International Journal of Architecture and Urban Development
Vol. 7, No.4 , Autumn 2017

Study about Realizability Situation and Utilization Contexts of Water Sensitive Urban Design

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Recieved 12.06.2016 ; Accepted 18.09.2017

ABSTRACT: Climate changes, failure to complete the natural cycle of water in the city due to unsustainable construction of the urban environments and increase of impervious surfaces, lack of nutrition of underground aquifer in the cities, unsustainable management of stormwater and the floods due to them in the periods of rainfall caused to provide an approach that is called water sensitive urban design. This approach offers methods in the three parts; Sustainable management of stormwater, domestic scale water management and wastewater management. Different countries have pay to utilize of these methods according to their climatic conditions and their urban forms each in different ways. This study shows for achieve success in use of WSUD methods we need situation and requirements such as: Legal framework, ability of methods to close water cycle in cities to natural water cycle, pay attention to aesthetic concepts and aspects, methods ability to achieve the technical objectives, pay attention to type of methods and the scale of site, pay attention to climate conditions and specifications in implementation of projects, the measure of selected methods efficiency, public acceptance and integrated planning in the projects.

Keywords:*Water sensitive urban design, Realizability, General context, Climate situations*

INTRODUCTION

Tehran metropolitan in terms of climate is located in warm and dry area and the northern parts of the city with a relative difference, experience more temperate climate than the central and southern parts. In recent years, the average rainfall in the city is faced with a significant reduction. However, despite the lack of rainfall in this metropolis, the stormwater management in Tehran is not made in a sustainable way and this is created two major problem about it. First, disruption of the natural water cycle due to the ground surface inability to attract and increase the permeability of the runoff caused by rainfall and numerous rivers in the city and complete the cycle above and second, the rapid fall flood in the city in case of rain. So, the urban design has made mechanisms to contribute to urban natural cycle due to retention, permeability, filtration and reduction of acute effects and both creation urban amenity spaces. The aim of this study is investigation of realizability situation and utilization contexts of water sensitive urban design in Tehran metropolis as well as determination of capacities and potential of this metropolis to take use these mechanisms adapted to its climate and environment.

The main hypothesis of this study is based on the premise that to successful implementation for water sensitive urban design mechanisms two categories of factors should be considered and realized. The first batch is major and general situations and contexts such as legal framework, directional and administrative levels, creating space and aesthetic aspects of projects, financial estimates, technical aspects of planning, etc. The second batch is relate to site condition and choice for proportionate methods according to climate features and city structure and environment potentials.

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MATERIALS AND METHODS

The type of this research is descriptive – analytical and data collection is done by library. The analyzing is done in follow parts as Water sensitive urban design and General principles for utilization of water sensitive urban design implementation.

RESULTS AND DISCUSSION

Water Sensitive Urban Design

Water sensitive urban design (WSUD) is an approach to land use planning, urban design, infrastructure engineering and environmental sciences that integrate urban water cycle including surface water (runoff), groundwater, wastewater and water supply management and storage. This approach utilizes from urban design principles to water cycle management in the cities and reduce damage to the environment and by adopting an interdisciplinary collaboration define and use integrated strategies for environmental, economic and social sustainability (WBM, 2007).

The aim of Water sensitive urban design is combination of sustainable management of surface water demands with planning and urban design demands and make close the urban water cycle to natural water cycle through that. Water sensitive urban design consider all kind of water in cities including drinking water, water for daily use, runoff from rain and storm, Health Considerations for water channels, wastewater and water cycle and redesign but the concern and focus is on sustainable management of stormwater and surface runoff in the cities (Hoyer el al., 2011).

Water Sensitive Urban Design Multiple Objectives

In fact, as a general description can be said that the 5 main objectives of water sensitive urban design include (CSIRO, 1999):

Water cycle management:
Increase infiltration runoff in underground beds;
Prevent damages caused by the floods in built areas;
Prevent excessive erosion of rivers, slopes and rivers;
Maintain and improve water quality if possible.

To minimize the sedimentation caused by water:
Protection of vegetation adjacent the rivers;
Minimize the emission of pollutants into surface water and groundwater;
To minimize the impact of pollutants entering the sewer system.
Enhancing water supply
To minimize the use of potable water resources;
Encourage to re-use of rainwater;
Encourage to treatment and re-use of wastewater;
Reduce irrigation needs.
Maintaining environmental values associated with water.
Maintaining recreational values related to water and creation of new spaces.

The Needs of Water Sensitive Urban Design

The natural water cycle includes evaporation, condensation, precipitation and infiltration that often is impaired and impairment in urban environment due to cities unsustainable built and can not properly complete its cycle. Urban water has pollutions and Impurities that can not infiltrate into the ground because flooring surface materials such as asphalt and other impervious pavements, quickly gathered and discharged into public drainage systems and does not leave any opportunity for evaporation. In fact the water sensitive urban design is necessary for sustainable management of stormwaters and runoffs in order to Increase the permeability of runoff, reduce pollutions and prevent urban flooding. (Hoyer et al., 2011) (Fig.1)

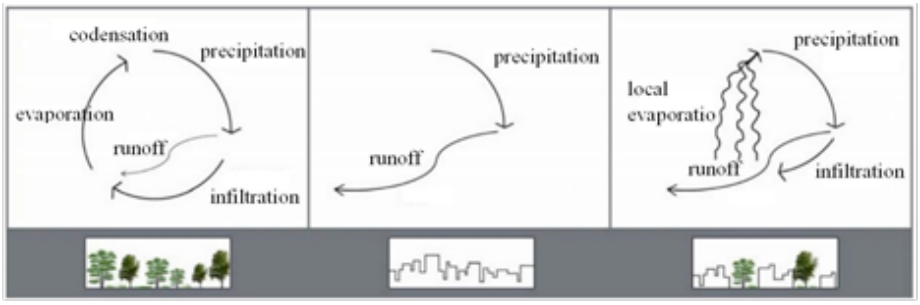

Fig. 1. Water cycle in natural systems (left); in an urban area without sustainable stormwater management (middle); and in an urban area with sustainable stormwater management (right). (Hoyer et al., 2011, 18)

Water Sensitive Urban Design Procedures

There are several procedures and technical solutions to facilitate the management of runoffs. These methods have been create as a response to the special needs of stormwater and runoffs management and the site condition in order to achievement to specified objectives.

General Principles for Utilization of Water Sensitive Urban Design Implementation

Legal Context and Frameworks

The first condition for sanction and realizability of WSUD objectives and programs is existence of the rules and regulations at both national and local levels to support and direction of the projects. In addition to, the technical and administrative rules and guidelines is also required for the success of such schemes.
National rules and regulations:
There are advanced rules and regulations in Europe in term of surface water and runoffs management. Trough the rules and regulation of the Europe Union, all countries are going to develop relevant regulations in their own countries for sustainable water management, particularly in term of runoff sustainable management in the cities. The overall framework of these regulations is accompanied with consideration to communication development and cooperation between communities, protection and regeneration of urban water systems. (The European Parliament and the Council of the European Union, 2000)
Germany is granted a strong role to federal rules in order to legislation and make support measures. These are include establishing clear rules on the management of water resources such as prevention of pollution and quality degradation of groundwater, domestic water treatment, environmental protection and protection against flood risks etc.
In Britain some protective programs are considered to water sensitive urban developments. That in this country is known as "sustainable urban drainage systems" or the abbreviation (SUDS) that pay attention to surface water management at the city scale. Also, this program is done with the aim of reduction of destructive impacts on environment and established programs and practices in domestic and building scale.
Water sensitive urban design in Australia (WSUD) is proposed as a series of recommended actions. These measures with the cooperation between government and municipalities are in order to legislation and planning to urban development based on WSUD strategies. The Council of Australian Government (COAG) in 2004 and 2008 has done significant efforts as “national water plan” for promotion of water reform particularly in urban environments. At the moment there is 9 implementation plan water management and reform in order to offer healthy , safe and reliable ware resources, increasing the efficiency of water use, encourage reuse and recycling of urban wastewater and targets related to water pricing and sales (Australian government national water commission (AGNWC), 2008). In the United States the basic rules for management of water resources and to determination of the relevant criteria in the federal states (Clean Water Act) and its implementing details in in the possession of states. In the US, “Environmental Protection Agency (EPA)” is responsible for organizing water quality and national standards in this field. In the Islamic Republic of Iran, the general policies in the field of water resources management system was notified in 1999, which its main topics include (IWRMC, 2015):

Create a comprehensive system to manage the entire water cycle based on the principles of sustainable development and landuse in the watersheds.
Improve the efficiency and attention to security, political and economic value of water in the extraction, supply, maintenance and water use.
Increase water extraction and minimize the natural and unnatural waste.
Preparation a comprehensive plan to proportionality in dam projects, watershed management, water spreading, and irrigation networks and land equipment and flatten, protect water quality and prevention from flooding and the use of unconventional water, promotion of knowledge and technologies and strengthening the role of people in the extraction and exploitation.
Water containment that comes out of the country and the priority use of shared water resources.
In order to achieve these topics, long-term development strategies were prepared that include some cases such as macro management, resource management, consumption management, economic value of water, quality control, supply cost, exchange of water, transmission among areas, management and structure, area division, preventive management, water distribution, public education, shared and boundary waters, information management, and multi-sectorial management. Iran Water Resources Management Company is responsible for the implementation of macro policies to manage water resources, knowledge, research, development, conservation and optimal utilization of water resources in the country.

Engineering Standards and Guidelines

The leading countries in the stormwater management have certain guidelines in the field of executive, structures and management. In Germany, decentralized management of surface water has been accepted as an alternative option to conventional methods of storm water management. Regulations for storm water management that has been approved in this country include sectors such as planning, construction and services for infiltration of rainwater systems and treatment standards for surface water decentralized management. Technical design specifications in this country have special attention to retention, infiltration and treatment of runoffs.
In Britain sustainable surface water drainage standards are implemented based on a set of design guidelines and recommended programs. These guidelines are presented by “Association for Research and Information Industry Building”.

In addition, there are professional publication and magazines in this fields that advise and pontificate planners, engineers and developers in relation to management, technical frameworks, planning and implementation (Construction Industry Research and Information Association (CIRIA). 2000).

In Australia sustainable management of runoff guidelines are provided at three levels: national, regional and local levels. These are included use of rainwater, environmental risk management, collection and removal of surface water and underground aquifers supply (Australian Environment Protection and Heritage Council, 2010). These guidelines are created by the several states according to each one's features that work as a guide for planners and urban designers in metropolitan areas and leads them to sustainable management programs of runoffs with water sensitive urban design approach.
Stormwater management standards and guidelines in the United States of America is done through the program guide called "Best Management Practices" (BMP) (US EPA, 2010). The general responsibility of this program is on "US Environmental Protection Agency, but municipalities according to local conditions and requirements do own related practices.
In Islamic Republic of Iran "water and wasetwater engineering and technical criteria office" is responsible for preparation and regulation of rules and technical guidelines related to water management in the country that is known as " water and wastewater standards" Which is subset the Ministry of Energy and has several specialized committees. These committees include committee on water resources management, river and coastal engineering committee, the committee on irrigation and drainage, irrigation and drainage committee, dam and tunnel transport committee, the committee on water, sewer committee, the environment committee (IWRMC, 2015).

Local Rules and Regulations

In Australia, government and state authorities provide policies, strategic guidelines and technical parameters set for the sustainable management of surface water but the local authorities who are responsible for determine the site conditions and specifications and project implementation. The permission of local water plan or implementation of water sensitive urban design infrastructure is issued locally in this country. Melbourne and Sydney have strong support of water sensitive urban design projects and issue the corresponding permissions. In many countries, national organizations take responsibility the task of preparing and approving major projects, water management and supervisory duties and planning, locate and their implementation is the responsibility of local governments. The study about sustainable management of runoffs plans especially as WSUD, shows that although national rules are the basis of these plans but the successful implementation of them depends on the locally organizing. In Iran "the regional water and wastewater organization" is executing of related rules that is responsible for water management at state scale usually. In Tehran, the organization is divided into 6 area. Meanwhile, municipal regulations as local governments are effective to implementation of water sensitive urban design methods.

Methods Abilities to Close the Water Cycle in Urban Environments in the Natural Water Cycle

The methods that WSUD offers to runoffs management can only be successful when achieve to water cycle reconstruction goals and closeness urban water cycle to natural water cycle. Natural water cycle is determined by factors such as high evaporation, high rate of infiltration and low surface runoffs. While in urban areas high amount of surface runoff, low infiltration and evaporation rates are low are visible normally. Therefore, all WSUD measures should be made to achieve these goals.

Consideration the Concepts and Aesthetic Aspects and Ability to Implement these Concepts

In this part the aesthetic aspects of these guidelines would be investigate.

Aesthetic Benefits

Surface water management executive mechanisms should as far as possible create additional benefits for environment in term of aesthetic aspects. Also WSUD practices can increase the public awareness from runoffs through design them in a way that be visible for public by designing it in such a way that they are visible to the public what as design in public spaces or private open spaces.

Methods Visibility

Conventional urban runoff management systems are out of sight and mind of the citizens. Therefore, when runoff management implement in urban space as a visible and palpable design element, will attract the attention of citizens and space users. Water flow created in these methods encourage people to follow the natural water cycle processes, seen created daily and seasonal significant changes enjoy it. So, when residents living in the vicinity of a dynamic process of surface water flow and the processes these processes are placed in front of their eyes, they are understand importance of water cycle in urban area more and more and become more sensitive to water finitude as a vital resource.

Use of Surface Water in order to improve the Quality of Public and Private Spaces

Surface water management measures and procedures in WSUD can be useful not only for improvement of visual aesthetic, but is effective to improving the quality of life in the city. Green spaces and water are two key factors to improve the quality of life in cities (Cities with high rates of water and green areas are generally leading in terms of livability). Methods and mechanisms provided in the surface water management help to increase these two factors and the existence of such

spaces, so can have a significant contribution to environmental sustainability indices.

Integration with the Environment
Mentioned methods and mechanisms should have compliance with their around environment, including urban landscape, buildings, urban structures, streets and can be well combine and integrated with them. For example, sand and gravel filters that have concrete rectangular pond with metal fences cannot be suitable and congruous for a natural landscape or create a detention pond with a widespread vision and perspective is not suitable for central districts of cities.
Although the WSUD mechanisms for manage surface water often works with natural structures, but are not limited to them. We can say that creativity, materials used and proposed plan as a way that result to the environmental integrity are three sides of a triangle for proper function, satisfaction and create stimulating environments mentally in the proposed mechanisms (especially in areas with high density). Surface water management practices must fit well in the urban environment, respond to environmental needs and invite people to use and attention to itself

Functional Capabilities and the Methods Ability for Achieve to Technical Objectives

Suitable Design
The proposed methods should be designed in accordance with the local environment. These methods are generally place oriented, so it is necessary to have always complete and accurate consideration to project site plan, for example Topography, ground permeability, underground aquifer water level and water quality. In addition to, designers and urban planners have to be aware of different technical practices and combination Possible of measures to optimize the management of surface water.

Suitable Maintenance
Presented methods by WSUD rely on suitable maintenance to ensure performance. Inadequate and unsuitable maintenance, for example in bios wales or green roofs not only affects their performance, but also significantly reduces its aesthetic values. To avoid such undesirable outcomes, maintenance and long-term care should always be considered during the design.

Compatibility and adaptability:
Situation of surface water management may be changed in the future. One of the reasons for these changes, is climate change (change in the pattern of rainfall, intensity, etc.). Another reason could be the impact of demographic and economic change of cities. The features and nature of these changes are "uncertainty" about them (Hoyer et al., 2011). So, WSUD methods and mechanisms about surface water management should be develop and spread like any other architectural design, urban design and infrastructure design solution to be flexible in faced with future situations.

Attention to Scale of Projects, Optimal Sites for Implementation, and Consider the Appropriateness of the Methods to Site Scales and Urban Implemented Context
Water sensitive urban design is generally implemented in 3 scales. Large scale (cities and urban areas), medium scales (residential areas, neighborhoods, parks, etc.) and small scale (urban blocks, housing units, apartments, houses and villas, etc.). Executive mechanisms to manage the flow of runoff in WSUD approach is divided into 3 parts in accordance with these scales:

The methods that their optimized place for implementation are personal sites such as residential, commercial, private homes, schools and etc. Rain water harvesting and rooftop retention are suitable for these sites, because the harvesting and use operation are located in one place.
The methods can be optimally and with minimal intervention in the environment and changes in the urban landscape located in public spaces because of their linear and narrow feature of design such as swales, open channels, infiltration trenches and permeable pavements.
The methods that need to more open spaces than two previous parts for implementation, such as bio retention, biotopes and detention ponds. Urban parks and wide open spaces in the city or surrounding area, are suitable sites for the implementation of these procedures.

To the Conditions and Types of Climate and Design Methods to Suit the Climatic Conditions
Water sensitive urban design presented methods depends on site climate conditions directly. However, climatic conditions and rainfall are various in different countries. In addition, microclimate in a country or in geographical areas may have significant differences compared with another areas. Therefore, utilization of WSUD methods and mechanisms should be in proportion to geographical area, local climate and rainfall patterns. In rainy climates with an aggressive approach can use all existing mechanisms such as rainwater harvesting or use green roofs and green walls, while in dry and hot climate the dominant approach emphasis on maximum use from minimal water resources, prevention of sudden floods on cities and supply the underground aquifers the more.

Usability and Efficiency in Utilization of Water Sensitive Urban Design Methods about Sustainable Management of Runoffs

Optimized Utilization
Provided mechanisms and procedures should be applied to create space (for recreation) as well as achieving the objectives of environmental protection. Retention and infiltration of surface runoff generally require relatively large space in urban areas that are difficult to obtain. In this situation we are faced

with a fundamental question that leads to two different paths: is not it better to utilize these valuable spaces for purposes such as the protection of space, recreation space and assign it to public landuse instead of surface water management? We can answer: WSUD mechanisms should set targeting to integrate both of these demands (Hoyer et al., 2011). So, the WSUD biggest advantage is that it is capable to offer a wide range of design solutions that they can manage the surface runoff and at the same time be able to create or complete recreation, natural environment and urban landscapes.

Perception, Awareness and Public Acceptance (the Amount of Positive Feedback from People)

Public Participation

The proposed methods for surface water management must consider the demands of all stakeholders and involve them in the process of planning and design. One

of the goals of urban design is to create environments that respond to the needs of residents, so it is often necessary that residents, owners and users of space are participated in the process of creating these environments. Thereby, plan acceptance, the proper use and maintenance of urban spaces created by these methods, can be better achieved and have an ongoing process. In addition, through the participation of local communities, needs and demands of residents and other stakeholders will be better known. Direct conversation with residents and stakeholders give an unique opportunity to discuss about surface water management, methods and mechanisms and their advantages and disadvantages. So, it can reduce unawareness and probable objections about it.

Acceptable Costs

The costs due to WSUD methods should be comparable and competitive with the cost of conventional methods, otherwise it may confront its acceptance with doubts. So, the financial justification is one of factors to choice the surface water management methods. In order to achieve broad acceptance of such plans, the resultant of WSUD systems life costs should be approximately equal or less than the cost of conventional runoffs management. So in this regard, as far as possible it should be avoided from the technical complexity and expensive systems.

One of the potential that exists in the WSUD methods and mechanisms for water management is multiple use of space, such as recreational space that provides the dual function of managing runoff. In this situation, the overall costs can be significantly less than if they are paid separately for infrastructure of related urban waste water and recreational spaces. The maintenance costs are also done jointly in WSUD approach and will have secondary conservations.

Integrated and Compilation Planning

Demands Integration

The combination of functionality, aesthetics and usability concepts is very necessary and essential, because WSUD methods desire to act as creative key element in open space and urban developments.

Interdisciplinary Planning

Water sensitive urban design is a topic that merges the fields such as water engineering and management, infrastructure engineering, urban design, urban planning and landscape together. WSUD ideas can only be implemented by a professional team of experts carefully, such as water engineering and infrastructure engineering (civil engineering), urban development (urban planners and urban designers), architects (architects and landscape architects) and a delegate of the local authorities. But urban design experts are stayed at the heart of this team as connectors and coordinators among these fields. They can manage and lead executive process methods to result with broader view from beginning to end.

The Impact on Public Awareness and Understanding

In surface water management often the acceptance and popularity of the projects is problematic part of instead of technical complexities of the procedures. WSUD is a relatively new concept like many urban design concepts. However, the prevalence and exposure of such projects can help to perception and development of surface water management concept by water sensitive urban design approach.

CONCLUSION

WSUD should like any other urban plan seriously consider all of issues that affect them or are affected with a comprehensive view before implementation, during implementation and after implementation. These issues can be about economic, social or environmental objects.

Water sensitive urban design is not only an infrastructure or engineering project but its results can include various aspects of urban matters.

The main challenges that water sensitive urban design is facing in order to the sustainable management of urban runoff include:

Such projects are facing with difficulties to implementation, especially in urban built environments. These difficulties and constraints include need to a slope for disabled people of the environments, need to interconnected longitudinal paths, drainage possibility from the substrate, lack of implementation of permeable paving in high traffic routes, etc.

Such plans because of the novelty and their multi-faceted structure, have difficult way ahead to get authorities reliable for choice as an alternative solution.

Approval and licensing process for such projects is often faced with challenges.

Because to city managers habit to previous methods and need to have some specific urban areas.

The integration and adaptation of these projects in its urban contexts requires design innovation, which in the absence of attention will not be able to achieve its desired objectives.

Combined practical and functional aspects and aesthetic concepts is difficult sectors of these projects.

Table 1. Categories of factors for success to implementation of water sensitive urban design.

Legal mechanisms	National laws and regulations	Technical guidelines
	Local regulations	
Moving towards natural water cycle	The ability of procedures that are utilized to close the Water cycle in urban environments to natural water cycle	
Aesthetic concepts and aspects	Aesthetic benefits	Visibility of methods
	The combination and integration with environment	
Functional capabilities	Proper design	Proper maintenance
	Compatibility and adaptability	
Attention to scale of the project	Pay attention to scale of the project in relation to the optimal site performance, methods of selection and urban context implemented in 3 large scale, middle-scale and small-scale	
Attention to site climate	Attention to the conditions and types of climate and design solutions according to the situation	
Methods Efficiency	Utilization capability and efficiency of water sensitive urban design methods to sustainable management	
Public awareness and acceptance	Public participation	Acceptable costs
Combined and integrated planning	Demands Integration	Interdisciplinary planning
	Impact on public awareness	

Interdisciplinary cooperation with a team-work consisting of experts with different views on sustainable management of runoff and align their views in order to achieve an overall identical concept, is difficult.

Because of the novelty of WSUD idea still the merits of this idea is unknown for many stakeholders and people.

This study shows that for success to implementation of water sensitive urban design methods 9 categories of factors should be considered. (Table 1)

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