QATAR UNIVERSITY

COLLEGE OF ENGINEERING

THE SUSTAINABLE URBAN EDGE DESIGN TOOLKIT FOR COASTAL CITIES, THE CASE OF DOHA, QATAR

BY

ALBANDARI SALMAN A H AL-HARAMI

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COMMITTEE PAGE

The members of the Committee approve the Thesis of
ALBANDARI SALMAN A H AL-HARAMI defended on 22/04/2019.

Dr. Shaibu Bala Garba
Thesis/Dissertation Supervisor

Dr. Fodil Fadli
Thesis/Dissertation Supervisor

Dr. Djamal Boussaa
Chair, Committee Member

Dr. Salim Ferwati
Internal Examiner, Committee Member

Dr. Benachir Medjdoub
External Examiner, Committee Member

Approved:

Abdel Magid Hamouda , Dean, College of Engineering

ABSTRACT

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Title: The sustainable urban edge design toolkit for coastal cities, the case of Doha, Qatar

Supervisor of Thesis: Dr. Shaibu B. Garba.

Dr. Fodil Fadli.

The city of Doha is undergoing rapid development in various sectors. Mega design projects and developments can be found scattered all over the city. However, when it comes to the overall urban fabric and masterplan of Doha, there is no clear vision or guidelines that are intended to be followed concerning the city's urban and coastal edge design.

The coastal city edges hold great opportunity both socially and environmentally when tackling problems facing the urban fabric. The edged have limitless possibilities of mitigating climate, environmental and urban problems. In Doha, QNDF 2032 introduced the concept of the greenbelt and the coastal management of the city, however, there are no clear set of tools, guidelines or design specifications that could be followed for the implementation of these concepts.

The thesis focuses on designing the toolkit required to fill the gaps of QNDF through the methodological approach defined as: (1) data collection, (2) filtering and analysis and (3) validation to assist in achieving the QNV 2030 following QNDF 2032. The outcome is a fully developed draft of the sustainable urban edge design toolkit for coastal cities that included a total of 47 design elements in total, along with a validation on the case of Doha which achieved 68% of the design elements. Future work and limitation are also explored.

DEDICATION

To my great family and friends

ACKNOWLEDGMENTS

In the beginning I would like to thank my family for supporting me through this journey. I am also thankful to everyone who assisted me in this project; including my supervisors who guided me through, as well as my colleagues and friends.

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CHAPTER 1: PROBLEM STATEMENT

1.1 Problem Statement

As the urbanization continues, a large amount of the world's population is expected to live in urban settlements by 2050. Qatar as most 21st century countries, is faced with rapid development which is leading to urban, environmental, social and economic problems.

The urban edges are developed as a practical management tool within the urban design discipline in order to mitigate several problems and issues within the urban fabric, promoting a more sustainable, compact and connected urban development. The urban edges promotes various objectives including growth management, nature protection, resources preservation, identity making, land use management and social integration (Cilliers, 2009).

Coastal cities by nature, like Doha, have the opportunity to develop both their blue coastal edge and green urban edge through multiple strategies; especially in order to enrich their edge resilience. Those strategies can work in parallel targeting both the (1) waterfront blue edge regeneration, focusing on the coastal edge of the city and the (2) urban greenbelt, which is the green urban edge surrounding the urban fabric or periphery of the city.

Qatar, also as a rapidly developing country, is now introducing the urban greenbelt concept through a social, environmental and economical approach in order to create a more sustainable urban edge. There is also a focus on regenerating and revitalizing the coastal waterfront of the city. Both of these design concepts were introduced through Qatar National Development Framework 2032 (QNDF) which concentrate on developing these concepts through various strategies of sustainable development and urban regeneration. However, there is no set of defined tools or guidelines in the QNDF to implement the strategies. Hence, this thesis plan to address the following:

(1) Analyze the current problems facing the urban fabric of Doha

(2) Study existing design guidelines for the development of blue and green edges

(3) Develop and validate a toolkit for sustainable edges of coastal cities covering the two strategies the (1) greenbelt surrounding the city of Doha and the (2) waterfront regeneration of the Corniche

1.2 Thesis Structure

The second chapter of the thesis discusses the theoretical background behind sustainable, green, and blue urbanisms including the exploration of the concepts and different case studies. The contextual background of the city of Doha is discussed in the third chapter; covering its characteristics, national vision and frameworks and current faced challenges. The sustainable urban edge design toolkit methodology is discussed in the fourth chapter. The fifth chapter discusses the toolkit development covering the site analysis of Doha, filtering, analysis and validation of the toolkit's design elements. The final outcomes including the conclusion, contribution, future work and limitations are discussed in the sixth chapter.

CHAPTER 2: THEORETICAL BACKGROUND

55% of the world population lives in the cities currently, by 2050 it is expected that this percentage will increase to 68% with 2.5 more billion moving to urban areas mostly in Asia and Africa (United Nations, 2018). Due to the rapid development and urbanization most of the post 20th century cities suffer from various problems ranging from urban sprawl to non-functional expansion. These problems are shown when studying the cities structure, use and form. Moreover, this expansion leads to crucial imbalance between the city centers and periphery lands; where the (1) city centers get more dense in regards to buildings, functions and population leading to vertical expansion with higher land values and rents, where the (2) suburban periphery have lower density of buildings, functions and population leading to more horizontal expansion (Krier, 2009).

The rapid urbanization of cities triggers certain design issues in the urban development. The economic growth is usually what leads the development of most postmodern urbanization focusing on uncoordinated areas and on focused projects, neglecting the larger urban fabric of the city leading to several concerns like: sustainability, climate change, resource availability, public health, and socio-economic problems. However, nowadays planners acknowledge and understand their role clearly of managing these problems and are trying to build a coherent and integrated development focusing on both the natural and urban systems (Macdonald & Larice, 2013). Planners are tackling the problems through various design movements yet mostly using the same design strategies, this is in order to reach the vision of a dense, compact urban form with high density of buildings and users, increasing the green spaces and walkable avenues with more functional and balanced land use taking into consideration the environment, socio-economy and physical aspects of cities.

With all reference to above, climate change is one of the biggest problems we are facing in the 21st century, of which is forcing us to think more about our cities urban form and their development plans. Reducing and controlling the greenhouse gases (GHG) is one of the main challenges most cities are trying to mitigate and incorporate in their future development plans

and policies. Various cities in Europe and the United Sates (USA) have already developed methods and procedures in order to try and control the GHGs (Krause, 2011; Reckien et al., 2014). Most of these strategies are focused on urban sustainability and leads to urban regeneration or rehabilitation with the focus on long-term plan. The sustainable urbanism is highly focused on the introduction of urban green spaces of which can be greenbelts, public parks, garden or any form of open public space of which is used by pedestrians (Sáncheza, Solecki, & Batalla, 2018). The introduction of those urban green areas needs not only a set of strategies, but it is to be adapted as a consistent mean of planning primarily (Matthews, Lo, & Byrne, 2015).

Sustainable planning of cities is not only focused on Green Urbanism, but it is also integrated with Blue Urbanism, especially when developing and planning coastal cities taking into consideration that the water edge is a main part of the city's structure of which hosts huge possibilities and opportunities for development. Coastal cities are a special case to investigate to understand the fusion between green and blue urbanism, in relation to sustainable urban regeneration for the city. This urban regeneration process can be in parallel focusing on both the greenbelt and the waterfront edge of the city.

In this regard, this chapter is an exploration of the most relevant theoretical concepts and definitions of sustainable urbanism and its principles, green and blue urbanism and their application, and a summary of the best practices for both concepts.

2.1 Sustainable Urbanism

Exploration of Concept

During the late 1960 to the early 1970, ecological and urban crises arose of which triggered the introduction of the sustainable urbanism movement (Marcotullio & McGranahan, 2007). Ecologically, the hasty industrialization period of 200 years showed its effect through various scales on the environment (climate change and Global Warming) reaching a collapsing point, additionally the industrial period was marked as a failure socially (Lehmann, 2010). Moreover, the urban crisis showed its effect due to two reasons, (1) the rapid sprawl of cities into the outskirts and farmlands surrounding them and, (2) the rapid expansion leading to extreme urban deterioration, effecting the quality of the urban life (Marcotullio & McGranahan, 2007).

In general, sustainability is defined as meeting the needs of the present without compromising the ability to meet future needs. However, when sustainability is linked to the urban context, it is considered as a new framework for the purpose of the development, design and management of cities (Haas, 2012) It is highly associated with architecture, urban planning and urban design, and takes great consideration in creating an equitable urban development both on the economic and social levels; therefore, there is a strong synergy between sustainable development and social justice, resilience, health and safety and green economic growth. (Adhya, Plowright, & Stevens, 2010b; Haas, 2012; Kasioumi, 2011).

Sustainable urbanism is considered as a self-aware movement of which proposes various tactics and principles for applying sustainability of urban design (Lance Jay Brown, David Dixon, & Oliver Gillham, 2014). According to (Hill, Paep, & Reeth) as shown in Figure 1, there are six fields of which sustainable urbanism is concerned with, which are: (1) Social Impact, (2) Spatial Quality, (3) Environmental quality, (4) Technical quality, (5) Economic impact and (6) Process quality, of which each field is concerned with more specific aspects and themes as shown in Figure 2.

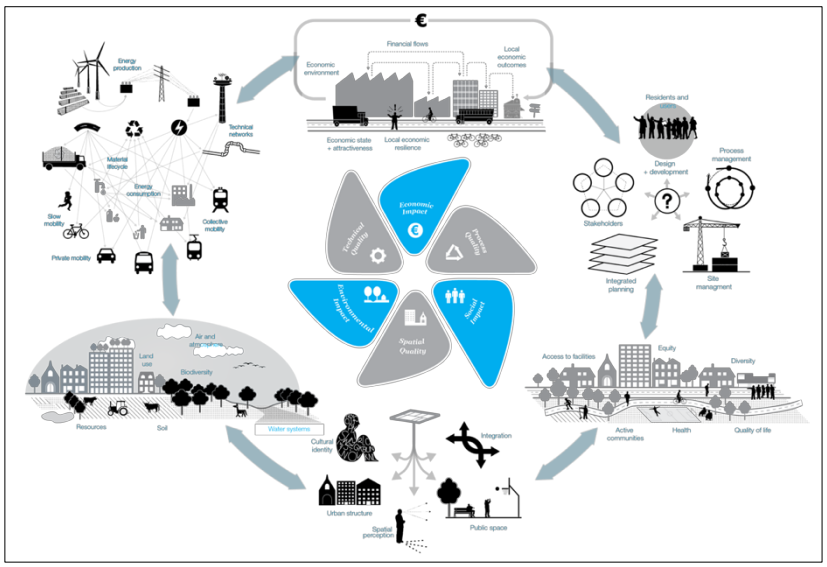


Figure 1 principles for applying sustainability of urban design, Source (Hill et al.)

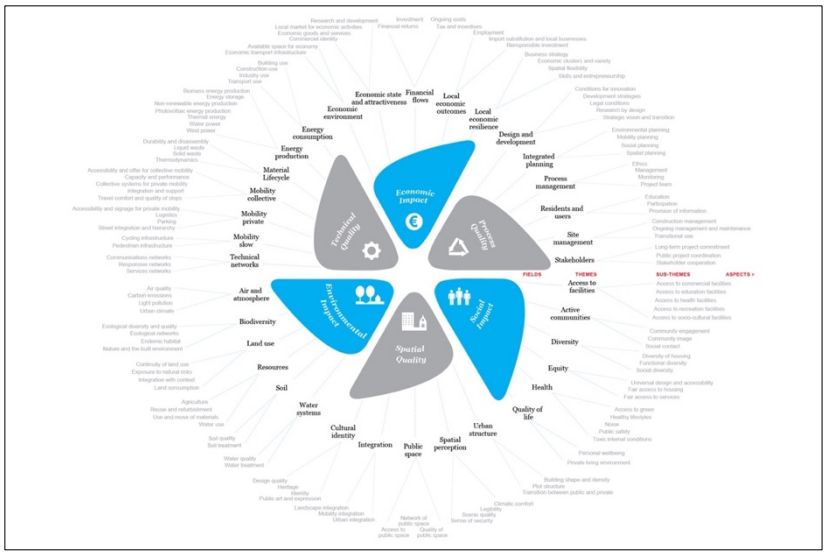


Figure 2 Sustainable Urbanism Fields, Source (Hill et al.)

Principles of Sustainable Urbanism

The principles of sustainable urbanism according to the Freiburg charter of which was developed in accordance with the city of Freiburg which reflects an exceptional example of sustainable urbanism; introduced 12 sets of principles of which are applied in accordance with the settlement typology. The principles introduced in order to achieve a sustainable city are: (1) City of Diversity, safety and tolerance, (2) City of neighborhoods, (3) City of short distance,

(4) Urban development along public transport routes (High-Density Model), (5) City of education, science and culture, (6) City of commerce, economy and employment, (7) City of nature and Environment, (8) City of quality design, (9) City of long-term planning, (10) City of communication, (11) Reliability, obligation and fairness, and (12) City of cooperation, participation and partnership (Daseking, 2014). Those principles are the basis for the cities objectives as discussed in the charter in order to have sustainable development by: (1) maintaining local identity and encouraging cultural variety, (2) proposing and developing public transport and taking them into consideration when developing cities, (3) source management and improvement of both underdeveloped and developed parts of the city, (4) introducing and linking green area, (5) construction and public space quality, (6) social equity and efficient use of land, (7) developing various housing options, (8) securing and creating innovative jobs, and (9) encouraging involvement of diverse parties (Daseking, 2014).

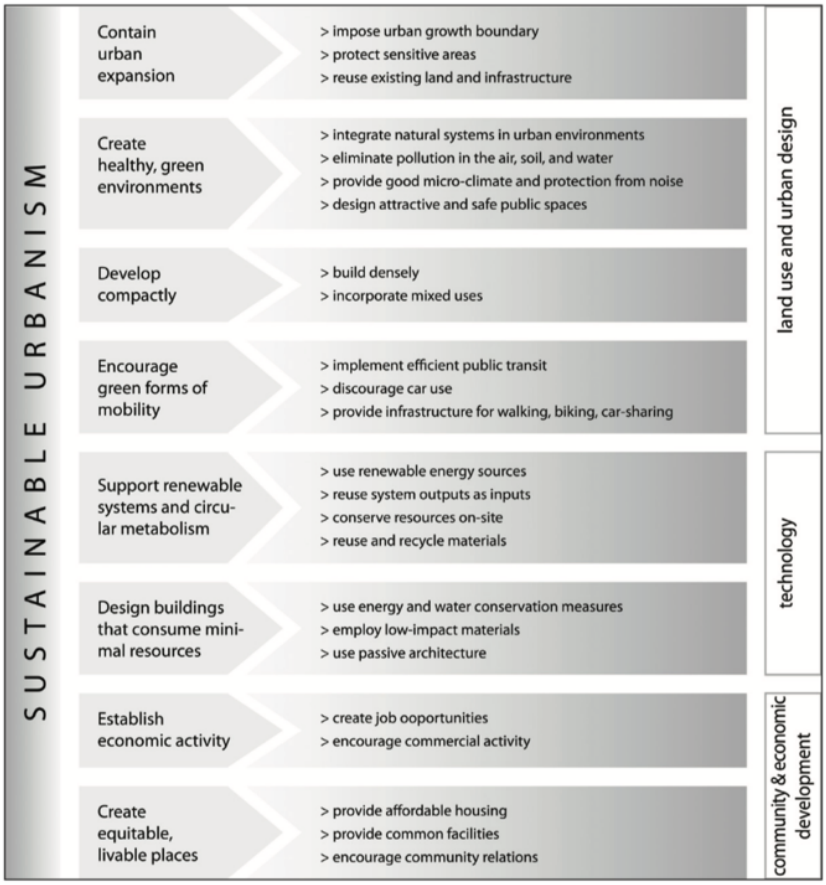


Figure 3 Principles of sustainable Urbanism, Source (Kasioumi, 2011)

In addition to these 12 principles set by the charter, Farr (2008), author of "Sustainable Urbanism: Urban Design with Nature", gives a definition statement with five main elements that lead to the creation of a sustainable urban development: (1) Compactness of city form, (2) Biophilia and design with nature elements, (3) High performance of buildings and infrastructure, (4) Sustainable corridors within the city, and (5) Sustainable neighbourhoods. In general, all these principles essentially support planning principles that produce a compact built form of vernacular urban lifestyle, and, with our modern needs, promote energy efficiency, and support less car-dependency.

Impacts and Advantages

One must understand and realize that sustainable urbanism is not an approach that targets a specific physical form of cities but is a concept that encompasses the non-physical

processes and immaterial aspects of the city too, especially socio-cultural processes, and government planning processes. Therefore, its effect starts primarily with the processes and operative approaches and eventually results into a sustainable urban composition. Starting with the social and societal benefit of sustainable urbanism, access to clean, green, inclusive spaces within the public realm is an integral element of the sustainability of the community. Social equity and justice are just as important as climate change and energy consumption (Adhya, Plowright, & Stevens, 2010a). This is relative to the social improvement and public good of urban design, but in relation to the creation of a responsive place for people; sustainability is looked at in relation to the creation process of urban design. Therefore, an essential advantage of sustainable urbanism is the process of place-making. According to Schneekloth and Shibley (2000) humans often transform and alter the places they live in through the creative process of design, and this in its own core is an act of sustaining their communities. Humans sustain their communities by changing them, controlling them, and constructing them into what suits them.

A very fundamental aspect of sustainable urbanism is its benefits to the health of the inhabitants of the city (Adhya et al., 2010a). According to Rorty (1999), the benefit of sustainably for health is a core value of the concept; it relates to the substance of the well-being of human health, and the advancement of human capacity through time. In addition to the health of inhabitants, the health of environment is an essential benefit of sustainable urbanism. By promoting the integration of nature and contact with green spaces, the ecological performance of cities increases, by promoting public transport and compact city forms, the use of the private car decreases and thus environmental pollution decreases, and by promoting high-performance buildings, there would be less energy consumption and consequently less damage to the environment (Dannenberg & Wendel, 2011).

Related Urban Movements

While sustainable urbanism is an urban movement with clear and direct goals of sustainable quality of life and environmentally-aware urban development, a few other urban movements were born from it, such as smart growth, new urbanism, and green buildings

movements. These are said to be the philosophical and practical bone for sustainable urbanism (Farr, 2008). While all of them stem from the same root, their sustainability approach and focus is different. For example, smart growth is considered to be the environmental conscience for sustainable urbanism, whereas new urbanism is primarily an urban design movement. Other urban planning movements include the landscape urbanism, which revolves around the design and planning of city by organizing its natural landscapes, by placing the ecology of cities in the forefront of the planning drivers.

2.2 Green Urbanism

Exploration of Concept

Green urbanism is concerned with the interaction between the urban environment and the ecosystems in order to generate a beneficial community for both people and natural environment (ŞTEFAN, 2016). The green urbanism movement encourages the dense development, energy efficiency, the revitalization of post-industrial zones and indorsement of sustainable development both socially and environmentally (Timothy Beatley, 2000; ŞTEFAN, 2016). It is defined by Lehmann (2010) and Roggema (2017) as an interdisciplinary movement, of which needs the collaboration between various disciplines such as: urban planners, ecologists, engineers, landscape architects, sociologist, economist, etc. Green urbanism unites the views of those disciplines where for example, ecologists are concerned with ecological footprint, pollution is tackled by public health and real estate prices are the concern of economists (Roggema, 2017).

Green urbanism is described by Lehmann (2010) as common sense urbanism, as it focuses not only the technical aspects of creating a sustainable city, but it is about how to create a health community both environmentally and socially. 15 principles are introduced with the triple-zero concept of creating zero energy use, waste and emission, to be addressed when approaching urban design projects, however each unique design requires the emphasis on different principles following a specific approach. Furthermore, green urbanism is said to be a movement that adopts a conceptual urban model of zero-emissions and zero waste, and transform existing urban area in post-industrial regeneration (Nunes, 2013; Lehmann, 2010).

Principles of Green Urbanism

The green Urbanism principles as shown in Figure 4, includes: (1) an understanding of the climate and context, (2) renewable energy, (3) zero waste, (4) water management and quality, (5) biodiversity, (6) sustainable modes of transportation and compact polycentric cities, (7) the use of local materials, (8) densifying existing districts with mixed use developments, (9) development of green buildings and districts, (10) focusing on livability and quality of life, (11)

local food production and supply, (12) fostering the identity and sense of place through balancing conservation and new developments, (13) the urban governance and leadership concerned with policies and decision making, (14) education and knowledge, and (15) developing countries strategies (Lehmann, 2010; Roggema, 2017; ŞTEFAN, 2016).

Principle	Aspects
Climate and context	Site's climate conditions, orientation and compactness, landscape, topography and resources, maintain complexity, own methods, and tailored strategies for every district take advantage of local potentials
Renewable energy	Availability of local renewables (energy potentials [72], city district as a producer of energy, distributed energy supply though decentralized systems, local storage, smart grid, energy efficiency, co-gen, cascading exergy principles, intelligent building management.
Zero-waste	Circular, closed loop, turn waste into resource, reduce, reuse, recycle, and compost waste to produce energy, remanufacturing, balance in nitrogen cycle
Water	Reduce consumption, efficiency of use, water quality, aquatic habitats, city as a water catchment area, storm water retention and flood management, rainwater harvesting, local treatment of waste-water, safe water and sanitation, algae, integrated urban water cycle planning, black and grey water treatment, dual water systems, drought resistant crops
Landscape and urban biodiversity	Local biodiversity, habitat, ecology, wildlife rehabilitation, forest conservation, urban vegetation, inner city gardens and urban agriculture, mitigating Urban Heat island effects, tree planting, restoring stream and river banks, de-pavements, carbon storage
Sustainable transport and good public space in compact poly-centric cities	Public space network, post fossil mobility, access to public transport, safe bicycle ways, smart vehicles, walkeable city, streetscapes for healthy active lifestyle, medium dense housing typologies
Local materials with less embodied energy	Advanced materials technology, local materials, modular prefabrication, lightweight structures, disassembly, resource recovery, reuse building components
Density and retrofitting existing districts	Densification of the city, mixed use urban infill, retrofitting inefficient building stock, better land use planning, public space upgrading, adaptive reuse, city above the city, self-sufficiency
Passive design for buildings and districts	Low energy, zero-emission design, reduce energy use, compact solar architecture, bioclimatic architecture, design for disassembly, solar architecture, flexibility in plans, energy generating buildings
Liveability and mixed use	Affordable housing, healthy community, social inclusion, mixed use, liveable and flexible housing typologies, secure tenure, diversity, integrating a diversity of economic and cultural activities,
Local food and short supply chains	Local food production, regional supply, urban farming and agriculture, community and allotment gardens, roof gardens, urban market garden, paper bags, recycling, organic produce
Identity and sense of place	Public health, cultural identity, urban heritage, air quality, distinct environment, grassroots strategies, affordable studio space, creativity of government and citizens, health, activities and safety
Urban governance and leadership	Evolutionary and adaptive policies, decision making, and responsibility shared with empowered citizenry, enabling citizens, updating building codes, improve planning participation, integrated public awareness, legislating controls on density and urban sprawl, support high quality densification, finance low-to-no-carbon pathways, eliminate fossil fuel subsidies, certify urban development projects
Education, research and knowledge	Up-skilling, knowledge dissemination, primary and secondary school teaching programs, university as a think tank, redefine education of architects, foundation of centre for sustainable urban development

Figure 4 Principles of Green Urbanism, Source (Roggema, 2017)

Urban Forestry

According to the report published by the Food and Agriculture Organization (FAO) of the United Nations, an urban forest is the network of the vegetation in the urban and peri-urban area. These are considered the backbone of the green infrastructure within cities (SALBITANO, BORELLI, CONIGLIARO, & CHEN, 2016). Urban forests can contribute to the sustainable development of cities in many ways such as improving the health and well-being of their users, contributing to food production, helping in sanitation of water by regulating the urban hydrological cycle and climate change mitigation, and enriching the ecological biodiversity within cities. The report document has a set of guidelines to maximize the benefit from urban forests to local and global issues. The guidelines and the most relevant policies are summarized in Table 1 below. In addition to the guidelines listed, the socio-cultural value of urban forests is listed as a vital benefit that helps communities to sustain their social ties and cultural identities across generations and in various urban scenes.

Table 1 Urban forestry guidelines according to the FAO 2016

Criteria	Policy and legal framework	Planning, design, and management
Human health and well-being	• Strategies to maximize the environmental benefit • Promote collaboration between sectors for public greening planning	• Ensure the availability, accessibility, proximity, and security of urban forests • Utilize urban forests for noise reduction and air filtration functions • Include urban forests in the design guidelines of schools and hospitals
Climate change	• Policies to maximize tree cover to match carbon reduction requirements • Consider the energy saving effect • Direct and indirect incentives for the maintenance and sustainability of urban forests	• Employing an ecological approach in maintaining and managing urban forests • Consider the impact of climate change on the urban forest and their growth and sustainability • Actively manage and assess urban forests for their benefit and performance
Biodiversity and landscapes	• Bring authorities departments together to facilitate the management and coordination • Implement local biodiversity plans • Promote multi-stakeholder approaches to address specific drivers of biodiversity	• Biodiversity conservation as a planning objective • Create a detailed ecological map inventory • Planting endangered local species of trees • Promote local ecosystem restoration programs

Economic benefits and green economy	• Policies and incentives for green businesses • Planning goals for turning grey to green	• Short-term and long-term urban forest management plans • Design strategies for green roofs to save energy • Utilizing bio products and urban waste in the management of urban forests to minimize costs
Land and soil degradation	• Policies related to the sustainable use and re-use of soil • Treatment and disposal of industrial waste • Regulations for tree-protection zones	• Related to preventing land and soil degradation, such as the development of greenbelts • Relation to land and soil remediation and restoration, such as programs of tree-based restoration processes.
Food and nutrition security	• Policies to facilitate public engagement in productive urban forest • Policies to enable food production in urban forests • Incentives for start-up companies engaging in urban forests	• Incorporate productive community urban forests in design plans of communities • Branding, marketing, and promoting food that is a product of urban forests

Greenbelts and Greenways

The greenbelt is a planning policy of which is mostly used to surround urban areas usually undeveloped wild and agricultural lands. It is used as a policy to mitigate urban development, improve environmental and socio-economic problems of cities. The greenbelt acts as a buffer or transition zone which stops the hasty urban development giving a special area for the wild to be established (Chen & Den, 2017). It originated as an urban movement from Europe and is considered one of initial concepts of green planning (Cohen, 1994). The policy of greenbelt planning is concerned with both urban and climatic aspects, a climatic greenbelt have a forest nature of which mitigates the weather condition (e.g. Sandstorms) and, an urban greenbelt's main function is to control urban sprawl. According to Bengston and Youn (2006), an urban greenbelt is a dividing boundary used to separate the urban area from the rural area, where areas outside of the line are categorized as rural area, and areas within the line are utilized for the city land-uses. It is important to note that urban greenbelts are not intended to be permanent, yet they are used as a regulatory tool to slow and limit urban growth (Nelson, 1994).However, over the years greenbelts became farther multi-functional, acting as a nature

conservation and offering recreational prospects of which can be seen implemented in the Greater London greenbelt (Amati, 2008).

Another European example that shows the integration of various functions is the European greenbelt, of which combines all historical, cultural and ecological aspects, yet again holds a great importance for recreational purposes as well. This is because green infrastructure is not viewed as an environmental tool only, but a planning and design tool that integrates recreation, culture, ecology, energy, sewage, flood control, storm water management and so on. Also, it focuses on having more native vegetation of which adds a more positive aspect to it.

In China, Beijing is the first city to implement the policy as an urban sprawl restricting tool, which has deviated from its main purpose and has eventually become a recreation and environmental protection instead. The greenbelt in China takes a semi-circular shape around the outer highway of the city, similar to all greenbelts in Beijing, Shanghai, and Xi'an, and it is considered an approach towards desert restriction (3-North Forest Program). In Beijing, the greenbelt consists of two parts, an inner belt and an outer belt. In Shanghai, the greenbelt is used to separate the urban and nearby areas for ecological and environmental improvements.

Table 1. Comparison of the application of green space planning and management concepts in China and Scandinavia

Green concepts		China	Sandinavia
Green Belt/ Green Wedges	Structure		
	Function	Controlling urban sprawl, nature conservation, woodland harmony, controlling desert expansion, biodiversity conservation	Controlling urban sprawl, nature conservation, untouched green space, woodland harmony, biodiversity, cultural history, living environment, and lessons from nature
	Planning Methods	Ring-road planning, aerial seeding and cash incentive for planting trees	Stakeholders from nature conservation and sustainable development
	Scale and Example	City scale (Green belt plan of Beijing) and Regional scale (Three-North Shelter Forest Program)	Local scale (Eco-park in Stockholm), City scale (ten Green Wedges of Stockholm) and Regional scale (European Greenbelt)

Figure 5 comparison table showing the application of green space planning concepts in China vs Scandinavia, Source ((XIU, IGNATIEVA, & BOSCH, 2016)

Another comparable policy and green concept that is introduced by researchers and decision makers is the greenways and green corridors, which are opposite to greenbelts, are integrated within the urban fabric and have a linear nature instead of wrapping around cities (Chen & Den, 2017). They are used to connect either the secluded urban areas or are interwoven with the urban fabric along the transportation corridors in the form of boulevards and parks (Parker, Head, Chisholm, & Feneley, 2008; Viles & Rosier, 2001; XIU et al., 2016). The main benefit of this urban greening concept is linking parks and gardens with each other in efforts to create an interconnected fabric of green spaces that supports and compliments the urban fabric (Taylor, Paine, and FitzGibbon, 1995).

Objectives and Benefits of Greenbelts

The main and ultimate benefit of most greening policies is environmental protection and improvement, but that happens in different ways and approaches in each green policy. Greenbelts, whether urban or climatic, eventually protect and reserve natural zones and rural areas from the effect of urban growth or the harsh environment. They also help in air filtration and decrease air pollution and enable more access points to nature and country side for health benefits and educational or recreational services (Yang and Li, 2016). These greenbelt areas can be then utilized for public use as camping areas or public forests that enable interaction with nature's habitats and animals. This consequently benefits the psychological and physical health of its users.

In addition to these benefits, greenbelts can be widely utilized as public spaces for the community. They can be part of the recreational public spaces network, or the ecological and environmental. In his article about the Business Side of Green, (Lao, 2015) discuss the viability of green-oriented businesses and how such green spaces can and should, in addition to their environmental benefits, bring economic benefits.

Policies and Legislations for Greenbelts

The main purpose of such a planning policy is to achieve sustainable development. The policies and legislative acts are set in relation to economic, social, or environmental objectives and outcomes. According to the National Planning Policy Framework of the UK (2012), there are six sets of legislation categories for the greenbelt policy, and they are the following:

1. Set Boundaries: establishing boundaries and specific areas of the greenbelt that can only be altered under exceptional circumstances.
2. Maintain Sustainable Development: planning authorities must always point out that the main objective of a greenbelt policy is sustainable patterns of development to benefit the community locally and globally.
3. Identify Safeguard Land: while urban development must be restricted within the greenbelt area, a safeguard land between the greenbelt and the urban area might be necessary to meet the long-term urban development needs in the future, in specific areas.
4. Prioritize Preservation: greenbelts can pass through urban areas of environmentally-preserved areas, therefore proper and adequate means of preservation or conservation must be taken into account where necessary.
5. Prevent Harmful Development: harmful development to and within the greenbelt must be prohibited unless necessary
6. Exceptions for Developments through the Greenbelt area: construction of the following establishments can be permitted within the greenbelt:
    - Buildings that serve for agriculture and forestry,
    - Buildings that provide appropriate facilities for outdoor sports and recreation activities,
    - Buildings that are replacements for previous ones with the same buildings specifications

- Buildings and projects that serve affordable housing for the local communities in relation to local development plans.

For cases of greenbelt extension, the following legislations apply:

7. When the boundaries and extents are already established, an additional greenbelt can only be added in special circumstances
8. In the case for proposing a new greenbelt, the local authorities should
    - Demonstrate and present proof of why other planning policies are not adequate
    - Present any major changes or circumstances that lead to the adoption of exceptional measures
    - Show and evaluate the consequences of the proposal in relation to sustainable development
    - Demonstrate the need for an additional greenbelt and how it can serve the objectives of the concurrent policies and frameworks.

Cases Studies of Urban and Climatic Greenbelts

Seoul urban greenbelt

The Seoul Greenbelt was part of the Korean government policy that was introduced in 1971 to control the extremely rapid economic and population growth of the country and resulting rural-urban migration rate (Song, 2003). The greenbelt areas were referred to as Restricted Development Zones (RDZs) as a part of the National Comprehensive Physical Plan. This policy was managed by the Ministry of Construction and Transportation and was activated in 1971 in 4 phases. The Greenbelt is 15-35 km wide, and total Greenbelt zone is 768.6 km2

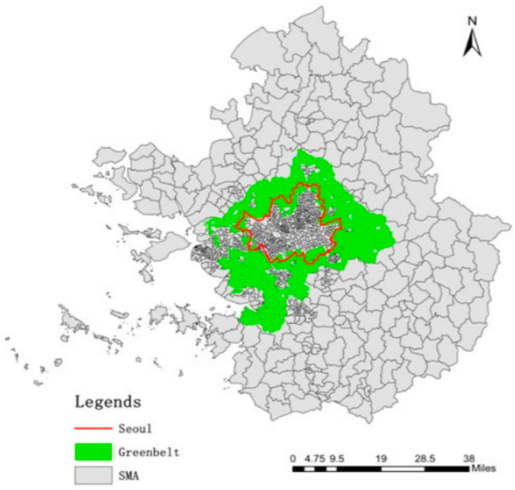


Figure 6 Map showing the location of the greenbelt surrounding the city of Seoul, Source (Han et al., 2017)

The greenbelt was set with a number of social, urban, and political objectives. It was a growth and management policy that was put to slow population growth and urban sprawl to make cities more functional and maintain a healthy living environment for people. It was also aiming to restrict and concentrate the industrial activity inside the side and protecting the nature from it. Prior to these objectives, the Seoul greenbelt was used for the national security of South Korea, to create a secure buffer zone to prevent national disasters and potential attacks from North Korea (Bae, 1998). While the greenbelt was successful in encouraging urban densification inside the city and increasing the value of land and property, it was not successful in limiting sprawl within the city. The sprawl was pushed further into the greenbelt and there was an increase of illegal activity against the environment (Choi, 1993; Kim, 1990, 1993).

China's climatic greenbelt

The Gobi Deserts is a vast body and a crawling nature for China. The desert is the fifth largest desert in the world and is rapidly decertifying parts of China. A challenge China is facing is the increasing population that lives in dry areas of the country and is constantly threatened

by the desertification. The China's Great Green Wall is an ambitious forestation project to combat the loss of China's grassland and continuous heatwaves and sand storms the country is suffering from. According to the National Forestry and Grassland Administration of China (2014), the government has adopted the Three-North Shelterbelt Project, also known as the Great Green Wall that started since 1978. The action plan was to have a 4,500-kilometer zone along the northern part of China's desert covered in an approximate of 100 billion trees. To facilitate this, and engage public efforts in the process, the Chinese legislative body has set a decision requiring every citizen over the age of 11 to engage in the planting movement.

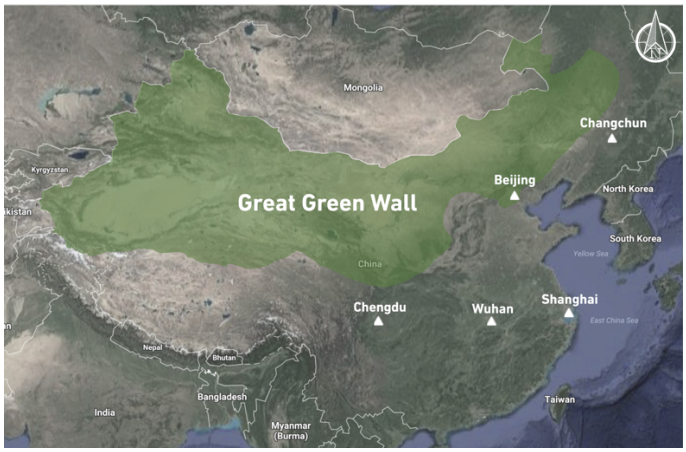


Figure 7 Map showing the suggested area for the Great Green Wall, an area approximately 22 times the area of Qatar

According to Tan (2016), a researcher in the Institute of Geographical Sciences and Natural Resource Research in Beijing, states that the undergoing project of forestation is seeing positive results. According to him, the region of the project has witnessed a significant improvement in its environmental status compared to other areas. Some of the major concerns of the project are the sustainability and continuity of the project; according to a research by (Cao et al., 2011) of Beijing Forestry University, only 15% of the trees that were planted in 1949 are still alive, and this is due to the rush to planting trees. It is always advised to follow

the nature instead of going against it; because otherwise it would prove unsustainable. In addition to that, concerns about groundwater consumption by the trees is present, which is a greater threat for the northern parts of China. It also threatens the natural biodiversity in the area by planting t specific species of trees only (Shankman & Liang, 2003). 66 Billion trees have been planted in the project, and a 100 billion trees are anticipated to be planted by the end of 2050.

Relation to Qatar

In relation to the context; Qatar in a hot arid region that suffers from severe sandstorms and heat waves annually. The country is the best candidate for a forestation campaign that help address multiple urban and climatic challenges and threats. An afforestation campaign can improve the environmental performance of the city by increasing its use and utilization of native tree species. More specifically, the country can greatly benefit from an integrated action plan that involves all sectors of the society, to address issues like quality of the public realm, lack of environmentally-oriented projects, and degradation of the air quality, and, on an urban matter, address issues of the quality of urban life in the country. It must be noted that as per the Qatar National Development Framework (QNDF) a greenbelt zone is marked on the periphery of the country, but no forestation initiatives, from both the public and private sector, have been activated (Qatar National Development Framework, 2014). There are tremendous amounts of opportunities to utilize the greenbelt area to reinforce and put in action an environmentally-sensitive urbanization approach.

2.3 Blue Urbanism and Urban Waterfront

While green urbanism is widely discussed and known by planners and urbanists, there is often a missing link between another important element of the city scape; the blue scape. Green and blue connectivity is vital in benefit for the ecology of cities, it is significant for habitat conservation and a comprehensive environmental approach. For this reason, this section of the literature explores the concept of blue urbanism to understand the overlap between the two, and the commonalities or differences between the two in order to utilize them adequately for the context of Qatar.

Exploration of the Concept

Blue urbanism is a theoretical approach that embraces the holistic nature of the world as a biosphere made up of seventy percent of water mass content. The utterly scientific fact might present a challenge to urban planners and designers, who are primarily targeting the creation of liveable cities and resilient built environments on land, yet coexisting with the various water bodies of seas, oceans, lakes and rivers (Dreiseitl & Grau, 2005).

To urban planning and design, blue urbanism is directly related to the vision of achieving a balanced growth model that integrates water into land especially for coastal areas, bearing in mind the environmental sustainability of marine life and ecosystems; urban resilience of cities and towns allocated by the shore; economic benefits gained in the long-run; as well as enhancing the human's sense of involvement and appreciation of nature. Comprehensively, blue urbanism is aligned with the core principles of sustainable urbanism, which include liveability enhancement; community creation; expansion of opportunity; promotion of equality and fostering sustainability (Lance Jay Brown, David Dixon, & O Gillham, 2014).

According to Beatley, one of the few internationally recognized researchers who explored the concept of blue urbanism; "thoughtful urban design has the power to connect land and water in a way that brings citizens closer to the sea and highlights the ocean as an integral part of the urban environment" (Timothy Beatley, 2014). Thus, the role of urban design is to

ensure that coastal cities would be ecologically resilient considering the challenges of rising sea levels, environmental pollution and climate change effects on marine life and urbanism alike.

In most of the literature, the concept of blue urbanism is represented as an ethical attitude rather than a theoretical conception (Bareford, 2014; Timothy Beatley, 2014). In fact, blue ethic is referred to as the "profound sense of connection and care for the ocean world, and a fascination and curiosity about its biodiversity and complexity" (Timothy Beatley, 2014). Based on Beatley's argument, the blue ethic is aiming at the creation of a physical foundation that allows better connection between water and urban land. Through effective design, planning and the involvement of active governance, blue ethic can be interpreted in the form of physical design schemes such as blubelts, waterfront regeneration, wetlands, resilient water-based recreational projects and mega-scale developments.

The concept of blue urbanism can be interpreted in line with biophilic city theory. Consequently, "biophilic cities embrace the blue as well as the green; the marine and aquatic as well as the terrestrial" (Timothy Beatley, 2016). Complementing green urbanism in the process of urban design is key to ensure equilibrium, which is fulfilled by adopting a planning tactic of creating blue networks and marine-oriented development striving to balance the green approach of urbanism. For coastal cities, the challenge of integrating the sea into the urban planning process as a source of sustainable energy and both a tangible and intangible supportive component for urban growth is the ultimate target of blue urbanism.

Waterfront Regeneration

Waterfront regeneration is greatly associated with re-development of degenerated waterfront areas and is a catalyst for further renewal developments in the inner urban land. It has primarily developed as an urban phenomenon since the 80-90s of the twentieth century (A. L. Jones, 2017), reacting to property development boom in both the United States and the United Kingdome (Bassett, Griffiths, & Smith, 2002; A. Jones, 1998; A. L. Jones, 2017; Samant, 2014), where the focus of development was placed on docklands, waterfront

revitalization programmes, rehabilitation and redevelopment of mixed-use facilities in addition to housing and touristic attractions by the water.

In her book 'Sustainable Cities for the Third Millennium', Mega explores chances and challenges of cities on the waterfront based on the ability of water to influence the development process of urban areas. The historical remains of port cities and the legacy of waterfront towns and urban centers, on the other hand, influenced urban planners and designers to rethink their potential through the prism of sustainable regeneration (Mega, 2010). Thus, policies and strategies have been adopted globally to ensure a sustainable development of urban waterfront regions, including the following ten principles in Berlin, 2000:

> *"Ten principles for the sustainable development of urban waterfront areas were adopted. They include (A) securing the quality of the water and the environment, (B) the integration of the waterfronts into the urban fabric, (C) the importance of the historic character, (D) the priority of mixed uses, (E) the prerequisite of public access, (F) the planning through public–private partnerships, (G) the importance of citizen participation and (H) international networking, (I) the long-term horizon and (J) the on-going character of the revitalization process" (Mega, 2010).*

The development of waterfront regeneration projects enforces the involvement of public-private partnerships in the design making process, where the form of governance has shifted in most of the recent projects from the absolute state controlled politics to a more flexible form of governance managed by international developers and private real-estate companies (Bassett et al., 2002; Feldman, 2000). In the state of Qatar, for instance, waterfront regeneration began as an authoritarian decision of the political system represented by the Emir of Qatar back in the 1970-1980s. The raise of the first master plan initiatives in Qatar- where the government was responsible for the physical planning of the city of Doha- marked the first efforts towards developing waterfront regeneration by land reclamation policies (Nagy, 2000a). Thus, the Doha Corniche emerged as a promenade and public park that still maintains its national significance as a favourable urban space in the city, embracing the Arabian Gulf Sea.

Coastal Zone Management

Coastal management for ecological landscape is a strategy - primarily adopted by the National Land Agency of Japan - that aims at the effective integration of applicable policies in the process of preserving coastal regions and conserving the environmental value of the marine ecosystem through functional aspects, including (A) provision of ecological services for human beings, (B) disaster prevention, and (C) human utilization (Isobe, 1998; Kumar & Chauhan, 2010). The integrated coastal zone management (ICZM) has its essence embedded in sustainable development, which targets the preservation of coastal areas for the future generations by seeking a balance between demand and supply. Accordingly, the key features of integrated coastal zone management involves the following:

> *"(A) To encourage participation and cooperation of various concerned groups such as the national government, local administrations, private sectors, Non Profit Organizations (NPO), fishermen and local communities, (B) To provide wide overviewed implementation giving full consideration to the whole of bays, inland seas and river, (C) To provide long-term viewed implementation setting a future vision of coastal areas under an analysis of natural cycles, (D) To provide a continuing implementation based on the results of continuous monitor and analysis of the execution of an ICZM plan" (Kumar & Chauhan, 2010).*

The Japanese experience in coastal management is focused on beach nourishment, thus creating new beaches and integrating water into land through artificial landfill techniques. The aim of such planning endeavors is to mimic natural habitat while creating recreational spots and supporting biodiversity and sanctuary conservation (Isobe, 1998). Through artificial shores and islands, waterfront parks, seaweed transplanting, seawalls and sunken piers, Japan proves that coastal management can be optimized and implemented as a successful, sustainable strategy for blue urbanism.

Constraints and Development Opportunities

Considering that most of the theories and best practices on blue urbanism, waterfront regeneration and coastal zone management has been embraced and developed in Western contexts and developed countries in the world, the application of similar trends in the context of the research, namely the state of Qatar; would be of a challenge both hypothetically and in design and planning application.

Firstly, the reasons for waterfront development in general in the Western context are related to economic necessities. In fact, "the rejuvenation of the waterfronts has also been fueled by economic restructuring, specifically the renewed importance of the city centers as locations for investment since the mid-1970s" (Feldman, 2000). In Qatar, the administrative and political aspirations are more likely to be influencing the development of mega-scale waterfront projects rather than merely the economical factor. Such influencing factors are guiding the process of urban development, fueled by a high population growth and a growing tendency to create urban legacies both inland and on the shores of coastal Qatari's cities such as Doha, Wakhra and Al-Khor (QNDF, 2014).

Other challenges are associated with the loss of waterfront character as a result of westernization of design and planning due to the flow of international expertise through mega-projects (Aoun & Teller, 2016; Bassett et al., 2002). A successful regeneration has to be logically planned based on community needs; a proper site analysis; a sensibility to the local planning practices and designing in harmony with the local culture and natural ecosystems.

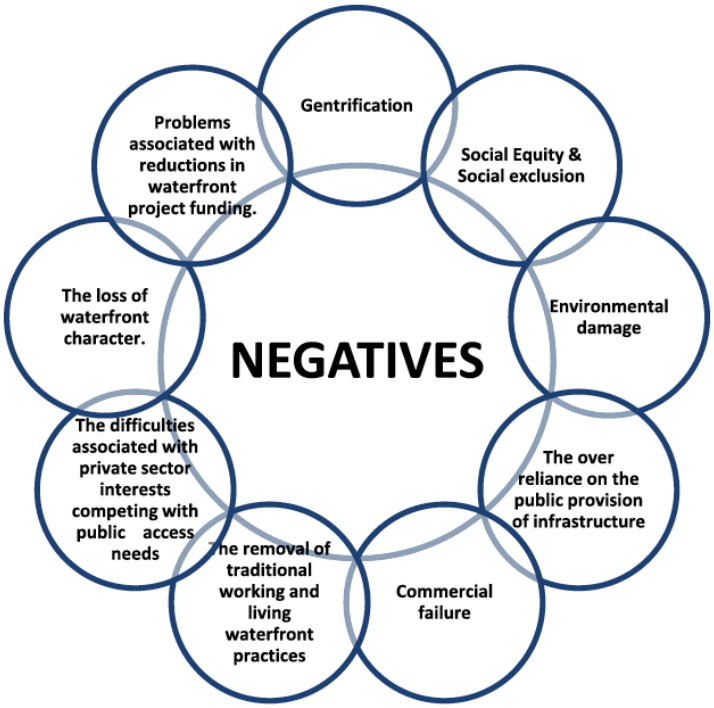


Figure 8 Negative aspects of waterfront regeneration, Source (Author)

On the other hand, waterfront regeneration projects have positive characteristics such as the great gains and benefits to the urban system through attracting high real estate investments. In addition, the creation of workplace with improved city infrastructures supports job creation and promotion of the district as an attractive, global core for creative citizens (A. L. Jones, 2017). Environmentally speaking, the development of waterfront districts through regenerative strategies would further upgrade shores and coasts to be of a higher urban quality, especially when blue urbanism is considered as the ethical motive of the development. Thus, the reduction of pollution is expected due to environmental design. Waterfront regeneration allows the integration of climatic adaptation methods as a primary strategy to fully utilize the good potential of sea breeze and the endless benefits of waterscapes in the design process. Figure below summaries the positive attributes of waterfront regeneration projects reference to Jones's approach (A. L. Jones, 2017).

Figure 9 Positive aspects of waterfront regeneration, Source (Author)

Case Study: The Staten Island Bluebelt -New York City

The inclusion of water as an active ecosystem in the city making process and urban resilience rather than a source of hazard and continous environemntal threat is the purpose of bluebelts,. In fact, a Staten Island in New York has developed a specific program in the late 1980s that includes “a system of streams, ponds and wetlands for managing strorm water” (Chang, 2013). The pioneering program is an example of ecologyically effective strom water mangement, preserving natural corridores for draigining water, thus supporting the natural cycle, wildlife ecosystems, and creating community spaces ("The Staten Island Bluebelt: A Natural Solution to Stormwater Management," 2019; Tollefson, 2013)

2.4 Chapter Summary

In this chapter three main concepts were explored in relation to their relevance to the thesis topic. Starting with sustainable urbanism, its main principles and contribution to sustainable development, then green urbanisms, its relation to urban forestry and greenbelts, and policies or legislative acts that put them into action, finally blue urbanism, in efforts to understand the concept, create a holistic understanding, and design an integrated approach that combines green and blue urbanism, from a sustainable development point of view.

CHAPTER 3: DOHA, QATAR | BACKGROUND CONTEXT

This chapter describes the urban context in which the research takes place, and traces back the evolution of its urban formation, its urban character, and urban challenges. While the chapter starts with an overview of the urban scene of the city, it aims to put emphasis and spot the light on the challenges that the country currently faces and the planning and development policies that are set with deal with them. The first part is a description and summary of what has been published in the literature in Qatar's urbanism and urban development, and the last part of this chapter is a summary and analysis of the Qatar National Vision, Qatar National Development Framework 2032, and specifically focusing on policies and regulations related to the greenbelt and waterfront management. This chapter is vital in identifying the gaps, shortcomings, and areas of opportunities for development and research.

3.1 Background

Qatar has marked a remarkable urban development during the last few decades. The country's economical, urban, and industrial development started from a small pearling and fishing community in the end of the 1940s to reach to the country of highest GDP per capita in 2013 (Gritchting, 2013). The economical revenues made by the oil industry that started soon after the Second World War were immediately invested in the country's infrastructure, and modernizing its facilities and services (Wiedmann, Salama, & Thiestein, 2012). Development of the country's road network enabled easy commute and directly impacted the pattern of its urban development. In addition to the ease of commute, government financial incentives were a prominent driver for the Qatar population to move to the outer areas of the city, where plots were given free of charge with free-interest loans for construction (Rizzo, 2014). The city expanded outwards following the ring-like artificial coastline, and as the road network grew perpendicular to the rings creating the basic formation of its urban form (AI-Thani & AI-Adhami, 2000; Rizzo, 2014).

3.2 Characteristics of Urban Form

Doha is the capital city of Qatar, located on the eastern coast of the country. Qatar is a peninsula that is surrounded by the Persian Gulf and Saudi Arabia from the south, and has an approximate area of 11,000 sq. km, and the country has a desert climate and geography, with an average temperature of 40 C (FAO-AQUASTAT, 2008). According to the ministry of Development Planning and Statistics, total population of Qatar has reached 2.63 m in 2016 (Statistics, 2016), and according to sources, Qatar is almost 100% urbanized (Nyakairu, Kuria, & Mbogori, 2012).

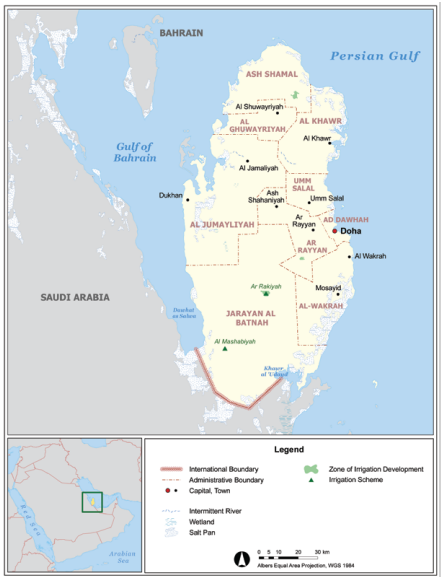


Figure 10: Map of Qatar (Source: FAO-AQUSTAT, 2008)

The urban character of the country historically starts with low single-family housing developments, that clusters on a tribal structure (Jaidah & Bourennane, 2009). The urban development continued on the same manner, especially when the urban spread was encouraged by the automobile (Elsheshtawy, 2004; Wiedmann et al., 2012). This low density pattern of urbanism is also claimed to be encouraged by the private sector handling the planning process. More than half of the city's urban area is occupied by low-rise residential developments, i.e.

compounds and residential complexes, and this creates a density urbanism of less than 6000 people per square kilometre (Wiedmann, Salama, & Mirincheva, 2014)

It is important to mention that the country did not have an authority responsible for the planning or building process until 1972, which was then called the Ministry of Municipal Affairs and Agriculture (MMAA) and was principally involved with urban planning (Wiedmann et al., 2012). The centralization of the planning process, since then, has allowed the direct input of the government revenue from oil into the construction of required infrastructure (Holla, 2016; Nagy, 2000b; Wiedmann et al., 2012).

There has always been a trend for mega-project driven development in Doha. Projects such as Msheireb Downtown, the Education City, The Pearl, Aspire Zone, and Lusail City are all examples of this urbanism (Rizzo, 2016). This facilitates the process of building the city in preparation for the FIFA World Cup 2022, which has accelerated all the construction projects in the country.

3.3 QNV 2030, and QNDF 2010-2032

Qatar National Vision 2030 is an outlook that was set by the governing body in Qatar in 2008 that defines the basis and guides the principles of its development and growth. Sustainability is set in the forefront of its aims, to "provides a framework within which national strategies and implementation plans can be developed" (Planning, 2008). The QNV 2030 document sets five main characteristics of the country's future that are seen as challenges as well as opportunities. These characteristics are: (1) the modernization but also preservation of traditions, (2) the needs of this generation and future generations, (3) managed growth and uncontrolled expansion, (4) the expatriate labour force and the selected path of development, (5) economic growth, social development and environmental management. These five aspects must be balanced, improved, and developed to provide high standard of living in the 21st century.

The Qatar National Vision 2030 has four main development pillars that all rest on sustainable development aspects: human development, social development, economic

development, and environmental development. These are set to ensure the development of the inhabitants of Qatar to become capable of sustaining a prosperous society, to create societal significance and strength and collaboration among all classes of the society, to promote a powerful and diversified economic force that secures and grants high standards of living, and to be responsible and environmentally-aware within all aspects of living and development (Planning, 2008).

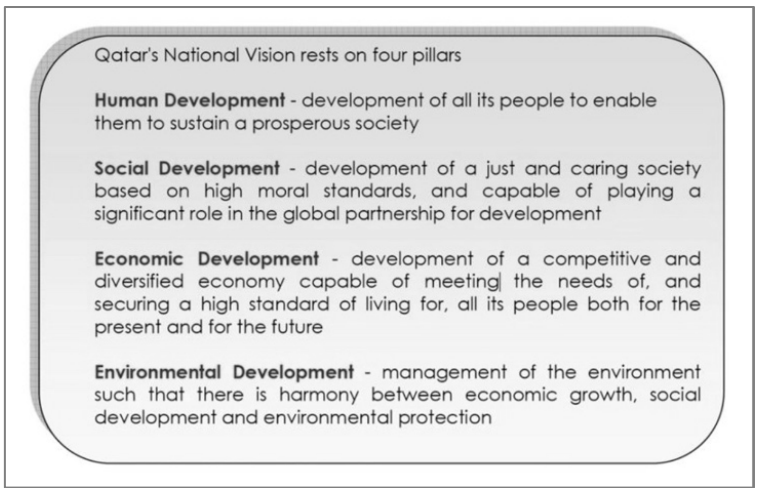


Figure 11: The four pillars of sustainable development set by Qatar National Vision 2030 (Source: Qatar National Vision 2030)

To put the Qatar National Vision 2030 in action for urban development and planning in the country, the Ministry of Municipality and Environment (MME) established the Qatar National Master Plan (QNMP) to provide a comprehensive guide for the spatial and urban planning and development, on all levels of the country, aiming for the integration of planning efforts and collaboration and implementation of this vision. According to the official and government-operated website of the QNMP, there are five elements of the master plan, which are: the Qatar National Development Framework (QNDF), the Municipality Spatial

Development Plan (MSDP), the Urban Centre Plans, the new and upgraded Zoning Regulations announced in 2017, and the Strategic Plans and Projects.

One of the main components of the Qatar National Master Plan is the Qatar National Development Framework 2032 (QNDF 2032), which is a detailed document for regulatory strategies and guiding principles for any spatial development in the country. In addition to that, based on detailed data collection and analysis, the QNDF envisions the urban development in relation to sustainable development and quality of life, and outlines important actions that are to be taken in order to achieve such visions. The figure below shows the hierarchy of documents and strategies starting from the Qatar National Vision 2030 going through the Qatar National Master Plan.

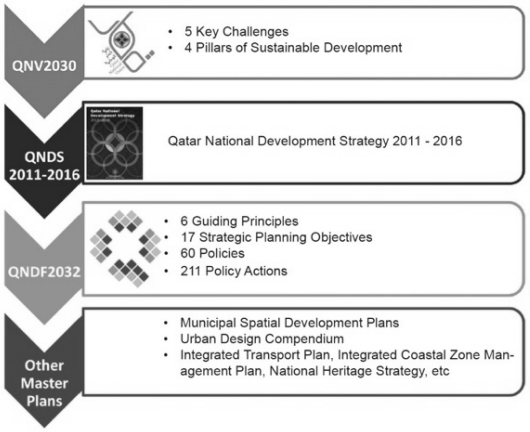


Figure 12: Hierarchy of the Qatar National Development Framework (Source: QNDF 2032, 2014)

The QNDF Document is structured in five sections of policies that are organized for each category with subsets and sub guiding principles. This allows the publication to provide all details the of development for all city districts, municipalities, towns, and villages.

In relation to sustainable urban development, and the greenbelt, the Qatar National Development Framework enacts the greenbelt as a planning and development policy within its National Spatial Strategy and planning concept in its second section (Figure 4). The details of the National Spatial Strategy provide some key recommendations that include:

> *"Enforcing a Greenbelt policy to contain the urban area of Metropolitan Doha and act as a buffer between other key cities and towns and their rural and agricultural surrounds" (Qatar National Development Framework, 2014)*

and also as part of the national food security plan;

> *"To provide for long term food security (the National Food Security Program) and other national government projects, and to ensure future urban development is contained within sustainable limits, land has been allocated for the creation of a Greenbelt around the urban area. The resulting long term planning area of 1282 km has been used to determine the plan boundary for the wider Doha area." (Qatar National Development Framework, 2014)*

Also, the framework sets the greenbelt a direct policy for the urban and rural development of the country, as part of the efforts for managing future growth around metropolitan centers. Figure 5 below shows the illustrations of the prospect development of metropolitan Doha and indicates the greenbelt in 2017 as an "emerging greenbelt" and in 2032 as a well-emerged and developed greenbelt that surrounds the city.

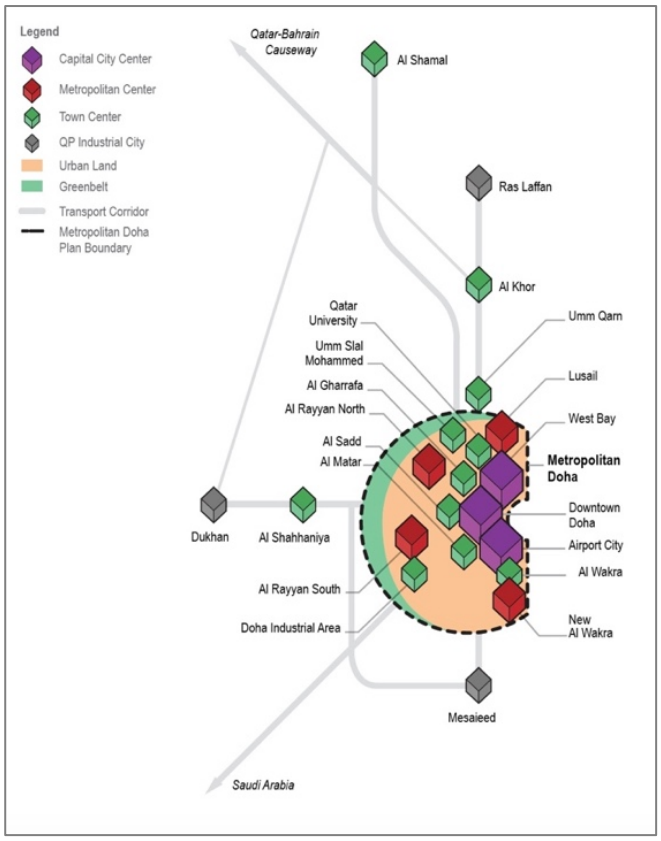


Figure 13: Greenbelt as part of the National Development Strategy concept (Source: QNDF 2032, 2014)

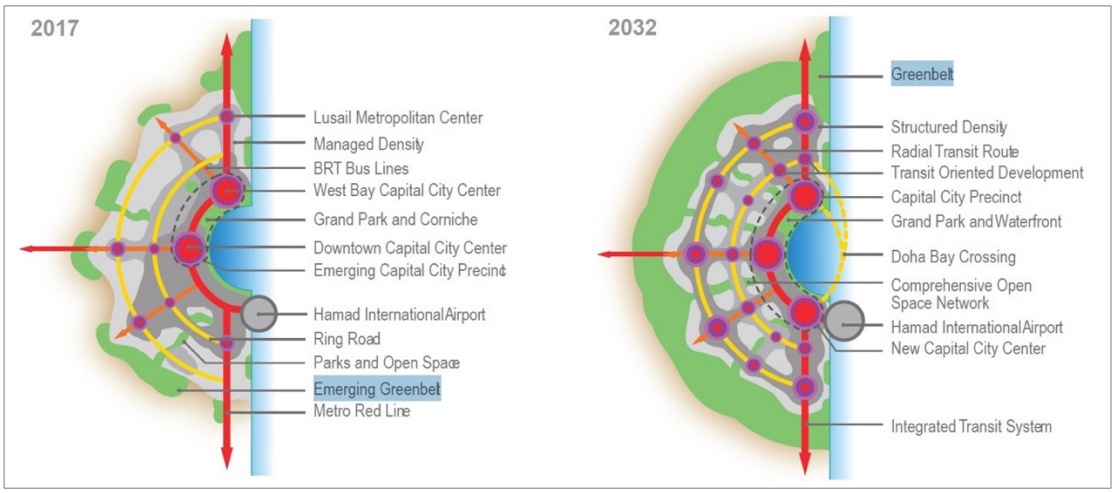


Figure 14: the envisioned development phases for the greenbelt as per the QNDF 2032 (Source: QNDF 2032, 2014)

To further elaborate, greenbelt is seen as an urban policy to maintain urban growth within the metropolitan boundary of the city and maintain a compact urban area. It is also seen as an opportunity to expand on agricultural activities and urban farms, which in turn aligns with the country's national food security plan. It is also envisioned to be a transition boundary between the metropolitan and built area of the city, and the vast natural desert scape beyond. The greenbelt exact boundaries are not detailed in the framework; however, its zone and envisioned area are mapped in the metropolitan development map of Doha. The greenbelt is also mentioned in the detailed municipality plans in sections related to public realm and environmentally-aware urban development.

In relation to the waterfront and coastal zone of Doha, QNDF 2032 mentions the waterfront or waterfront developments across the country in sections related to the improvement of community recreational facilities and their supporting accessibility and public realm requirements. It is also mentioned in policies in relation to waterborne transportation; as with the emergence of many waterfront projects and mega-projects, such as Lusail and The Pearl, waterfronts can be seen as a transportation portal for an integration transport strategy.

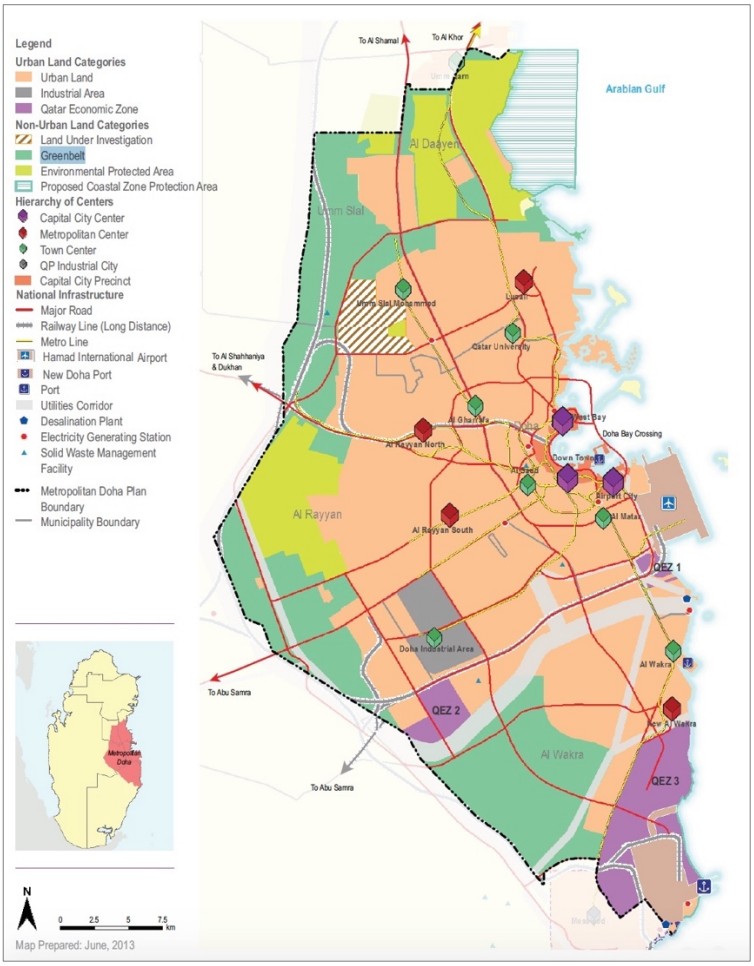


Figure 15: Map of metropolitan Doha in 2032 with greenbelt zone assigned (Source: QNDF 2032, 2014)

The Integrated Coastal Zone Management Plan (2017) is part of the QNDF 2032 that is specialized and specific to the management and protection of the coast of Qatar as part of its natural and environmental assets. The document provides guidelines for developments and restricted developments in order to sustain the well-being of the coastal zone. The Management Plan established two main considerations: (1) a successful planning of the coastal zone starts by understanding its environmental nature, and (2) that the coastal zone comprises three main elements: the land, the inter-tidal zone and the sea (for the purpose of establishing a boundary, it is taken within 1km of the coast and 1km from the mean high water inside the Gulf). The

purpose of the action plan is to protect the coastal zone from inappropriate development, QNDF strategies related to the coastal zone, ownership and planning, and key regulatory policies.

There are four main categories in the coastal zone of Qatar, according to the Management Plan, and they are: (CZ-I) Protected Areas and Aquifer Protection Zone, (CZ-II) Developed Areas, (CZ-III) Future Development Zone, and (CZ-IV) QP Jurisdiction Zone boundary (and areas that have not been designated as CZ-I, CZ-II or CZ-III), shown in the Figure below. Each category is detailed in related to environmental sensitivity, environmental specifications, and ownership. There are some prohibited activities, those of such that impose a direct damage to the ecology of the coastal zone, and some permitted activity with guiding regulations to control the use and maintenance of the zone.

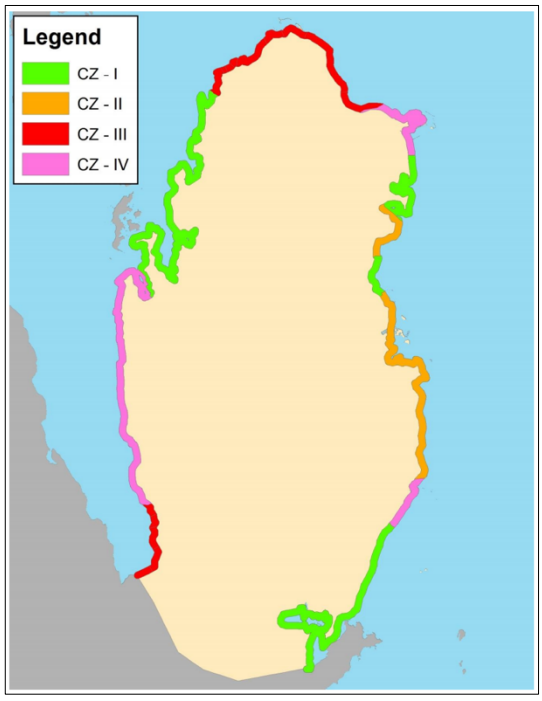
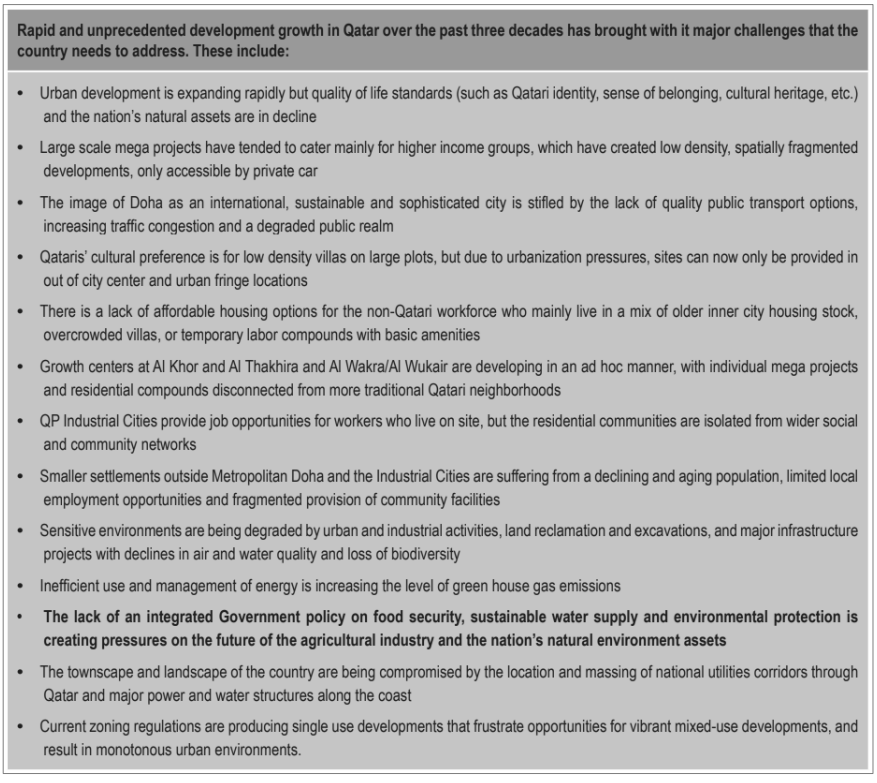


Figure 16: the four Coastal Zone Types (Source: Integrated Coastal Management Plan, 2014)

3.4 Current Urban Challenges

According to the Qatar National Development Framework 2032 (2014), there are 17 key challenges that need to be addressed as a priority for the urban development of Doha facing both tehe urban nd coastal edge. These include urban spatial fragmentation, the significant and apparent lack of an enriching landscape and townscape, the severe degradation and human-impact on the some sensitive environments and ecologies that threatens the biodiversity and well-being of these places, giving priority to infrastructure corridors which harms the landscape of the country, and the lack of an integrated policy for food security, sustainable water supply, and environmental protection. The complete list of the 17 challenges is in the figure below.



Rapid and unprecedented development growth in Qatar over the past three decades has brought with it major challenges that the country needs to address. These include:

- Urban development is expanding rapidly but quality of life standards (such as Qatari identity, sense of belonging, cultural heritage, etc.) and the nation's natural assets are in decline
- Large scale mega projects have tended to cater mainly for higher income groups, which have created low density, spatially fragmented developments, only accessible by private car
- The image of Doha as an international, sustainable and sophisticated city is stifled by the lack of quality public transport options, increasing traffic congestion and a degraded public realm
- Qataris' cultural preference is for low density villas on large plots, but due to urbanization pressures, sites can now only be provided in out of city center and urban fringe locations
- There is a lack of affordable housing options for the non-Qatari workforce who mainly live in a mix of older inner city housing stock, overcrowded villas, or temporary labor compounds with basic amenities
- Growth centers at Al Khor and Al Thakhira and Al Wakra/Al Wukair are developing in an ad hoc manner, with individual mega projects and residential compounds disconnected from more traditional Qatari neighborhoods
- QP Industrial Cities provide job opportunities for workers who live on site, but the residential communities are isolated from wider social and community networks
- Smaller settlements outside Metropolitan Doha and the Industrial Cities are suffering from a declining and aging population, limited local employment opportunities and fragmented provision of community facilities
- Sensitive environments are being degraded by urban and industrial activities, land reclamation and excavations, and major infrastructure projects with declines in air and water quality and loss of biodiversity
- Inefficient use and management of energy is increasing the level of green house gas emissions
- **The lack of an integrated Government policy on food security, sustainable water supply and environmental protection is creating pressures on the future of the agricultural industry and the nation's natural environment assets**
- The townscape and landscape of the country are being compromised by the location and massing of national utilities corridors through Qatar and major power and water structures along the coast
- Current zoning regulations are producing single use developments that frustrate opportunities for vibrant mixed-use developments, and result in monotonous urban environments.

Figure 17: Key planning challenges for Qatar (Source: QNDF 2032, 2014)

In addition to the challenges listed in the Framework, research and literature on Qatar is increasingly discussing the issues that face the urban development of Qatar in relation to its sustainable development visions. After their research on the urban morphology and urban growth patterns, Shandas, Makido, and Ferwati (2017) conclude that the city has grown four times bigger than what it used to be only three decades ago, and the country is evidently facing the challenge of urban sprawl. With the low to mid-rise style of urban density the country is allowing, the city continues to expand outwards, which adds the burden for the adequate provision for infrastructure as the city expands. The speed and pattern of growth are causing the compromise of sense of space, and adequate public realm, and quality of air and environment (Furlan & Alsuwaidi, 2017; Rizzo, 2014). The integration of infrastructure systems in itself is a challenge for the young country. Concurrently with the sprawl, environmental quality of neighbourhoods is also threatened. Most neighbourhoods do not have access to a public park or gardens, and most city districts do not have direct contact with nature. Lastly, the climatic conditions of the harsh arid weather and seasonal sandstorms affect the health of inhabitants and well-functioning of neighbourhoods, and further worsen the urban heat island effect (Makido, Shandas, Ferwati, & Sailor, 2016).

3.5 Chapter Summary

This chapter is essential in understanding the urban planning processes, policies, regulation, and guidelines that drive urban development in relation to sustainable development. Also, it is vital to identify the status of concepts such as the greenbelt and waterfront management in relation to both, sustainable development and urban regeneration.

CHAPTER 4: RESEARCH METHODOLOGY

This chapter focuses on the methodological approach followed in creating the sustainable urban edge design toolkit supporting the development of coastal cities. This toolkit focuses on the bigger urban fabric of cities and the problems associated with it, targeting in parallel both edges, the (1) blue edge, being the coast lines of the city, and the (2) green edge being the greenbelt surrounding the city creating a complete toolkit set that can be used to create a sustainable circle for coastal cities, with the fusion of both the green and blue urbanism.

The toolkit is developed through several stages that includes data collection, filtering and analysis, and finally validation for the case of Doha.

4.1 Sustainable Urban Edge Toolkit Development Methodology

Urban design is a subdivision of the city planning of which emphasizes on the three stages of analysis, design and management of the environment with specific attentiveness to the empirical qualities of the place (Southworth, 1990). Another definition of urban design was introduced by Colman (1988), he stated that urban design as a discipline improves the urban spaces with high principles targeting both the visual quality and functional efficiency. Generally, several virtues and principles make up the definition of urban design; targeting social, environmental and management factors, therefore all these qualities are crucial to be addressed in the design methodology.

The urban edges were developed as a practical management tool within the urban design discipline, in order to mitigate several problems and issues within the urban fabric promoting a more sustainable, compact and connected urban development. The urban edges promotes various objectives, from growth management, to nature protection, resources preservation, identity making, land use management and social integration (Cilliers, 2009).

Therefore, in order to design and develop such a toolkit the aspects of urban design and urban edges in specific should be taken into consideration, of which corresponds directly to the three pillars of sustainability being the social, environmental and economic. However, the thesis

focuses only on the environmental and social while adding also the management (Planning) pillar due to its importance.

The methodology of developing the sustainable urban edge design toolkit consists of the following main stages (Figure 20):

1. Data Collection
2. Analysis and filtering
3. Validation

Data Collection

The data collection is the basic and first stage to be carried out and it is based on two parts: (1) conducting a literature review and understanding all the disciplines, concepts and contexts connected to designing the toolkit; (2) collecting precedent and applicable international design guidelines for both the green and blue edges, from which the new toolkit is to be derived and developed.

The selection of the precedent guidelines (PG) was based on availability, inclusivness, and relativity. Four main guildines are selected as follows:

(1) Waterfront edge design guidelines (WEDG) (WATERFRONT ALLIANCE PROGRAM, 2018) , which is issued by the waterfront alliance program to encourage the resilience, ecology, and connectivity at the water's edge.

(2) A 21st century metropolitan green belt (Higher Education Innovation Funding, 2016), which was issued by the Higher Education Innovation Funding (HEIF) project aiming to promote and develop the metropolitan greenbelt.

(3) Guidelines on urban and peri-urban forestry (SALBITANO et al., 2016), which was issued by the food and agriculture organization of the united nations to assist in the planning, design and management of sustainable, resilient landscapes.

(4) Green Belts: a greener future (Natural England and the Campaign to Protect Rural England, 2010), which was issued by the natural England and the campaign to protect rural England to enhance the benefits and services provided by the greenbelt land.

The guidelines collected are organized through a table identifying: (1) edge type, (2) guideline document reference, (3) category of assessment, (4) design element to be implemented, (5) brief explanation about the design element, (6) tool type.

Table 2 Data collection summary, Source (Author)

SN	Edge Type	Doc. Reference	Category	Design Element	Brief Explanation	Tool Type
#	Blue or Green	PG reference	Based on PG's categorization	Element Title	A summary of the element	Design or Planning

Analysis and Filtering

the second and third stages are done in a recursive manner where each element retrieved from the precedent toolkits is analyzed, filtered and then validated through a proposed design or strategy. The analysis step is based on the following:

1. Each edge type (Blue, Green) is analyzed and filtered separately, considering their characteristics, design categories, design elements, etc.
2. All similar design categories and elements (within each edge type) from different references are merged in order to avoid replication and achieve a more precise toolkit.
3. The new formed tools are then filtered.

The filtering stage proceeds as follows:

1. The filtering process of the tools is based on the QNDF 2032 (Ministry of Municipality and Environment, 2014a).
2. The tools are divided and filtered based on 2 of the pillars of sustainable development (Social and Environmental Development) with the addition of the new management pillar leading to 3 out of 6 sustainable guiding principles of QNDF, which are (Figure 18):
    a. Quality of life (QL): "Improve the living, working, playing and learning environment and offering choice, affordability and access for all people"
    b. Connectivity of People and Places (CPP): "Providing integration, mobility, accessibility and connectivity to improve the social, cultural and economic interaction of people, institutions and businesses in Qatar"
    c. Environmental Values (EV): "Supporting the preservation and rehabilitation of the natural and built environments"
3. The filtered guidelines are then organized through the same table of data collection structure with the addition of (1) code reference of design element, (2) code mapping, (3) pillar type, and (4) sustainable guiding principle

Table 3 Data filtering summary, Source (Author)

Code Reference	Code Mapping	.. Data Collection Table ..	Pillar Type	Sustainable Guiding Principle
Filtered design element code	To map the collected data with the filtered design elements		Social, Environmental or Management	QL, CPP or EV

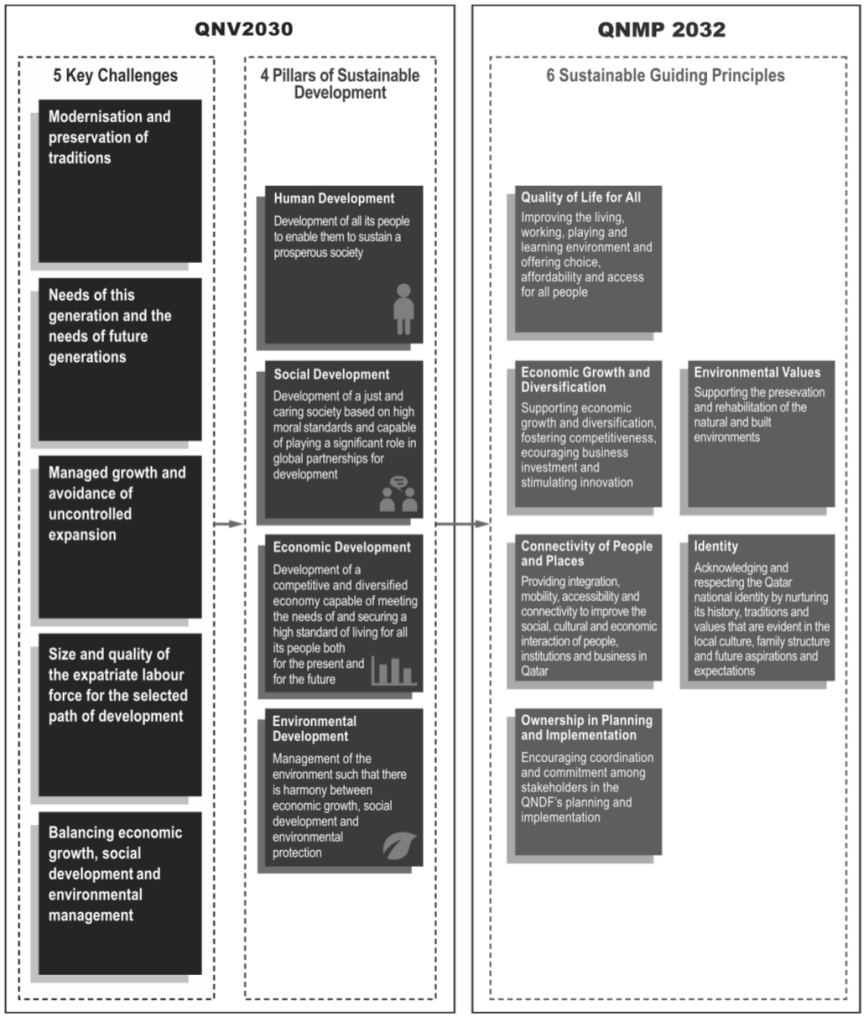


Figure 18 QNDF Sustainable Guiding Principles, Source (QNDF 2032)

Validation

The third stage is done through modeling and design proposals, where the tools introduced are to be assessed based on its application to the case of Doha, what problems will it solve and how. Afterwards, the proposed guidelines and design implementation of tools are defined for each edge type. This stage should also target achieving three of the four QNDF 2032 visions, which are: (1) Producing an attractive and livable urban environment, (2) Promoting environmental sustainability, (3) Providing a robust and innovative spatial and physical legislative planning framework (Figure 19).

Figure 19 QNDF Vision, Source (QNDF 2032)

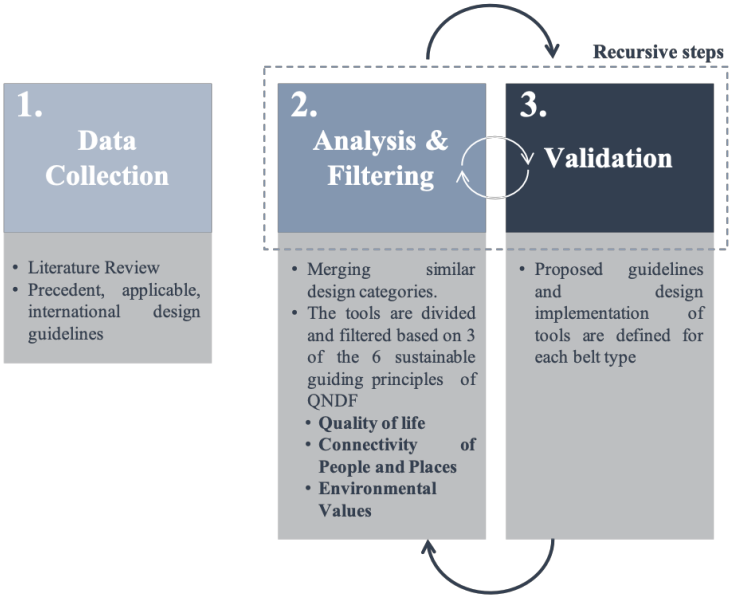


Figure 20 methodological approach summary, source (author)

CHAPTER 5: THE CASE OF DOHA, QATAR | TOOLKIT DEVELOPMENT

This chapter involves the implementation of the methodology explained in Chapter 4. A brief site analysis for the case of Doha is conducted, as this site will be used to assist in the validation of the toolkit after the stages of filtering and analysis is completed.

5.1 Site Analysis

Study Area & context

This part is concerned with the site analysis of the case of Doha city, of which the toolkit is to be developed for mainly. Having the site analysis as the first step is crucial as it helps in understanding the overall context of the study of which the followings steps are based on. The analysis, filtering and validation recursive steps requires having an understanding of various aspects of Doha that will lead to a more precise toolkit design.

The site analysis covers the following, (1) the analysis of the overall context of Doha, (2) the analysis of the costal edge of Doha, (3) the analysis of the outskirt edge (periphery). The analysis will focus on various aspects such as: climate, access, land use, population, existing systems, existing functions, etc.

Overall Doha

Doha City is the main and biggest city of Qatar with the highest population density. As seen in figure 21 below, an overall analysis was conducted. As shown below, the contours are generally low near the coast lines and within Doha city and gets higher going inwards. There are three main natural reserves two in the north and one in the south, none of which crosses or passes by the city of Doha. Moreover, existing agricultural areas are shown in dark green in the figure below, yet again most of which are beyond the peripheries of Doha city mostly scattered in the middle parts of Qatar going north. As for the infrastructure, as seen in dark red, the main roads are all diverging from Doha's ring roads leading to other cities. Most of Qatar's lands are connected with highways and can be accessed easily. The new development of the metro is also focusing on Doha city connection and accessibility; moreover, the metro plan has also focused

on the connection with other cities as shown below, this will ease the movement for the residents as well as for the 2022 world cup preparations.

Figure 21 Overall site analysis, Source (Author)

Land Use

In regard to the land use of Doha, below figure 22 shows the overall planned land use as retrieved from the Ministry of Municipality and Environment (MME, 2018). As seen from the land use map, the residential areas cover most of the area within Doha, lower in density the center and higher near the periphery. Scattered mixed use area can be found mostly in the center

of Doha and near the new city of Lusail. As for the industrial zones, 1 major area is found in the lower south of Doha being the main industrial area and a low impact industry zone is near Umm Salal Municipality. Green and sport Zones can be found scattered as well, mainly in the center and lower part of Doha, with lower density near the north, Green areas as marked near the corniche of Doha, is the planned development to convert most of the area facing the corniche into a big public Park. Special development and tourism zones are mainly found along the coast line and in the heart of Doha.

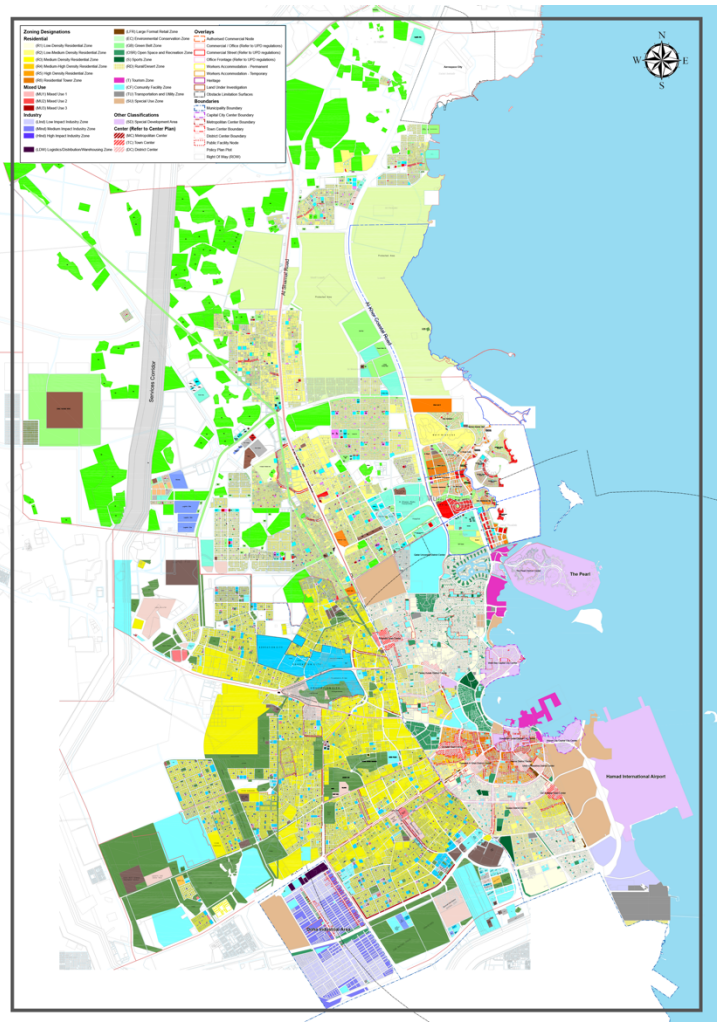


Figure 22 Land use map, Source (MME, 2018)

Population

The population of Qatar has increased dramatically over the years. As per (The World Bank), Qatar's total population in 2017 was 2,639,211. However, as per the population census of the (Ministry of Development Planning and Statistics, 2015) the populations was analyzed per Municipality, where a huge difference can be shown comparing Doha to other Municipalities. It can be seen that Doha hosts almost 40% of Qatar's population, followed by the adjacent municipality of Al Rayyan with 25%. Moreover, as shown in the map below retrieved from the Qatar National Development Framework 2032, a huge growth in population is expected to be seen in Doha and all its surrounding municipalities, of which will need a strict and managed plan for the city in order to host the expected increase of people.

Table 4 population census, Source (Ministry of Development Planning and Statistics, 2015; Ministry of Municipality and Environment, 2014a; The World Bank)

Municipality	Population (2015)	Area (Km²)
Al Shamal	8,794	859.8
Al Khor	202,031	1613.3
Al-Shahaniya	187,571	3309.0
Umm Salal	90,835	318.4
Al Daayen	54,339	290.2
Doha	956,457	202.7
Al Rayyan	605,712	2450
Al Wakrah	299,037	2577.7
Qatar | Total	**2,404,776**	**11,621.1**

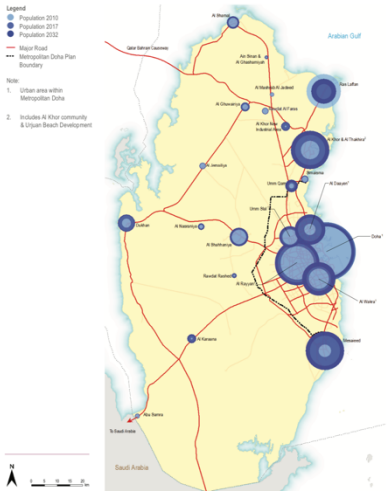


Figure 23 population density per municipality, Source (QNDF 2032)

Systems

Moreover, various existing systems were investigated Concerning water, infrastructure substations, reservoirs, etc. The figure below shows three main maps of (1) trunk water pipeline, (2) treated sewage effluent trunk pipeline, (3) main roads inside the city of Doha [from left to right]. As shown trunk water and TSE pipelines overlaps within the major corridors and are connected from the corniche all the way to the periphery; moreover, some of the pipelines are connected to the treatment sewage plants. Three treatment sewage plants are shown below in purple are located in Doha municipality and more can be found in the adjacent municipalities of Al Rayyan and umm Salal. One desalination plant can be found in Al Wakraa at Ras Abu Fontas, it is marked with the dark blue circle. Moreover, several reservoirs can be found some of which are primary and others are primary, all are marked with light blue circles and can be found scattered all over the city. Lastly primary substations can also be found scattered and are marked with orange circles.

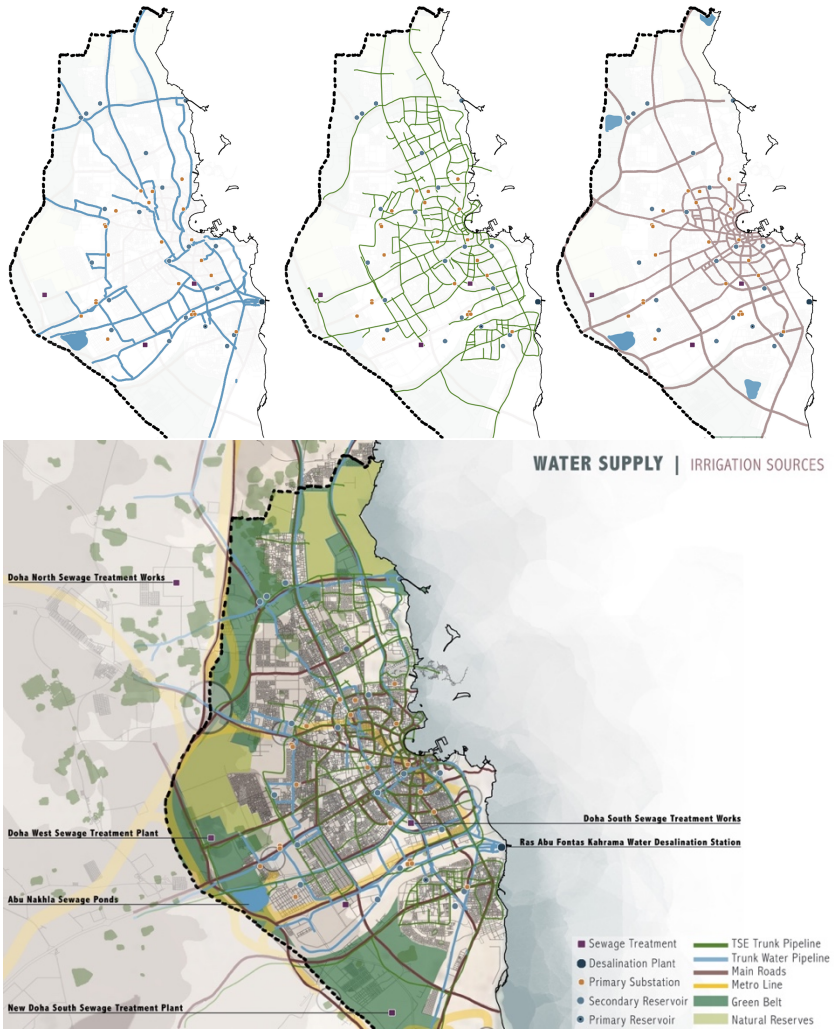


Figure 24 Existing water and road systems, Source (Author)

Existing Functions and Activities

The major existing functions and activities are shown in figure 25 below. It can be seen that most focal activities are within the central area of the city where different activities are scattered. No specific area has a mixed use of major activities from various sectors. Moreover, concentrating on the edges of the city, as shown below no major or important functions can be defined near the periphery. As for the coastal edge, various functions can be marked, being the corniche acting as the central business district of the city, diplomatic zones, commercial and mixed-use zones, etc. However, no functions can be identified focusing on the open public green space and environment development.

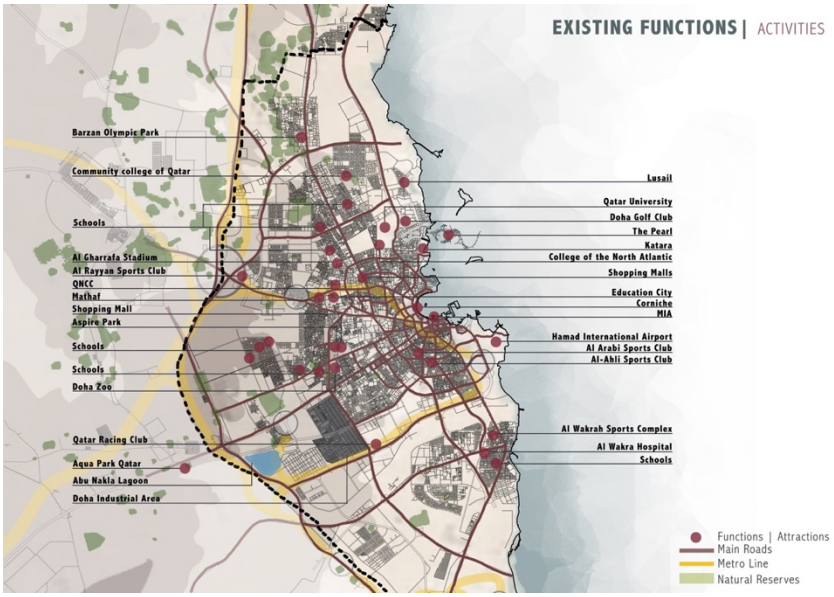


Figure 25 Existing functions and uses, Source (Author)

5.2 Filtering and Analysis of Toolkit

The filtering and analysis stage will follow the criteria and steps discussed in chapter 4 (filtering and analysis section). Table 5 and 6 represents the result of the filtering and analysis process.

Blue Edge

Table 5 Blue edge filtered design elements, Source (Author)

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
B-SAP1	B1, B2	Site assessment and planning	Create an interdisciplinary, integrative design team to analyze and study the various aspects of the site	A comprehensive group of selected professionals. They are to provide an extensive analysis of the context either socially, environmentally or ecologically. This is done in order to align intended design approach with site conditions and vulnerabilities.	Planning	Management	
B-SAP2	B2, B3	Site assessment and planning	Developing a community engagement and management and maintenance plans	This will ensure both the community and stakeholder engagement in the project plan and vision. Moreover, management plans will help with the continuing performance of the edge be it concerned with access, resilience, risk management, etc.	Planning	Management	
B-CRM1	B5, B9	Coastal risk management	Diminish coastal hazards risk	Reduce potential damage to site concerning sea level rise, fossil fuel emissions with regards to the climatic conditions and site features	Design	Environmental	EV
B-CRM2	B6	Coastal risk management	Responsive ecological edge	Protection of coastal habitats and raise resilience to both sea level rise and coastal storms	Design	Environmental	EV

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
B-CRM3	B7	Coastal risk management	Maximize connection with water through multiple senses	The site design to consider and improve connectivity to the water through visual and psychological aspects. Moreover, allow for maximum air and light access from land.	Design	Social	QL, CPP
B-CRM4	B8	Coastal risk management	Preserve maritime industry	Preserving the maritime industry holds environmental, health, social and economic interests.	Design	Environmental	QL, EV
B-PAC1	B10, B13, B16	Public accessibility and connectivity	Provide quality and direct public access to the waterfront, both for pedestrian use and multiple transportation modes	provide or develop public connection and access with the target of increasing the interaction of people with the water. Moreover, introducing sustainable transportation modes be it on land or water. This will help in creating and engageable and healthy waterfront enhancing the wellbeing of people.	Design	Social	QL, CPP
B-PAC2	B11	Public accessibility and connectivity	Reduce industrial operations effecting the health and wellbeing of people	Reduce industrial operations near the waterfront edge as it usually accompanied with negative effects either health or physical.	Design	Social	QL
B-PAC3	B12, B17	Public accessibility and connectivity	Provide diverse educational, cultural, entertainment	Provide various community programs triggering historical, cultural or environmental aspects. Moreover, introduce low-impact maritime activities	Design	Social	QL

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
			programs and maritime activities for the public	of which helps in connecting people to the water.			
B-PAC4	B14	Public accessibility and connectivity	Provide employment opportunities	Supporting employment and training opportunities in the maritime related fields of which can support the educational and skills development.	Design	Social	QL
B-PAC5	B15	Public accessibility and connectivity	Maximize the connection between the waterfront and the greenways	Increase the integration and relation between the blue edge and green corridors in order to create public spaces encouraging physical activities and alternative transportation options leading to maximizing the health and wellbeing of people.	Design	Social	QL, CPP
B-ER1	B18	Edge resilience	Select suitable strategy for edge envisioned use	Choosing the suitable edge strategy of which will help in balancing all the needs and future uses be it physical, ecological, or community.	Planning	Management	EV
B-ER2	B19	Edge resilience	Preserve and follow natural shoreline	preserving and imitating the natural shoreline shape and characteristics such as: slope, material, etc. this will help in supporting native biodiversity	Design	Environmental	EV

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
B-ER3	B20	Edge resilience	Protect the edge	Helping in preserving and protecting the water edge from working and active use	Design	Management	
B-ER4	B21	Edge resilience	Ecological structures	improve the biodiversity of natural, local shorelines through imitating the structure and materials when developing man-made edge	Design	Environmental	EV
B-NR1	B22, B23, B24	Natural resources	Preserve and repair biodiversity and ecosystem	Minimizing the influence on natural resources, increase the diversity of the ecosystem and encourage the introduction of native and rare ecosystems.	Planning	Environmental / Management	EV
B-NR2	B25	Natural resources	Minimize human disruption of natural resources	Minimize the interaction between sensitive natural wildlife and public activities.	Planning	Environmental / Management	EV
B-NR3	B26	Natural resources	Minimize and clean contaminated Environment	Reducing contamination of former industrial functions along water edge which effects both the environment and public health.	Planning	Environmental / Management / Social	QL, EV
B-NR4	B27	Natural resources	Sustainable fill and soil management	Minimizing the environmental effects of fill material can lead to lower carbon footprint, cost reduction and environmental impacts.	Planning	Environmental / Management	EV

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
B-NR5	B28	Natural resources	Introduce sustainable renewable energy sources	Introducing renewable energy alternatives, such as wind, tidal and solar energy	Planning	Environmental / Management	EV
B-NR6	B30, B31	Natural resources	Reduce, manage and improve storm water quantity and quality	Reducing the volume and treatment of storm water at the water edge naturally or mechanically	Design	Environmental / Management	EV
B-NR7	B33	Natural resources	Minimize impact on urban heat	Minimizing the impact on urban heat through absorbing surfaces	Planning	Environmental / Management	EV
B-NR8	B34	Natural resources	Connect with educational sector for tracking and monitoring of the site	Working with people form academia and scientists in order to monitor and evaluate the changes and development of the edge.	Planning	Social / Management	QL
B-INV1	B35	Innovation	Innovative, advance design implementation	Support new and advanced design solutions to be implemented either technical, material, methods, etc.	Design	Management	

Green Edge

Table 6 Green edge filtered design elements, Source (Author)

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
G-GBL1	G1, G43, G44	Greenbelt land	Greenbelt land cover, location and use	Greenbelts are mostly located in the urban fringes or peripheries of the urban fabric. The land cover of the greenbelt Spreading into the countryside. The land cover and use various per case and can be determined after the analysis.	Planning	Management	
G-GBL2	G52	Greenbelt land	Landscape management	Managing the landscape and maintaining the plans, as the natural landscape in subject to change.	Planning	Management	
G-RM1	G17	Risk management	Minimize risks and hazards of urban forests and green lands on people, and infrastructure	long-term planning and management plans are to be developed by policy makers and all concerned stakeholders in order to mitigate potential risk	Planning	Management	
G-RM2	G19	Risk management	Implement proactive risk control and mitigation measures	Minimizing the risk through periodic risk assessments of various elements in the greenbelt such as trees, soil, etc. using multiple techniques and methodologies	Planning	Environmental/ Management	EV

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
G-RM3	G18, G21	Risk management	Risk management and emergency responses	Introducing a risk management strategy and warning systems in case of emergencies that will help with easier prevention, control and mitigation	Planning	Management	
G-PAC1	G3, G5, G8	Public accessibility and connectivity	Provide quality and direct public access to the greenbelt, both for pedestrian use and multiple transportation modes	provide or develop public connection and access with the target of increasing the interaction of people with the green. Moreover, introducing sustainable transportation modes. This will help in creating balance between natural and built environment with engageable and healthy greenbelt enhancing the wellbeing of people.	Design	Social	QL, CPP
G-PAC2	G7, G39, G40, G45, G46, G47, G49, G50, G51	Public accessibility and connectivity	Provide multifunctional green and open spaces including routes and trails	Introducing and developing multifunctional green spaces to be accessed by all people encouraging physical activities and improving mental health. Those areas are to have appropriate services to improve social interaction and recreational purposes.	Design	Social	QL, CPP
G-PAC3	G10, G41	Public accessibility and connectivity	Introduce greenbelt around public buildings	Developing green area around public buildings such as schools, hospitals, religious buildings, etc. of which effect positively on the therapeutic and psychological needs of the public.	Design	Social	QL

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
G-PAC4	G9	Public accessibility and connectivity	Maximize the thermal comfort, pollution filtration and noise reduction	Developing and designing public green spaces taking into consideration those functions.	Design	Social	QL
G-PAC5	G48, G42	Public accessibility and connectivity	Provide diverse educational, cultural, entertainment programs and activities for the public	Provide various community programs triggering historical, cultural or environmental aspects. Moreover, the proximity to urban areas and educational facilities offers multiple educational activities.	Design	Social / Management	QL, CPP
G-PAC6	G11	Public accessibility and connectivity	Develop greenways/blue ways	Promoting alternative ways of transportation. This will benefit physical and mental health and reducing pollution	Design	Social	QL
G-ER1	G2	Edge resilience	Urban Regeneration	Preventing and restricting the development on green lands. Boosting the recycling of abandoned urban areas	Planning	Environmental/ Management	EV
G-ER2	G4	Edge resilience	Urban containment	Mitigating urban sprawl and preventing/limiting the use of private car	Planning	Environmental/ Management	EV
G-ER3	G12	Edge resilience	Climate change	Mitigating climate change such as: storm water, air quality, carbon, urban energy consumption, cooling, flooding and weather conditions.	Planning	Environmental/ Management	EV

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
G-NR1	G6, G35	Natural resources	Food production	Production of fresh and nutritious food including natural remedies in order to satisfy food security	Planning	Social	QL
G-NR2	G36, G37	Natural resources	Wood security	Developing strategies for wood security which will help in wood-energy planning with the supply of wood and wood fuel	Planning	Environmental	EV
G-NR3	G22, G24	Natural resources	Soil protection and fertility	Helping in combating desertification, restoring soil and preventing drought and floods especially in arid environments	Design	Environmental	EV
G-NR4	G14, G23	Natural resources	Use native trees, vegetation and endangered species	Helping in maintaining soil protection and fertility, moreover easier to manage and maintain	Planning	Environmental	EV
G-NR5	G31	Natural resources	Innovative tree-based approaches	Minimizing the water consumption, improving quality of water and recycle wastewater	Planning	Environmental	EV
G-NR6	G32, G33, G34	Natural resources	Green infrastructure	Developing permeable surfaces in areas affected by flooding and storm water, green roofs and streets, etc.	Design	Environmental	EV

Code Reference	Code Mapping	Category	Design Element	Brief Explanation	Tool Type	Pillar Type	Sustainable Guiding Principle
G-NR7	G13, G55, G56, G57	Natural resources	Biodiversity Conservation	Conservation of natural resources and biodiversity, through restoring the functionality of urban landscapes. Biodiversity actions plans helps in detecting the vital habitats needed in the area. Various indicators can be used to measure the biodiversity such as birds and butterflies.	Planning	Environmental	EV
G-FF1	G58, G60	Farming and forestry	Agricultural land	Allocating a high percentage of the greenbelt for agricultural production. Moreover, targeting diversification of activities	Design	Environmental	EV
G-FF2	G59	Farming and forestry	Agricultural land management	Providing support for the land management with specific environmental objectives	Planning	Environmental/ Management	EV

5.3 Validation of Toolkit

Blue Edge

A. Selected location

The proposed location for the validation of the blue edge is the Doha Corniche. even though Qatar has various coastal waterfronts in different cities, the corniche is considered the main coastal waterfront of Qatar where various actives occurs. However, the Doha corniche faces multiple problems that can be solved by implementing the developed toolkit.

The Corniche follows almost a perfect linear curve extending 7.5 km connecting between the two edged of the two of oldest hotels of Doha being the Sheraton Hotel and the Marriot Hotel with various harbors and piers hosting traditional Dhows, to the addition of the Doha port. The corniche hosts most of the administrative, cultural and commercial facilities with multiple open public areas. In 2007, Qatar National Master Plan (QNMP) foreseen an upgrading of the Corniche to confirm its role as the symbolic landscape of Doha, strategize on increasing open green spaces. Challenges of urbanism in Doha is represented by spatial division and social segregation, yet the Corniche remains one of the few places where all the communities of the city come together, acting as a social interface that is accessible without cars. Today, reweaving the public realm is one of the major potential legacies to achieve Qatar National Vision 2030 for a sustainable future, with the potential for Corniche Park and Promenade to become more integrated and accessible, with improved connections to the city and surroundings, as well as increased social and cultural diversity.

The proposal of Doha corniche tackles issues of urban agriculture, food security, scarcity of ground water as well as sustainable urban realm and landscapes, and a productive waterfront of the city. The main Objectives of the proposal are, (1) developing a resilient planning for urban food and food security during critical times, (2) integration of local culture and agricultural heritage into modern urban food practices, (3) creating multi-functional green and blue infrastructure to serve today's and tomorrow's challenges, (4) creating a productive,

attractive waterfront for Doha, (5) providing a platform for regional and international exchange of innovation and technologies on agriculture.

The main challenges facing the corniche are divided into urban and environmental problems. The environmental problems are related to: (1) food security, (2) scarcity of ground water, (3) global warming and climate change, (4) rise of sea-level, (5) lack of biodiversity, and (6) unsuitable land for agriculture. Where the urban problems are as follows: (1) lack of sustainable urban realm, (2) waste management, (3) lack of urban forestry, and (4) energy efficiency. The proposed solutions are discussed below in details with their relation to the toolkit design categories and elements.

The overall proposal of the sustainable urban blue edge is shown in figure 26. the proposal shows all the design solution implemented in order to reach a resilient edge tackling all problems listed above.

Figure 26 Blue edge design proposal, Source (Author)

B. Toolkit validation

The validation of the toolkit in the case of Doha's Corniche is based on four main circles of programs. Those programs tackle the main challenged the area is facing. The programs and proposed land use form a circle from in-land to in-water according to the proximity to existing land use and activities. The circles of programs are as follows:

1. Ecological protection: Location is suitable for mangrove planting and coastal protection enhancing the biodiversity and ecological performance
2. Productive programs: Proximity to Bidaa park, central location on corniche, suitable for urban productive farming
3. Cultural attractions: proximity to the old souqs and port area, and
4. Coastal management: helping with water surge and rising sea level because of climate change

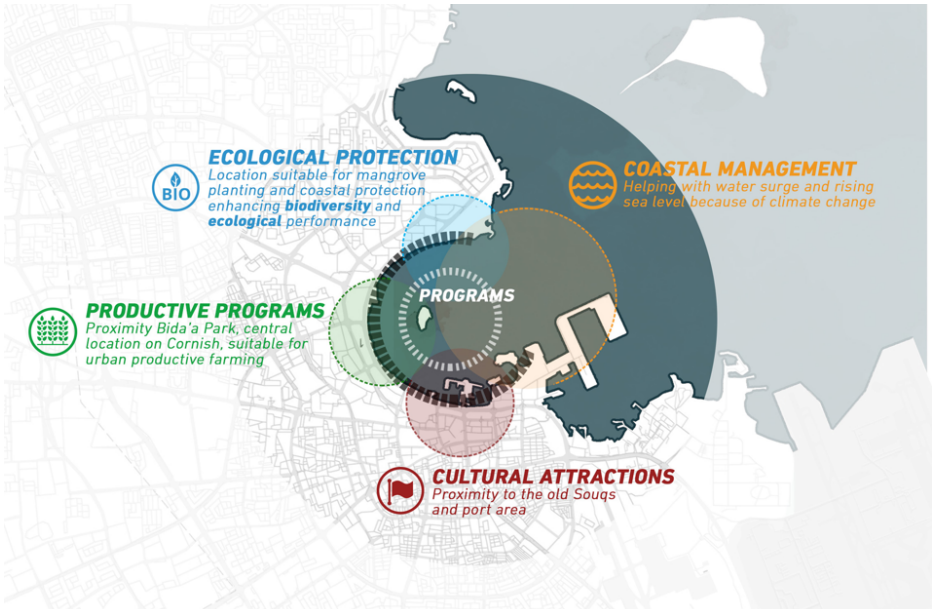


Figure 27 Circles of programs, Source (Author)

Moreover, the design is also based on the circles of network where the introduced concept of saline agriculture creates a connected network of:

1. above water: which is on surface planting - using rooftops, vertical gardening, and hydroponic farming in towers,
2. on-water: floating community gardens and farms, mangroves, planting piers, and
3. underwater planting: observation chambers and underwater gardens

creatively utilizing saline water, creating productive and interactive public realm.

Figure 28 Circles of network, Source (Author)

B.1. Al Bidaa park

Figure 29 Al Bidaa park proposal, Source (Author)

Renewed Al Bidda Park is planned on a site of particular historical and cultural significance being the same site of the old closed Al Bidaa park. with a creation that reflects Qatari heritage and culture. Nature, Culture, History and Function are the four key design factors contributing to the development of the park. The park is to contain a series of connected recreational areas and production gardens. It is to act as the main gate to the project, with the introduction of the new dredged water canal of which is a representation and memory of the old coastal line of Doha. The park is to be extended crossing the coastal edge of the corniche, creating a clear integration of the blue and green.

In reference to the design elements of the toolkit, the park is to create a clear sense of connection both visual and physical allowing for maximum breathable connection *[B-CRM3]*. Moreover, the park provides a wide range of open public spaces that allows for various recreational activities and various transportation modes with direct access to the waterfront. As well as providing huge employment opportunities for various fields. *[B-PCA1, B-PCA4, B-PCA5]*. The development of the park is considered a good edge strategy which will help in balancing various needs and future uses be it physical, ecological or community *[B-ER1]*.

Moreover, the introduction of a huge green area as the park will help greatly in reducing the urban heat in the area *[B-NR7]*.

Toolkit Reference: B-CRM3, B-PAC1, B-PAC4, B-PAC5, B-ER1, B-NR7

B.2. Cultural herbs gardens

Figure 30 Cultural herbs gardens proposal, Source (Author)

The development of herbs gardens is not a new concept, since the past those gardens held a great significance due to their culinary, medicinal, aromatic and ornamental use. In order to revive and encourage the connection with the locals' culture, the floating herbs gardens are community garden open to the public to grow in for production to be sold at the market. Involving the older generation as its their specialty and connecting them with the younger generation for the traditions and culture to continue.

In reference to the design elements of the toolkit, the herbal garden provides a good example of open public space with direct access to the water, moreover it acts as a great educational and cultural tool that can help with the introduction of various activities due to the use of native plants. It also creates numerous employment opportunities for the different age groups of the public. *[B-PAC1, B-PAC3, B-PAC4]*. The cultural gardens help in achieving a resilient edge with minimizing the urban heat due to the green surfaces as well *[B-ER1, B-NR7]*.

Toolkit Reference: B-PAC1, B-PAC3, B-PAC4, B-ER1, B-NR7

B.3. Composting island and water breakers

Figure 31 Composting island proposal, source (Author)

Aiming to divert compostable material, it is planned to have trucks collecting the city's organic waste to the multi-layered composting station built on the island. The space on top of the composting facility would be used for elevated recreational parks. To develop the city's unused island, it offers a potential solution for cutting pollution and waste, while also providing

new public spaces. Breakwaters are introduced due to their benefits in coastal management, and the protection of the waterfront from the climatic conditions. They help in mitigating the waves movement tackling the problem of coastal erosion.

In reference to the design elements of the toolkit, the composting island provide an open recreational and natural area for the public use with the introduction of parks and beaches. Moreover, the composting facility will provide huge employment opportunities for the city *[B-PAC1, B-PAC4]*. In addition, the introduction of the water breakers and the island helps in balancing the needs for a resilient edge *[B-ER1]*.

Toolkit Reference: B-PAC1, B-PAC4, B-ER1

B.4. Underwater gardens

Figure 32 Underwater gardens proposal, source (Author)

The underwater gardens, also known as nemo gardens aims to create a system that utilizes natural resources already available, but by creating an alternative system of agriculture. Dedicated to the growth of vegetation for human consumption and medical applications, but also is concerned about the physical-chemical-biological processes occurring during the plant's development under sea. It is considered as an eco-friendly, Self-sustainable and Ecological solution.

In reference to the design elements of the toolkit, the introduced design proposal preserves the maritime industry from a different perspective *[B-CRM4]*. Moreover, the proposed design would provide a huge educational and recreational activity being a newly introduced concept *[B-PAC3]*. Moreover, it is considered a suitable design strategy implementation for the selected area *[B-ER1]*.

Toolkit Reference: B-CRM4, B-PAC3, B-ER1

B.5. Open market zone

The proposal is to create an open market area (figure 32), in which daily food products from the different gardens and fisheries is to be sold to the public, creating a new type of market in the corniche and a new open public space to satisfy the population needs and wants, considering all the new residential projects near the corniche.

In reference to the design elements of the toolkit, the open market zone would offer an open public area with the opportunity for multiple activities and various non-motorized transportation options. Also, it will help in providing new employment opportunities *[B-PAC1, B-PAC4]*.

Toolkit Reference: B-PAC1, B-PAC4

B.6. Post-industrial zone

The industrial zone is mainly recycled ship containers acting as the main zone of command and operation for the whole proposal or development, including the command centers

for the floating gardens, underwater gardens, compost island and cruise terminal (figure 32). Moreover, includes the handling, storage and processing of all produced food in the site.

In reference to the design elements of the toolkit, the post-industrial zone helps in preserving the maritime industry in an advanced way being the main command center for all maritime application *[B-CRM4]*. Changing the function of the port and reducing the industrial operations helps in mitigating health and physical problems. Moreover, the new function will help in generating new employment opportunities in different fields *[B-PAC2, B-PAC4]*. In addition, the elimination of industrial function from the port helps in reducing contamination *[B-NR3]*.

Toolkit Reference: B-CRM4, B-PAC2, B-PAC4, B-NR3

B.7. Floating gardens and fisheries

Figure 33 Floating garden & fisheries proposal, Source (Author)

The floating garden and fisheries are introduced in order to complement traditional fish farming which is known as a local traditional activity. They help in promoting long-term food

security and resilience. The floating gardens can work in a 3 layers system, the lower being the fisheries, the middle is the green vegetation production and another layer can be added with is the solar panels for renewable energy source.

In reference to the design elements of the toolkit, the proposal helps in maintaining the maritime industry *[B-CRM4]*. Furthermore, it helps providing educational, cultural and environmental purposes and activities. With the introduction of employment in maritime related jobs *[B-PAC3, B-PAC4]*. It is also of a good edge strategy and utilization of the water edge *[B-ER1]*. Additionally, it helps in introducing renewable source of energy and minimize the impact of urban heat through the green spaces *[B-NR5, B-NR7]*.

Toolkit Reference: B-CRM4, B-PAC3, B-PAC4, B-ER1, B-NR5, B-NR7

B.8. Oyster reefs

Figure 34 Oyster reefs proposal, source (Author)

The introduction of oyster reefs at the edge of the corniche provides various benefits such as: nutrition, attraction of water species such as fishes and crabs, mitigating erosion, removal of nitrogen from coastal of which tackles the problem of algae.

In reference to the design elements of the toolkit, the introduction of oyster reefs helps in diminishing coastal hazards and risks, from erosion to flooding. Moreover, it helps in the protection of the coastal habitats and improve edge resilience *[B-CRM1, B-CRM2]*. It is also considered a sustainable strategy for edge planning as it helps in improving the quality of the storm water acting as a natural filtering and treatment tool of water coming from the urban city dumped in the sea *[B-ER1, B-NR6]*.

Toolkit Reference: B-CRM1, B-CRM2, B-ER1, B-NR6

B.9. Productive and active piers

Figure 35 Productive & active piers proposal, Source (Author)

The floating piers has mixed functions of productive food and activities. It is focused on the agricultural food production of basic daily needs from fruits and vegetables, including community garden in which people can be part of the process. The plants are to be irrigated using a mixture of the TSA water being discharged through various points within the corniche edge and the saline seawater, mitigating the increase in seawater rise levels and decrease in natural groundwater Moreover, the piers act as a public space for people to visit and enjoy with activities and services. It is a mix between leisure, education and wellness.

In reference to the design elements of the toolkit, the piers maximizes the connection with water through various senses *[B-CRM3]*. Besides, it provides a large area for public access, activities and employment opportunities *[B-PAC1, B-PAC3, B-PAC4]*. It is a good planning strategy for the blue edge as it helps in mitigating urban heat *[B-ER1, B-NR7]*.

Toolkit Reference: B-CRM3 B-PAC1, B-PAC3, B-PAC4, B-ER1, B-NR7

B.10. Mangroves

Figure 36 Mangroves proposal, Source (Author)

The introduction of mangroves along the coastal line of the corniche helps in mitigation various climatic and environmental problems. It protects the shorelines from extreme weather condition such as floods, winds, waves, etc. moreover it helps in mitigating coastal erosion due to their natural roots upholding the sediments. In addition, it helps in filtering and maintaining the quality of the water. Mangroves also have the potential of attracting other species such as crabs, fishes, etc.

In reference to the design elements of the toolkit, the mangroves proposal helps in reducing coastal hazards, raising edge resilience and protecting the coastal edge creating connection between blue edge and green both from inside water and outside through connection with greenways *[B-CRM1, B-CRM2, B-PAC5]*. It is considered a suitable ecological edge strategy of which imitates the natural characteristics of Qatar's shoreline *[B-ER1, B-ER2]*. It is also a good mitigating tool for storm water as it helps in filtering and treating the water before its dumping into the sea. Also, it helps in minimizing the impact of urban heat *[B-NR6, B-NR7]*.

Toolkit Reference: B-CRM1, B-CRM2, B-PAC5, B-ER1, B-ER2, B-NR6, B-NR7

B.11. Hydroponic towers

Hydroponic towers work by growing plants in a water based, nutrient rich solution. Re-Using the multiple underdeveloped or unoccupied towers in west bay for planting purposes and producing organic food can make it the main source of vegetation distribution within the area. The irrigation of the greenery can be through the usage of TSE water from neighboring towers, with addition to saline water.

In reference to the design elements of the toolkit, the hydronic tower targets two elements of the design tools which are the suitable edge strategy of using abandoned tower for

food security and production purposes. Moreover, innovative and advance implementation of new concepts

Toolkit Reference: B-ER1, B-INV1

B.12. Saline agriculture

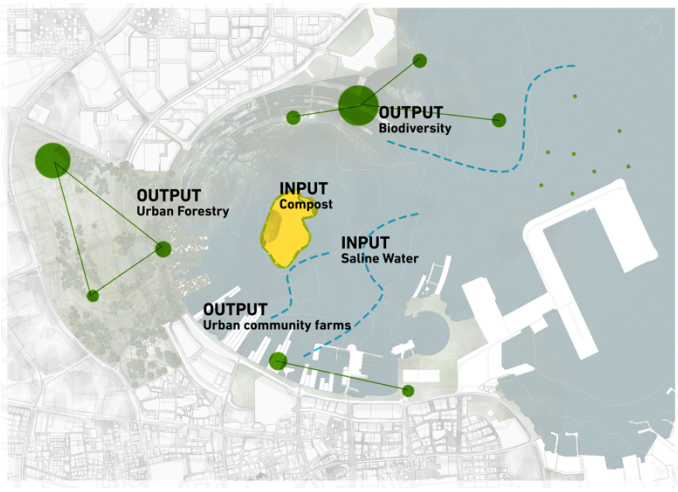


Figure 37 Food production using saline proposal, Source (Author)

The world population, particularly developing countries will benefit from saline agriculture and its urban practices. In addition, to coastal urban cities such as Doha. With the continuous increase of the world population the requirements for food, freshwater and fuel are bigger every day. There is an urgent necessity to develop, create and practice new type of agriculture which has to be environmentally sustainable and adequate to the ecological context. Saline agriculture is an innovative way of using salted soils or water such as seawater, salt contaminated water, etc. for irrigation purposes. The agricultural use of saline water or soil can benefit Qatar in facing multiple challenges. The process of saline agriculture mainly produces food and bio-products.

In reference to the design elements of the toolkit, use of the saline agriculture concept is considered highly innovative and advance design implementation tool. It uses advanced methods and materials in order to mitigate existing problems.

Toolkit Reference: B-INV1

B.13. Renewable energy

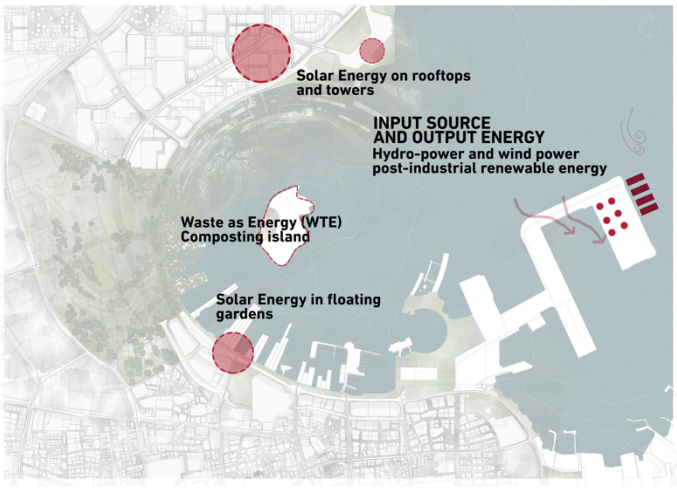


Figure 38 Energy sources proposal, Source (Author)

The design proposal attempts to produce and utilize renewable energy sources. The energy sources as proposed as; (1) Solar energy on towers and roof tops, (2) hydro-power and wind power of post-industrial zone, (3) composting island facility as waste energy, (4) solar energy in floating gardens. In reference to the design elements of the toolkit, the renewable energy targets the design element of introducing sustainable renewable design resources.

Toolkit Reference: B-NR5

C. Summary

The blue edge proposals have the following Outcomes:

1. coastal management: creating a protected shoreline with natural and ecological methods that help and enrich the biodiversity of the place. Moreover, oyster reefs an mangroves development, helps in filtering the water and protecting the shoreline from rising sea level.
2. Food security: using sustainable water supply and environmental protection and as per the Qatar National Food Security Program, the program can be activated through this proposal with the proposed development of all the urban spaces used as productive landscapes
3. Biodiversity and ecology: creating an interactive eco-system and enhancing the ecological performance of the waterfront. In addition to functionally serving as protection against water surge and coastal erosion, mangroves also help in increasing carbon capture.
4. Public realm: through the proposal, the corniche becomes more livable and interactive with various programs. This amplifies the significance and quality of the public realm by creating different high-quality attractions. In addition, industrial spaces are converted into clean, productive and social spaces.

Green Edge

A. Selected location

The proposed location for the validation of the green edge is the Doha city. even though Qatar has various cities where the greenbelt can be implemented, Doha is considered the biggest and most populated city where almost 40% of the population resides, therefore it is true to say that it also hosts most of the urban problems. The city of Doha faces multiple problems that can be solved by implementing the developed toolkit.

The city of Doha hosts multiple problems such as: (1) rapid scattered development leading to declination in quality of life standard, (2) large mega projects targeting only higher income groups, (3) lack of quality public realm and sustainable transportation option, (4) the preference of low density residential area leading to urban fringes and sprawl, (5) energy and water resources, (6)food security, (7) zoning regulations and land-use, (8) climatic problems.

The greenbelt proposal was introduced in Qatar National Development Framework 2032 as a concept, however there are no clear set of tools or guidelines to be followed for its implementation. Therefore, this proposal will help in implementing the design toolkit developed and testing its validity in Doha.

The project aim in the city of Doha is a large-scale intervention for Urban Forestry, that targets to enhance the green infrastructure of the city and create a continuous network of vegetation. Surrounding Doha with a Greenbelt, connecting though Greenways, and ending with Coastal blue edge. It has the four goals of: (1) Enhance green infrastructure, (2) enhance Environmental quality in life within a city, (3) promote sustainable development and supporting QNV 2030 and QNDF 2032, (4) Preventing natural hazards like forestation, extreme sandstorms and coastal erosion. The impact of the greenbelt development in the city is as follows: (1) helps with temperature control, (2) precipitation and water sources, (3) introducing and developing ecosystems, (4) introducing agricultural lands, (5) developing recreational areas and supporting tourism, (6) infrastructure, and (7) land values.

The overall proposal of the sustainable urban green edge is shown in figure 39. the proposal shows all the design solution implemented in order to reach a resilient edge tackling all objectives listed above. The proposed solutions are discussed below in details with their relation to the toolkit design categories and elements.

Figure 39 Green edge design proposal, Source (Author)

B. Toolkit validation

The validation of the toolkit in the case of Doha's urban edge or periphery is based on three main proposals. Those proposals tackle the main challenged the area is facing. The programs and proposed land use are defined according to the proximity to existing land use and activities. The proposals are as follows:

1. Climatic greenbelt: mitigating climatic problems facing the city of Doha
2. Urban greenbelt: focusing on social opportunities
3. Green corridors: creating a link between the wildlife and urban area

B.1. Climatic greenbelt (forest and fields)

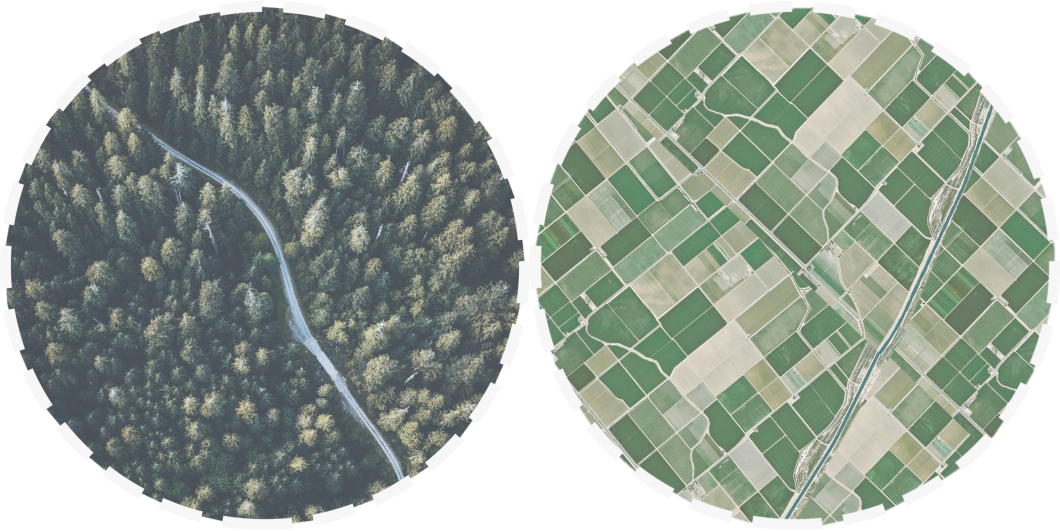


Figure 40 Climatic greenbelt proposal

The development of the climatic greenbelt is to mitigate the extreme climatic conditions facing Qatar, mainly with the problem of desertification. Therefore, there is a need to introduce forestation zone of which utilizes native plant species in order to mitigate those problems. In addition, a clear management and maintenance plan should be developed in order to preserve the introduced zone. In regard to the irrigation of the huge forestation zone, the

unutilized treated sewage effluent presents a good alternative instead of using regular irrigation water.

This resource should be put to the best use by irrigating the “green belts” once they are established. The Change in the proposed density of the forestation will lead to the creation of various ecosystem, moreover, land rehabilitation and its development over the years should be taken into consideration. Additionally, the climatic belt will also help in stopping the urban sprawl. Furthermore, Green agricultural fields supporting the greenbelt forest are introduced which will also assist in providing food.

Various Trees types were investigated howver the most approprait to be used in the climatic greenbelt are the wind stopper trees, which are thick, strong, providing enough protection from wind and sand. Such examples of species are: Cupressus sempervirens, Kigelia pinnata Azadirachta indica Adr.Juss

Figure 41 Trees types in climatic greenbelt, Source (Ministry of Municipality and Environment, 2014b)

In reference to the design elements of the toolkit, the climatic greenbelt was strategically placed in order to mitigate the climatic conditions of desertification *[G-GBL1]*. The greenbelt also offers quality public access both for pedestrian and multiple transportation.

Moreover, it helps in pollution reduction and air filtration with the introduction of greenways *[G-PAC1, G-PAC4, G-PAC5, G-PAC6]*. The climatic greenbelt is also located in the urban fringes and abandoned lands with the purpose of mitigating urban sprawl and various climatic change conditions *[G-ER1, G-ER2, G-ER3]*. The introduction of forestation and agricultural lands will also help in food and wood production with the use of native plants *[G-NR1, G-NR2, G-NR4, G-FF1]*.

Toolkit Reference: G-GBL1, G-PAC1, G-PAC4, G-PAC5, G-PAC6, G-ER1, G-ER2, G-ER3, G-NR1, G-NR2, G-NR4, G-FF1

B.2. Urban greenbelt (people focused)

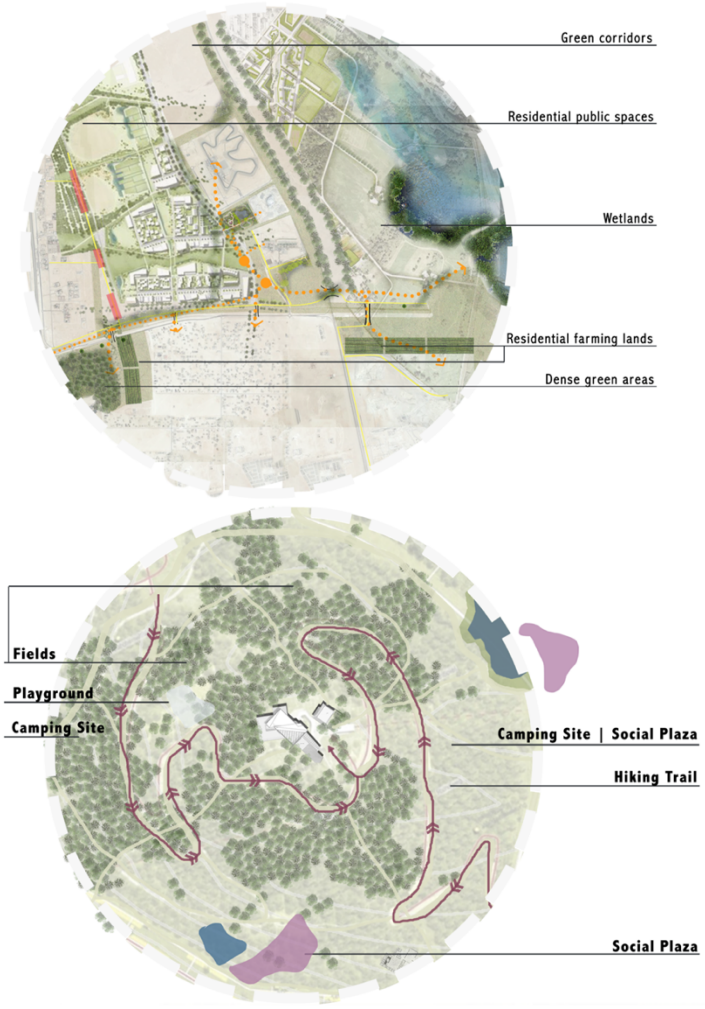


Figure 42 Urban greenbelt proposals, Source (Author)

The urban greenbelt proposals are focusing more on the people. Greenbelt land helps in mitigating urban sprawl and connection the urban areas to the wildlife yet taking into consideration the preservation of the wildlife. Furthermore, the designation of various lands for forestry and agricultural purposes. In addition, it is concerned with developing various social, recreational and open areas for the public either secluded or integrated with the development of everyday uses such as schools, hospitals, etc. the urban greenbelt holds a great impact on the greenbelt, especially on the social pillar as it offers, (1) leisure and recreation, (2) communication and mobility, (3) health, (4) urban structure and identification.

The urban greenbelt proposals introduce the following:

1. Green corridors: Changing highways to become green corridors. Planting local species and adding an aesthetic to the long roads
2. Residential public spaces: Parks and playgrounds that serve the residents of the area, and propose activities around the greenbelt
3. Wetlands: Creates new form of public realm, and a place for interaction with environment and people, enhancing the existing environmental condition.
4. Residential farming lands: Promoting the culture of planting for residential use, to help in food security, and greening the landscape
5. Dense green areas: Some areas can allocate denser greenery closer to residential units, to improve air quality and environmental experience.
6. Open public, recreational areas: the introduction of various open spaces such as camping sites, playgrounds, hiking trails, etc.

Regarding the trees types to be introduced in the urban greenbelt, decorative trees, flowers, fruit trees for productive fields, and trees that provide shade are the best options. They are to be Indigenous types for biodiversity and sustainability. Such examples if Species are: Clerodendron inerme, Jasminum sambac, Rosaceae, Bougainvillea, Acacia sclerosperma, Hibiscus rosa, Lawsonia inermis, Acacia saligna, Boswellia sacra.

Figure 43 Trees types in urban greenbelt, Source (Ministry of Municipality and Environment, 2014b)

In reference to the design elements of the toolkit, the allocation of the urban greenbelt was based on its proximity to existing developed urban areas *[G-GBL1]*. The urban green belt introduced a quality linkage a connection for the public with the green, it provides multifunctional green open recreational area. Moreover, it integrated the greenbelt with the existing urban fabric and public building such as schools, hospitals, etc. impacting on the therapeutic and psychologic needs of the public. Due to its proximity with built area it maximizes the thermal comfort, minimizing pollution, air filtration and noise reduction. The belt also offers multiple greenways and blueways of which benefits the people's health *[G-PAC1, G-PAC2, G-PAC3, G-PAC4, G-PAC5, G-PAC6]*. Another advantage of the urban greenbelt is the mitigation of urban sprawl and climatic changes such as storms, flooding, etc. *[G-ER2, G-ER3]*. In addition, the urban greenbelt offers various natural resources such as the production of food and wood with the introduction of various agricultural lands *[G-NR1, G-NR4, G-NR6, G-FF1]*.

Toolkit Reference: G-GBL1, G-PAC1, G-PAC2, G-PAC3, G-PAC4, G-PAC5, G-PAC6, G-ER2, G-ER3, G-NR1, G-NR4, G-NR6, G-FF1

B.3. Green corridors (Urbana and agricultural greenways)

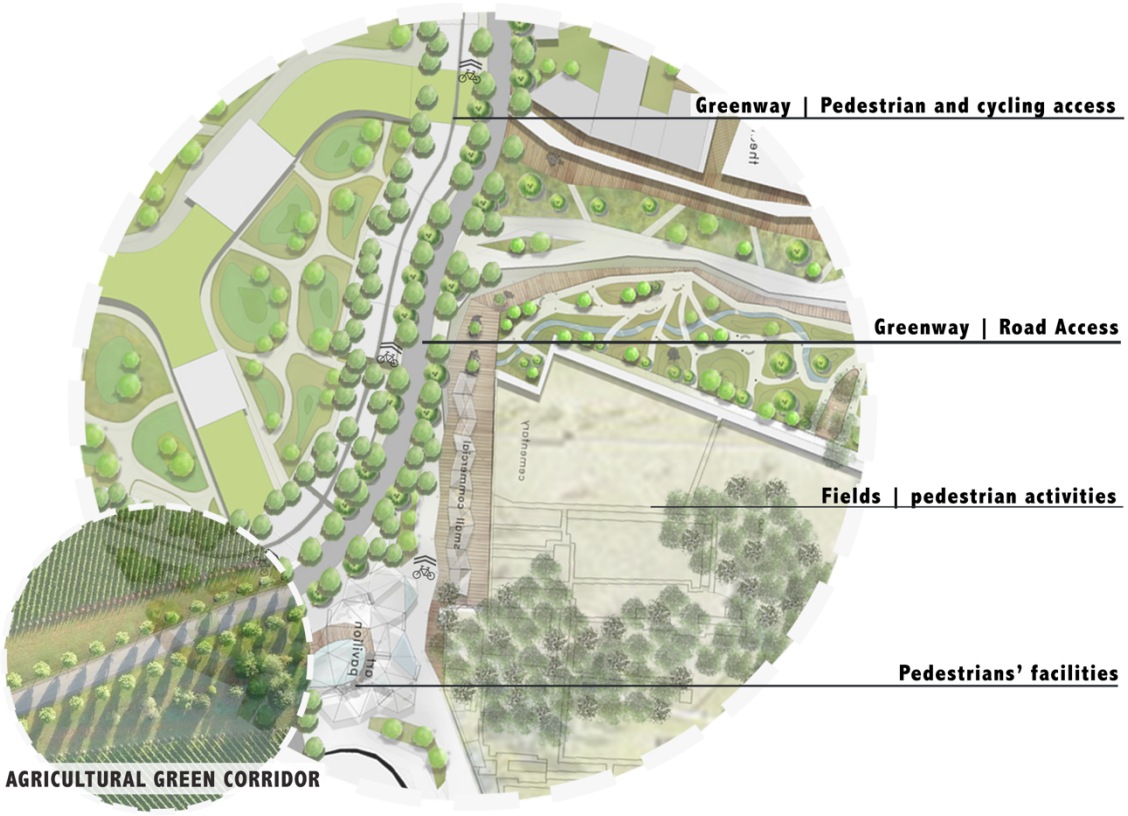


Figure 44 Green corridors proposals, Source (Author)

The greenway provides recreational and pedestrian use instead of a typical street corridor. It promotes the introduction of green open areas and maintaining vegetation. Both urban and agricultural green corridors provide recreation, transportation, fitness, and economic benefits for the public. The urban forestry corridor will provide a linkage between the areas around the proposed location. For such proposal the best trees types are productive trees for agriculture and indigenous plants for symbolism and awareness such species are: Cordia obliqua, Pithecellobium dulce, Ficus carica, Tamarindus indica

Figure 45 Trees types in green corridors, Source (Ministry of Municipality and Environment, 2014b)

In reference to the design elements of the toolkit, the green urban and agricultural corridors are to be located in different areas where needed as per the analysis *[G-GBL1]*. The green corridors provide quality public access and connection to green areas with multiple transportation modes with various open public spaces with cultural, historical and educational activities and programs. The green corridors. Additionally, it helps with maximizing urban comfort, reducing pollution and noise, and serves as air filtration *[G-PAC1, G-PAC2, G-PAC4, G-PAC5, G-PAC6]*. Furthermore, the belt helps with urban and climatic containment and mitigation *[G-ER2, G-ER3]*. The agricultural green corridors also help with food production due to the introduction of agricultural lands with the use of native plants and endangered species *[G-NR1, G-NR4, G-NR6, G-FF1]*.

Toolkit Reference: G-GBL1, G-PAC1, G-PAC2, G-PAC4, G-PAC5, G-PAC6, G-ER2, G-ER3, G-NR1, G-NR4, G-NR6, G-FF1

C. Summary

The green edge proposals have the following Outcomes:

1. Urban edge management: creating a protected urban edge, mitigating both climatic and urban problems. The greenbelt helps with the containment of

urban sprawl of Doha city. Moreover, it helps with the climatic problems of desertification, flooding, storms, air filtration, urban heat, etc.

2. Food security: using sustainable water supply and environmental protection and as per the Qatar National Food Security Program, the program can be activated through this proposal with the proposed development of all the urban spaces used as productive landscapes.
3. Biodiversity and ecology: creating an interactive eco-system and enhancing the ecological performance of the urban area. In addition to functionally serving as protection against climate conditions, green areas help with the development of the biodiversity.
4. Public realm: through the design proposal, the Doha urban edge becomes more livable and interactive with various offered programs and activities. This amplifies the significance and quality of the public realm by creating different high-quality attractions.

CHAPTER 6: CONCLUSION AND FUTURE WORK

6.1 Conclusion

In conclusion, this thesis focuses on the creation of a sustainable urban edge design toolkit for the coastal cities, with the validation of the tool through design proposals on the case of Doha tackling both its blue and green edge. The thesis follows a methodological approach defined as: (1) data collection, (2) filtering and analysis and (3) validation to assist in achieving the QNV 2030 following QNDF 2032.

The data collection stage included a review of four precedent guidelines which resulted in a total of 96 design elements for both blue and green edges; which was then filtered to only 47 design elements based on two pillars of the sustainable development (Social and Environmental) with the addition of the new management pillar leading to three out of six sustainable guiding principles of QNDF (quality of life (QL), connectivity of people and places (CPP), and environmental values (EV)). A brief site analysis was conducted to validate the toolkit based on the context of Doha. The analysis included a study on the climate, land use, population existing systems and functions etc. Design proposals introduced in chapter 5 are used to validate the filtered design elements.

Matrix shown in Table 7 summarizes the percentage of the design and planning tool validated in relation to the total design elements of the toolkits for both blue and green edges. 66.7% design elements of the blue edge toolkit were validated, in which 75% of it was design tools as planning tools cannot be easily validated in this stage. In the green edge, a total of 69.6% design elements were validated, where design and planning tools covered equally 50% of the total validation.

It is important to note that not all introduced design tools can be applied in the cases used for validation (i.e how the corniche was selected for the blue edge, and the city of Doha for the green edge). The toolkit was developed generally to meet the development needs of coastal cities. Therefore, the tools can be applied in specific cases depending on the site context

and use. However, our validation outcomes clearly show that the sustainable urban edge design toolkit is highly applicable for coastal cities.

Table 7 Design validation summary matrix, Source (Author)

		Edge Type			
		Blue		**Green**	
		Toolkit Count	Validated Count	Toolkit Count	Validated Count
	Design Elements	**24**	**16**	**23**	**16**
Tool Type	Design	14	12	9	8
	Planning	10	4	14	8

6.2 Contribution

The thesis is aligned directly and facilitates achieving the National Vision 2030 of Qatar. It also helps directly in bridging the gap found in the Qatar National Development framework 2032 by the introduction of the sustainable urban edge design toolkit that will help in the application of the proposed concepts of the greenbelt and costal edge in the framework.

Moreover, as a governmental employee working in the Public Works Authority of Ashghal (PWA) which is considered the main governmental entity concerned with infrastructure and planning of the city after the Ministry of Municipality and Environment (MME), the thesis study can greatly influence the application of the tool as it can be communicated with the concerned stakeholders for further development, testing and application.

6.3 Future Work and Limitations

In order to develop the sustainable urban edge design toolkit further, it can be communicated with the concerned entity like MME or PWA and other related entities to discuss it further and coordinate with the concerned stakeholders. Sharing the tool will allow it to be further improved as multi-disciplinary team is required to evaluate it based on their different disciplines. Moreover, as most the documents concerned with the QNDF is confidential, it'll be easier and more applicable if these government entities were to review it and align the tool to their plans.

Furthermore, the tool can be published to be accessed by planners, policymakers, other concerned parties, etc. for the toolkit to be validated both locally and globally on coastal cities. The development of the toolkit was not dependent on any cultural, religious, or other elements that are particularly concerned with the case of Qatar. This will help in the implementation of the toolkit in different countries. The validation of the toolkit through these various cases can also help in identifying the strong and weak points that the toolkit upholds for further development.

The toolkit can be further revised and developed in the future, through referring to extra deigns guidelines references. The existing design guidelines are in most cases confidential, therefore with access to more certified and competent guidelines, the developed toolkit can be further studied and analyzed.

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APPENDIX 1: PRECEDENT DESIGN GUIDELINES

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
B1	Blue	Waterfront edge design guidelines	Site assessment & planning	Develop a multidisciplinary design team	Project is informed by a comprehensive group of experts.	Planning
B2	Blue	Waterfront edge design guidelines	Site assessment & planning	Assess site wide social and ecological context and vulnerabilities	Provide an analysis of the project site to inform a design approach in line with site conditions and a baseline from which to measure performance over time.	Planning
B3	Blue	Waterfront edge design guidelines	Site assessment & planning	Develop and implement an equitable plan for community engagement	Engage community stakeholders in the vision, design, and implementation of the project to create a welcoming and equitable waterfront for all.	Planning
B4	Blue	Waterfront edge design guidelines	Site assessment & planning	Create a maintenance and adaptive management plan	Ensure the maintenance, ongoing performance, and adaptive management of waterfront projects in support of access, ecological health, and resiliency.	Planning
B5	Blue	Waterfront edge design guidelines	Responsible siting & coastal risk reduction	Avoid or reduce risk from coastal hazards	Reduce human health and safety risks and potential damage to site features.	Design

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
B6	Blue	Waterfront edge design guidelines	Responsible siting & coastal risk reduction	Site with ecological sensitivity	Prevent adverse ecological impacts caused by structures to important habitat areas and increase resilience to sea level rise and coastal storms.	Design
B7	Blue	Waterfront edge design guidelines	Responsible siting & coastal risk reduction	Site or design structures to improve visual and other sensory connections to the water	Enhance and maximize light, air, and visual and psychological access to the water from upland areas.	Design
B8	Blue	Waterfront edge design guidelines	Responsible siting & coastal risk reduction	Support industrial water-dependent uses	Support and preserve water-dependent uses related to maritime industry and commercial shipping and promote associated economic, environmental, and public health benefits.	Planning
B9	Blue	Waterfront edge design guidelines	Responsible siting & coastal risk reduction	Provide an emergency preparedness and response plan	Protect human safety by planning for emergency conditions, which includes effective communications and operations both prior to and following extreme events.	Planning
B10	Blue	Waterfront edge design guidelines	Community access & connections	Provide quality public access areas on the waterfront	Create or improve high quality public access areas on the waterfront that maximize interaction with the water and are shaped by community	Design

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
					priorities, to promote equitable, engaging, and healthy waterfronts.	
B11	Blue	Waterfront edge design guidelines	Community access & connections	Reduce industrial impacts to human health and wellbeing	Minimize the adverse impacts of industrial operations on the surrounding community.	Design
B12	Blue	Waterfront edge design guidelines	Community access & connections	Provide diverse programming and passive educational features	Provide robust programming opportunities to enhance the historical, cultural, and environmental context, promote stewardship and build diverse community ownership.	Design
B13	Blue	Waterfront edge design guidelines	Community access & connections	Increase transportation access to the waterfront	Improve public access to the site by expanding and encouraging sustainable transportation options, especially waterborne transportation.	Design
B14	Blue	Waterfront edge design guidelines	Community access & connections	Create maritime-related employment opportunities	Provide employment opportunities and vocational training in maritime fields to support the local economy and water-related industries.	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
B15	Blue	Waterfront edge design guidelines	Community access & connections	Increase waterfront pathway and greenway connectivity	Increase connectivity of green and blue spaces along the waterfront to promote physical activity, health and wellbeing, and encourage non-motorized transportation options.	Design
B16	Blue	Waterfront edge design guidelines	Community access & connections	Provide direct connections to the water for people and boats	Enable people to safely and directly access and interact with the water to enhance human wellbeing and promote stewardship of the waterways.	Design
B17	Blue	Waterfront edge design guidelines	Community access & connections	Support diverse and sustainable maritime activity	Promote low-impact, safe design that accommodates a diverse range of vessels and facilitates educational programming.	Design
B18	Blue	Waterfront edge design guidelines	Edge resilience	Choose an appropriate edge strategy for the context and intended use	Ensure the structural integrity and sustainability of the shoreline and near- shore area using a strategy that has the greatest possible positive impact on the environment and community, given the intended use and context.	Design
B19	Blue	Waterfront edge design guidelines	Edge resilience	Maintain or emulate natural shoreline shape	Support native biodiversity and reduce the impacts of channelization by maintaining or mimicking local, natural shoreline shape, slope,	Design

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
					material, and heterogeneity to the extent possible.	
B20	Blue	Waterfront edge design guidelines	Edge resilience	Protect the working edge	Protect edge from structural damage over time due to active use.	Design
B21	Blue	Waterfront edge design guidelines	Edge resilience	Ecologically enhance structural components	Lower the impact and improve the biodiversity of man-made edges through mimicking the structural heterogeneity and materials of the natural, local shoreline.	Design
B22	Blue	Waterfront edge design guidelines	Natural resources	Maintain and restore biodiversity and ecosystem services	Preserve or minimize impacts to natural resources and the services they provide.	Planning
B23	Blue	Waterfront edge design guidelines	Natural resources	Restore/increase ecosystem connectivity	Increase the diversity of habitats, restore continuity of ecosystems, and reduce fragmentation.	Design
B24	Blue	Waterfront edge design guidelines	Natural resources	Support native habitat complexity and biodiversity	Support native, rare, and biodiverse ecosystems through planting plans and management.	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
B25	Blue	Waterfront edge design guidelines	Natural resources	Avoid human disturbance to natural resources	Avoid ongoing disturbance to wildlife due to human activity.	Planning
B26	Blue	Waterfront edge design guidelines	Natural resources	Redevelop and clean up contaminated sites	Reduce contamination in the environment.	Planning
B27	Blue	Waterfront edge design guidelines	Natural resources	Sustainable fill and soil management	Reduce environmental impacts associated with fill use and management.	Planning
B28	Blue	Waterfront edge design guidelines	Natural resources	Resilient energy sources	Provide lower-impact, renewable energy systems	Design
B29	Blue	Waterfront edge design guidelines	Natural resources	Practice environmentally responsible construction	Reduce the environmental impact of construction practices.	Planning
B30	Blue	Waterfront edge design guidelines	Natural resources	Reduce and manage stormwater quantity	Reduce the overall volume of stormwater quantity, using recharge or infiltration whenever feasible.	Design

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
B31	Blue	Waterfront edge design guidelines	Natural resources	Improve stormwater discharge quality	Reduce water quality impacts of stormwater.	Design
B32	Blue	Waterfront edge design guidelines	Natural resources	Reduce water use	Reduce impact on freshwater resources as well as load to municipal systems and potential for combined sewer overflows.	Design
B33	Blue	Waterfront edge design guidelines	Natural resources	Reduce contribution to urban heat	Reduce contributions to the cumulative impacts of impervious and heat absorbing surfaces.	Design
B34	Blue	Waterfront edge design guidelines	Natural resources	Partner with academic and scientific institutes to study/monitor the site	Expand capacity for tracking, monitoring, and evaluating waterfront areas and contribute to a broader body of knowledge about waterfront issues and best practices.	Planning
B35	Blue	Waterfront edge design guidelines	Innovation	Inventive design	Encourage innovative design and pilot studies of new materials and methods.	Design
B36	Blue	Waterfront edge design guidelines	Innovation	Exemplary performance	Encourage projects to exceed the current standards of WEDG.	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G1	Green	A 21st Century Metropolitan Green Belt	Openness	keeps land permanently open	A strategic gap helps distinguish between the aim of tightly defined cities and openness. Openness is an aesthetic consideration; some people simply prefer open countryside to buildings. It is also a matter of degree, how much openness do we retain? This leads to two options, one that achieves the aesthetic preference for the countryside and one that doesn't.	Planning
G2	Green	A 21st Century Metropolitan Green Belt	Urban regeneration	Encouraging the recycling of derelict and other urban land	Limiting building on greenfield sites to locations away from cities promote urban regeneration by preventing the use of greenfield land, then the use of a wide Metropolitan GreenBelt is one way	Planning
G3	Green	A 21st Century Metropolitan Green Belt	Access and environmental quality	Provide quality public access areas on the greenbelt	Create or improve high quality public access areas on the greenbelt that maximize interaction with the green and are shaped by community priorities, to promote equitable, engaging, and healthy greenbelt.	Design

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G4	Green	A 21st Century Metropolitan Green Belt	Compactness of urban form	urban containment	resisting 'sprawl', but including a more explicitly environmental purpose of avoiding excessive use of the private car for personal travel.	Planning
G5	Green	Guidelines on urban and peri-urban forestry	Human health and well-being	Creating balance between the natural and built environments	Well-designed and managed urban forests and other green spaces can play important roles in ensuring healthy lives and promoting well-being through disease prevention, therapy and recovery.	Planning
G6	Green	Guidelines on urban and peri-urban forestry	Human health and well-being	production of fresh and nutritious food as well as natural and traditional remedies for use by local communities.		Design
G7	Green	Guidelines on urban and peri-urban forestry	Human health and well-being	encouraging physical activities and improving mental health.		Design
G8	Green	Guidelines on urban and peri-urban forestry	Human health and well-being	Optimize the availability, accessibility, proximity, permeability and security of urban		Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
				forests to promote the use of such resources by all citizens		
G9	Green	Guidelines on urban and peri-urban forestry	Human health and well-being	Maximize the thermal comfort, pollution filtration and noise reduction functions of urban forests	When planning and designing public spaces and streets	Design
G10	Green	Guidelines on urban and peri-urban forestry	Human health and well-being	Include urban forests in the planning and design of hospitals and schools	For their proven therapeutic and psychological benefits for patients and children	Design
G11	Green	Guidelines on urban and peri-urban forestry	Human health and well-being	Develop greenways/blueways to increase alternative mobility	Way of promoting physical and mental health and reducing pollution	Design
G12	Green	Guidelines on urban and peri-urban forestry	Climate change	Making cities more resilient to the effects of climate change	Mitigate stormwater runoff, improve air quality, store carbon, decrease urban energy consumption by shading and cooling (potentially mitigating the urban heat island effect), and reduce the impacts of extreme weather and floods	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G13	Green	Guidelines on urban and peri-urban forestry	Biodiversity and landscapes	Biodiversity conservation	Increasing and restoring the functionality and connectivity of urban and peri- urban natural landscapes can make a valuable contribution to the conservation of natural resources and biodiversity.	Planning
G14	Green	Guidelines on urban and peri-urban forestry	Biodiversity and landscapes	Promote the planting of endangered native species	Including those that provide habitats for birds and other local native species, and aim to create highly diverse forests.	Planning
G15	Green	Guidelines on urban and peri-urban forestry	Economic benefits and green economy	Develop detailed short-term and long-term urban forest management plans	Strategies: - at the site level – select low-maintenance, resilient native species to reduce management costs; - at the landscape level – increase the area of urban forests and other green spaces to attract homebuyers, retailers and investment, and increase the area of green space in public areas and business precincts (e.g. shopping malls, central business districts and parking lots) and the use of big-canopy tree species to attract visitors; - at the municipality level – ensure	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
					"clean, green" cities through long-term planning and design, and use branding and marketing to fully exploit the economic potential of green infrastructure.	
G16	Green	Guidelines on urban and peri-urban forestry	Economic benefits and green economy	Define tangible and intangible ecosystem services and benefits	Investment in urban forests is a promising strategy for sustainably creating jobs, increasing income, and boosting local green economie - improve the living conditions and livelihoods of urban residents - Increase property and land values and rental prices and attract investment, businesses and tourism - Generate employment and business opportunities - production of foods	Planning
G17	Green	Guidelines on urban and peri-urban forestry	Risk management	reduce the threats posed by urban forests to people, property and infrastructure.	Policymakers, decision-makers, urban planners, urban foresters and private landowners should all be aware of the risks posed by urban forests, which can be greatly reduced with long-term planning and sound management practices.	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G18	Green	Guidelines on urban and peri-urban forestry	Risk management	Detecting forest fire	Develop an early-warning system for detecting forest fire, and design adequate forest fire prevention and response mechanisms.	Design
G19	Green	Guidelines on urban and peri-urban forestry	Risk management	Implement proactive risk control and mitigation measures	By conducting periodic tree risk assessments, using methods such as walk-by inspections (for individual trees) and drive-by (windshield) surveys (for stands).	Planning
G20	Green	Guidelines on urban and peri-urban forestry	Risk management	Transfer risk	for example by purchasing insurance.	Planning
G21	Green	Guidelines on urban and peri-urban forestry	Risk management	Hazard management and emergency responses	for example to clean up urban forest debris and repair tree-caused damage in the wake of storms.	Planning
G22	Green	Guidelines on urban and peri-urban forestry	Mitigating land and soil degradation	protecting soils and increasing their fertility	Urban forests can help combat desertification, restore degraded soils and lands, and prevent drought and floods	Planning
G23	Green	Guidelines on urban and peri-urban forestry	Mitigating land and soil degradation	Retain native trees and vegetation	to increase land and soil protection, especially in peri-urban areas.	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G24	Green	Guidelines on urban and peri-urban forestry	Mitigating land and soil degradation	protect peri-urban and urban soils from winds and adverse climatic events	especially in arid and semi-arid environments.	Design
G25	Green	Guidelines on urban and peri-urban forestry	Mitigating land and soil degradation	Implement sustainable tree-based agricultural practices	Maintain soil fertility and productivity over the time, especially in peri-urban areas.	Planning
G26	Green	Guidelines on urban and peri-urban forestry	Mitigating land and soil degradation	Assess and monitor the extent and severity of land and soil degradation processes	such as desertification, salinization, compaction, contamination and erosion in urban and peri-urban environments	Planning
G27	Green	Guidelines on urban and peri-urban forestry	Water and watersheds	proactive planning approaches to reduce soil erosion and control sediment flows.	For example, consider the effects of upstream urban and agricultural development on the flow of water and sediments into reservoirs, irrigation systems, floodplains and urban areas.	Planning
G28	Green	Guidelines on urban and peri-urban forestry	Water and watersheds	maintaining and improving water quality	Adopt silvicultural approaches aimed at maintaining and improving water quality, especially for drinking.	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G29	Green	Guidelines on urban and peri-urban forestry	Water and watersheds	Restore degraded watersheds	Through tree-planting, agroforestry and natural regeneration to improve watershed functioning.	Planning
G30	Green	Guidelines on urban and peri-urban forestry	Water and watersheds	Establish riparian forest buffer zones	To protect streams, lakes and other wetlands from disturbances and encroachment.	Planning
G31	Green	Guidelines on urban and peri-urban forestry	Water and watersheds	Use innovative tree-based approaches	To help reduce water consumption, improve water quality, and recycle wastewater in urban and peri-urban environments.	Design
G32	Green	Guidelines on urban and peri-urban forestry	Water and watersheds	Assess and monitor flooding and stormwater runoff		Planning
G33	Green	Guidelines on urban and peri-urban forestry	Water and watersheds	Increase the percentage of permeable surfaces and tree cover	Especially in urban areas most affected by flooding and stormwater runoff events.	Planning
G34	Green	Guidelines on urban and peri-urban forestry	Water and watersheds	Green infrastructure approaches	such as forested bioswales, permeable pavements, green roofs, green streets, wooded wetlands, rain gardens, bioretention, bioinfiltration, forested filter strips, and linear	Design

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
					stormwater tree pits to mitigate the impacts of stormwater runoff.	
G35	Green	Guidelines on urban and peri-urban forestry	Food and nutrition security	Food production	Contribution of urban forests and other green infrastructure to the food and nutrition security of residents, and incorporate urban food forestry and agroforestry (e.g. in community gardens and orchards) into municipal plans. Assess the “environmental footprint” and social impact of urban forest food production.	Design
G36	Green	Guidelines on urban and peri-urban forestry	Wood security	Map and monitor the woodshed	to assist in developing strategies for municipal-scale wood security, which combines aspects of forestry and energy, may support effective urban wood-energy planning	Planning
G37	Green	Guidelines on urban and peri-urban forestry	Wood security	Supply of wood and woodfuel	When planning urban forests for the supply of wood and woodfuel, choose suitable, fast-growing tree species (e.g. reaching their economically optimum size in 8–20 years).	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G38	Green	Guidelines on urban and peri-urban forestry	Sociocultural values	Urban greening projects are designed according to the architectural and aesthetic standards of local communities	Considering geographical, cultural and socioeconomic gradients. This is particularly important in cities with a high influx of migrants with differing ethnic or religious backgrounds.	Design
G39	Green	Guidelines on urban and peri-urban forestry	Sociocultural values	Design multifunctional green spaces	For use by the entire community, with suitable amenities and sociocultural services to make them attractive and to improve social interaction and inclusion.	Design
G40	Green	Guidelines on urban and peri-urban forestry	Sociocultural values	Support the transition and cultural continuity	Support the transition and cultural continuity of migrants moving from rural areas to urban neighbourhoods by promoting the collaborative design and management of green spaces and related infrastructure (e.g. barbecues, secluded areas for families, benches and iconic trees).	Design
G41	Green	Guidelines on urban and peri-urban forestry	Sociocultural values	Create green spaces around public buildings	(e.g. schools, hospitals and municipal buildings), religious buildings (e.g. churches, mosques, synagogues and temples) and cemeteries.	Design

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G42	Green	Guidelines on urban and peri-urban forestry	Sociocultural values	Educational values	Manage urban forests to maximize their educational value for local communities (especially youth).	Planning
G43	Green	Green Belts: a greener future	Green Belt land	Quantity and location of Green Belt	Most Green Belt land is on the 'urban fringe' or the edge of conurbations and extends into the deeper countryside.	Planning
G44	Green	Green Belts: a greener future	Green Belt land	Land cover & use	The characteristics of Green Belt land vary considerably as would be expected of such a large area of land.	Planning
G45	Green	Green Belts: a greener future	People and the natural environment	Provision of space for outdoor recreation	The Green Belt is an important resource of opportunities for informal recreation.	Design
G46	Green	Green Belts: a greener future	People and the natural environment	Provision of routes and trails	provide opportunities for people in urban communities to connect with the countryside.	Design
G47	Green	Green Belts: a greener future	People and the natural environment	Accessible natural greenspace	should have a variety of greenspace, including routes and trails The need for local outdoor recreational opportunities is ever more important with the challenge	Design

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
					of adapting to climate change and a low carbon economy.	
G48	Green	Green Belts: a greener future	People and the natural environment	Educational activity	The proximity of Green Belt to urban areas and many schools and colleges offers opportunities for a range of environmental education activities.	Planning
G49	Green	Green Belts: a greener future	People and the natural environment	Recreational use of Green Belt land	The Green Belt offers a range of opportunities for outdoor recreation	Design
G50	Green	Green Belts: a greener future	People and the natural environment	Health related recreation	promotes and supports people to meet regularly and walk to improve their health.	Design
G51	Green	Green Belts: a greener future	People and the natural environment	Outdoor sporting activity	Green Belts provide space for more organised recreation and sport.	Design
G52	Green	Green Belts: a greener future	Attractive landscapes	Landscape scale management	The natural environment is constantly subject to change influenced by both natural processes and human impact. To ensure that the character and biodiversity of areas are maintained it is important	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
					to plan and manage at a landscape scale	
G53	Green	Green Belts: a greener future	Attractive landscapes	Quality of landscape	measure change in countryside quality based upon seven landscape variables: Agriculture; Boundary Features; Trees and Woodland; Historic Features; Semi- Natural Habitat; River and Coastal; Settlement and Development.	Planning
G54	Green	Green Belts: a greener future	Attractive landscapes	Active management of the Green Belt	Management Strategies for Green Belts, produced through the planning process, provide a means to identify potential funding opportunities for landscape improvement and to establish programmes.	Planning
G55	Green	Green Belts: a greener future	Healthy natural systems	Priority habitats	Biodiversity Action Plan identifies the most important habitats for nature conservation	Planning
G56	Green	Green Belts: a greener future	Healthy natural systems	Birds in the Green Belt	Birds are used as an indicator of general biodiversity	Planning

SN	Edge Type	Doc. Ref	Category	Design Element	Brief Explanation	Tool Type
G57	Green	Green Belts: a greener future	Healthy natural systems	Butterflies in the Green Belt	Indicator for assessing biodiversity and have been developed as indicators of finer scale habitat and landscape changes than birds.	Planning
G58	Green	Green Belts: a greener future	Thriving farming and forestry	Agricultural land	A high proportion of Green Belt is classified as being in agricultural production	Design
G59	Green	Green Belts: a greener future	Thriving farming and forestry	Agri-environment schemes	provide financial support for environmentally beneficial land management. Each measure has a specific environmental objective such as the protection or enhancement of biodiversity, soil, water, landscape, or air quality, or climate change mitigation or adaptation.	Planning
G60	Green	Green Belts: a greener future	Thriving farming and forestry	Farm diversification in the Green Belt	Green Belt planning policies are to hinder development that enables farmers to diversify their activity	Planning