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Establishing a green-and-blue network within an existing settlement in central Hanoi towards urban ecologicalisation

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Abstract. As a mega city, Hanoi must solve huge problems in its urban development of which landscape is among the greatest and most urgent issues to deal with. Locally, within one settlement, landscape is often simply regarded by many city residents as a small park that helps improve environmental quality, especially in summer, and provides an open space for the local community to have a walk a few times a day. But actually, landscape plays a much more important role in one settlement as a complete unit and also as a miniature of a large city. Internationally, landscape is a complex concept as well as an integral part of urban ecology, and sustainability has been set at a much higher level and the final goal to reach. In central Hanoi, where the population and construction density is so high that the green area per capita is among the lowest in Asia, it is high time to rethink about the enhancement of living quality in a difficult situation. The academic article will focus on landscape ecology, rather than on landscape only, in central districts and propose an ecologicalisation for a typical settlement here towards a more liveable city concept.

1. Introduction

In 2015, Hanoi was selected along with 21 Asian cities for a city greening assessment survey. The green area per capita in Hanoi was just 11.2 m², significantly below the average figure (38.6 m²) and incomparable to Singapore (66.2 m²) and Guangzhou (166.3 m²) [1]. The Government requires that by 2020 Hanoi and Ho Chi Minh City as two special metropolitan areas of the country will have secured 15 m² of green area per capita [2], including tree rows along streets while two tree rows are not conventionally counted into this indicator. Thus, it is still a long way for Hanoi to reach its modest goal towards 2020, before going further to match the continent’s average level, seeing that there are only two years left.

In fact, the current green area is unevenly distributed across the city. As a result of the expansion in 2008, the whole province of Ha Tay and some part of Hoa Binh province were annexed to Hanoi. The total green area of Hanoi has increased manifold, because the expansion has taken all the forests, green belts, green corridors and farmland. In ten central districts, the greening indicator as of 2014 was extremely low, under 2 m² per capita [3].

Figure 2 shows an aerial view of a typical living quarter in a central district of Hanoi with a very high building density. All the roofs are made of either galvanised steel sheets or ceramic tiles while most of the ground area is covered with either concrete or asphalt as heat-absorbing materials. Green areas, if any, are scarce and scattered. Consequently, Hanoi is facing both urban heat island and flood as two great challenges, apart from traffic congestion, air pollution and water contamination. Over the past five years, the summer air temperature has increased from 40°C (in 2012) to 42.5°C (in 2017).
Figure 1. Green area per capita indicators in Asian cities [1] and in Hanoi’s ten central districts [3]

![Image of green area per capita indicators](image1)

**Figure 2.** A typical residential quarter in Hai Ba Trung district (central Hanoi) [4]

Furthermore, in 2016 and 2017, the city authority decided to cut down approximately 8,000 tall shade trees along Nguyen Trai road, Pham Van Dong road and Nguyen Chi Thanh road (Figure 3) for sky train and urban traffic improvement projects, despite the petition of scientists and the protest of the public. It will take at least 20 years to have the same exuberant shade trees again. In the meantime, as climate change keeps on going and the summer air temperature continues to rise, Hanoi and its inhabitants will have to cope with an uncertain future.

**Figure 3.** Landscape of Nguyen Chi Thanh road in Hanoi in 2014 (left) and in 2016 [5]
In Vietnam, urban ecology has just been considered over the past 20 years in view of landscape as the first step of a multi-scalar approach. For example, in her master’s thesis, Thu Trang Dam investigated into the history of landscape architecture in Vietnam and evaluated the quality of landscape (parks and street tree rows) in the historical centre of Hanoi and 17 socialist settlements between city ring road no. 1 and city ring road no. 2. She scrutinised the languages of trees and the arts of planting trees in living quarters and public building complexes and proposed a number of combining trees and plants of different species and sizes on three scales (single house, group of houses and entire living quarter) to improve the landscape and environment [6]. Choosing to study green areas only, she did not mention water surface as an important element in shaping landscape architecture and did not regard “bio-diversity” or “sustainability” as one of the key factors in securing a good living quality in cities in a broad sense either. Another expert, Tat Ngan Han, classified urban landscape in Vietnam into four main types (roads and streets, city squares, city parks and living quarters) and each main type consisted of several patterns. He emphasised the importance of water surface and recommended that it should be combined with green areas in several ways, depending on the typology and other natural conditions of the site, as well as on the socio-cultural context of the local community. Then he went into detail with the meaning and several design strategies of each pattern, but mostly in garden and park planning. He also proposed a list of 76 shade tree species and 53 ornamental plant species that can be grown in cities with characteristics of each species for reference, together with a step-by-step guidance for an urban landscape project [7]. Tat Ngan Han, just like Thu Trang Dam, did not take into account urban ecology as a complex system and as a biological resource that plays a vital role in both nature and the built environment. More recently, An Thinh Nguyen, published one handbook in landscape ecology in which he described a number of scientific terms related to landscape (including eco-zone, bio-diversity, multi-functional landscape, landscape matrix etc.) and addressed landscape ecology on territorial scale in a comprehensive manner by taking an interdisciplinary approach (combining biology, geography, life science and earth science) to ecology as the core of landscape in general [8]. However, he did not deal with landscape in view of urban planning or urban design as he specialises in environmental studies.

Today, in the context of environmental pollution, ecological degradation and rapid urbanisation with extremely high building density, the study on landscape ecology is a very important and urgent task, especially in theory, in order to pave the way for practical solutions that will help enhance the living quality for millions of inhabitants living in such a heavily polluted mega-city as Hanoi. The study becomes even more necessary, when most of research projects deal with landscape either on a large scale or in specific cases. Not only improving the landscape or protecting the environment, these studies should also accentuate the significance of ecology as a complex system and enrich biodiversity as one of the most important natural resources to human beings.

The paper is primarily based on theoretical investigations into landscape ecology in combination with current tendencies in urban landscape development. Then, a preliminary study on integrating two landscape systems into one complex and complete network within a neighbourhood as a basic unit shall be undertaken, and further developed into a more detailed concept for a city-wide application.

2. Landscape in view of ecology

By nature, landscape has been closely connected with agriculture, forestry, geography, archaeology, ecology, climatology, environmental science, life science, earth science, etc. throughout its long history of development. One of the most outstanding and influential theories in urban landscape is Ebenezer Howard’s book “Garden Cities for Tomorrow” published for the first time in 1898 in which he idealised a small city with 32,000 inhabitants planned on a concentric pattern with open spaces, public parks and six radial boulevards, 37 m in width each, extending from the centre. The garden city would be self-sufficient and when it reached its full population size, another garden city might be developed nearby. Howard envisaged a cluster of several garden cities as satellites of a central city of 58,000 people, linked by road and rail. With gardens, a city would remain a low building density while ensuring a high living quality [9].

Today, modern technology has broadened the horizons in sciences, including in landscape. Modern landscape has been integrated with and immensely supported by GIS, along with worldwide
communication network. These effective tools facilitate landscape management and observation of landscape change over the years. The scope of work is not limited to a country or a continent any more, but developed on planet scale in order to find solutions to global issues, such as climate change and natural disaster mitigation.

One of the modern theories to be highlighted is multi-functional landscape. Multi-functional landscape is shaped to bring more benefits to local communities. Urban planners, landscape and building architects should be responsible for landscape design in order to meet the needs of residents and help the whole system of urban landscape work as smoothly and effectively as possible, from large-scale consideration (city) to small-scale investigation (building). A successful creation of high-performance and multi-functional landscape will accelerate the expansion of regional landscape with an integration of the metabolism within an eco-system and landscape design process. The aim of this task is to establish a strong eco-system needed for a liveable city and all of its settlements where wellness as the number one factor can be secured. A multi-functional landscape design solution must take into account various factors that may have long-lasting influences on that area and include the human intervention in natural cycles to a certain degree. Thereby it is possible to establish or re-establish both forms of environment: natural environment and built environment, so that social sustainability as the final aim can be achieved and reflected in the following aspects:

- Supporting physical and biological activities of an eco-system by protecting and enhancing the local biodiversity in aquatic environment and terrestrial environment, in both quality and quantity;
- Providing services, including energy supply and public facilities;
- Regulating technical plans, reducing waste and reusing waste materials from city parks;
- Organising socio-cultural activities [10].

The two terms - biotope and ecotope - were used and developed respectively Friedrich Dahl in 1908 and Carl Troll in 1945. Biotope is an area of uniform environmental conditions providing a living place for a specific assemblage of plants and animals while ecotope is defined the smallest ecologically distinct landscape features in a landscape mapping and classification system. As such, they represent relatively homogeneous, spatially explicit landscape functional units that are very useful for stratifying landscapes into ecologically distinct features for the measurement and mapping of landscape structure, function and change [11]. Both concepts show a respect for ecology and describe an eco-system as a natural context that is vital to all kinds of human activity. Therefore, biotope and ecotope work as important measurements of landscape and pave the way for landscape to become an integral part of modern urban planning in the era of environmental crises.

3. Landscape in view of sustainability

Sustainability is understood as the practice of maintaining processes of productivity indefinitely - natural or human made - by replacing resources used with resources of equal or greater value without degrading or endangering natural biotic systems, and has been officially defined in the Brundtland Report “Our Common Future” as “a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains two key concepts: the concept of 'needs', in particular, the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs” [12].

Sustainability in urban planning and landscape design can be most clearly reflected in the efforts to maintain local biodiversity by focusing on vernacular flora and fauna as well as by closing the on-site water and material cycles. Moreover, renewable energy is encouraged to be generated and used on-site, most preferably and economically solar energy and wind energy. Similarly, rainwater as “gift from the sky” should be collected and used for various purposes instead of tap water. Saving for long-term use in the future is a guiding principle that should be applied to all other natural resources.

Socially considered, sustainability will not be achieved without the commitment of the public in any urban development project, including in landscape, because their behaviour has a strong influence on nature and landscape in general. It is the local people who decide how their living quarter may look
in terms of urban design and landscape quality. Their awareness is a driving force for their participation and action programmes aimed at the protection of environment, improvement of landscape and development of ecology towards sustainability. Local people are expected to play a much more active role in the decision making, implementation and monitoring of implementation as well as the co-management of urban landscape along with the local authority within their neighbourhood as the first step in the three-level hierarchy of urban landscape [13]

![Diagram of Bio-diversity](image)

**Figure 4.** Bio-diversity as a central factor of urban landscape and ecology [14]

### 4. Green and blue network

Green-and-blue network is the interconnection of a green system and a blue system within one area in a city as shown in Figure 4. The advantage of developing such a broad network is apparent. As a single factor, parkland or water surface can reduce the summer air temperature by 3°C, but when they are combined, the effect will be greater, by 5°C [15].

The green factor in a green-and-blue network consists of all kinds of vegetation, from grass to tall shade trees. In reality, there are three patterns for a settlement to develop: patch (point or small area), corridor (line that links points or small areas) and matrix (lines that intersect one another and cover a large area) [16]. Forman’s concept (patch-corridor-matrix) for the green factor will also apply to the blue element, with a fountain or pond (patch), canal (corridor) and lake or river (matrix).

As part of city greening, city farming is becoming popular again in Hanoi and other cities today, over three decades after the socialist plan economy and its self-sufficiency policy ended. The excessive use of pesticides, preservatives and chemicals in agriculture has risen up the public concern about food safety. That is the reason why more and more city residents have nowadays decided to grow vegetables and several kinds of fruits at home. They have made full use of every square metre available in and around their houses/apartments for this purpose: pavements, corridors, loggias, balconies, courtyards, backyards, terraces and roofs are all used as mini or medium-sized gardens. So, the greening rate in concrete-and-glass cities has considerably increased. This is an unexpectedly positive aspect of food poisoning. In view of urban ecology and sustainability, city farming needs to be further developed and integrated into the spatial planning of a neighbourhood, especially those with a high building density and low greening rate in central districts.

Located in the tropical zone, Hanoi should take full advantage of its bio-diversity and high rainfall (1,700 mm a year) [17] to enrich urban landscape. This amount of rain water can be collected to water an abundant number of plants and trees. A small part will percolate into the ground and keep the underground water level stable. Rainwater is often seen as a major cause of flooding. However, this argument is not absolutely correct, because rainwater has not yet been properly used. Actually, to an
urban eco-system, rainwater is much more important than most people often think. This is not just a landscape-shaping element or climate-regulating factor, but also provides an appropriate living environment for numerous species of plants and creatures. Grey water discharged from households and public buildings, after an on-site technical treatment process at a certain level of purification (about 70%), can be mixed with rainwater and stored in a retention pond or lake nearby where the natural cleaning process by means of phytoremediation continues to take place. Some of the remaining soluble substances, especially the ions of heavy metals will be absorbed by certain aquatic plants. These plants are quite diverse: some grow on water surface while others live entirely under water. It is recommended to raise different species of aquatic plants together in one place, since some can dissolve or decompose organic substances in water while others just absorb inorganic compounds. As a result, the purification will be more effective, and more importantly, biodiversity can be achieved. Once these plants absorb soluble substances in water to their maximum capacity, they can be removed and treated, and new plants should be put into that retention lake and another cleaning process will begin.

5. How to establish a green-and-blue network within a neighbourhood in central Hanoi?

Central Hanoi, as aforementioned, is characterised with high population density (14,700 inhabitants per km²) [18] and also a high building density (up to 70% in some wards of ten central districts) [4]. That means there is not much space left for a green-and-blue network. In these wards, there are merely tree rows along the streets which should not be accounted in the green area per capita indicator. Only a few wards and neighbourhoods make good use of a city park or a city lake nearby. However, the local residents share it with people from other parts of the city. Therefore, such an open and public place is usually overcrowded. It is important to establish a green-and-blue network within each settlement for local residents themselves. In other words, they will have their own abundant eco-system within a short walk from their homes and enjoy what nature brings back to them.

This green-and-blue network is an open museum to show children how beautiful nature is and educate them how to protect nature as well as living environment. Apart from regulating the microclimate, storing rain water, improving the landscape and encouraging social communication, this network plays a much more essential role in restoring, maintaining or enriching bio-diversity and acts as a mini bio-sphere in city.

With this in mind, a settlement-wide network should be established in three levels: private (single house or building), semi-public (group of houses/buildings) and public (entire settlement). A broad range of plants can be applied and vernacular plants will be prioritised. Creating identity is a higher requirement in city greening. The plants which contain poisons or have unpleasant smells will not be selected for a safety reason. When the plants grow well enough, they may attract birds, insects and small animals. An open water network should be integrated and it is recommended to turn illegally occupied public places into water bodies which provide an ideal living environment for certain species of aquatic flora and fauna. In modern urban design, underground public buildings and parking areas are quite common in order to restore the ground to nature. Similarly, green roof and façade will also maximise the naturalisation and ecologicalisation in a densely constructed urban area.

Some residents may feel anxious about open water areas as larvae of pest insects that annoy them may proliferate in summer months. Therefore, no canals ponds or lakes may be designed within a living quarter. Nevertheless, the case of the Cheonggyecheon river in Seoul transformed into an underground sewage tube in the 1960’s and restored as a beautiful man-made flow as well as a tourist attraction site 40 years later is still a good lesson to learn. In the food chain theory, larvae of pest insects are eaten by small freshwater fish. If fish are put into lakes and ponds, they can control the development of larvae.

The depth of a canal, a pond and/or a lake within a living quarter must be calculated to ensure that it will be safe for children. For a bio-retention pond or lake, the water depth should be 0.4 m within 5 m distance from the bank. A rainwater canal is normally 3 to 4 m in width and 1.5 to 2 m in depth in order to drain away rainwater in case of downpour. It is necessary to put up high inox railings all along the canal on both sides to prevent children from climbing and falling into water.

Another crucial point in landscape design for cities and towns to be noticed and practised is creating permeable ground surface, so that rainwater can percolate into the deep soil layers and add a
certain amount to the level of underground water and help keep it stable. It is suggested to use grassland or sand surface on top of soft soil for children’s playgrounds, grass-filled paving blocks for car-parking areas and pathways, and porous concrete or permeable asphalt for main roads.

**Table 1.** Recommendation of establishment and development of green-and-blue network within a neighbourhood in central Hanoi [19]

| Category                  | Green and blue network | Green factor | Blue factor |
|---------------------------|------------------------|--------------|-------------|
|                           |                        |              |             |
| Level 1: Private          |                        |              |             |
| Housing pattern 1: Villa or garden house | Garden, Roof, Terrace, Frontyard, Courtyard, Backyard, Balcony, Loggia, Corridor, façade, Aquarium, Canal, Pond, Lake | ● ● ● | ○ ● ● ● |
| Housing pattern 2: Shop house |                        |              |             |
| Housing pattern 3: Row house |                        |              |             |
| Housing pattern 4: Flat or apartment |                        |              |             |
|                           | Playground/mini-park, Tree row along pathway | ● ● ● | ○ ● ● ● |
| Level 2: Semi-public      |                        | ● ● ● | ● ● ● |
|                           | Public park, Tree row along pathway | ● ● ● | ● ● ● |
| Level 3: Public           | ● ● ● | ● ● ● | ● ● ● |

Note: ● Recommended ○ Optional

**Table 2.** Recommendation of species for green-and-blue network within a neighbourhood in central Hanoi [19]

| Space level       | Green area                                                                 | Water surface                                    |
|-------------------|-----------------------------------------------------------------------------|--------------------------------------------------|
| Private           | Vegetables, medicinal or spice herbs, flowers, creeping plants, ornamental trees, fruit trees, etc. | Water lily, algae                                |
| Flora             | Birds                                                                       | Gold fish                                        |
| Fauna             |                                                                             |                                                  |
| Semi-public and public | Grass, flowers, creeping plants, ornamental trees, fruit and shade trees, etc. | Algae, water lily, lotus, reed, coon tail, umbrella palm, water hyacinth, etc. |
| Flora             |                                                                             |                                                  |
| Fauna             | Birds, butterflies, crickets, earth worms, ants, bees, beetles, lady birds, etc. | Fish, shrimps, crabs, snails, water spiders, frogs, etc. |

Thus, the step-by-step implementation of ecologicalising a settlement with a high building density in central Hanoi will be recommended as follows:
- Step One: Conserving all the existing open public places, mostly green areas, for future use as mini-parks or flower gardens in semi-public areas and medium-size parks in public areas;
- Step Two: Acquiring the land area illegally occupied for various land-use purposes for future use as water surface, retention ponds in semi-public areas and lakes in public areas;
Step Three: Planning two medium-size parks/ponds or four small parks/ponds may be considered, subject to the size of the land area, instead of one large park/lake;

Step Four: In all cases, green and blue factors are coupled together and planned in a way that ensures an even distribution and easy access;

Step Five: Parks and gardens are interconnected with rows of trees along roads and streets. Similarly, ponds and lakes form a water network with canals;

Step Six: Selecting appropriate species of plants and animals to grow/raise in terrestrial and aquatic environments. Applying the concepts multifunctional landscape, biotope and ecotope. As time goes by, new plants will grow and more animals will come, hereby diversifying the local bio-sphere;

Step Seven: Integrating city farming in each household, making full use of open areas available;

Step Eight: Undertaking regular maintenance of parks and ponds/lakes.

Figure 5. Interconnection of green and blue factors into an eco-network within a neighbourhood in central Hanoi [20]

6. Conclusions
Green and blue factors, as clarified, are indispensable elements in all cities and living quarters, because they will bring great benefits to the local communities, especially in central districts where the needs for more green areas and water bodies are stronger than in the suburbs. Today, a city and even a settlement must be a complete eco-system and a rich bio-sphere.

As two major components of this bio-sphere, green and blue factors can take various forms. They should be combined and flexibly applied to all open spaces and public places available, either on a small scale or a large scale. This green-and-blue network can be emphasised as an outstanding feature of a built environment that is worth living for people. Moreover, it will represent a new lifestyle, when everyone understands the importance of nature and ecology and will do his or her best to achieve the goal.

From a neighbourhood as the first step, this concept will be upgraded to a city-wide level as a more complex system which requires further investigations. In this long process, policy makers, landscape designers, life scientists and project managers need to work with local communities in realising such a holistic concept.

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