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Original Research Article

Ecological Aesthetic Practice and Water Sensitive Design in Landscape Studies*

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Abstract | In recent years, the concept of water sensitive urban design has received considerable attention as an efficient approach to solving problems caused by conventional surface water management in Australia. Water Sensitive Urban Design (WSUD) contributes to natural water cycle restoration in urban development. The technics proposed by this approach, in relation to optimal planning and management, improve the quality of runoff and reduce its volume, expand green space, and integrate the natural process with the city landscape. As the WSUD approach concentrates on technical-based scopes of environmental (ecological) interventions, it cannot be used as a comprehensive solution for environmental interventions. Therefore, it is assumed that WSUD can be used to develop a landscape model for environmental intervention by employing ecological aesthetic design principles. The extant study reviews the relevant literature to find the gaps in this technical approach. This study was conducted to analyze and match the components obtained from research literature by using logical argumentation regarding the position of water sensitive approach in the development. Besides, necessity of ecology aesthetic was taken into account for a sustainable landscape. Since water-sensitive technics follow the natural processes to be matched with varying environmental conditions, these technics have a natural beauty. It should be mentioned that the beauty of nature has been proved while its relationship with culture has remained undefined. As the mediating element between ecology and culture in landscape design, ecological aesthetics outlines the process of landscape design using WSUD solutions and measures to improve the mental and human aspects of the landscape.

Keywords | *Water sensitive urban design (WSUD), Surface water management, Environmental interventions, Ecological aesthetic, Ecological landscape.*

Introduction| One of the greatest challenges for natural and social scientists is to understand how urbanizing regions evolve through the complex interactions between humans and ecological processes (Alberti, 2008). Neglecting such natural water in urban development has a bad impact on the economic, ecological, and visual values of the city and subsequently on the rights of the next generations and water hydrology cycle. In this context, urban development prevents from water entry into the subsoil layers by increasing the impermeable surfaces causing the risk of flooding, which reduces the quality of surface waters (Locatelli, 2016, Zhiliang, 2012). Such issues have made experts achieve some methods for surface water management. This study aims

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to examine the water sensitive urban design approach as a new urban management model and an ecological solution for sustainable urban development (Kazemi, 2014), which was established in Australia. According to objectives set by CSIRO (2006), WSUD reduces runoffs, increases the quality of water, and integrates the stormwater transmission and treatment system with the urban landscape to protect natural systems. This approach is linked with the urban landscape; hence, WSUD is performed based on the landscape interventions with objectives and functions of aesthetics and society culture (Mansouri, 2010). Accordingly, this study was conducted to propose a strategy to link WSUD and discipline objectives.

Question and hypothesis

As WSUD usually focuses on technical-based scopes of environmental interventions, it cannot be used as a comprehensive solution for environmental interventions. Therefore, it is assumed that WSUD can be used to develop a landscape model for environmental intervention by employing ecological aesthetic design principles.

Literature review

An effective solution is required for urban water management to mitigate the harmful impacts of urban development on groundwater reserves, quality of water resources, and climate conditions of cities. The natural water cycle has been considered in urban planning and development to match the surface water management with the natural ecosystem performance. This idea has changed the attitude toward the development of cities, which has been accepted as a similar concept with various titles in different countries. In 1972, the approach emerged as Low Impact Development (LID) and Green Infrastructure (GI) in North America; this was called the Sustainable Urban Drainage System (SUDS) in the UK. China introduced new urban policies including Sponge Cities Concept in 2013. Water Sensitive Urban Design (WSUD) was launched in Australia. Such diversity is originated from the variability of components and stimuli in different communities. The concepts and approaches are selected based on the basins, infrastructures, seasonal climate, local water cycle, and social expectations (Radcliffe, 2019, Hoyer, Dickhaut, Kronawitter & Weber, 2011) (Table 1).

According to Wong, water-sensitive measures which are increasingly advancing in Australia and Singapore can be used as a great model for other countries because these two countries are experiencing all of the issues related to urban water that are challenging cases in other parts of the world (Wong & Brown, 2009). Hence, the extant study aims to address measures associated with the water-sensitive approach. The term "WSUD" introduced by Mouritz in 1992 who defined it as an approach that identifies the urban design opportunities, landscape architecture, and stormwater management infrastructures and links these components together (Radcliffe, 2019, 9). National Water Commission (2004) defines the WSUD as the integration of urban planning with management, protection, and conservation of the urban water cycle that ensures urban water management is sensitive to natural hydrological and ecological processes. Moreover, this approach sets multidimensional objectives of hydrology management and water quality to improve urban amenities and to reduce heat island effects (Hoban, 2019, Nassar, El-Samaty & Waseef, 2017). According to available information, the water-sensitive approach focuses on the objective and technical dimension without any systematic attitude. In this regard, Vernon studies the residential open spaces by designing a model in which all of the WSUD elements do not play a vital role in creating a sense of place as a landscape quality while they are important in different components of place's physical design (Vernon & Tiwari, 2009). Hence, the WSUD approach cannot meet all of the human and cultural needs and values alone. According to the abovementioned information, previous studies have not offered a certain solution for a water-sensitive approach's requirements to design landscape.

Methodology

This paper examined a water sensitive design approach using the Bibliographical research method. In this context, the factors affecting the ecological landscape were determined because water sensitivity and ecology were of the same type. Then, logical argumentation was applied to match this approach with principles of ecological aesthetic design. The indicators obtained from literature were used to analyze how interventional principles of ecological aesthetics should be used in the water-sensitive design which was a technic-based and objective approach to landscape design. As a feature of logical argumentation, logical coherence for a conceptual system that proposes a comprehensive explanation (Groat & Wang, 2013). Besides, this research model provides an extensive and organized application that is essential for every theory or research plan.

Water sensitive design

The evolutionary framework of water resource management in Australia identifies six distinct cities. Early 19th century, the water supply city was the first modern urban water condition in Australia, which its principles were to provide the growing population with water supply. With concerns raised for public health and the outbreak of tuberculosis and cholera diseases, a city with a sewer system was designed to remove wastewater from the city. In the mid-20th century, a drainage city was created with the expansion of low-density and scattered cities. Increasing community concerns about the degradation of

Table 1. Sustainable approaches to urban runoff management. Source: Hoyer et al., 2011; Radcliffe, 2019.

Sustainable approaches to urban runoff management	Origin	Uses
LID – Low Impact Development	USA, 1972	LID articulates planning and design approaches to runoff management based on sustainable runoff management methods.
GI – Green Infrastructure	USA	Like LID, GI describes runoff management approaches and methods to reduce or remove runoff during infiltration, evaporation, or stormwater reuse.
SUDS– Sustainable Urban Drainage Systems	UK	SUDS explains measures related to sustainable runoff management.
BMP–Best Management Practices	Europe	BMP includes some practices for stormwater management.
DRWM - Decentralized Rainwater/ Stormwater Management	Germany	DRWM articulates technics and measures associated with water management.
IUWRM – Integrated Urban Water Resource Management	Global	An integrated approach to urban water (not just runoffs or stormwater) management.
WSUD- Water Sensitive Urban Design	Australia, 1992	This approach aims to integrate sustainable stormwater management, especially decentralized stormwater management with urban design.
Sponge Cities	China	Within this approach, stormwater is preserved, infiltrated, and treated naturally for reuse.

local waterways and requires open and green space for the society, waterways cities were created in 1970 then water cycle city was developed based on integrated water cycle management. The last option is water sensitive city, which embraces a combination of environmental preservation values, water supply, flood control, public sanitation, aesthetics, livability, and economic sustainability (Wong & Brown, 2008). Wastewater and stormwater systems have been existed for over one century. These systems have provided drinking water supply, collection and disposal of wastewater to protect human health, and mitigation of urban flood risk. The current urban water systems are under the influence of some challenges including rapid population growth and resulting urbanization, climate change impacts, and infrastructures that are aging and reaching capacity constraints. To address these issues, urban water services are now being implemented with integrated urban water management and WSUD approaches (Sharma et al., 2016). The concept of water-sensitive design embraces the integration of urban planning with urban water cycle management and aims to minimize the impacts of urban development on the ecological hydrology (Nassar et al., 2017). Various techniques can be used in the WSUD system which includes sedimentation basins, sand filters, treatment basins, rainwater tanks, pervious pavements, rain gardens, constructed wetlands, garden swales, natural treatment basins, natural treatment waterways, and green roofs (Bawden, 2009).

WSUD pursues some major objectives (Fig. 1); accordingly, CSIRO (1999) expresses five critical objectives of rainwater management and planning:

1. Protect natural systems and improve natural waterways in urban environments;
2. Integrate the stormwater treatment and transition into the urban landscape. Use stormwater in the urban landscape by incorporating multiple greenways that maximize the visual and recreational amenities in cities;
3. Protect water quality and the quality of water draining from urban development;
4. Reduce runoff and peak flows from urban development by minimizing urban impervious areas;
5. Add value while minimizing the development costs of drainage infrastructures.

Runoff is indeed a valuable resource in WSUD in contrary to the conventional runoff management method, which makes the city sensitive to floods and disturbs the ecology (Kazemi, 2014). The new approach provides numerous opportunities to use water in urban design and development of social comfort and urban environment (CSIRO, 2006). One of the advantages of WSUD is the ability to integrate the plant with its design and provides substitution of a potable water source (such as a stormwater tank) to irrigate the vegetation (Table 2). According to studies on green space and plants, trees at the micro-climate scale can reduce the temperature of cities, evaporation, and create shadows (Nassar et al. 2017) (Fig. 2).

Levels of WSUD practicing

WSUD incorporates water cycle management and sustainable measures within the urban development process; hence, its objectives and advantages are not achieved only by constructing a lake or wetland but these solutions and measures are created based on the runoff management

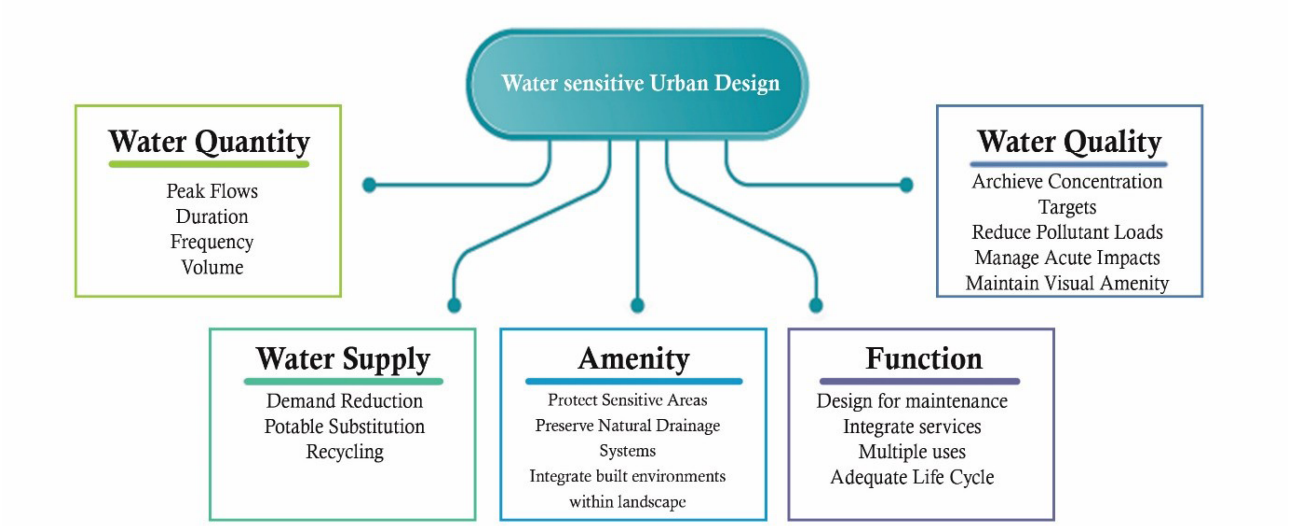

Fig. 1. WSUD objectives. Source: BMT WBM, 2009.

Table 2. Advantages and disadvantages of WSUD. Source: CSIRO, 2006, 49.

	Opportunities	Constraints
Economic	- Reducing capital costs (pipework and drainage) - Construction cost saving. - Reducing the costs of water quality improvement by retaining existing waterways. - Reducing development costs of drainage capacities. - Making a desirable and marketable development by incorporating water features, water frontages, networked public open spaces, and preserving and enhancing ecological systems. - Contributing to required public open spaces allocation and offering cost benefits where areas are suitable for residential development but are suitable for passive recreation.	- Increasing maintenance and operation costs. - Losing profits in areas that traditionally have been made available through the piping of watercourses. - The market may be sensitive to new urban forms. - There may be a possible need for a piping system in water management-based design techniques in steep terrain with severe precipitation. - The land ownership may limit the opportunity to implement water sensitive initiatives. - The benefits may be reduced where potentially attractive residential areas must be preserved as open spaces.
Environmental and Social	- Maintain the hydrological balance by using natural processes of storage, infiltration, and evaporation. - Restoring and enhancing urban waterways. - Minimizing the impact of urban development on the environment. - Increasing the diversity of natural habitats and suburban landscapes. - Groundwater recharge - Amenable urban and residential landscapes. - High visual amenities. - Opportunities to lick community nodes through public open space.	- Opportunities are limited in areas with high aquifer surfaces. - Topography and erosion: limitations in areas of high slope. - Ground conditions: opportunities are limited in areas of poor soil and shallow depth of bedrock. - Perceived safety risks. - Lack of public acceptance against new forms in the urban landscape.

needs and site opportunities. Accordingly, Best Planning Practices (BPPs) and Best Management Practices (BMPs) are integrated to achieve optimal WSUD use (Nassar et al., 2017). Fig. 3 depicts the general classification framework of WSUD measures, solutions, and techniques. Optimal planning solutions include site recognition, planning, and design of WSUD approach.

According to objectives proposed by SCIRO (2006), WSUD is an appropriate response to protect natural systems, to integrate stormwater with the landscape, to preserve water quality, to reduce runoff's peak flows, and to minimize development costs. WSUD is applied by urban and landscape design measures. Hoyer classifies the principles of WSUD to water sensitivity, aesthetics, functionality, usability, public perception and acceptance, and integration of demands. According to the above-mentioned studies, this approach focuses on technology and concentrates on the objective measures at all water management and planning practices.

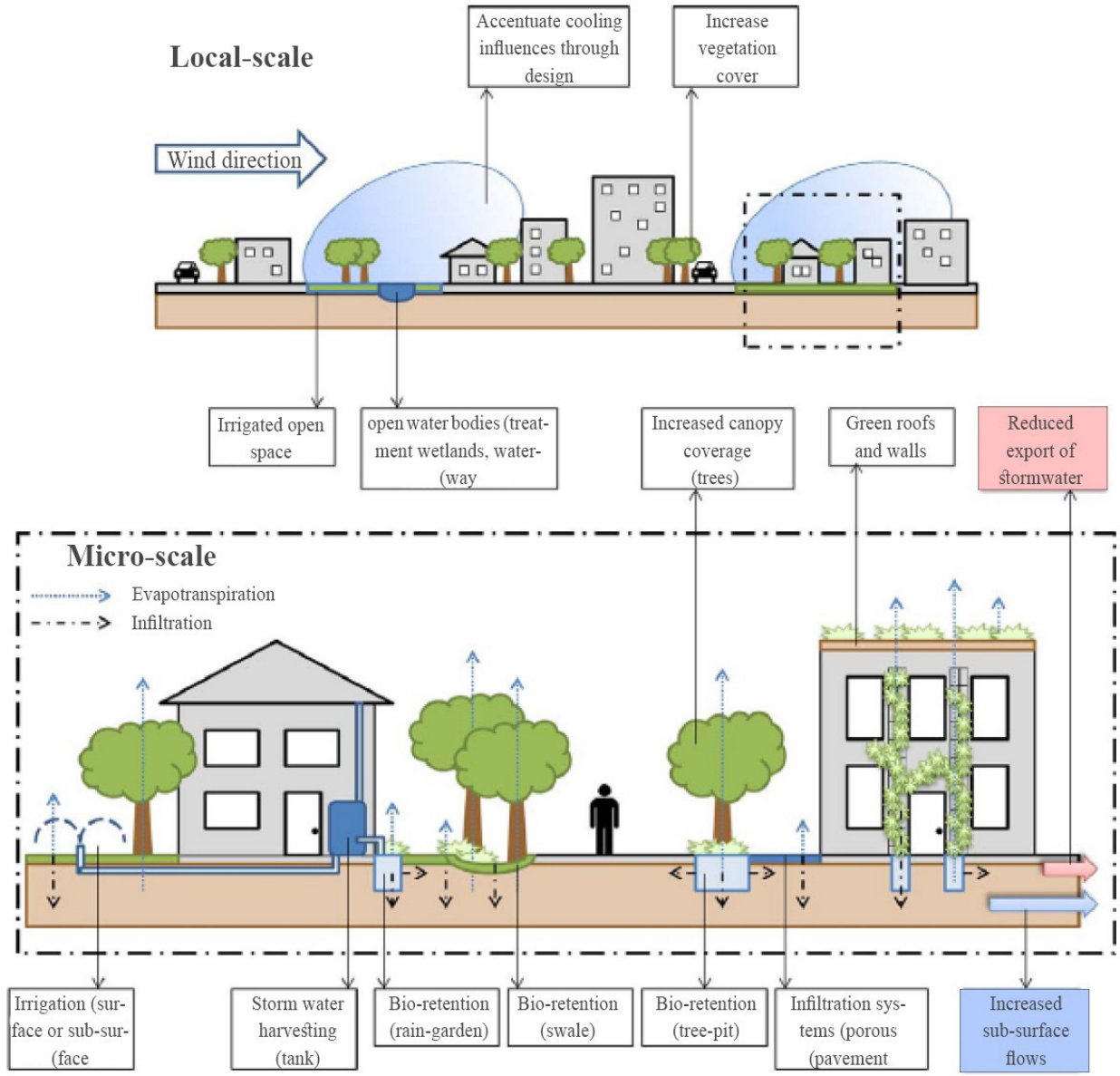

Fig. 2. WSUD techniques and urban micro-climate. Source: Author adopted from Nice, 2016.

WSUD, however, can integrate sustainable stormwater management to create sustainable and habitable cities through urban design. Hoyer argues that ecological, social, and aesthetic qualities are important because they influence public perception and acceptance (Hoyer et al., 2011). Accordingly, social-cultural dimensions have not been incorporated into WSUD-based environmental interventions. Hence, this substantial aspect must be taken into account to achieve a sustainable environment. As an ecological and management solution for the urban water cycle, WSUD is used to create a city, which provides natural ecosystems' features (Kazemi, 2014). Table 3 reports water-sensitive features and components and required ecology. The next section examined the principles of ecology landscape principles to find a solution for the enhancement of social-cultural dimensions of the WSUD approach.

Ecological landscape

As practical design approaches, ecological approaches are used considerably by experts for environmental design. Mozingo (1997) emphasizes protecting existing efficient ecological systems, improving the degraded ecological systems, and intensifying the environmental processes to mitigate ecological degradation through ecological landscape design. Vroom (2006) claims that ecological design is a sustainable design whose basic premise is first to allow the ongoing process that sustains life to remain intact and to continue to function along with development, and second,

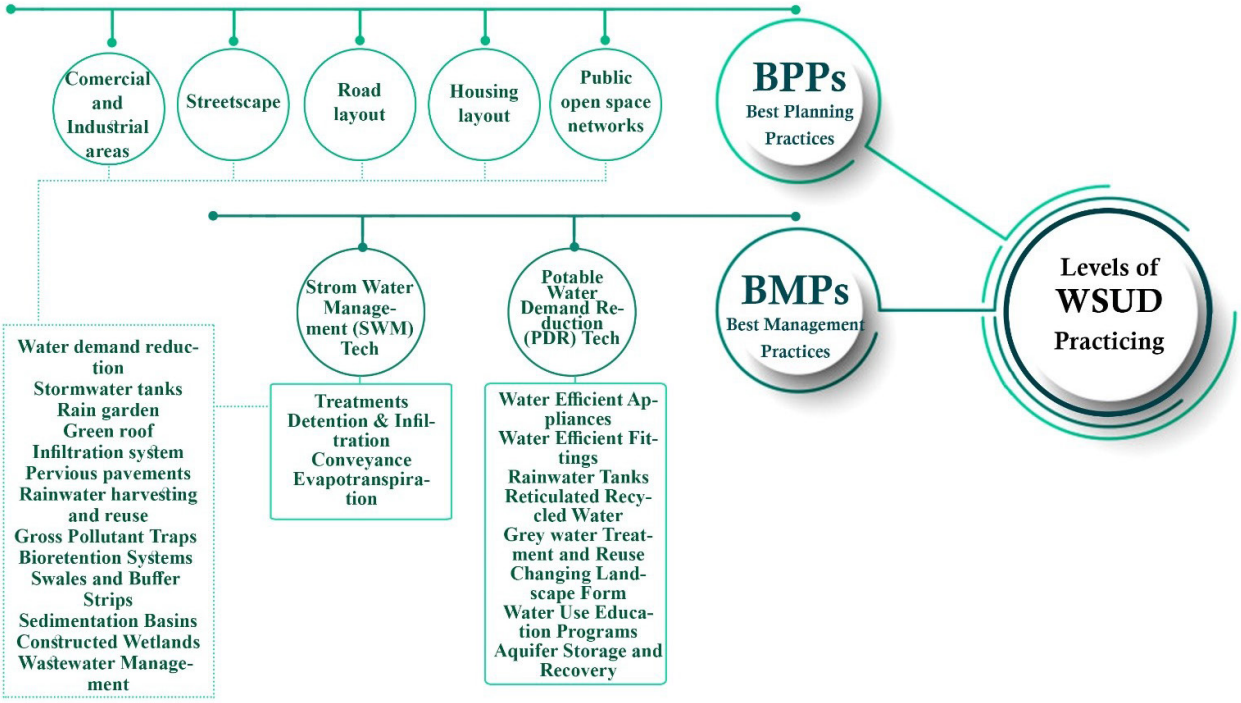

Fig. 3. Classification of WSUD techniques and practices. Source: Authors adopted from Nassar et al. 2017; BMT WBM, 2009; Bawden, 2009.

Table 3. Features of water sensitive approach and ecology. Source: Authors.

Water sensitive features	Component	Ecological features	Component
- Hydrological balance - Consistency with varying conditions - Adaptability - Natural system maintenance and protection - Adaptation with the environment - Enhancement of ecological systems - Natural water cycle - Natural storage - Diversity of natural habitats - Minimizing the impact of urban development on the environment - Prevent erosion	- Water - Vegetation - Natural patterns and edge	- Suitable vegetation for natural circumstances - Habitat heterogeneity - Diversity of vegetation - Biodiversity - Richness and unity - Being close to nature - Integrated ecosystem - Balance - Pattern change - Limited quality of ecology due to increasing human activities	- Vegetation - Vertical elements - Water - Edge - Land cover and role - Human activities and land use

is to provide the urban population with opportunities to enjoy the sensory and symbolic delights in natural and semi-natural environments. Vroom proposes four categories of the ecological implementation referencing Franklin (1997) and Hough (2004), which are the following:

- The design of sustainable water systems considering hydrological cycles and the prevention of erosion;
- The establishment of connecting zones between urban open spaces and the countryside;
- The protection of wildlife;
- The application of ecological principles in planting plans (Min, 2011).

Habibi (2016) states that the recognition of urban landscape based on the form and landscape of the city and non-physical factors of environment (experience, character, feature, sociological, psychological, and ideological intentions) leads to environmental response. The design is a cultural practice or a cultural product that is made of natural materials, is formed in nature, and is affected by specific social associations. Moreover, ecological design not only includes technical

aspects of ecology but also cultural values play a vital role in landscape sustainability, attracting public attention, and an increasing sense of care, which establishes cultural sustainability (Nassauer, 1988; Nassauer,1997). Because people correct and manage the environment based on the outcomes of aesthetics experience to construct a suitable habitat and beautiful landscape, aesthetics is necessary to establish a culturally ecological landscape (Svabo & Ekelund, 2015; Lee-Hsueh, 2018).

Ecological aesthetics

Human activities in ecological processes cause deterioration of water resources and landscapes' beauty. As a powerful force, the beauty of the landscape affects human emotions as well as ecological sensibilities (Kovacs, LeRoy, Fischer, Lubarsky & Burke,2006). Since aesthetics pleasures are not just confined to responding to ecologically beneficial landscape models, Gobster addresses the ecological aesthetic expressing that landscape design, planning, and management establish a desirable relationship between ecological phenomena and aesthetics of landscapes that are culturally sustainable (Gobster, Nassauer, Daniel & Fry, 2007). Carlson assumes that ecological aesthetic links the beauty of nature to ecological sustainability (Carlson, 2007). Ecological aesthetics adopts the biological principles of ecosystem management (biodiversity, sustainability, etc.) then claims that environmental aesthetics for humans must be consistent with its principles (Parsons & Daniel, 2002). Moreover, ecological aesthetics involve sensual connections to natural and cultural processes, and socio-ecological practice needs to consider aesthetics (Steiner, 2018). This term presents a complex and systematic concept, and understanding its aesthetic depends on the extent of integration of nature with social products (DeKay, 2012). Fig. 4 shows the methodology of landscape ecology aesthetic. While ecology supports an objective basis, aesthetic is a subjective matter (Min, 2011).

Lee-Hsueh (2018) has defined the indicators of ecology aesthetics based on his proposed model including coherence, openness, complexity, being close to nature, diversity, richness, and turbulence that are similar to qualities of landscape introduced by Bell (2015) to make aesthetic and excellence of environment meaningful. The above-mentioned qualities embrace diversity/complexity, correlation, the spirit of place, mystery, multiple scales, and power.

Discussion

According to the theoretical framework, the ecological aesthetic is the mediator of the relationship between ecological patterns and landscape aesthetics. Ecological aesthetics indeed link the sustainability aspects of ecology to the subjective aspects of natural beauty, which leads to a connection between nature, culture, and art that contributes to an understanding of aesthetics (Gobster et al., 2007, Min, 2011). Because aesthetic experiences are desirable feelings originated from a direct understanding of spatial aspects and interim landscape patterns, Water Sensitive Urban Design can be used as a sustainable ecological solution, which provides high performance in maintaining and protecting the ecosystem and visual attractions of the natural ecosystem. However, WSUD does not embrace some features such as unity, culture, sense of place, participation, and human activity in environmental interventions. According to Table 4, the aesthetical aspect of ecological aesthetics is on a subjective basis. Therefore, it can fill the gaps existing in the WSUD approach. Hence, if the use of WSUD measures requires mediation for landscape design,

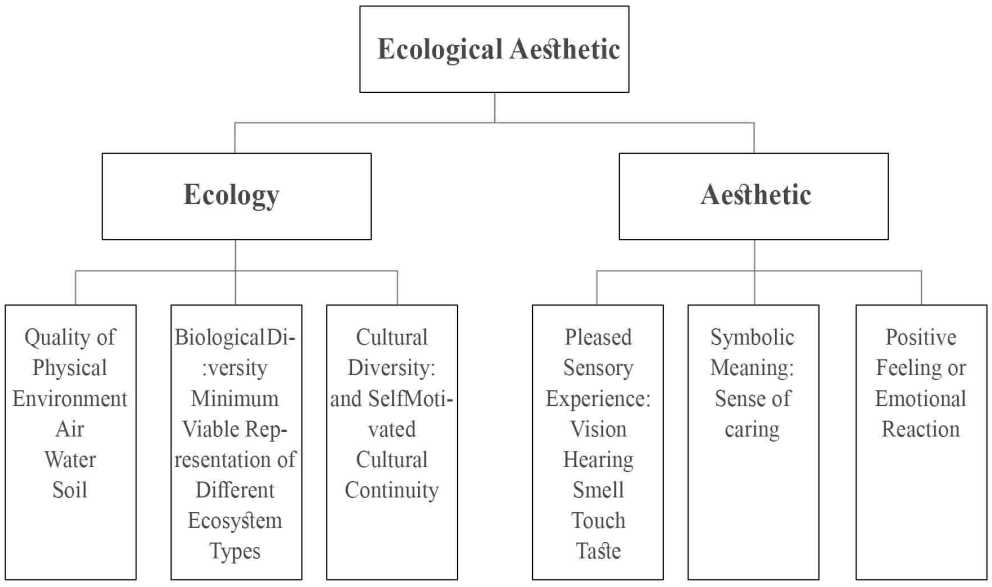

Fig 4. The methodology of landscape ecology aesthetic. Source: Thorne & Huang, 1991, 63.

principles of ecological aesthetic can promote the process and play the mediating role as follows:

1- WSUD employs technical intervention in the environment and concentrates on stormwater management to enhance and protect ecology systems, to prevent erosion, to consider the hydrological cycle, to preserve wildlife, and to provide opportunities for connection between people and urban open spaces. In this context, WSUD creates constructed wetlands and biological treatments (rain gardens, swales, etc.), biodiversity and ecological diversity, stormwater reuse, green roofs, and walls.

2- Ecological aesthetic presents a systematic and process-centered attitude, which leads to cultural experiences, unity, a sense of place, and a positive feeling in the environment.

Conclusion

As an approach to urban design and planning, the water-sensitive design integrates the water cycle management into the urban development process to create natural landscapes in the city, and to preserve sensitive ecological environments. Besides, WSUD integrates the built environment with the landscape. There is an undeniable relationship between the community and the urban landscape. This relationship encompasses subjective concepts. This approach needs to make a relationship with the community, establish collective experience, make the mind coherent, and evoke feelings of the viewer. Water sensitive techniques follow the natural processes to match themselves with varying environmental conditions. The beauty of nature has been proved, while its connection to the culture has remained undefined. As a connecting element, ecology aesthetics can link the ecology to the culture to design landscape by using WSUD measures. In this context, the ecological aesthetic can improve the subjective and human dimensions of the landscape (Fig. 5).

Table 4. Comparing criteria of ecological aesthetic and SWUD. Source: Authors.

Criterion	Ecological aesthetic	SWUD
Profession of philosophy	- Holistic, ecological, evolutionary, subjective, and objective (Koh, 1988)	- Ecological, objective
Value	- Ecology-based, inclusive, interaction-based (Byoung-Wook, 2012)	- Ecology-centered, technique-centered
Concentration field	-Creativity aesthetics in nature and art, emphasis on the conscious/unconscious experience and creativity (Koh, 1988); - Focused on processes and systems (Parsons & Daniel, 2002)	- Stormwater quality and management
Designer's approach	- The tendency of the designer to create dynamic experience and environment (Koh, 1988)	- The willingness of the designer to create an environment by maintaining the ecology and restoring the natural water cycle
Function	- Protecting the air, water, and soil quality - Assuring the presentation of different types of ecosystems - Enhancing cultural, educational, aesthetical, and spiritual experiences when interacting with nature (Thorne & Huang 1991)	- Match with the design of the surrounding area - Using an appropriate method considering the local conditions and applications - Considering essential conditions for maintenance - Considering some amenities for consistency under varying and uncertain circumstances
Public perception and acceptance and human landscape	- Cognitive, perception through senses (vision, hearing, smell, touch, taste, motion, etc.) (Byoung-Wook, 2012) - Active, engagement, experimental, relationship, pleasure through understanding landscapes, durability, unity, symbolic (Parsons & Daniel , 2002)	- Cost-effective - Public participation - Education - Experiencing natural environments
Design principles	- Inclusive unity, dynamic balance, and complementarity (Koh, 1988) - Conservation (shape for efficiency), attraction (shape for pleasure), and connection (shape for the place) (Hosey, 2012)	- Natural cycle, benefit, integration in the surrounding area, appropriate design and maintenance, efficiency, public involvement, acceptable costs, and impact on public perception (Hoyer, 2011)
Landscape form	- Elegant, vibrant, dynamic, natural, elements reflecting the place, procedural (Parsons & Daniel , 2002; Byoung-Wook, 2012)	- Focused on processes and systems - Natural, elements reflecting nature
The relationship between designer and impact	- Artistic works are produced and understood through involvement and adaptability - Art for people and place - Reducing the distance in the human environment system (Koh, 1988)	- Opportunity to create activity nodes through hydrological balance by natural processes - Protecting and enhancing the ecology

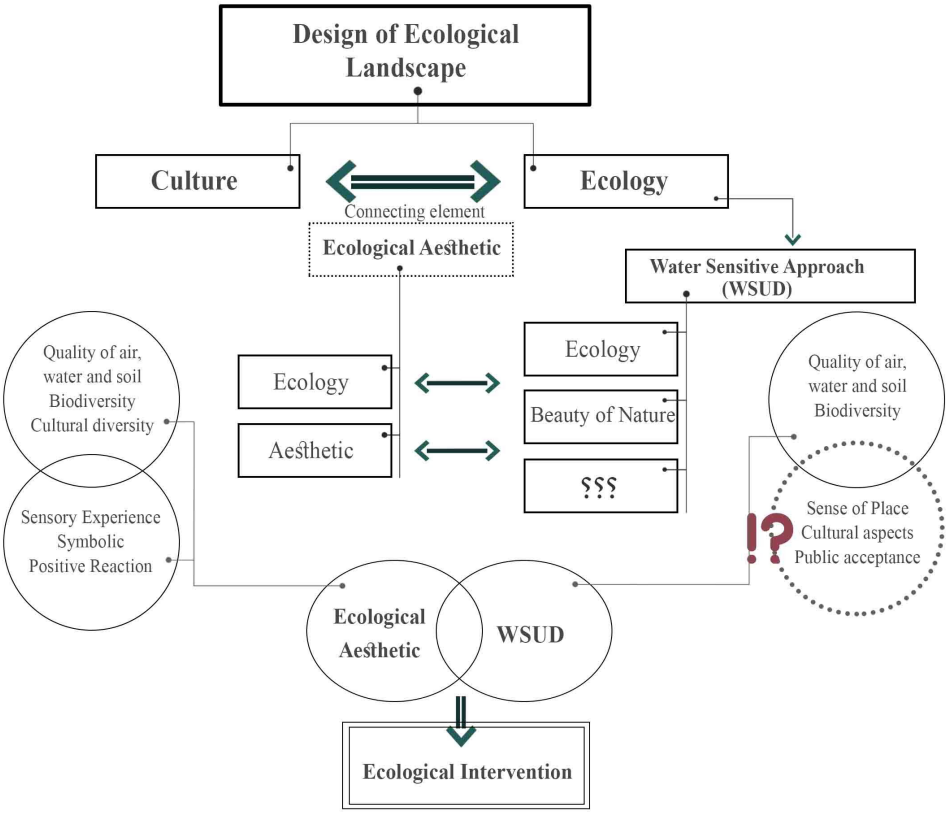

Fig. 5. The relationship between WSUD and ecological aesthetic to achieve sustainable landscape. Source: Authors.

Endnote

*This article is taken from dissertation of Narges Ramezani entitled "Landscape Design of Yasuj Waterfall Street Approach to Water Sensitive Design" which is supervised by Dr. Amin Habibi and Dr. Seyed Amir Mansouri and advised by Dr. Mansour Mosalanejad was carried out in 2020 in the Faculty of Art and Architecture of Shiraz University.

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