城市设计原则与水资源管理实践之间的差距，这项研究旨在设法将公共场所建设与城市供水基础设施设计相融合，从而将水资源利用重新纳入公共空间设计，从而打造出外观优美、环境可持续发展并且满足未来需求的当代城市形态。对传统城市供水状态的分析表明，数百年来，雨水排放和收集系统已融入到了 Lahijan 公共空间设计之中，对于多孔城市 Lahijan，打造蓝天白云、绿树成荫的环境是关键。为了打破旧传统，引进新技术，本文得出的结论是，对于长期缺水的城市环境，必须将水资源利用重新纳入公共空间设计之中。因此，未来的水敏型城市 Lahijan 要通过存储、输送、渗透、蒸发来重塑城市的雨水管理基础设施，以便应对不断变化的环境影响，同时解决水资源短缺、洪水和污染问题。

关键词：
城市供水基础设施； 公共空间； 多孔城市； 雨水； Lahijan；伊朗

1 INTRODUCTION

The emergence of the modern urban water system in Iran, albeit facilitated access to clean water and accelerated fast discharge of waste- and stormwater to the sewers, it left some negative imprints on Iran's urban and natural environment. Among which urban sprawl and horizontal expansion of cities, larger stress on country's natural water cycles, pollution of water resources and depletion of green spaces are of great importance. Such impacts are even more critical in a time when cities are experiencing more frequent extreme weather events including destructive floods and draughts of a changing climate. Consequently, many Iranian cities are facing higher levels of air temperature and risks of water shortage in warm seasons as well as increased risks of urban flooding and pollution of water bodies in wet seasons.

Studying the traditional knowledge and learning from locally practiced techniques can help us to pave the path in finding new ways to face the growing water challenges of the country and to move towards the sustainability of water resources. The strong connection of traditional methods to the regional geography and their adaptation to the local climate are the keys to durability of them. However, after the modernization process, many of such local methods lost their value and effectiveness, and gradually became forgotten. One may argue that traditional practices are not able to solve all water-related issues of the current time; however, combining the traditional knowledge and the recent technological capacities can offer a good mix of "old" and "new" practices and techniques to assist the communities to achieve the sustainable management of their water resources. In Mays' words, "Many present day water problems could be solved using the traditional methods developed and used for hundreds of years. … This has blinded many people of the forgotten sustainable ways of the ancients. So that in reality highly advanced methods are not required to solve many water problems, particularly in many of the poor and developing parts of the world." (2010, pp.217, 218) Such strategy might become even more fruitful in a country like Iran, where the rapid pace of urban expansion requires further development of urban water infrastructure; while some of the traditional techniques of water management are still in use and there is a tendency to preserve them.

The present research is built upon a case study conducted in Lahijan, a small Iranian city. Lahijan, situated in the Caspian coastal plain in the north of Iran, is one of the oldest cities of the country. With the area of 1013 hectares and population of some 94000 people, it is the third most populous urban settlement of the northern province of Guilan, and was the capital city of the province in the past. Employing desk research and fieldwork, the paper studies the past and the present status of the city and its urban water infrastructure development. Bridging between the urban design principles and traditional water management practices, the research aims to identify the sustainable urban water management techniques of the past, which were fitted into the local context while meeting the water demands of the communities. Following the principles of traditional water management techniques, the study seeks to connect place-making with urban water infrastructure planning in order to reintroduce water into design of public spaces, and turn them into an integrated component of stormwater management infrastructure. Such integration would be the key factor to create visually pleasant, environmentally sustainable and yet resilient contemporary urban forms.

In recent urban planning and design literature there is a convergence of research and case applications addressing sustainable water management systems through place-making projects (Wong & Ashley, 2006; Heaney, 2007; Ahern, 2007; Novotny, 2009; Wong & Brown, 2009; Sipes 2010; Novotny *et al.*, 2010; Hoyer *et al.*, 2011). In contrast to the conventional fragmented system, under an "Integrated" water management system, the urban water infrastructure design has a strong bond with urban design and place-making processes of cities. Integrated water management techniques are known under different names in various parts of the world: Low Impact Development (LID) and Green Infrastructure (GI) in the USA, Sustainable Urban Drainage Systems (SUDS) in the UK, Best Management Practices (BMPs) in Europe, and Water Sensitive

Urban Design (WSUD) in Australia. All of such techniques, however, aim to minimize the hydrological impacts of urban development specifically targeting stormwater.

Contrary to the current stormwater management practices, which are concentrated on reducing peak flow rates to prevent flooding, through mimicking natural hydrologic processes, various integrated water management techniques create functional green spaces to control and manage stormwater as close to the source as possible. Low-impact development (LID) techniques aim to maintain, repair or replicate the predevelopment hydrological functions of urban areas (including storage, infiltration, and groundwater recharge) to control runoff and the transport of pollutants. "In a retreat from decades of large, centralized hard-pipe solutions that treat stormwater as a burden and ship it off-site as quickly as possible, LID is a paradigm shift that keeps stormwater on-site for longer periods and manages it as a valuable resource." (Sarte, 2010, p.104)

Similar to LID, Sustainable urban Drainage Systems (SuDS) seek to shift the paradigm towards surface water and introduce it as a valuable resource. "SuDS aims to slow down and reduce the quantity of surface water runoff from a developed area to manage downstream flood risk, and reducing the risk of pollution; through harvesting, infiltrating, slowing, storing, conveying and treating runoff on site and, where possible, on the surface rather than underground. Water then becomes a much more visible and tangible part of the built environment to be enjoyed by everyone." (Woods Ballard *et al.*, p.19) Accordingly, the SuDS Design Philosophy aims to deliver such multiple benefits, manage surface water runoff through mimicking natural hydrological processes, enhance biodiversity, beauty, and the natural aesthetic of buildings, places and landscapes, deliver resilience, and make developments more sustainable.

Green infrastructure design is yet another technique which employs "an interconnected network of natural areas and other open spaces to conserve natural ecosystem values and functions, to sustain clean air and water, and to provide a wide array of benefits to people and wildlife (Benedict and McMahon 2006). Ahern (2007, p. 267) defines green infrastructure as "spatially and functionally integrated systems and networks of protected landscapes supported with protected, artificial and hybrid infrastructures of built landscapes that provide multiple, complementary ecosystem and landscape functions to a broad public, in support of sustainability". In his definition, Ahern emphasizes the idea of infrastructure as a networked system that follows a multi-scale approach with recognition of pattern:process relationships and an emphasis on physical and functional connectivity. Among others, the concept of connectivity directly applies to water flow as the most important flow in any landscape, particularly in human-dominated and urban environments. Disruption of hydrologic connectivity is a major concern when planning for sustainability.

Comparable to the previous techniques, Wong and Ashley introduce Water Sensitive Urban Design (WSUD) as an interdisciplinary concept, which is based on the integration of the two key fields of 'Integrated urban water cycle planning and management' (IUWCM) and 'urban design'. They argue, "WSUD brings 'sensitivity to water' into urban design, as it aims to ensure that water is given due prominence within the urban design process through the integration of urban design with the various disciplines of engineering and environmental sciences associated with the provision of water services including the protection of aquatic environments in urban areas. Community values and aspirations of urban places necessarily govern urban design decisions and therefore water management practices (Wong & Ashley 2006). Wong &Brown characterize a Water Sensitive City by "three pillars, which must be seamlessly integrated into the urban environment". The three pillars of water sensitive cities indicate: (1) Cities as water supply catchments; (2) Cities providing ecosystem services; and (3) Cities Comprising Water Sensitive Communities (Wong & Brown 2009, p.676).

Hoyer *et al.* (2011) also highlight the multidisciplinarity of Water Sensitive Urban Design in which the objectives of the urban water management system is combined with the ones of a responsive urban design and a functioning urban landscape. Although WSUD embraces all different aspects of urban water management including water supply, sewage treatment, flood management, protection of water bodies such as rivers and creeks, and providing social amenities and improving the livability of the urban environment, stormwater management seems to be a key element.

Unlike the conventional approach in which stormwater is mainly considered a problem, under all various integrated water management techniques, stormwater is not only recognized as a resource but also a great asset to provide the amenity of the city. Echols highlights the failure of engineered stormwater facilities in considering its otherwise ecological, social or aesthetic qualities of the built infrastructure, he states, "sustainable stormwater management can be used to create places that serve both the demands of urban drainage and urban planning. From the urban drainage point of view, people want to have a system that is reliable, simple to construct and easy to maintain, while also considering its costs. Alongside, from the view of urban planning, sustainable stormwater systems should be beautiful, meaningful, and educational (Echols, 2000, p.1).

2 LAHIJAN'S DEVELOPMENT THROUGHOUT THE HISTORY

Similar to the majority of Iranian cities, Lahijan went through rapid urban expansion and population growth within the last decades. Despite its rapid expansion of the 20th century, the current urban form of Lahijan can be traced back in Safavid era*. Safavid city* (1502-1736) of Lahijan experienced a golden age when its agriculture- and commerce-based economy was flourishing. The region owes the richness of its flora and fauna, and the variety of its agricultural resources to its humid subtropical climate and the density of its hydrographic system. Rabino (1916, p.115) says, "Perhaps nowhere else in the world are there so many rivers, streams and torrents as in the Caspian provinces". As a result of a significant amount of precipitation, the region is gifted by innumerable watercourses, permanent streams or seasonal flows which are the primary sources of water to feed the lagoons or the ponds. Hence, the running waters of streams and watercourses and the still water of lagoons and ponds are significant components of Lahijan's traditional urban form. Apart from their original function as a source of water for various domestic and agricultural activities, such water structures were contributing to the quality of urban spaces in different ways. They were improving the aesthetic qualities and visual attractiveness of the urban environment and offering leisure and recreational spaces to people in warmer seasons. The residential neighborhoods, the polo field, which was built by the direct order of Shah Abbas the great, and the pond were the main components of Lahijan's urban landscape in Safavid dynasty. The three components were surrounded by cultivated lands in the north and the south; while the river and the hills were drawing the western and eastern edges of Lahijan, respectively (Figure 1).

Qajar city (1758-1925) of Lahijan witnessed the further development of city's residential districts. Lahijan found its seven oldest neighborhoods in this period. Each of which enjoys a specific character and socio-economic status. They, however, share the same physical and functional pattern in which the housing areas surround a functional center. The functional centers contain the public facilities of each neighborhood, and they are connected through key passages of the city to shape the main urban structure of Lahijan.

The diversity of available water resources in the region, which could offer the citizens alternative sources of water for domestic and agricultural purposes, is among the main driving forces of urban development during Qajar monarchs. Since the level of groundwater in the area is very high, digging wells and bringing groundwater up to the surface has always been a common habit of the residents to supply their domestic water demands. In Bromberger (1989, p.16) words, "such easy access to water gives exclusive and original features to the settlements in northern Iran: in central part of Iran activities such as fetching water, watering the livestock and doing the washing, mean daily visits to communal facilities of the neighborhood, village or the city; on the contrary, the easy access to source of water in private sphere of the household have turned drawing water and bathing into private affairs: the well is virtually a constant component of the house located in the courtyard."

In addition to the surface- and ground water resources, rainwater was yet another important source to fulfill the water demands of the community. Roof water collection and farm ponds were the main rainwater harvesting techniques which were used by people for a long time. Despite the fact that Guilan province has an annual average precipitation of about 1000 mm, it is not concurrent with cultivation season, and therefore, use of farm ponds sounds to be an intelligent technique to harvest the water in rainy seasons and use it later in the cultivation period (Madani, 2014). Since evaporation rate is never a concern in northern Iran, the uncovered open cisterns (locally called *Istakhr*) became the popular rainwater harvesting technique among the local communities. Historical investigations reveal that almost all the cities and villages in Guilan province had one or more ponds to meet their agricultural demand for water. Ghoddousi refers to farm ponds as "structures which are constructed by small earthen walls on Rat or hilly land to collect and store rainwater, surface runoff and flood flows" (1999, p.292). In Banihabib's words, "the rain and stormwater running from the upper or neighboring catchments is collected and directed into these small reservoirs." (1999, p.337)

Lahijan has probably seen its most significant changes in Pahlavi period. *Pahlavi city* (1925-1979) of Lahijan is characterized by the emergence of new streets and residential districts, as well as modern urban water infrastructure. The streets of Pahlavi city were not only functioning as physical connections to facilitate the mobility but also providing places of socializing and leisure activities. New residential districts are other components, which were added to the former structure of Lahijan in this period. The development of new residential areas along with modern transportation networks resulted in an increase in hard and impervious surfaces of the city. In the absence of an efficient drainage system, less porosity and perviousness of urban surfaces caused higher risks of flooding in Lahijan (Figure 2)**.**

H.L.Rabino, a British consul serving in Rasht, the capital city of Guilan province, visited Lahijan in 1906; he describes the city in his book, "Lahijan has seven neighborhoods, 2260 houses and a population of some 11000 people..." (Rabino 1916) Since then Lahijan has seen a significant population growth. Just in the last 55 years, the city's population grew almost fivefold and passed 94000 residents. To accommodate such rapidly growing population, the *Post-Revolution City* (1979-2016) has seen massive expansion (Figure 5). Many agricultural fields inside the city have been reclaimed to provide room for further densification projects and expanding transportation networks. Following the decreased surface of green spaces and cultivated lands inside the city and introduction of modern water infrastructure, Lahijan Pond lost its primary function as a source of water for agricultural purposes. Besides, the growing network of streets of the city cut the natural connections between the streams and seasonal flows and the pond. Covering the floor and walls of the pond by concrete was yet another step in the transformation of the pond. Neither a cistern to harvest the rainwater for future agricultural activities, nor a sponge to hold the excess urban runoff to avoid flooding, the natural pond was transformed into an artificial lake and lost its original character. Such changes, albeit facilitated the maintenance of such large body of water inside the city and ensured sanitary concerns, damaged its natural aquatic life. The artificial lake, however, has become a great recreational space with beautiful scenery inside the city, is one single entity disconnected from surrounding natural environment (Figure 3). Currently, the pond is not a source of water anymore- as it was in the past; rather it is a large artificial component in the city which receives its water from other underground water resources. Instead, to reduce the risk of urban flooding, the city started to further expand its drainage system to convey urban runoff as fast as possible out of the city.

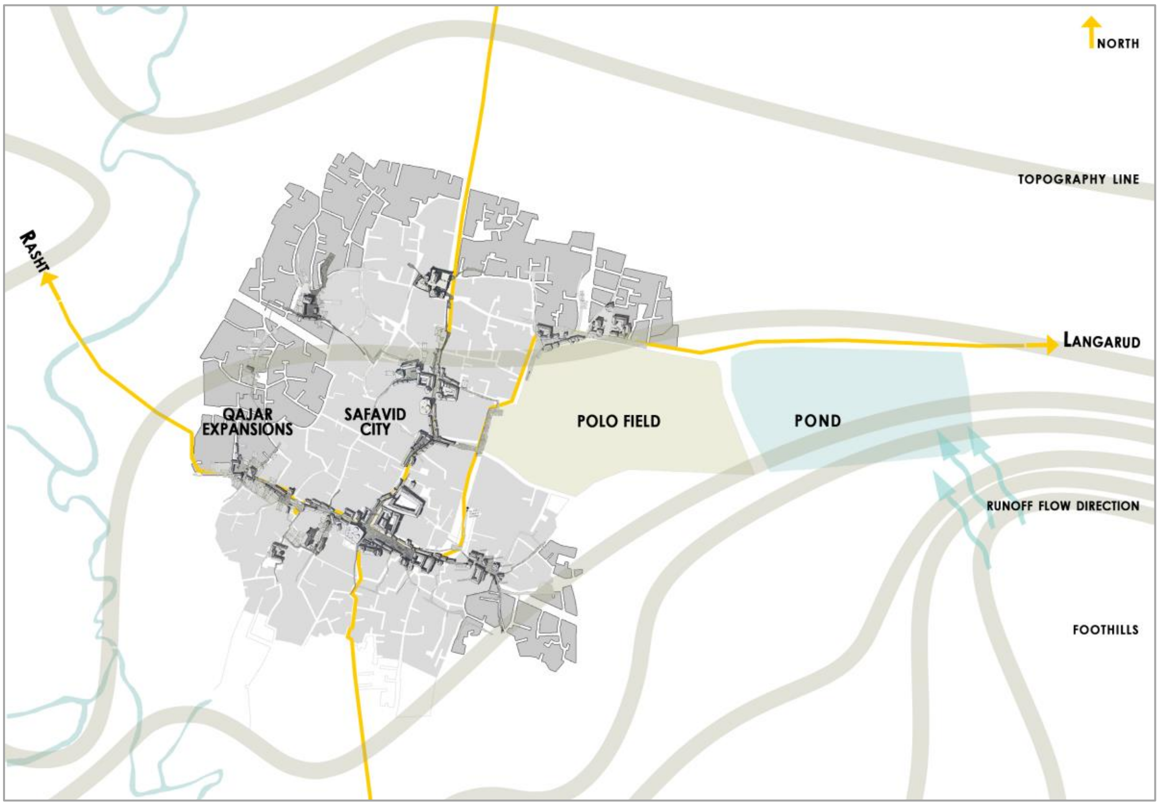

Fig. 1 The urban structure of Qajar city of Lahijan: residential neighbourhoods, the polo field, and the farm pond

Fig. 2 Pahlavi city; the expanding area of built up spaces and paved streets

Fig. 3 The natural pond in 1970s (left) and its transition to an artificial lake in 2000s (right)

3 ANALYSIS SUMMARY

3.1 CENTRALIZING A DE-CENTRALITY: STORMWATER NOT A SOURCE OF WATER ANYMORE

By the beginning of the 20th century, the city experienced a faster pace of urbanization. Due to the rapid growth of the population, which was followed by fast urban sprawl, the traditional techniques were not able to respond to the increasing demand of the community. The emergence of modern urban water systems in the second half of the twentieth century was yet another reason to accelerate the paradigm shift from a traditional distributed system to the centralized network of underground water pipes. Although the underground urban water networks provided easy access to clean water, and solved the sanitation and maintenance problems of the former infrastructure, it caused less popularity of traditional water management practices. One can mention the example of farm ponds in the region; While harvested rainwater by farm ponds was meeting the water demands of the agricultural activities for centuries, the emergence of modern irrigation systems and lack of proper maintenance caused gradual deterioration and later disappearance of many farm ponds in Guilan. Therefore, unlike traditional systems, which were relying on the locally available sources of water to respond the demands, the current urban water network employs available technologies to bring water from farther distances, and lack the climatic and geographical considerations of the previous system. In contrast with the network of decentralized local practices scattered all over the territory, the present urban water infrastructure is a central system of underground water pipes, which delivers water to each and every household. The new technology-oriented urban water infrastructure paid the slightest attention to the local environment where this new system is implemented. In other words, "this quick-and-fix approach to use of new technologies to solve complex development problems of developing economies dismisses the achievements of the past and underestimates and minimizes the many difficulties some of the new technologies have brought in their work." (Borri & Grassini, 2014, p.112)

The current water supply of Lahijan is partially afforded through 13 deep wellbores located in outskirts of the city as well as the treated water from Water Treatment Plant of Sangar Dam Lake, located some 89 kilometers away. Despite availability of urban water supply, many families still use their private wells as extra free of charge sources of water in case of urban water cut or shortage of water in warms seasons. Long distance water transfer from Sangar Water Treatment Plant as well as uncontrolled abstraction of groundwater from wells affects the hydrological cycles and local ecosystems. More importantly, this is happening in a time when the cities have less and less infiltration capacity to recharge the region's groundwater resources (Figure 4).

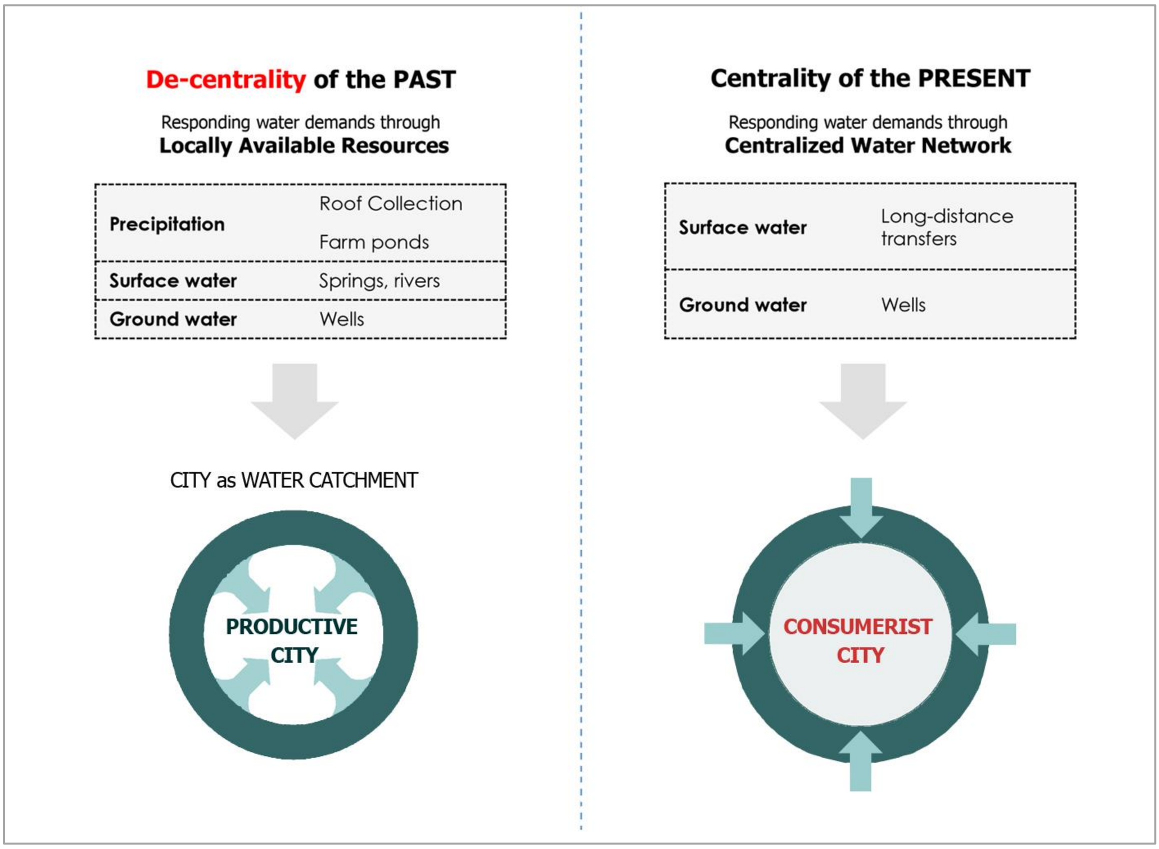

Fig. 4 Water resources in traditional and modern urban water supply system

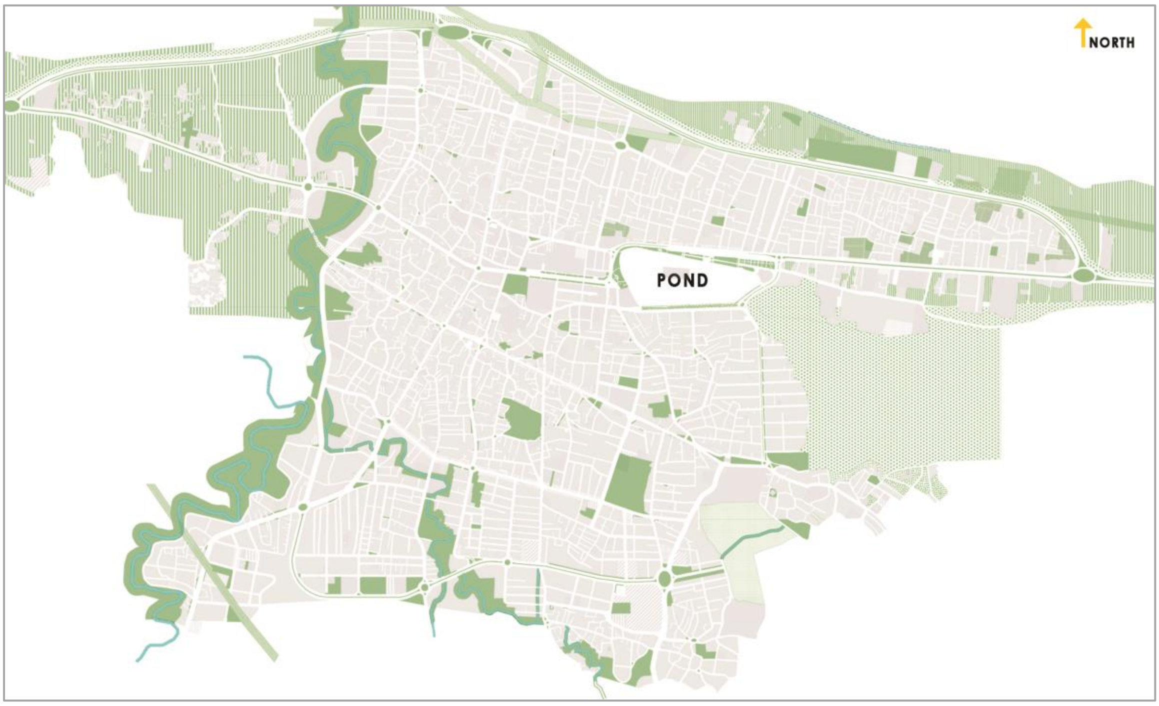

Fig. 5 Limited number of Green patches in contrast with the expansive impervious areas of post-revolution city represents the limited on-site stormwater management capacities

Fig. 6 Flooded urban streets of Lahijan, October 2013

3.2 MORE WASTEWATER DISCHARGE: STORMWATER EQUALS WASTEWATER

Lahijan enjoys an average amount of 1228 mm of rainfall and 136 rainy days per year. Hence, it has a considerable amount of stormwater to manage. In wet seasons, the city has to manage greater amount of stormwater than wastewater that the residents produce. Currently, the drainage system of the city is a mix of combined (185 km) and separated (61 km) sewers, and thus the larger amount of stormwater and urban runoff is mixed with waste and conveyed through one conduit. Furthermore, the existing wastewater treatment plant of the city does not have the capacity to treat all the loads of wastewater. The construction of Lahijan water treatment facility, which started in 1994, is not yet finished and is projected to be completely done by 2026. The ultimate capacity of the treatment facility will be about 36000 cubic meters per day, while currently, the treatment facility is capable of receiving and treating some 26000 cubic meters of wastewater per day. If the wastewater is not treated, the pollution is just conveyed elsewhere. Discharging effluent water without receiving any treatment impose several challenges to the city and its surrounding natural environment including pollution of nearby water and soil resources. Apart from the pollution of water and soil resources, the treatment facilities consume a lot of energy, and thus, contribute to higher carbon emission and air pollution. On one hand combining stormwater and wastewater in one conduit under the current urban water infrastructure eliminates the possibility of harvesting and treating rainwater and reintroducing it to the system as a new source of water. On the other hand, the traditional stormwater management techniques are not capable to manage all the loads of rain and runoff in the city. There is, however, a lesson to learn from such traditional practices to change the conventional approach towards stormwater as waste and recall the true capacities of rain and stormwater as valuable resources in the urban water management system of the city.

3.3. LIMITED POSSIBILITIES OF ON-SITE STORMWATER MANAGEMENT: STORMWATER NOT AN ASSET BUT A MENACE

As mentioned previously, Lahijan like the rest of Caspian plain enjoys much higher amount of annual precipitation than other parts of the country. Due to such availability, rainwater should be considered a great asset and source of water for the city. However, lack of proper stormwater management system has turned urban runoff and stormwater into one of the main challenges of the municipality, particularly in wet seasons. Despite lack of proper drainage network, the traditional city was offering various opportunities for distributed on-site stormwater management. Before the onset of rapid urban expansion and densification of Lahijan in Pahlavi and post-revolution period, the urban open spaces including green spaces of orchards and cultivated lands as well as courtyards and gardens of private properties were offering various storage, infiltration, and evaporation capacities to the city. Such capacities were significantly decreasing the risk of urban flooding in cases of intense precipitation. Among the trends, which strongly affected such nature-oriented mechanisms of stormwater management in recent century, is the growing use of automobiles in the cities. Dominance of automobiles in the last 50 years not only affected the urban form of Lahijan, but also negatively influenced air and water quality. Following the new car-dependent lifestyle, the urban form of Lahijan changed to create room for connecting roads and parking spaces. The results were increased imperviousness of city surfaces and lower infiltration capacities, and thus, increased surface runoff and more frequent flash floods (Figure 5). As a consequence of less on-site stormwater management possibilities inside the city, the main goal of stormwater management set to be fast conveyance of urban runoff and stormwater out of sight to the nearby water bodies. Employing the available technologies, the municipality began to develop a drainage network. Time and again, such fast conveyance system of stormwater is neither environmentally sustainable nor resilient to the extreme weather events. The channels have not only a limited capacity to contain all the loads of stormwater but also limited entering points to let the stormwater inflow to the channels. In events like heavy precipitation the entering points cannot manage the intensity of rain and the channels cannot receive the total amount of rainfall and thus, the stormwater will overflow on the streets and other public spaces of the city.

Frequency of flooded streets in recent years reveals that the current stormwater management infrastructure does not have enough capacity to manage the urban runoff and that the system is only functional under normal weather conditions. Furthermore, the urban open spaces of the city cannot assist the stormwater management process of the city in emergencies. The failure of the current infrastructure is even more critical in a time when all the cities around the globe are going to experience more frequent extreme weather events of a changing climate including destructive floods (Figure 6)

3.4 SWALLOWED GREENERY IN FAVOR OF A GRAY CITY

Over the centuries, Lahijan was known as a green city with rich and beautiful landscape. Due to the availability of fertile soil and rainfall, city's economy was mainly centered on agriculture, and vast areas of rice and tea cultivations were among the main components to shape the inner and outer landscape of the city. In recent decades, however, Lahijan is losing its original character as a green city; agricultural fields have been swallowed to provide space for new developments, and single-family houses are being replaced by multi-story buildings to accommodate the growing population. Urban forests are destroyed while a few urban parks and sport pitches are added. Consequently, the green character of Lahijan is weakened and a strong division between the natural and built environment is happened. Less greenery in the city means decreased area of permeable and soft surfaces and higher risks of erosion and flash floods due to the increasing area of impervious and hard surfaces. The figures from Municipality of Lahijan reveal that just in the last 40 years, some 250 hectares of cultivated fields and other green open spaces are replaced by various impervious surfaces including roads and streets, paved paths and rooftops.

In addition to lower degrees of perviousness and less on-site stormwater management capacities, the expanding dark and hard surfaces of Asphalt and concrete exacerbate the Urban Heat Islands effects inside the city. On the contrary, neighborhood parks and other large green spaces, which enjoy much cooler environment than other parts of the city in warm seasons, are becoming very rare. Based on the available data from Iran's national Meteorological Organization (1956-2014), both average minimum and maximum air temperature in Lahijan has increased, a trend which is expected to continue in the future. The higher levels of air temperature in warm seasons increase the energy demands to condition the indoor spaces, which cause further temperature rise in urban areas.

4 DISCUSSION: ENGAGING TRADITIONAL PRACTICES TO THE NEW URBAN WATER MANAGEMENT PARADIGM

In parallel with demographic shifts, Iranian culture is also changing, becoming more consumerist and wasteful and less environmentally friendly. Despite the fact that Iran has limited sources of water, it is exhaustively exploiting and extensively polluting them, imposing so much pressure on its natural water cycles. Due to the limited availability of fresh water and to move towards sustainability of such rare resources, there is a certain need to rethink of our available water and our consumption patterns.

Following the concept of the water sensitive city which emphasizes the unseen potential of cities as 'water supply catchments (Wong & Brown 2009), the future sustainable urban water management must provide access to a diversity of water sources through centralized and decentralized infrastructure. Such diversity reduces the stress on surface and underground water resources, and introduces new sources of water including rain and stormwater to the urban water systems. The revival of traditional water harvesting systems of the region can play an important role in proposing new strategies which benefit from traditional knowledge and solutions as well as advanced technologies of the current time. As explained earlier, distributed water systems and the practices of rainwater harvesting and building cisterns and storage tanks to collect and store the water are not alien concepts in Iran, and particularly in Guilan region. On the contrary, while such practices were common in the past, they are currently almost forgotten and not in use anymore. Recently, however, there is a growing awareness about the importance of stormwater as a valuable source of water and asset for the city. Rather than larger withdrawal and long distance transfer of fresh surface water or extraction of groundwater, stormwater can be stored, treated and reused for various potable and non-potable purposes. For example, stored rainwater can be used for toilet flush or fire sprinklers when treated. Moreover, rainfall and urban runoff are the main sources to recharge depleted groundwater aquifers. Reintroducing rainwater as an alternative source of water of the city decreases the stress on surface and ground water resource and thus, contributes to the sustainability of fresh water resources. Furthermore, collecting rainwater and reusing it for non-potable purposes, rather than mixing it with wastewater and discharging it to the sewers, reduces the loads of waste entering the wastewater management infrastructure and the pressure on Lahijan's water treatment facility.

The current stormwater management infrastructure of the city is a set of surface channels and underground conduits with limited capacity in conveyance of stormwater out of the city. In addition to inefficiency of the existing infrastructure, the current design of the urban spaces is not of any assistance. Among others, the rapidly expansion of hard surfaces is a very important factor to further uncover the weak performance of the current drainage system of Lahijan. An overview of the present status of the city reveals the limited number of green open spaces (soft surfaces) in Lahijan and their uneven distribution within the city. This makes some parts of the urban fabric very vulnerable, so that if the underground wastewater infrastructure fails to manage the urban runoff in case of heavy rains, the urban environment is not resilient enough to adapt to the situation to receive and manage the excessive water temporarily. Hence, the limited capacity of the current drainage of Lahijan along with low on-site stormwater management capacities of the urban spaces calls for a changing paradigm in design of public spaces including urban squares and streets to reduce the impacts of unpredictable weather events.

According to Novotny *et al.* (2010), "the conventional approach which is based on fast conveyance systems should change to storage-oriented, slow-release systems characterized by storage in ponds, on flat roofs, in underground cisterns, ponds, lakes, etc.; infiltration into shallow aquifers; soft treatment (rain garden, bio-filters, earth filters, wetlands, ponds); slow conveyance in grassed swales (rain gardens) and natural or nature mimicking surface channels. Fast conveyance has no social benefit except getting rid of water as quickly as possible." (p.186) The shift from strictly engineered systems of urban sewers to nature-oriented network of water sensitive urban spaces (Wong & Ashley, 2006) will not only reduce the environmental impact of the urban water system but also provide social amenities and contribute to the higher quality of urban environment and life of the communities.

Borrowed from Ahern's classification of landscape elements in designing the green infrastructure of cities (2007), Lahijan's urban surfaces must change to increase their various storage, infiltration, and evaporation capacities. Such capacities will improve the distributed onsite stormwater management possibilities in Lahijan and turn the city into a functioning urban landscape in which each and every component plays a role to sustain the system. Publicly owned green spaces and water bodies such as parks, sport fields, gardens, cemeteries, campuses, vacant lands, wetlands and lakes are examples of urban land use and surfaces that can shape the water sensitive patches of any given urban landscape. In addition to patches, water sensitive corridors would also play critical roles as the main connectors to form and define the backbone of a nature-oriented stormwater management infrastructure of the city. Long strips of publicly owned land within the city including canals, streams, drainage ways and green streets are examples of such corridors to shape the green network of urban landscape.

Rehabilitating and modifying Lahijan's pond and reintegrating it to the stormwater management infrastructure can be yet another step to build new concepts based on old traditions to achieve the sustainability of urban water management system. In other words, under the new water sensitive urban paradigm, instead of large distance transfers of stormwater, on-site and local harvesting and treatment will form a distributed urban water system, in which the pond plays a crucial role. Moreover, such surface stormwater management system provides recreational amenities to the community and contributes to the aesthetic qualities of the city.

In addition to increasing on-site stormwater management capacity of different urban spaces, creating a distributed yet well-connected network of such water sensitive surfaces within the city is important. Such a network of urban surfaces, however, is not a natural network, mimics the characteristics of a natural landscape. Thus, connectivity is considered as one of the most significant characteristics of a well-functioning landscape. The urban landscape of Lahijan today is suffering from low connectivity. The landscape elements are either disappeared and replaced by urban elements or fragmented and highly separated from each other. Despite the fact that the concept of connectivity is highly related to water flows and a fragmented hydrological system is not capable of well-functioning, water systems seem to be among the most affected ones; in which they are largely disconnected after the development of grey (civil) infrastructure of the city. The significance of connectivity is important in achieving the resiliency of the system, so that if part of the system fails to function, the rest of it goes on and prevents the collapse of the whole system (Figure 7).

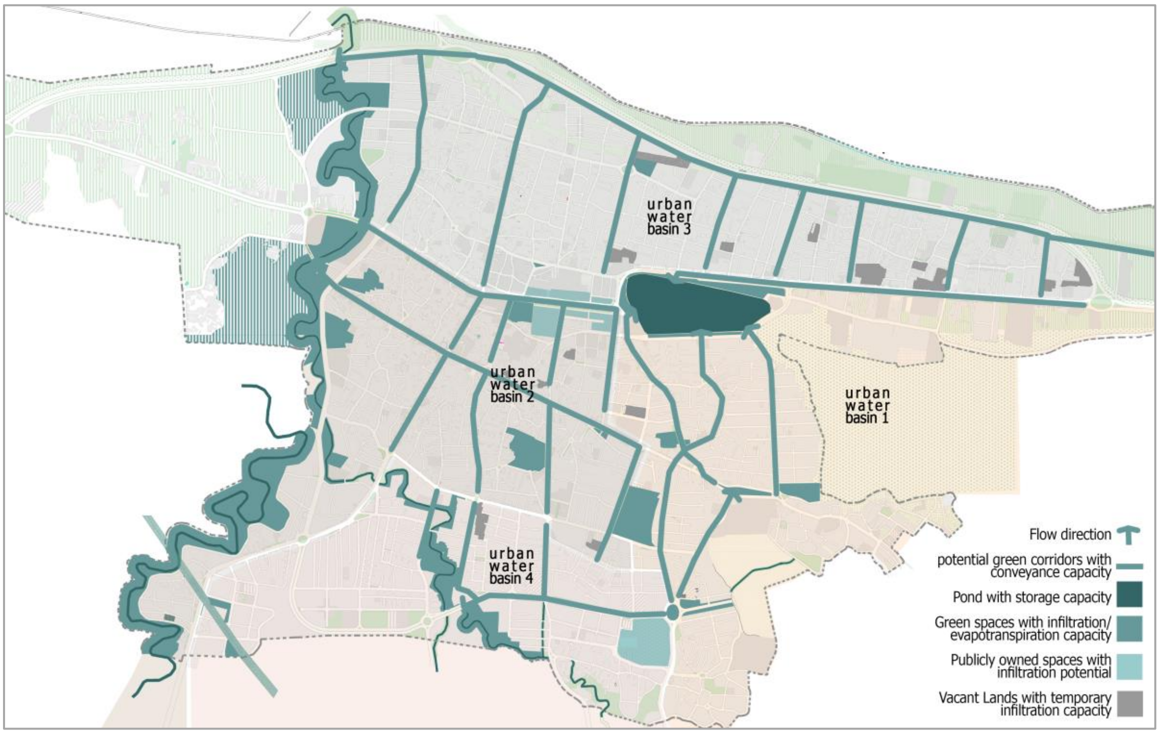

Fig. 7 A scheme of the network of water sensitive public spaces of Lahijan

Due to the small size of the city, the enhancement of the grid of green spaces offers all urban residents walking distances to one or more of such green spaces. Besides their functions, the green spaces will improve the quality of the urban environment and will contribute to the revitalization and regeneration of the green character of Lahijan.

Among the other benefits of increasing on-site stormwater management practices through water sensitive urban surfaces is its effect in moderating the temperature extremes and cooling down the urban spaces. Such capacity is highly appreciated in present time when the city is affected by Urban Heat Island (UHI) phenomenon and the urban areas are experiencing warmer temperature than the surrounding rural environments. Water evaporation absorbs a considerable amount of heat energy. Evaporation of water --direct evaporation from surrounding bodies of water or evapotranspiration from vegetation and surrounding soils, raises the moisture content of surrounding air, lowers the air temperature, and therefore cools down nearby surfaces. Hence, availability of water in urban spaces is the first requirement to apply passive evaporative cooling strategies. As discussed earlier, water can be provided through presence of ponds, pools, fountains as well as vegetation in urban spaces. Brophy *et al.* argues, "the presence of a body of water will help to moderate temperature extremes due to its high thermal storage capacity. ...The temperature of hard landscaping materials can be lowered when water is sprinkled, run over or through them. This is especially beneficial in built-up areas with large surfaces of heat retaining materials, exposed to high solar radiation." (2000, p.13) accordingly, encouraging on-site stormwater management practices inside the city through improving various conveyance, storage, evaporation and infiltration capacities of urban runoff assures the stronger and longer presence of water in public paces of the city, and mitigates the negative impacts of UHI effects inside Lahijan.

5 CONCLUDING REMARKS

The current stormwater management system of Lahijan is neither sustainable to accommodate the future water demands of the city, nor resilient to adapt to the conditions of a changing environment. To overcome such challenges, the stormwater management system of Lahijan must change to become an integrated part of the urban design of the city. After the long period of absence of water in urban settings, water must become a key component in design of the public spaces, which its real values are celebrated and its many benefits are revealed.

To achieve the sustainability of our fresh water resources and to reduce the stress on surface and underground waters, stormwater would be considered an asset and resource of the city rather than a menace. The analysis of the urban water state of the traditional city reveals that stormwater has been an integrated part of the design of Lahijan's public spaces for centuries, and that the urban spaces through various storage, conveyance, infiltration, and evaporation capacities were shaping the key elements in constructing the landscape of the porous city of Lahijan. Accordingly, urban spaces of the future water sensitive city would become an integrated part of a distributed on-site stormwater management to adapt to the impacts of a changing environment. Connecting stormwater water management with place-making will provide higher living standards for the citizens, and it will also address the problems of water scarcity, flooding and pollution. Water sensitive urban surfaces provide the possibilities to collect rainwater and reintroduce it as a source of non-potable water to urban water system; to hold excess amount of water in case of heavy rain and discharge it slowly; to increase the groundwater recharge potentials and decrease the discharged wastewater to public sewers, and so forth. Thus, water sensitive public spaces help communities to achieve the sustainability of their local water resources and the resiliency of their urban environment.

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IMAGE SOURCES

Cover Figure: Lahijan Pond from Ramin Shoraka

Fig. 1, 2, 4, 5, 7: figures from the author

Fig. 3, 5: figures from Lahijan Municipality archive

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An architect by profession, Masoumeh Mirsafa is currently a PhD candidate at Department of Architecture and Urban Studies of Politecnico di Milano. For her PhD, she studies "water-sensitive future of small Iranian cities" in which she aims to identify how integrating place making practices into urban water management can contribute to a more sustainable and yet resilience urban development of the country. Between 2010 and 2012 she studied Sustainable Urban Design from Lund University, Sweden, and later she worked as a researcher at Centre for Middle Eastern Studies of Lund University (CMES). Her research activities focus on sustainable urban development and climate sensitive urban design.