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SUMMARY

The water supply system in Beirut, Lebanon is far from able to fulfill the needs of the residents. It is plagued by water quality and quantity problems leaving residents to depend on informal services where regulations are loosely applied, and authorities' oversight is almost completely absent.

Reviewing the available literature, it becomes clear that NBS are gathering momentum and becoming an important application in the field of urban water management. They are applied to integrate nature with the built environment while securing the availability of clean water to the increasing urban population.

The objectives of this research are to identify the current role of NBS for water management in Beirut and to identify the factors that have facilitated or hindered the implementation of NBS in Lebanon at the governance and technical levels.

The methodology followed was to interview 15 relevant actors following an interview guide formulated for this research based on the literature review. The interviews were semi structured and audio recordings were later transcribed into text. This was analyzed in Atlas.ti to code it based on key notions from the literature. In addition to that, the groundwater quality around Horsh Beirut park was tested aiming to show the importance of green areas for water management in Beirut.

The transcribed interviews, the legislative texts and project documents found were analyzed at three different levels. First, the barriers and drivers towards NBS integration in the water sector were extracted from the interviews. Further barriers and drivers were extracted from analysis of the laws and strategies present. On the second level, these barriers and drivers were analyzed in comparison with the literature. Then, deeper analysis was made of the whole context of water management to deduce cross cutting barriers and drivers. The main drivers towards NBS integration related to the need of change in the approach towards solving the water problems in Lebanon, the need for decentralization, and the importance of bottom-up governance. While barriers, included the absence of long-term visions and a disconnect between the various levels of governance.

A governance framework based on the main conclusions was proposed as well as some innovative projects integrating NBS into the water management of Beirut.

KEYWORDS

Nature-based solutions ; water management ; governance ; drivers and barriers ; Beirut ;

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To my family, my backbone.

To my friends who kept me going.

To my professors who made this possible.

To Mr. Mofid Dhayni and Dr. Wissam Khadra for their support.

"Great things are not done by impulse, but by a series of small things brought together."

Vincent van Gogh

LIST OF ABBREVIATIONS

NBS	Nature-based solutions
TDS	Total dissolved solids
WMS	Water management system
WWTP	Wastewater treatment plant
EIA	Environmental impact assessment
SDG	Sustainable development goals
PPP	Public private partnership
O&M	Operation and maintenance
MoEW	Ministry of Energy & Water
MoE	Ministry of Environment
MPH	Ministry of public health
CDR	Council for Development and Reconstruction
BWE	Bekaa water establishment
LRA	Litani river association
NGO	Non-governmental organization
GIS	Geographical information system
IDW	Inverse Distance Weighted
BDL	Banque Du Liban
UNFCCC	United Nations Framework Convention on Climate Change

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Lebanon is considered the 18th most densely populated country in the world (The World Bank, 2017). In 2008, 86% of the Lebanese population were living in an urban setting, and this number is expected to reach 90% by 2030 (UNHabitat, 2011, UN-Habitat_b, 2012) With this increase in urban population naturally comes an increase in built area which is expected to cover 884 Km^2 in 2030, mainly concentrated in and around coastal cities and as informal areas on the belts of cities (CDR, 2005). These figures are especially worrying considering that the implemented urban policies in Lebanon date back to 1932, are loosely enforced, and most attempts to update them failed to have an impact (UNHabitat, 2011).
One of the already prominent outcomes of the increase in built up area is the absence of green spaces in the city. It is currently estimated that Beirut has 0.8 m^2/capita of green space (Nazzal and Chinder, 2018) which makes these green areas almost insignificant compared to other developed cities such as Nantes which has 57 m2/capita of green spaces (Nantes Métropole, 2013) (fig.1). This lack of green spaces is also observed in other neighboring developing cities but to a lesser extent, Istanbul the capital city of Turkey offers up to 10 m2/capita of green spaces (Ilgar, 2016), while Amman, the capital of neighboring country Jordan offers 2.5 m2/capita (Bazian, A. R., 2019).

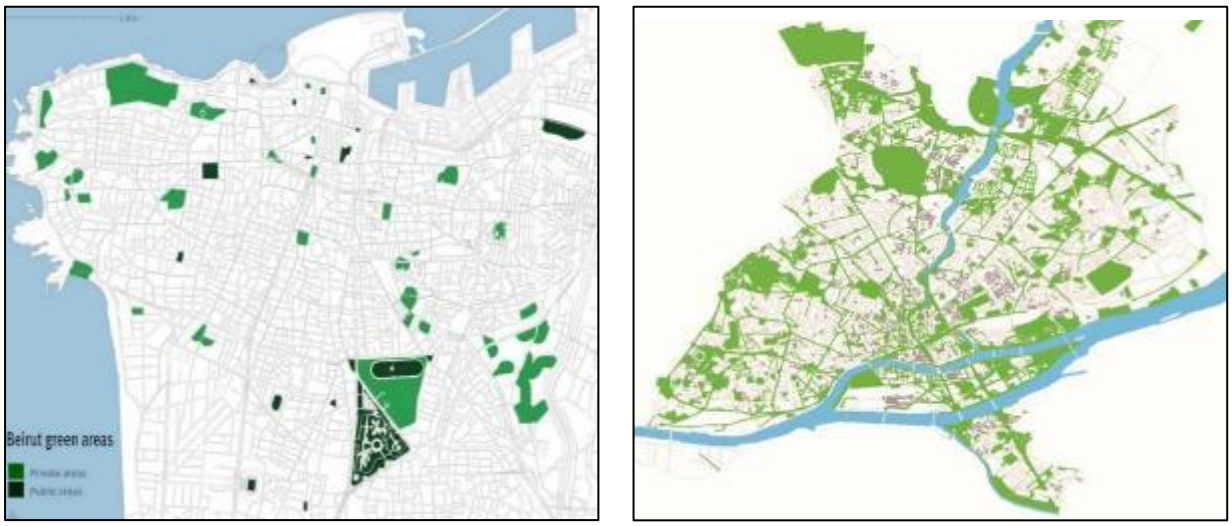

FIGURE 1 COMPARISON BETWEEN BEIRUT (LEFT) (AUB NEIGHBORHOOD INITIATIVE 2015) AND NANTES (RIGHTS) URBAN GREEN AREAS (NANTES MÉTROPOLE 2013)

As open space became less and less available in cities, and as it difficult to clear buildings to provide green open spaces, the idea of green roofs is becoming more prominent as one of the potential solutions. The cities of Copenhagen, SE (Merchant, B., 2010) and Toronto, CA (Alter, L., 2009) now require new buildings to have green roofs and they were joined recently by San Francisco (Snow, J., 2016) which became the first US city to do so. Furthermore, France has a nationwide law which forces new buildings in commercial zones to install green roofs or solar panels (Agence France Press, 2015).

Green roofs come as part of a bigger movement towards what is now known as nature-based solutions (NBS) and which are now being molded to tackle urban problems and specifically water management issues (Raymond, Berry, et al., 2017). In addition to tackling the issues of floods, water scarcity, and improving the quality of available water, NBS aim to drive urban water management systems further towards resiliency (Raymond, Berry, et al., 2017).

In dense urban areas, water systems are under pressure to satisfy the ever-increasing demand for fresh water while also facing the unpredictability brought on by climate change. All of this leads to a decrease in the quality and quantity of the fresh water available for the urban population. In Beirut, the capital of Lebanon, Scientists have been researching the decline in underground water quality since the 1980's (Khair, Aker, et al., 1994, Metni, EL-FADEL, et al., 2004, Lababidi, Shatila, et al., 1987) when Beirut hosted only a fraction of the 2.2 million inhabitants it serves today (World Population Review, 2019, Index Mundi, 2018). Underground water holds a great importance in Beirut as the residents depend on more than 3000 water wells (MOE/UNDP/ECODIT, 2010), most of which are unregulated, over pumped and have now experienced irreversible saltwater intrusion (MOE/UNDP/ECODIT, 2010). Furthermore, Constantine et Al (2017), recently found that 85% of the wells they tested in Beirut contained TDS and Cl^- levels that exceeded drinking water quality standards. And upon further analysis, they attributed that to saltwater intrusion which is exacerbated by over pumping. Not only in Beirut, but all around the world urban groundwater aquifers are under constant threat of overexploitation and sea water intrusion (Richey, Thomas, et al., 2015, Ashraf, AghaKouchak, et al., 2017).

In the context of Beirut, the pressures exerted on water systems, the deterioration of groundwater quality, the lack of green areas, and the outdated urban policies are challenging problems with wide ranging causes, implications, and potential solutions. This research will attempt to tackle some aspects of these problems with a focus on how nature-based solutions are helping tackle similar challenges and how could their potential be fully employed.

1.2 Problem statement

The water supply system in Beirut, Lb is far from able to fulfill the needs of the residents. It is plagued by water quality and quantity problems leaving residents to depend on informal services such as private wells, water tankers, and bottled water. All this only worsens the situation as laws and regulations are loosely applied and authorities' oversight is almost completely absent.

Low water availability is only a part of the bigger problem in the water management system of Beirut. The lack of resources, bad management of available resources and lack of data and studies are some of the main factors affecting the sector in Beirut and Lebanon in general (El-Fadel, Zeinati, et al., 2000).

Reviewing the available literature, it becomes clear that NBS are gathering momentum and becoming an important application in the field of urban water management. Be it in developing or developed countries NBS are being applied to regulate the urban water cycle and to merge

nature with the built environment while securing the availability of clean water to the increasing urban population (Raymond, Berry, et al., 2017).

Therefore, keeping in mind that NBS are being applied in various locations in Lebanon, that they already have an impact on water management in Beirut, and taking into consideration the recent laws that have been issued to improve governance of the water sector, it will be necessary to study the factors that have enabled adoption of NBS so far in Lebanon in general and specifically in Beirut, and to also focus on the factors that have prevented a wider application of these solutions in a country which is desperate to improve its water resources.

1.3 Research Objective

The objectives of this research are to identify (qualitatively and if possible, quantitatively) the current role of NBS for water management in Beirut and to identify the factors that have facilitated or hindered the implementation of NBS projects for water management in Lebanon at the governance and technical levels.

It is outside the scope of this study, and very challenging, to determine causality between the identified governance and technical factors and the role of NBS in water management. Therefore, the identified factors will be considered as potential barriers and drivers present.

1.4 Provisional research question and Sub-questions

What are the factors hindering or facilitating the implementation of NBS in the water system in Beirut, Lebanon focusing on freshwater availability?

- What is the current level of NBS integration into the water management system in Beirut?
- What is the current level of knowledge about NBS within actors in WMS and how does that affect adoption?
- How do recent laws and regulations in this sector impact NBS?

1.5 Limitation of the study

This study will focus on the governance and technical levels of NBS integration, this means that due to time limitation the social and financial aspects will be only studied indirectly. Both those aspects are considered to be an integral part of NBS adoption but in themselves are also a very wide areas of study and difficult to cover considering the time limitations of this study.

Furthermore, there might be difficulties in obtaining studies, measurements, and other data about some of the targeted projects. Another issue is that some of the projects studied will be outside the city Beirut. But Lebanon is a very centralized country where all the water bodies are under the governance of the ministry of energy and water and all the municipalities are directly under the ministry of interior affairs.

Lastly, the fact that I used to work at the Lebanese ministry of environment, and I had worked with some of the respondents might impact interviews, but this will be mitigated through cross referencing information from multiple sources.

CHAPTER 2: LITERATURE REVIEW

2.1 NATURE BASED SOLUTIONS AS A NEW TERM

NBS is a relatively new term in the literature and in policy therefore it is important to adopt one of the many definitions used when describing those solutions. The chosen definition should be recent but tested in the literature, it should be based in theory and research and be generally accepted in the literature. For that, after a review of the available definitions, the one that appears to be repeatedly used in literature and policy documents is the definition presented by Cohen-Shacham et al. (2016, p. 5):

> "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"

The main aspects of NBS can be extracted from that definition. First, it is clear that the main purpose is to employ nature to solve the societal problems being faced. Second, taking a "problem focused approach" is a major characteristic helping differentiate NBS concept from previously discussed "ecosystem services" or "natural resources management" approaches. The third aspect of NBS stressed on by that definition is their multifunctionality, it is a key trait of NBS that they simultaneously bring on benefits for society, nature, and economy

On the other hand, and because NBS is a new term, several aspects of it remain unclear or contested in the literature. One of these aspects is the differentiation between NBS and previously adopted ecosystem approaches. Nesshover et al. (2017) compared NBS to six other commonly used ecosystem approaches from the points of view of definition, uses, and aim. They concluded that although some of those approaches might have a lot in common with NBS, many of them are focused on one subject while NBS is a more holistic approach. And while many of those should inform NBS application, an NBS approach should always include multiple perspectives to account for the complex soci-ecologicale systems where it will be applied.

In conclusion, it seems that the literature considers NBS as an umbrella topic where projects need to account for societal, economic, and natural challenges while aiming to reach a solution for the given problem. Due to those characteristics, NBS are being employed to tackle the complex problems of urban water management in various setting and for various purposes.

2.2 NATURE BASED SOLUTIONS FOR INTEGRATED URBAN WATER MANAGEMENT

Due to rapid urban development and to the increased stress on the water resources, in recent years the approach to water management has evolved from only trying to mitigate the impacts on the ecosystem to a more sustainable approach of managing ecosystem services to secure water demand; this approach became known as integrated urban water management. Various authors have summarized the merits of this approach which can be listed as follows (Zarghami, Abrishamchi, et al., 2008, Mitchell, 2006):

1- A holistic approach to the water cycle and all types of freshwater resources,
2- Considers the requirements of the ecosystem as well as the anthropogenic requirements,
3- An inclusive process to the various actors,
4- A sustainable process economically, socially and environmentally.

Comparing this list to the characteristics of NBS discussed in section 2.1, it is clear how NBS play a role towards integrated water management, hence why various international and national agencies have issued reports detailing their response to current and future water security problems through NBS (WWAP/UN-Water, 2018, Cohen-Shacham, Walters, et al., 2016).

The role of NBS spans across the water cycle, from protecting sources, to improving availability and quality, to mitigating the associated risks and disasters, all aiming at improving water security. The success of NBS in improving watershed management, stormwater regulation and providing safer drinking water in urban environments is proven by Lafortezza et al. (2018) whom compiled a great list of NBS projects applied to create more resilient cities.

A list of some interventions that can be considered under the umbrella of NBS in the water management sector is represented in table 1 below.

TABLE 1 NBS IN THE WATER MANAGEMENT SECTOR (RAYMOND, BERRY, ET AL., 2017, (NATURAL HAZARDS – NATURE-BASED SOLUTIONS DATABASE, 2017)**)**

Intervention	Main Benefits for WM	Example project
Restoring urban waterbodies	– Flood protection – Increase water infiltration/storage – Improve surface and sub-surface water quality (Raymond, Berry, et al., 2017)	Retrofitting Sustainable Urban Drainage Systems in an Urban Regeneration Area / Sweden
Creating artificial water bodies for short term water storage	– Run-off reduction – Flood protection – Reducing loads on sewer and storm water systems – Increase water infiltration/storage – Improve surface and sub-surface water quality (Raymond, Berry, et al., 2017)	Making Space for Water project - Moors for the Future / UK
Increasing the use of vegetation in urban areas / urban parks	– Increase water infiltration/storage – Improve surface and sub-surface water quality (Raymond, Berry, et al., 2017)	Active, Beautiful, Clean Waters Programme / Singapore
Creation of wetlands in river-basins	– Run-off reduction – Flood protection – Increase water infiltration/storage – Improve surface and sub-surface water quality (Raymond, Berry, et al., 2017)	Espirito Santo Integrated Sustainable Water Management / Brazil

Watershed restoration, preservation and protection	– Increase water infiltration/storage – Improve surface and sub-surface water quality (Lafortezza et al. (2018))	Uttarakhand Decentralized Watershed Development II / India
River shed management	– Flood protection – Increase water infiltration/storage – Improve surface and sub-surface water quality (Cohen-Shacham, Walters, et al., 2016)	Investigating the impact of floodplain woodland on flood flows in the River Cary catchment, Somerset / UK
Coast protection/restoration	– Flood protection – Increase water infiltration/storage – Improve surface and sub-surface water quality (Lafortezza et al. 2018)	Eco-engineered Coastal Defense integrated with Sustainable Aquatic Food Production (ECOBAS) / Bangladesh
Sustainable agriculture	– Run-off reduction – Improve surface and sub-surface water quality (Cohen-Shacham, Walters, et al., 2016)	Environmental Land and Management and Rural Livelihoods / Tajakistan

2.3 BARRIERS AND DRIVERS FOR NBS IMPLEMENTATION

While attempting to determine the barriers and drivers for NBS most literature focuses on the physical aspects and gives less attention to the social, institutional, and political aspect (Matthews, Lo, et al., 2015). While Byrne and Jinjun (2009), among others, determined classes which shape the efficiency of green infrastructure as an adaptive response. The theoretically determined factors are: characteristics of the urban environment; planning regulations; governance structures; and the contributions of urban residents (Byrne and Jinjun, 2009).

As a new approach, it is expected that NBS will face implementation barriers especially considering that ecosystem and integrated approaches before it faced and still face barriers towards wider adoption (Angelstam, Andersson, et al., 2013, Boelee, Janse, et al., 2017).

A review of the literature culminates in a list of barriers that have been frequently reported and which this study will investigate further in the context of Beirut (Faivre, Fritz, et al., 2017a, Kabisch, Frantzeskaki, et al., 2016):

1- Lack of financial resources
2- Deprioritizing NBS in urban planning
3- Potential operational and performance unknowns
4- The focus of cities on economic growth instead of sustainable targets
5- Short term political cycles cannot support the long-term targets of NBS
6- Separation of tasks and duties between various departments

Further review of the literature helps classify the barriers and drivers for NBS implementation into specific sectoral subcategories which would make identifying these easier during data collection (table 2).

TABLE 2 DRIVERS AND BARRIERS FOR NBS ADOPTION AS REPORTED IN THE LITERATURE (WWAP/UN-WATER, 2018, IRGA, BRAUN, ET AL., 2017, BROWDER, OZMENT, ET AL., 2019, KABISCH, FRANTZESKAKI, ET AL., 2016)

	Drivers	Barriers
Social	Citizens preference for green areas / nature	Lack of mechanisms for citizens involvement
Governance	The literature identifies NBS projects that were championed by one person Presence of strong support from some ministries / governing bodies Public support for politicians with green / nature related targets	Short term political cycles can't support the long-term targets of NBS Climate change/adaptation and similar topics low on political agenda No legal basis for supporting such projects
Technical	NBS were shown to offer long term benefits across various sectors Increase in the number of guiding documents Increase in the number of projects in various settings and conditions	Deprioritizing NBS in urban planning Potential operational and performance unknowns Potential absence of guidance for NBS Difficulties in providing clear evaluations of the performance of NBS-related projects
Financial	NBS can be cheaper than engineering solutions and provide multiple benefits PPP or other cost sharing mechanisms	Cities focus on economic growth instead of sustainable targets separate financing schemes Might be easier to secure funding for grey infrastructure over green
Cross-cutting	Cross cutting benefits of NBS across various sectors Country commitments to SDG, Paris agreement and other international treaties	Separation of tasks and duties between various departments/agencies Staff responsibilities and capacities Competing interests between green solution and traditional planning (open green areas vs densification)

2.4 ASSESSMENT OF NBS IMPACTS THROUGH INDICATORS AND FRAMEWORKS:

To help understand the impacts of NBS projects and to help provide supporting evidence that would make NBS preferred over conventional solutions, various authors have proposed assessment frameworks that help capture the benefits of NBS.

Three of these studies are considered to be highly significant for this research and used as the base to build the framework that will guide the study.

Raymond, Berry et al. (2017) presented an impact evaluation framework of NBS projects with a focus on each of the various sectors where NBS can be applied. In the water management sector, they presented physical and economic quantitative indicators that can be applied at various scales. Furthermore, they presented methods that can be used to assess a project's environmental and monetary impact as well as to assess the potential co-benefits that arise when applying these projects (table 3).

TABLE 3 LIST OF IMPACT ASSESSMENT METHODS FOR NBS (RAYMOND, FRANTZESKAKI, ET AL., 2017B)

Impact assessment method	Example
Monetary assessment	– Estimation of avoided damages and costs from flooding – Social cost benefit analysis
Non-monetary assessment	– Reduction of inundation risk for critical urban infrastructures
Environmental assessments	– Change in run-off coefficients in relation to precipitation quantities – Measurement of water and ground water quantity and quality
Integrated approaches	– Modelling of services provided by vegetation (trees) with the i-Tree Eco model – Assessment of wider social costs and benefits of water management strategies using the ecosystem services assessment framework

In a second paper, Raymond et al. (2017b) focused on the assessment of the co-benefits of NBS projects. Hence, they produced a seven-stage process to guide that assessment with a set of qualitative and quantitative indicators to help. The seven stages are as follows:

1- Identify the problem or opportunity
2- Select and assess NBS and actions
3- Design NBS implementation Processes
4- Implement
5- Frequent engagement of stakeholders
6- Transfer and upscale NBS
7- Monitor and evaluate co-benefits

The paper further details the working steps of each stage while offering potential methods depending on various scenarios of NBS application.

Further to that, Calliari et al (2019) conducted a review of some of the recent relevant frameworks in the literature and presented a new framework which is dubbed as a "dynamic assessment" of the impacts of NBS projects. The center point of this framework is that it considers that NBSs are built and operated in a dynamic setting that is impacted by a large

number of factors, most important of which is climate change. Hence, they set out to create an adaptive assessment method which considers adaptive management based on forecasting by working with relevant actors to set goals and compare alternatives.

2.5 CONCEPTUAL FRAMEWORK

The conceptual framework presented at this stage of the research is shown in fig 2.

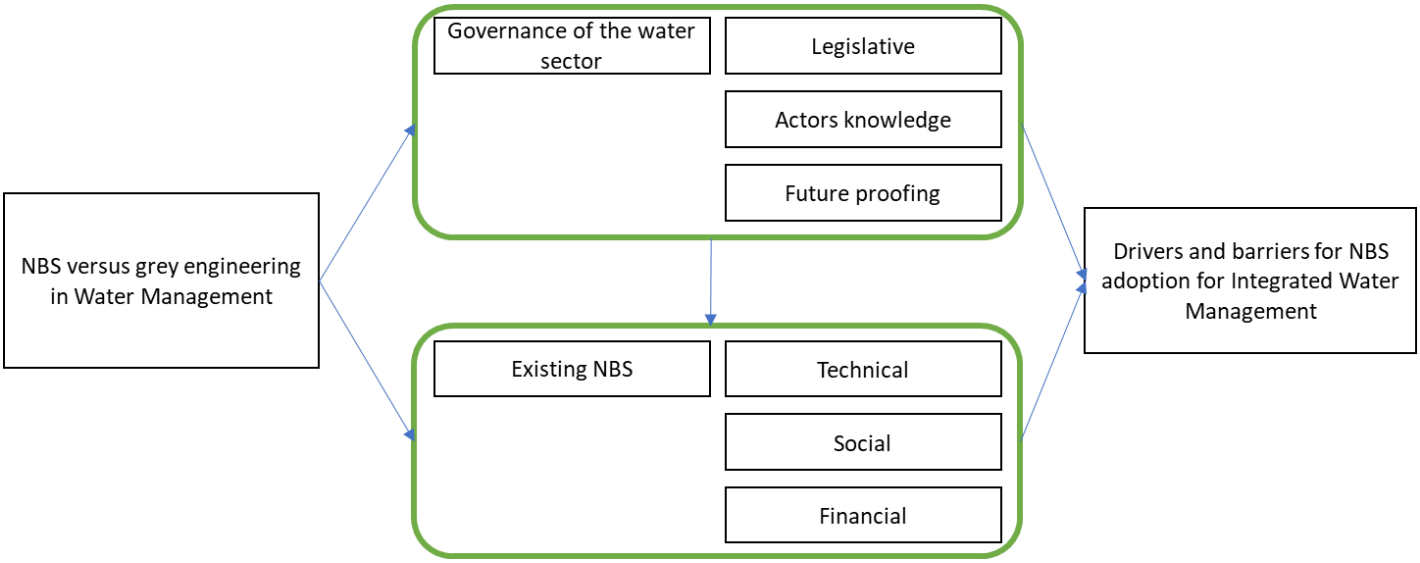

FIGURE 2 PROPOSED RESEARCH FRAMEWORK

The main thinking behind this framework is based on the literature review described above and its main goal is to determine the important drivers and barriers facing NBS adoption in Beirut's water sector.

System analysis will be used to describe the current water management in a city. This type of thinking is necessary to be able to describe the whole cycle to find the links between the different sources and users which will potentially highlight the role of NBS.

Furthermore, at this level the knowledge of the actors in the water sector regarding NBS should be assessed as they are a key characteristic of the system governance.

The second step is to assess the current importance and impact of NBS solutions that were found in the system or that were found to impact the system. This will be done using the criteria and indicators that were found in the literature.

The first and second step will be critical to determine what are the enabling factors and barriers in the system which will be a steppingstone to determine the future role that NBS might play in the water management.

CHAPTER 3: THE WATER SECTOR IN BEIRUT

3.1 INSTITUTIONAL FRAMEWORK

The roles and responsibilities in the water management sector in Lebanon are not clearly identified and often they overlap or contradict. Multiple central and local, institutions and agencies are part of legislation, oversight, planning and implementation in this sector, which leads to a "chaotic situation" as described by the general director of hydraulic and electric resources at the Lebanese ministry of energy and water (Comair, 2007, p. 25).

Table 4 represents the main institutions that play a role in water management in Beirut. These roles might not match the actuals roles currently performed by the institutions due to various institutional and governance limitations; but this would be better determined during the field work. Furthermore, the relations between the various governance levels will be important to determine in order to analyze the governance dynamics (Frantzeskaki and Tilie, 2014).

TABLE 4 INSTITUATIONAL ARRANGMENT OF THE WATER SECTOR IN LEBANON (COMAIR, 2007, EL-FADEL, ZEINATI, ET AL., 2001)

Institution	Main Roles
Ministry of Energy & Water (MoEW)	– Jurisdiction over all surface and subsurface water resources – Protection and development of hydraulics natural resources – Preparing national water masterplans – Designing, operating, and managing large water facilities – Administrative supervision over water establishments
Ministry of Environment (MoE)	– Sets water quality and wastewater re-use standards – Oversees waste treatment, sewage disposal – Oversees wastewater disposal from industries
Ministry of public health (MPH)	– Controls epidemiological programs and maintains statistics on waterborne diseases – Conducts sampling surveys and bacteriological analysis of water sources and supplies in coordination with water supply authorities
Regional Water establishment: Beirut and Mount Lebanon Water Authority	– Setting the water fees for potable, irrigation and industrial uses which are approved by MoEW – Studying water require – Development of water resources – Design and execution of extension of existing networks
Council for Development and Reconstruction (CDR)	– Principal economic and physical planning and development agency of the central government
Municipalities	– Preparing plans for sanitary and water projects – Establishment of sewage disposal facilities – Protection of the environment and pollution control
Consultancies	– Local or international – Conduct impact assessment studies – Participate in strategies consultations and data collection

3.2 WATER RESOURCES AND MANAGEMENT

As with many cities around the world, the formal source of water on which Beirut relies are outside the city borders. In addition, green and blue areas are almost non-existent in Beirut as shown in figure 1 which only exacerbates the problems. The major water sources (table 5) are the Jeita springs situated at around 30 km north of Beirut and provide an estimated three quarters of the current fresh water supply to Beirut. The water extracted from this source is treated at the Dbaye water treatment plant around 10 Km north of Beirut. The watershed for the Jeita springs covers a large area where multiple jurisdictions apply, and a large number of people are served. A plan has been put in place aiming to protect this watershed aiming to conserve the water quality (BGR, 2013).

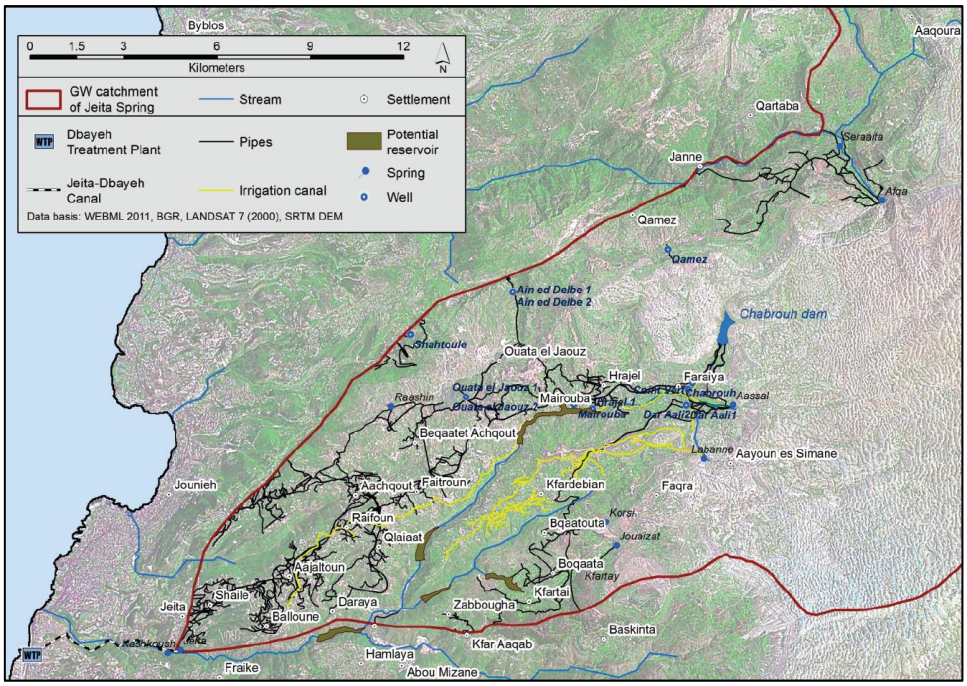

FIGURE 3 JEITA WATERSHED (RED LIMITS) SERVING BEIRUT AND MOUNT LEBANON (BGR, 2013)

The other one third of the formal freshwater delivery is provided by wells situated around 15 km to the south of Beirut on the shores of Damour. These wells were first dug in the 1970s and have been in constant use since. The area around these wells has been progressively urbanized which is putting pressures on the wells leading to a decrease in the quantity and quality of the water provided (Khadra, 2017).

On the informal side of water delivery, Beirut's residents have resulted to various solutions to compensate the shortage caused by the lacking government services. The most used and impactful of those methods are artesian water wells dug in almost every building (MOE/UNDP/ECODIT, 2010). Another source on which Beirut's residents highly depend is private water tankers. These tankers extract water from springs and artesian wells to provide an estimated 33,0000 m3/day for their customers (Constantine, Massoud, et al., 2017).

The common problem between formal and informal water services is that the residents do not trust their quality, so they do not use them for drinking. For that, they resort to bottled water services and Lebanon was ranked 8th worldwide by bottled water consumption (Semerjian, 2011).

TABLE 5 SOURCES OF WATER FOR BEIRUT

Source	Size	Reference
Naameh wells	25% of water supply	(Khadra, 2017)
Jeita springs	75% of water supply	(BGR, 2013)
Private wells	Unknown	
Bottled drinking water	111 L/capita/year	(Semerjian, 2011)
Water tankers	~32,600 m3/day	(Constantine, Massoud, et al., 2017)

CHAPTER 4: RESEARCH DESIGN AND METHODS

4.1 REVISED RESEARCH QUESTIONS

The main research question of this study is:

> What is the current role of nature-based solutions in the water management system of Beirut, and what are the drivers and barriers to integration?

The sub research questions are:

- What are the NBS that are now used in Beirut and Lebanon for water management?
- How do governance dynamics in the water sector affect NBS integration (drivers and barriers) in water management in Beirut?
- What are the technical drivers and barriers towards NBS integration in water management in Beirut?

4.2 OPERATIONALIZATION: INDICATORS FOR THE VARIABLES

The operationalization of research is further detailed with variables and indicators as indicated in table 6 below. A detailed description of the indicators used can be found in Annex 2.

TABLE 6 OPERATIONALIZATION OF RESEARCH

Concepts	Variable	Indicator	Data collection
What are the NBS that are now used in Beirut and Lebanon? (Qualitative data)	NBS role in water management in Beirut	Number of NBS considered in the WMS	Case studies: NBS vs grey engineering projects Desk research Interview
What are the impacts / co-benefits of NBS currently applied? (Qualitative / quantitative data) (Raymond, Berry, et al., 2017)	Impact evaluation methods (to use the one most valid based on data available): – Monetary assessment – Non-monetary assessment – Environmental assessment – Integrated modeling	Technical Run-0ff coefficient Absorption capacity Flood peak reduction Increase GW available Water quality Air quality Temp reduction Economic Reduction of stormwater treated Flood mitigation	Desk research about the completed NBS projects Interviews with project proponents

What is the level of key actor's knowledge about NBS? (Qualitative data) (Think Nature, 2019b)	Knowledge of actors	– Awareness of various NBS application – Awareness of benefits/co-benefits of NBS – Awareness of gaps / barriers / drivers	Semi structured interview with key actors
How does governance of the water sector impact NBS adoption? (Qualitative data) (Frantzeskaki and Tilie, 2014, Browder, Ozment, et al., 2019)	Strategic level	– Incorporate sustainable landscape vision into strategies and policies – Harmonize sectoral plans to incorporate multiple goals for harnessing natural systems – Create incentives for local actors to participate through policy and public finance – Encourage or require decision-makers to consider green infrastructure options in planning processes – Empower civil society to build partnerships. – Develop a regulatory framework that supports green infrastructure in planning processes and as a compliance mechanism – Participate directly in green infrastructure partnerships. – Build the knowledge and technical capacity to implement green infrastructure	Review of key legislations Key actors semi-structured interviews
	Tactical level		
	Operational level		
	Reflexive level		
What are the factors facilitating and hindering the implementation of NBS? (Qualitative data) (Browder, Ozment, et al., 2019)	Social	– Public hearing was conducted? – Benefits/co-benefits of NBS explained to public – Feedback of the public	Case studies of implemented NBS and grey solutions in the water sector (EIA review, proponents' interviews, documentations review) Desk research
	Technical	– Technical considerations during design – Design alternatives conducted – Design team aware of green alternatives	
	Financial	– Source of funding – Conditions on funding – O&M source/responsibilities	

4.3 Research Strategy and Methodology

The main chosen research method for this thesis is the case study methodology. Case study research concentrates on a limited number of situations and analyses these situations in depth aiming to determine what are the variables that would answer the research question (Van Thiel, 2014). These variables are usually numerous, and some can be unknown at the beginning of the research, hence the importance of going into detail analysis of the chosen cases. Furthermore, this strategy helps contextualize the chosen cases into their greater context which might shed light on important aspects that might have been unknown to the researcher (Van Thiel, 2014).

To support the findings of the case studies and to help further answer sub-research questions desk research and interviews will be used. Desk research will be used to find and analyze policy documents, strategies, and project documents hoping to extract the indicators needed to answer the sub-research questions. While semi-structured interviews with important stakeholders in Beirut's water sector will help answer sub-question two and three.

Additionally, because NBS are a recent development, and because initial desk research did not find any studies where the impacts of NBS in Beirut was studied, the field work will include an attempt to measure the benefits that Horsh Beirut park has on the surrounding groundwater. This will be done through site visits to the areas around the park and onsite measurements of the water quality. The methodology of this research is further explained in chapter 5 section 1 and in annex 4.

For the proposes of this study a survey would not be possible due to the lack of previous research on NBS in Lebanon which means that the variables to be included in the survey cannot be fully specified before the field work. Furthermore, desk research on its own is also not sufficient because the need to do interviews with the main actors which is important to determine governance dynamics and barriers and drivers. Lastly, quasi-experiment research is used for deductive research where the variables are few and clear which is not the case for this research (Van Thiel, 2014).

These factors, and the limitations of the study discussed in section 1.5, validate the choice of case study methodology. The internal validity of the study will be strengthened by the various interviews to be conducted at various levels and in different settings and by reviewing the findings of the research with experts as envisioned in the research timeline (Annex 3). This would make it possible to take the lessons learned from the projects implemented outside Beirut and contextualize them into the Beirut context.

Furthermore, the external validity of the research will be limited. This is a characteristic of the case study methodology which focuses on one setting and directs research to that context (Van Thiel, 2014). Therefore, the findings of this research might only apply to cities or countries that have a similar context.

4.4 Data collection, Sample Size and Selection

4.4.1 A preliminary list of projects that will be subject of this study and further analyzed:

This list of projects (table 7) is based on personal experience during my work at the Lebanese ministry of environment and based on desk research conducted. It comprises a list of NBS projects already completed in Lebanon and some grey engineering projects that were completed or planned, all in the water sector.

It is expected that more projects will be found before and during the data collection period and based on these finding a purposive sampling approach will be followed and detailed to sample the ones most suited for this research.

TABLE 7 LIST OF PROJECTS THAT WILL BE SUBJECTS OF CASE STUDY ANALYSIS

Project name	Type	Main Purpose	
Ammiq wetland conversation project	NBS	Protection/conversation wetland	(A Rocha, 2019)
Qab Elias Environmental Project	NBS	Woodland restoration	(A Rocha, 2019)
Bcharee reed bed WWTP	NBS	Wastewater treatment	(LEWAP, 2017)
The Litani River Basin Management System	NBS	Wastewater treatment	(USAID, 2014)
Ablah Wastewater treatment plant and Litani River Authority Constructed Wetland	Grey Engineering	Wastewater treatment	(ReWater MENA, 2019)
Protection of Jeita Spring	Grey Engineering	Watershed protection	(BGR, 2013)
Greater Beirut Water Supply Augmentation project	Grey Engineering	Dam project	(World Bank, 2019)

Not all projects first envisioned were targeted mainly because the lack of access to stakeholders in the allocated time for the field research.

4.4.2 A preliminary list of interviewee by position:

This list contains public and private bodies that are influential in the planning, design, implementation and O&M of projects and strategies in the water sector. The list was built on personal experience in Lebanon and through desk research. Individuals from these bodies will

be targeted for a semi-structured interview aiming to understand governance dynamics, barriers and drivers, and their knowledge of NBS for the water sector.

1. Ministry of Environment:
    a. Department of Urban Environment: Responsible for regulations and legislations relating to wastewater management and takes part in projects review and approval
    b. Department of Natural Resources: Responsible for safeguarding water resources and the rules and regulations in that sector
2. Ministry of Energy and water:
    a. Department of Water Design: Responsible for water resources conservation and project design
    b. Department of Technical Studies: Responsible for design, monitoring, and research in the water sector
    c. Department of Environment Correction: responsible for wastewater treatment projects and flooding protection
3. Establishment of The Water of Beirut and Mount Lebanon
    a. The regional water authority in greater Beirut area and responsible for project implementation, O&M, and quality control in the water and wastewater sectors
4. Litani Water Authority
    a. The water authority with control over the Litani watershed which is the biggest watershed in Lebanon and where several projects to feed water to Beirut city are being planned.
5. Council for Development and Reconstruction
    a. The "arm of the government" in charge of planning securing financing & executing public investment projects
6. Beirut Municipality
    a. The various departments inside the municipality responsible for nature and water related projects
7. Higher council for privatization
    a. Responsible for PPP law and oversees all projects completed through a PPP
8. Consulting companies working in the water sector
9. Urban planning authority

4.4.3 A PRELIMINARY LIST OF LAWS AND REGULATIONS TO BE ANALYZED:

TABLE 8 PRILIMANRY LIST OF REGULATIONS TO BE ANALIZED

Title	Nature	Short description
Water Law 2018	Law	Newly approved law that governs the water sector
CEDAR projects list	Internationally funded project proposals	A list of projects in various sectors valued at $11 billion presented by donor countries to help Lebanon. A large portion of these projects is related to the water sector.

Law 86/87 dated 1967	Law	Prohibits the exploitation of groundwater for private use
Buildings / green areas codes	Laws / regulations	
MoEW Water Strategy 2010	Strategy	A plan which set the strategy of the water sector over a 10 years period. Most of which has failed. This strategy is set to be updated before the end of 2019.
Project specific laws and regulations	Laws / regulations	Regulate various large-scale projects or projects in coordination with international donors
Funding organizations investment plans and strategies in Lebanon	Strategy	Many international funding bodies working in Lebanon set out plans detailing their strategies for the coming time period

4.5 Validity and Reliability

This kind of research is usually labor intensive and time consuming. Therefore, it is important to pick a representative sample of projects to study in detail and to use qualitative analysis software to analyze the documents and interviews. Data sampling and time distribution should be given special attention during research preparation due to the limited time and resource availability, which is even more challenging in this case because I will only be able to spend three weeks in the research area.

As for the timing of the research, the winter of 2018-2019 witnessed the highest rainfall in Lebanon since a few years and reached twice the amount of the last winter (Annahar, 2019). This might have an impact on some respondent's perception of the water sector in Lebanon, and it might impact the research of water quality around Horsh Beirut Park. To counter this, the chosen respondents have been active in the water sector for a long period of time and they realize that one year of heavy rainfall would not solve the problems of water quality and quantity. Furthermore, this will be noted in the write-up about the Horsh Beirut research.

Literature review when preparing the scope of the research for this case will be challenging. On one side, it is important to do the review to determine what are the possible variables that need to be looked at and construct the research framework. But on the other side, and because NBS in Lebanon has been rarely a subject of study, it is important to keep an open mind and not be fully directed by what other research has found. Moreover, there are only a few recent publications discussing the governance of the water sector in Lebanon. These difficulties will be countered by the fact that the case study research method leaves room for new variables and indicators to surface during the study.

For the same reasons as mentioned above, the findings will be very specific for the situation; hence generalizations will not be possible.

In addition to that, the report (chapter 5) will contain a detailed description of the processes used, this will allow review of the methods followed and how the results were obtained thus increasing the reliability of the study.

An important pitfall of case study research to note is the fear of loss of objectivity by the researcher due to frequent and prolonged contact with the case. This is a bigger risk in this case as well because was involved in the water sector in Lebanon for the past three years. But this is not seen as a problem in this research due to short time available for the study and because interviewee for the research will be of various backgrounds and roles in the sector hence a bigger scope will be analyzed.

In addition to that, the secondary data used might have gaps and missing data points in it which might impact the internal validity of the research. For that, triangulation with other data collection methods should be performed. This triangulations will happen between the desk research envisioned, the interviews finding and the validation of findings with actors to be conducted after obtaining preliminary results.

CHAPTER 5 DISCUSSION OF RESULTS

In this chapter the findings of the data collection will be presented and analyzed aiming at validating and finding correlations between the answers given in the interviews, the analyzed documents, the analyzed laws and regulations and the theory as presented in the conceptual framework.

The data will be first presented under three major headings. First is the analysis of the results of the research conducted around the Horsh Beirut Park, second is the presentation and discussion of results from the interviews, and third is the presentation and discussion of results based on linking the interviews, the document and the literature with analysis.

5.1 QUANTIFYING THE IMPORTANCE OF HORSH BEIRUT ON GROUNDWATER QUALITY

Further write up about this section, detailed methodology and detailed results are presented in annex 4.

5.1.1 INTRODUCTION AND STUDY AREA

It was challenging to obtain any quantification of the importance of green areas in Beirut from desk research. The ministry of energy and water as well as the water establishment in Beirut did not provide measurements or indicators as to what is the role of green areas in water management in Beirut. Therefore, in the course of the data collection period, I decided to try and quantify the importance of the largest (and arguably only) green area inside the city of Beirut which is Horsh Beirut Park (fig. 4).

FIGURE 4 HORSH BEIRUT PARK (PICTURE TAKEN BY ME)

One of the benefits of green areas in urban environments is to maintain and improve the quality and quantity of underground water. To test that hypothesis and aiming to quantify the benefit from Horsh Beirut park, the conductivity of the water from wells adjacent to the park was

measured and compared to data obtained from a larger sample across all of Beirut (data which I do not own). An attempt was made to prove that/if the water quality deteriorates as we move further away from the park.

5.1.2 METHODOLOGY

To test this hypothesis, measurements were made in the wells of the buildings around the park and conductivity and pH of the water were taken in addition to as much as possible information about the characteristics of the wells. Private use wells in Beirut are a sensitive topic as many of them are unlicensed, therefore many buildings refused our request to obtain a sample. Because of that, of the almost 60 buildings approached only 19 samples were obtained. The obtained samples were distributed around the park and all within a few hundred meters (fig. 5) and the data is shown in table 9.

TABLE 9 CONDUCTIVITY AND PH OF TESTED WELLS

Well	X	Y	Cond	pH
1	35.507903	33.874368	766	7.42
2	35.5068	33.875025	950	6.72
3	35.505801	33.874049	992	6.58
4	35.505982	33.874035	859	7.05
5	35.504966	33.874815	1028	6.68
6	35.514024	33.869441	1541	6.57
7	35.511872	33.869106	1106	5.78
8	35.51049	33.879726	891	7.29
9	35.506981	33.870301	730	6.5
10	35.506605	33.871613	541	7.05
11	35.507604	33.870957	726	7.24
12	35.508071	33.878331	2520	6.59
13	35.5124457	33.8720028	757	7.16
14	35.5139722	33.8720833	815	6.71
15	35.514869	33.871241	597	7.07
16	35.515974	33.870723	734	6.84
17	35.512839	33.868947	2150	6.19
18	35.507994	33.879731	386	7.38
19	35.509919	33.880221	1210	7.06

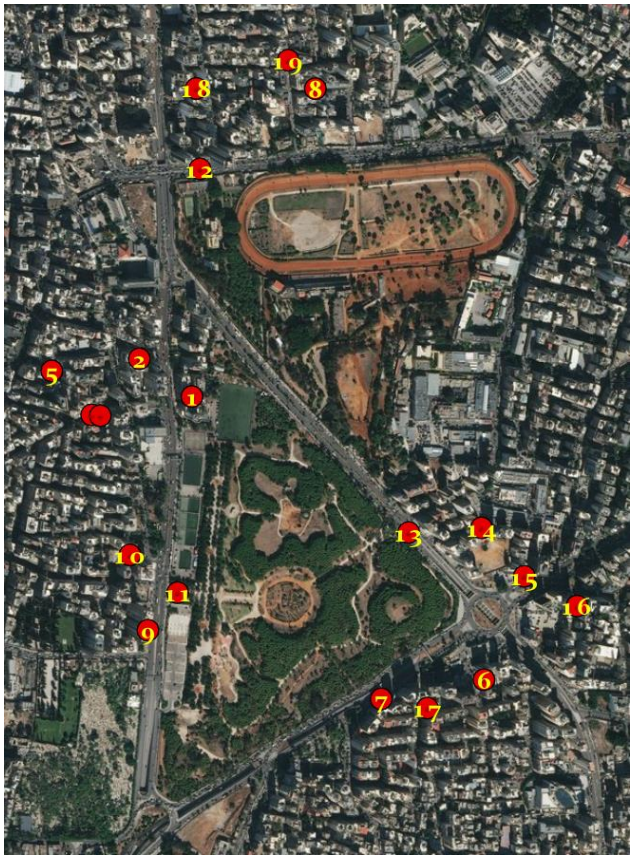

FIGURE 5 HORSH BEIRUT PARK AND SAMPLING POINTS IN RED

To analyze the obtained data a geological map of Beirut (fig, 6) was used where the geological layer on which the park lays (in red on map, red sand layer) was highlighted for analysis. The map dates back to 1944, but it is the most detailed and up to date map available for Beirut (communication with Dr. Wissam Khadra).

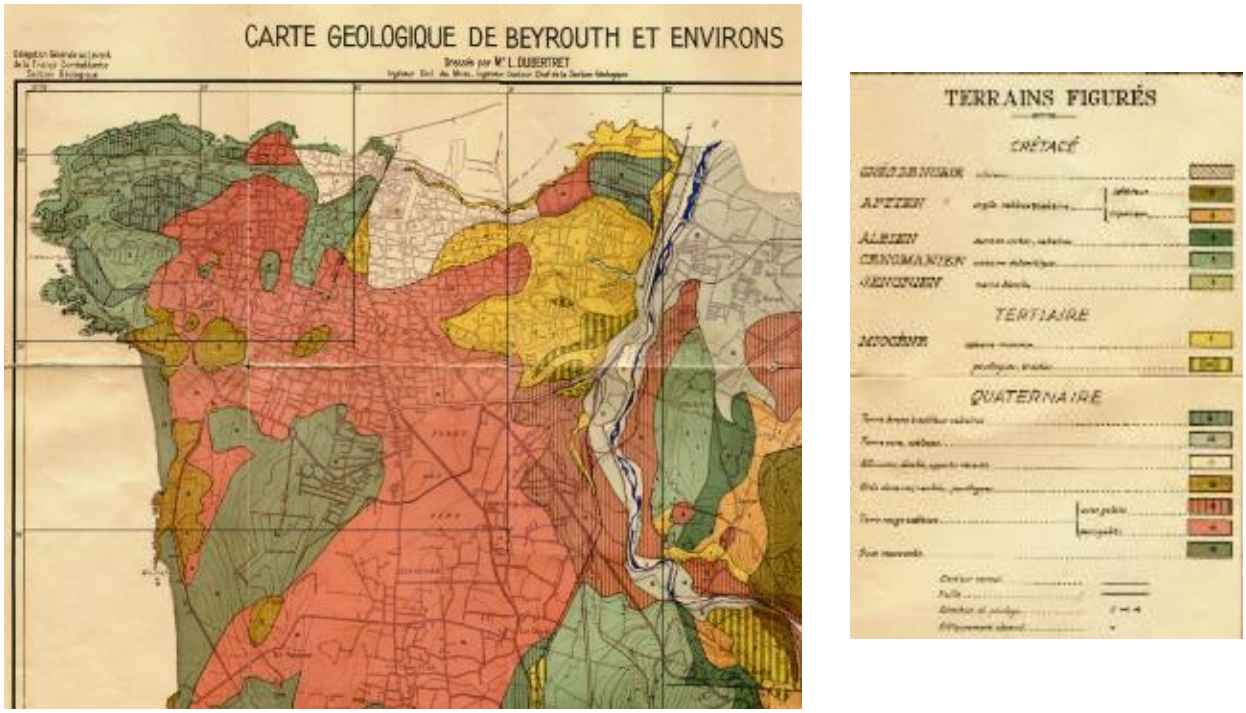

FIGURE 6 GEOLOGICAL MAP OF BEIRUT (SOURCE: COMMUNICATIONS WITH DR. WISSAM KHADRA)

The next step was to build the map on ArcGIS as shown in figure 7 containing the location of wells where data was collected for this research (red dots), the location of wells where data had been collected for previous research which I do not own (not shown on this map), the geological layer to which Horsh Beirut Park belongs (red layer), and the area of Horsh Beirut (green layer):

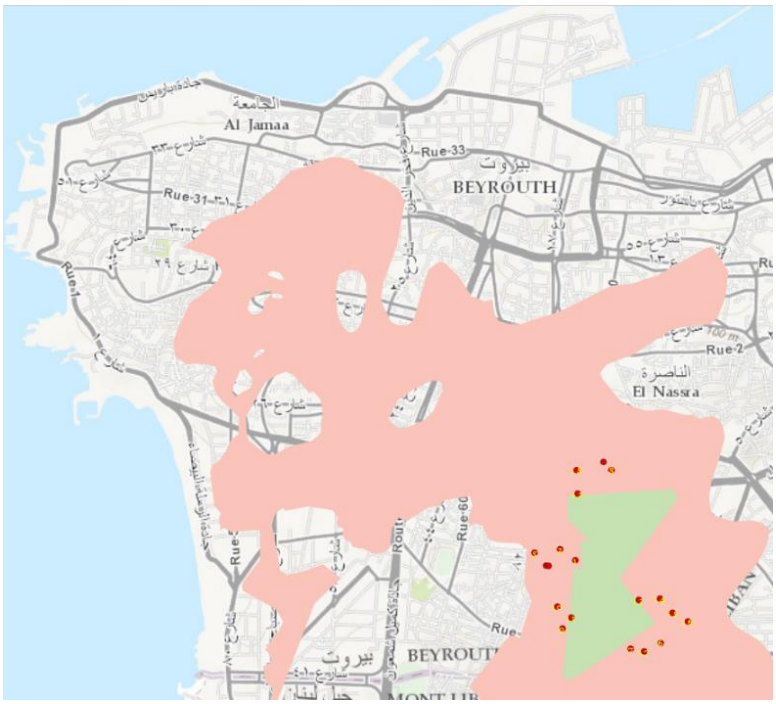

FIGURE 7 MAP CONTAINING ALL DATA BEFORE ANALYSIS

5.1.3 Analysis

In ArcGIS, Inverse Distance Weighted (IDW) interpolation was reported being used in the literature as a method to estimate groundwater quality over a large surface (Rawat and Singh, 2018). Therefore, IDW was applied to estimate the conductivity across Beirut as shown in figure 8. From there, it could be seen that the area surrounding the Horsh Beirut Park does indeed have lower conductivity. And as higher conductivity is a common indicator of sea water intrusion (Hayashi, 2004), hence the lighter red color around the park indicating less polluted and less saline groundwater. A preliminary conclusion is that the park by allowing improved infiltration of rainwater is protecting the areas around it from sea water intrusion affecting the aquifer.

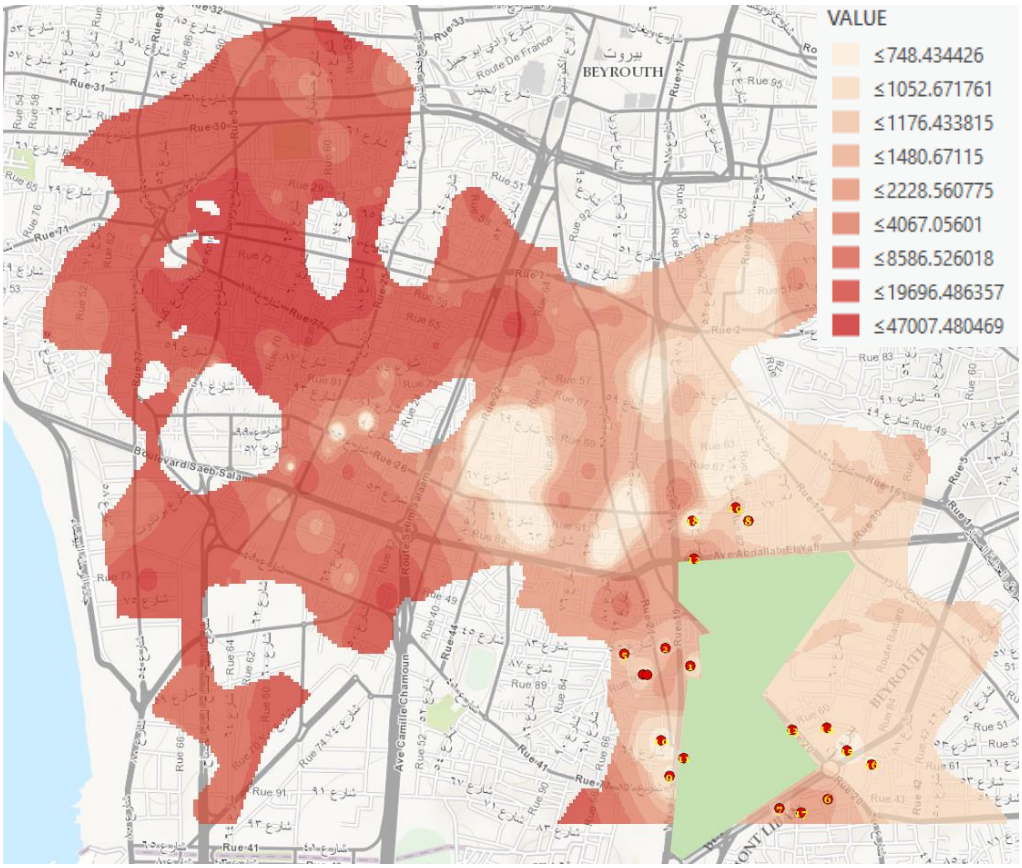

FIGURE 8 IDW OF CONDUCTIVITY OF GROUNDWATER ACROSS BEIRUT

5.1.4 Limitation of the study and recommendations

The limitations encountered:

- The geological map used is old, but no better map was found
- The data gathered for Beirut area was gathered few years before this research but at the same time of the year
- It was not possible to obtain samples from several location due to resistance from owners based on the sensitivity of private wells use. For the same reason, reported depths and water extraction from wells cannot be fully trusted.

Recommendations:

- Gathering further data from wells around the park by adopting a more community centered approach. Stakeholders sessions should be conducted to explain to the well's owners the reasons for the intervention thus ensuring access to more wells and better data.
- Targeting other smaller green areas in Beirut to understand if they offer the same benefit
- Targeting other geological layers to determine the contribution of geological formations to salinity and sea water intrusion.
- Gathering data across a longer time period and for various pollutants.

5.2 INTERVIEWS FINDINGS

At the end of the data collection period 15 interviews in total were conducted with actors across the water management sector. Some of these are government actors while others have completed grey engineering or NBS projects for water management (table 10).

The interviews were conducted at the office of the interviewees and recorded after obtaining their permission. They were conducted based on a bilingual interview guide provided in annex 1 and it was usually preceded by a presentation (annex 1) with some examples of NBS for water management. As soon as it was possible after the interview, the audio recording was transcribed and coded according to the codebook presented in annex 5.

Only two interviewees chose not to include their names and one refused to allow recording hence written notes were taken.

TABLE 10 LIST OF INTERVIEWEES

	Name	Position	Reason for interview
1	Bassam Sabagh	Head of Urban Environment service at the Lebanese ministry of environment	Knowledgeable of various projects and laws and regulations
2	Carla Nassab	Energy Engineer at CEDRO	First green roof project in Beirut
3	Ciara Noone	Project manager at ACTED	Working on NBS implementation in greater Beirut area
4	George Saykali	Urban Planning authority	Knowledge of regulations and planning
5	Manal Moussallem	Senior Environmental Advisor for the Minister of environment, UNDP	Knowledgeable of various projects and laws and regulations
6	Anonymous	Water management department at the ministry of energy and water	Participated in setting guidelines in the water sector and in watershed management projects
7	Nasim Abou Hamad	Head of department at the Litani river authority	This authority is taking steps to clean up the Litani river

8	Ricardo Khoury	Partner and Head of Environmental Services Division, ELARD	Knowledge of various water related projects
9	Toni Zoghbi	Beirut water establishment	Management and planning for the water sector in Beirut
10	Vahakn Kabakian	UNFCCC project director	Working on rainwater collection guidelines & stormwater projects
11	Yves Chartouni	Manager at Edde farms	The first artificial groundwater recharge attempt in Lebanon
12	Zeina Majdalani	Office of the prime minister	Coordination role between various institutions in the water sector
13	Anonymous	Manager at CDR	Overviews water and wastewater projects
14	Nabil Amasha	Prof. at the Lebanese University	Pioneer and active in constructed wetlands projects
15	Bassam Jaber	Consultant in the water sector	Previous head of Beirut water establishment

Here it is important to note that it was not possible to set any appointment with actors working at the municipality of Beirut and whom are knowledgeable about green areas and water management in the city. The Beirut resilient city strategy presentation was found online, but upon further inquiry about it at the municipality no further information was given.

5.2.1 MOST IMPORTANT PROJECTS ANALYZED

This section presents the major projects analyzed for this research. Other projects were researched and discussed during the interviews, but these projects are the ones that informed this research the most.

5.2.1.1 Stormwater management using NBS in Beirut Southern Suburb, 2019

The project is in the planning phase aiming at completing a pilot by 2019. The NGO ACTED working in partnership with Beirut water establishment and the union of municipalities of Beirut's southern suburb are trying to improve storm water management. The project includes soft approaches such impact modeling and feasibility assessment in addition to completing pilots in rainwater harvesting, pervious paving and rainwater garden among other NBS approaches to improve stormwater management.

5.2.1.2 Groundwater recharge project in Bekaa Area, 2018

A project aiming at testing managed aquifer recharge for the first time in Lebanon. Started with coordination between ELARD consultancy, ARCADIS, The American University of Beirut, and the relevant governmental bodies. The project was on track to testing in winter of 2018 but confronted political hurdles which led to a halt in testing.

5.2.1.3 Protection of Jeita Springs plan, 2014

The German consultancy BGR worked with the relevant Lebanese authorities to complete plans for the protection of the quality of the Jeita Springs. The plan aimed at determining the main sources of pollution in the watershed and proposed location for installation of wastewater treatment plants. Furthermore, the plan proposed locations that need to be protected and where activities should be limited to protect groundwater resources. It was not possible during this research to go deep into the process of this project due time passing since its completion.

5.2.1.4 Various projects using constructed wetlands for wastewater treatment across Lebanon

Constructed wetlands for wastewater treatment are increasingly used for wastewater treatment in Lebanon, and they are being discussed to be part of strategies in some areas. Not one specific wetland project will be discussed, but one of the pioneers of this solution in Lebanon will be interviewed and it will be discussed with relevant actors.

5.2.1.5 Installation of green roof on the Central Bank building in Beirut, 2014

In 2014 CEDRO launched a project to install a green roof on the top of the Central Bank of Lebanon in Beirut. The Central Bank aimed from this project to incentivize other financial institutions to follow with similar green solution. It could be considered the first green roof projected in Beirut.

5.2.2 LIST OF BARRIERS AND DRIVERS AS IDENTIFIED BY INTERVIEWEE

Most of the governance drivers and barriers that were extracted from the interviews (table 11) were found to be similar to what was expected based on the literature review (table 2). In addition, some unique drivers and barriers were mentioned, and they were therefore added to the analysis.

TABLE 11 GOVERNANCE DRIVERS AND BARRIERS FOR NBS INTEGRATION IN WATER MANAGEMENT IN BEIRUT

Drivers	# of Mentions	Barriers	# of Mentions
Presence of a champion	4	Competes with grey eng.	13
Co-benefits of NBS	10	Government silos	5
Government support	9	Low priority for NBS	11
Local support	15	Absence of laws	17
Public support	8	Short political cycle	0
Quick application NBS	1	Staff capacities	9
SDGs	0	Hard to change mentality	3
Staff capacities	9		

5.2.3 DRIVERS MENTIONED IN INTERVIEWS

5.2.3.1 Presence of a champion or pioneer who drives the integration of new methods:

This was found to be relevant to the case of NBS in Beirut as most of the projects that are being implemented are driven by a personal motive and not a centralized strategy.

> 3:1 "we're trying to change how cities look at storm water as a resource and to support urban areas to become more resilient to water shocks."

These champions are bringing outside expertise which are present in Lebanon and trying to apply new methods which they deem important.

> 3:9 "I've worked with an environmental firm in Australia called Alluvium so I used to do urban stormwater management."

> 11:1 "ELARD company linked us to Dutch consultancies with AUB, and they contacted us to ask about interest in a MAR project for our land."

5.2.3.2 Co-benefits of NBS

As it was previously discussed implementing NBS would bring about various benefits for multiple sectors. Based on the interviews, this was a governance driver as it encouraged partnerships and knowledge exchange across various sectors whenever an NBS was being implemented.

> 3:7 "Head of the water union is an engineer, water establishments are engineers, and we have the consultant, so we're all speaking the same language. And we will do a pilot to show the value in term of infiltration and cost."

> 7:2 "So we thought that it's good for the municipalities with technical support from our side, and we tried to secure financial support for them, we thought it could be good for them to find short term simple and inexpensive solutions to stop WW from getting into the [Litani] river"

5.2.3.3 Government support:

Although it was not always the case, but the central government or certain actors from the government were found to support the implementation of NBS.

> 3:18 "Even CDR when I told him about the project, they were interested to hear about it after we get results."

> 11:1 "The project was a cooperation between MoEW, MoA, BWE, LRA, ELARD, Dutch consultancies."

Furthermore, a change in thinking towards a more holistic approach was detected when interviewing some government actors.

> 6:3 "We are now moving into studying the whole basin. Which focuses on all sectors. Water, industry, tourism, environment."

> 7:7 “Regarding governance, the old thinking was to manage water on our own as an authority. Now we are moving into participative governance.”

5.2.3.4 Local and public support

Despite the presence of central government support, the majority of the push towards NBS was noted to be coming due to support from local government such as municipalities and local water establishments.

> 3:19 “Regarding the union, we’ve had a great work record, and I’ve known him for 4 years, so when I told him that I wanted to do this project he was accepting and because he wanted to make Dahye green and he said prove anything and I’ll do it. When I talked to the water establishment, they were super interested. I asked our consultant why no one is doing these projects although there’s knowledge”

> 4:6 “There’s only one plan in Hermel area where they [the municipality] left green spots in the village in the zoning plan of the village. They worked in coordination with an engineer and they proposed that zoning for us and we welcomed their proposition.”

Furthermore, this support was backed by support from the public.

> 5:8 “This would make the strategy much more appealing to people and more acceptable sustainability wise. If it’s in the interest of the MoEW to include these aspects to make it more acceptable by the public”

> 11:10 “We noticed a great interest from the surrounding. When talking to our contacts in other farmer and landowners, everyone showed interest and some of them came over to see the system. Some people were waiting for results to make up their mind.”

5.2.3.5 Staff capacities

Staff capacities was a controversial topic. It was sometimes mentioned that government (central and local) staff as well as other relevant actors do possess the needed knowledge about NBS in the water sector. Examples of when staff capacities were a driver:

> 2:3 “The team at BDL was very helpful because there’s an engineering team in the bank who supervises all the projects that are related to the bank, they were on board with us and they helped us a lot.”

> 9:11 “for example Bour Al Barajne Municipality, someone worked with them to separate sewage water from storm water, and to start ground water recharge projects, and they welcomed all these ideas and the projects are underway now.”

> 1:6 “These big municipalities have the manpower, finances, and engineering know how to apply this.”

5.2.3.6 Sustainable Development Goals

Some literature had highlighted SDGs as a driver for NBS adoption as these solutions offer a way to reduce carbon footprint and improve the ecosystem. Although Lebanon does

have commitment to the Paris agreement and other international accords these were not mentioned in the interviews. This could indicate lack of knowledge from the actors to the SDGs targets of Lebanon, lack of awareness to some co-benefits of NBS, or that SDGs targets and international environmental accords are not high on the priorities of the interviewed actors.

5.2.4 Barriers mentioned in interviews

5.2.4.1 Competition between grey solutions and NBS

This competition is still very prevalent in Lebanon and usually NBS come out losing whereby funds and resources get diverted towards grey engineering projects which are well known to the local actors.

> 2:6 "Regarding space, solar water heaters and PV are now being focused on by LCEC, and although these can be made to be on the same roof [with green roofs] we don't have the knowledge how to do that."

> 5:1 "so now they focus more on the heavy infrastructural aspects and the cliché types of non-structural measures such as demand management etc…"

5.2.4.2 Presence of government silos

As NBS are a cross sectoral solution to multiple problems with various co-benefits, the presence of silos in the government that will limit communication, knowledge exchange and complicate the implementation of NBS.

> 7:9 "The other part of governance we are looking at is to widen the mandate of the authority. It shouldn't only be involved in water provision and electricity production."

> 5:6 "When they approached MoE to be part of the committee I noticed that the strategy doesn't include components that are of importance to them. it's not that people don't want to include the environmental component, because when they studied in the past it wasn't that important"

> 7:13 "The central government still insists on lining riverbeds with concrete. And we tried to stop this"

5.2.4.3 Low priority given to NBS during planning

As NBS is still a new concept, it is expected to be deprioritized in planning.

> 4:3 "They're now even looking at regulating metal sheds on the top of roofs for commercial purposes. There's a fifth façade law under discussion in the parliament now. They're thinking in a very monetary way, making money. So those sheds on rooftops will be regulated and allowed to exist in return for the bldg. owner paying extra fees."

> 6:4 "We started, but we are facing opposition at the ministry because they rather spend money on water networks and tanks."

> 7:11 "So the law doesn't include NBS, such as sustainable farming, and natural channels

> No no it's a very traditional. It sees that WW problem needs to be treated with collectors and conventional WWTP"

This is peculiar in the case of Lebanon where grey engineering solutions have failed to deliver good services and therefore it is thought that decision makers should go looking for new and different solutions.

5.2.4.4 Absence of laws supporting NBS

This is was quoted to be the most prevalent governance barrier towards NBS adoption.

> 3:13 "also the national water strategy is now being developed and I am trying to talk to the ministry about including the stormwater measures in it."

> 6:8 "Current water law, which is under review, does mention working at the basin level, take pollution and environment into account, and polluter pays concept. But the law still needs implementation decrees to allow for its implementation. I think the law sufficiently mentions these factors but it is still missing implantation decrees. Because of the review it is undergoing."

It is expected to find that laws and regulations are lagging behind a new concept. But what is interesting in the case of Lebanon is that the law regulating water management was issued recently in 2018 and is being updated now. Furthermore, the water and wastewater strategy that was issued in 2011 is also being updated. So opportunity should be present to include rising concepts

5.2.4.5 Staff capacities

As mentioned before, staff capacities to implement NBS was mentioned both as a driver and barrier:

> 2:7 "We don't have the workforce and companies that possess the know how to implement green roofs."

> 8:6 "But unfortunately I think all these levels are absent in lebanon. We don't have the technical know-how, nor we have awareness, we might have some, that these solutions exist and are effective."

5.2.4.6 Short political cycle

This barrier was meant to represent the contradicting long term targets of NBS versus the short political cycles which would impact NBS adoption because politicians are looking for short term goals. This was not mentioned in the interviews as a barrier which could indicate lack of strategic planning and no interest in long term goals from politicians.

5.3 Relating findings to operationalization of variables

This section of the thesis will focus on presenting the collected data in a form similar to the operationalization presented in table 6. There will be an attempt to present the concepts and determine the variables using the indicators outlined in table 6.

5.3.1 Determining the NBS used for water management in Beirut

Some literature (Cohen-Shacham, Walters, et al., 2016) defines a typology for the various types of NBS (fig. 8) which ranges from using the present ecosystem for its benefits, to restoring a deteriorated ecosystem and improving its services, and finally creating a new ecosystem when and where its benefits are needed. None of the institutions managing water in Lebanon have studied the benefits brought on by the natural ecosystem to the water sector.

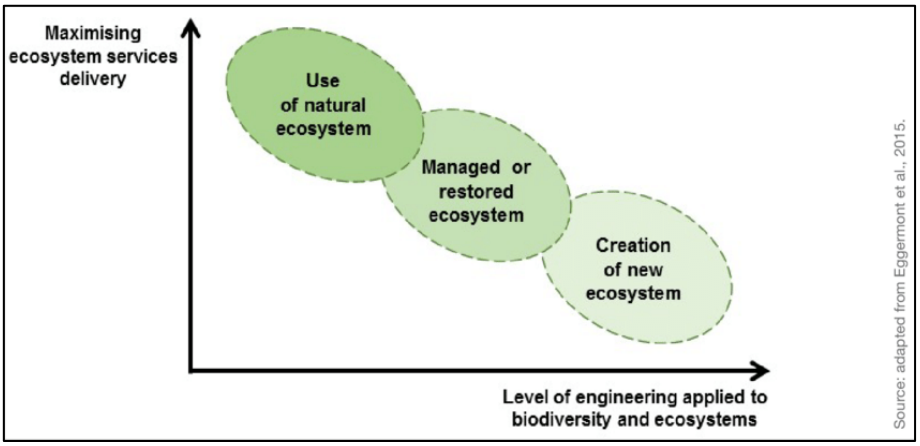

FIGURE 9 TYPOLOGY OF NBS FOR WATER MANAGEMENT

5.3.1.1 Use of Natural System

Through studying the impact of Horsh Beirut on the surrounding water quality this thesis manages to prove that the already existing ecosystem provides benefits to the surrounding. Although expected, this finding should drive towards more protection of the Horsh Beirut park which is slowly deteriorating with time (fig. 10) and which was once again struck with a disease and closed to public only after a brief period of being open (Beirut.com, 2017).

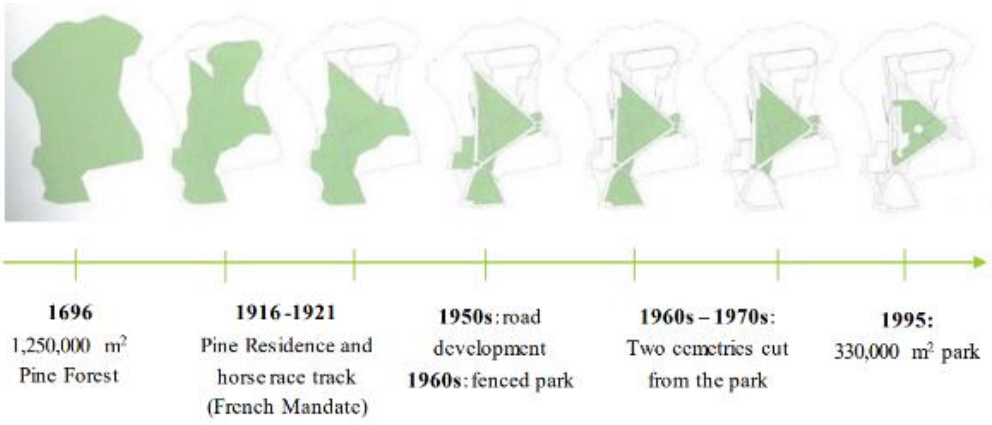

FIGURE 10 DEVELOPMENT OF HORSH BEIRUT PARK THROUGH THE YEARS (ARBID, 2010)

This lack of attention is further apparent in the fact that only one of the interviewee has mentioned the Park as a possible target for an intervention to improve water management in

the city. Furthermore, the park is not mentioned for strengthening/protection in any of the urban resilience plans issued by the city of Beirut.

5.3.1.2 Managed or Restored Ecosystem

The interviews conducted and the projects that were found and targeted for this research show that this is the type of NBS which is currently taking off in Lebanon and Beirut more specifically.

A key interviewee from the central government mentioned a change in approach towards water management to focus on watershed management instead of point sources management:

> 6:3 "We are now moving into studying the whole basin. Which focuses on all sectors. Water, industry, tourism, environment."
>
> 6:7 "We are starting to study El Kaleb river basin. We are doing parts of the study as money become available"

This is reinforced by the presence of the Jeita Springs protection plans (As indicated in table 5, Jeita watershed provides 75% of the current water supply to Beirut) which has been set in 2011 and is being implemented gradually. This plan although it focuses on the watershed, but it only targets grey engineering solutions such as wastewater collectors and treatment plants. It omits the importance of restoring and protecting the natural environment and its role in water quantity and quality improvement.

Law 77 was issued in 2018 to govern the water sector, and although it is currently being updated as I was informed by several respondents, it will be analyzed in its current state. The 90^{th} clause (Law 77, p. 2698) of this law is concerned with the protection of water collection areas whereby it specifies the range of protection around collection points, activities allowed in that range, and the steps needed to preserve the quality and quantity of the water. Despite that, this clause fails to mention the importance of conserving/restoring the natural ecosystem as method to protect and augment water reserves and quality.

5.3.1.3 Creation of New Ecosystems

No indications were found in the interviews or the desk research that lead to thinking that there is any action being taken towards augmenting the natural ecosystem in and around Beirut. Although, I believe that this would be the next logical step to look at to face the problems that are hitting the water sector. Increasing the green and blue areas are a must in a city where only 0.8 m^2/capita of green space is available (Nazzal and Chinder, 2018).

5.3.2 Impacts and Co-benefits of present NBS

The only impact that was possible to quantify was the impact of the Horsh Beirut park on the salinity of the surrounding water wells. It was shown through preliminary analysis that the conductivity, and by relation the salinity, of nearby water wells is generally lower than other areas of Beirut despite this area undergoing as much development (Marot, 2018).

Other co-benefits were also mentioned in the interviewees as drivers for the NBS projects already implemented in Lebanon. Main co-benefit of these is the reduction in energy used associated with NBS such as green roofs and constructed wetlands for wastewater treatment. Moreover, strengthening groundwater resources in areas where the water is needed will save pumping and transport costs and the associated energy use. Electricity is a very weak sector in Lebanon and is usually the reason for WWTP failures because of the increased O&M expenses on generator fuels.

> 2:2 "The idea was to see the performance and energy reduction and runoff water reduction and boosts health and comforts for employees. It was supposed to be open for employees of the central bank for their breaks. But eventually no one had access to the roof."
>
> 7:4 "We saved a lot of energy, which is important in Lebanon."
>
> 9:4 "It turns out that it's costly to repump the water from that dam. Therefore, we are considering to do MAR recharge in the area in Nahr El Kalb and Dayshouniye area and Damour Area. We are focusing on areas around rivers for water recharge."

Although those co-benefits were not possible to quantify but they remain a major technological driver for the adoption of NBS for water management.

5.3.3 The level of actors' knowledge about NBS

For this section it was originally planned to use key terms from the literature and based on Think Nature's survey (Think Nature, 2019) to assess the knowledge of interviewed actors about NBS, its co-benefits and gaps and barriers. But this did not go as planned.

Preliminary contacts before the interviews began showed that it would be preferable to start the interview with a presentation (Annex 1) about NBS to either introduce the actors to the topic or refresh their memory and direct the conversation. After this, it would not be valid to assess their knowledge about the subject because they were just given the information.

Furthermore, coding the interviews for such keywords did not reveal any valid analysis. Actors could be knowledgeable about a certain form of NBS or a certain application, hence it is not valid to judge the knowledge using the approach across the varying positions of the actors involved in this research.

Third, analysis of knowledge of barriers and drivers resulted in similar outcome to what was presented in section 5.2.2.

Hence, I believe that the keywords analysis approach would not result in valid nor reliable results assessing actors' knowledge. The results of a preliminary assessment are presented in table 12 without further analysis and without basing the rest of the analysis in this thesis on it.

TABLE 12 ASSESSING ACTORS' KNOWLEDGE ABOUT NBS

Variable	Number of interviewee mentions	Comments
Awareness of various NBS application	13/15	13 of the interviewees mentioned valid NBS and their use, the 2 other were not involved in NBS application.
Awareness of benefits/co-benefits of NBS	15/15	Once told about the potential NBS all actors were able to determine benefits
Awareness of gaps / barriers / drivers	15/15	All actors mentioned potential gaps and barriers to adapt NBS

5.3.4 How does governance of the water sector impact NBS adoption?

As indicated in table 6 the governance in Beirut will be handled at four different levels as the operationalization of the variables and questions raised in the literature when discussing the application of NBS into the water sector (Frantzeskaki and Tilie, 2014, Browder, Ozment, et al., 2019).

At the strategic governance level responses from interviewees working at the central government level and the available laws (law 77/2018) and strategies (water sector strategy 2011) will be used to assess the long-term policies and visions. The technical challenges in the water sector appear to be clear but lack any quantification or analysis. Combating the increase in impermeable areas, increased pollution of water sources, and decreased quantities available are the main topic brought up during the interviewees.

There doesn't seem to be any new guided large-scale attempts from the government to combat those issues. Based on the interviews, the water sector strategy issued in 2010 has failed to achieve its targets so far and it is currently being updated by the ministry of energy and water. And two dams (Bisri and Janeh) are currently being built which are supposed to be a solution to Beirut's water shortage. Those projects are highly contested and Lebanon's experience with dams has been negative due to the karstic geology and the uncontrolled dumping of industrial and municipal wastewater constantly polluting surface water (Saadeh, Semerjian, et al., 2012, Jaoude, Karanouh, et al., 2010). At the same time, some attempts at introducing new approaches to face those challenges are taking place but remain very limited. At the ministry of energy and water, it was found that there is change in direction towards aiming at basin level management for the major rivers, but this remains limited by financial constraints and competition with "typical" projects:

> 9:17 "and we're working to protect the Basin of Shwayfet area"
>
> 6:7 "We are starting to study El Kaleb river basin. We are doing parts of the study as money becomes available"

Simultaneously, the Beirut water establishment started piloting RO projects to tackle groundwater salinity issues.

> 9:16 “But we can’t wait for those projects. We can’t keep the people drinking salty water. We started two projects in Hazmiyeh for RO to desalinate well water, and we’re planning to do 2 more projects because we had success with the first one.”

These remain isolated attempts that are not part of any bigger strategy or plan. It is not clear if the decisions being taken are based on a vision or if they are taken based on the availability of resources for a certain idea, no indications of the former were found.

At the tactical level it appears that whenever an NBS related idea is being implemented or planned many partnerships are built around it:

> 3:7 “Head of the water union is an engineer, water establishments are engineers, and we have the consultant, so we’re all speaking the same language. And we will do a pilot to show the value in term of infiltration and cost.”

> 11:6 “The project was a cooperation between MoEW, MoA, BWE, LRA, ELARD, Dutch consultancies.”

These partnerships are essential for the completion of NBS projects and they show that coordination between various institutions can be achieved once the resources (financial, technical…) are made available.

On the same level, several activities were identified that can be considered as steering activities. But although many of these activities are already completed, they have failed to guide any large-scale shift in strategies or thinking. Some of these activities are the first green roof in Beirut (discussed with respondent 2) and several rain-water collection attempts (discussed with respondent 10). This issue will be further discussed in the next section.

Regarding funding mechanisms, none of the respondents highlighted any funding potential for water related NBS projects. Two mechanisms were mentioned, NEEREA and LEEREFF, but they both relate to green energies. And although they can be used to fund projects which might contribute to water management and energy efficiency (such as green roofs and green walls), they remain limited. The majority of the funding to the projects targeted for this thesis came from NGOs working in this sector or from international organizations. This highlights the low priority of NBS and ecosystem services as solutions on the strategic level.

At the operational level, there’s a lack of information dissipation mechanisms, lack of knowledge sharing, and a lack of any guidance that would assist in implementation of NBS in the water sector.

Few of the actors interviewed knew about the efforts taking place in the water sector unless they were directly involved in the project. Furthermore, respondent one who is the head of the urban department at the ministry of environment, believes that creating the required technical guidelines for NBS implementation would be critical in their uptake by municipalities:

> 1:5 “Therefore, issuing a set of guidelines from the MoE or MoEW. This is something we could take action on”

Finally, at the reflexive level which considers monitoring and evaluation of existing policies several key findings and challenges could be determined.

First, regarding laws and regulation, the two major overseeing texts regarding the water sector are being revised currently. Law 77 (Water Law) is under review despite being issued only recently in 2018, apparently this review is not happening due to feedback or due to any assessment that was completed. But private conversation with some actors indicated that the law was issued in a rush aiming to fulfill some of Lebanon's commitment to international treaties and is now being worked on to modernize it. While the Water Sector Strategy issued in 2010 and setting targets to 2020 is currently being reviewed because very few of the targets mentioned in it were achieved hence the need for a serious review.

Here opportunity arises because the old texts did not include mention of NBS or ecosystem services as a potential to strengthen the sector. Therefore, there might be possibility to include some recommendations in the new texts. This opportunity was discussed with several of the actors whom welcomed the idea:

> 5:4 "For aspects related to Urban, in case you see a window to include so solutions I think it's the right time to propose them."

> 8:7 "I think it's now or never the opportunity to lobby for NBS inclusion in the strategy aiming for sustainable water management. a lot of these plans are not undergoing the SEA or doing the SEA post strategy. The SEA is a good tool to mainstream and try to include the environmental concepts into strategies"

5.3.5 What are the other factors facilitating or hindering the implementation of NBS?

5.3.5.1 Technical factors

Although the interviews did not go into details about the technical aspects of the NBS projects, but the technical difficulties were at times as impactful as governance barriers during implementation. This section will consider the technical factors as they were mentioned in the interviews, as well as the social and financial aspects which merit a mention as they were sometimes central to the discussions.

A key point that was constantly repeated during the interviews was the need for a large land area to apply NBS. From constructed wetlands to stormwater management these solutions would require large areas of free land which is difficult to find in Beirut:

> 7:3 "We faced the problem of not finding enough land for these wetlands, which we assume there's a need for 2 m2/person. Especially for larger size municipalities of 10000 and more habitants where this solution becomes impossible."

> 13:2 "In the Bekaa area there are huge areas of land available so NBS projects can be applied as opposed to Beirut where empty land is rare"

Although this is true for some solutions, many solutions have been implemented on a smaller scale where not much land is needed and where positive results were obtained. Neighborhood

scale initiative can focus on introducing ecosystem services into each area which collectively on the city scale would have the desired impact of NBS. An example of this is the Zoho district climate proofing plan in Rotterdam (Urbanisten, 2016) whereby the climate hazards that were faced in the neighborhood were fought with neighborhood level interventions such rain gardens, impermeable tiling and community gardens.

Another major technical barrier that was mentioned in the interview was the topography and geology of Lebanese cities. Having steep inclines would limit the type and location of solutions to be implemented, but in addition, the lack of information and geological analysis is a setback to any NBS project. This lack of proper geological mapping of Lebanon would add unpredictability to any assessment and future planning as well as add cost and delays to any project. Evidence to this is the "Jeita Watershed Protection Plan" where the project proponent had to spend two years to geologically delineate the watershed and where protection efforts need to be focused (BGR, 2013).

On the other hand, several technical factor pushed local actors towards implanting NBS rather than conventional grey engineering solutions. As discussed previously in section 5.3.2 NBS are bringing a decrease in energy use which is a major sought-after benefit in Lebanon. In addition, actors in the water and wastewater sector are seeking new types of solution after years and years of spending on the same types of projects without any improvement in the sectors. A 48% unaccounted-for water and 8% wastewater treatment rates (Water Sector Strategy, 2010) call for new solutions to be injected into the sector.

Moreover, the adopted NBS in Lebanon have shown to be faster to construct and start operation. This fact alone was a major driver towards several of the constructed reed bed for wastewater treatment that were adopted in several location in the Bekaa region.

> 7:1 "we are promoting this idea because we see that the planned WWTPs in Bekaa region is slow, we don't see any [conventional WWTP] completing within 5-6 years although some WWTPs were approved for construction."
>
> "The constructed wetland under study is a Free Water Surface (FWS) wetland constructed in 2013 at a publicly owned site (southeast of the Litani River Authority agricultural extension center in Kherbit Kanafar in the southern plains of the Bekaa Valley" (Amacha, Karam, et al., 2017) [constructed and operational in one year]

5.3.5.2 Social factors

No opinion surveys were conducted but some insight can be gained into the social aspect of NBS adaption in Lebanon by looking into the documents of the targeted projects and from the interviews.

From the conducted interviews it appears that the public is a strong driving force towards NBS adoption. Even representative of the central government believe that the public will be key to a greater adoption of NBS:

> 11:12 “I believe that having the needed guidelines, the people will start pressuring the municipalities to adopt these measures, and municipalities won’t be able to claim that they don’t know,”
>
> 7:20 “I believe that NGO created by the people living around the river are key for future movement in the area, they should organize and push for solution.”

As for the projects themselves, public support was key, and the completed projects always attracted attention of neighboring communities:

> 11:10 “We noticed a great interest from the surrounding. When talking to our contacts in other farmer and landowners, everyone showed interest and some of them came over to see the system”
>
> 2:8 “And at the opening there were many heads of Banks who showed great interest in having similar projects, but that interest later died out maybe because they didn’t enough cost benefit to such a project.”

Furthermore, the public participation section in the EIA reports of the “Jeita Spring Protection” project indicates an overwhelming support for the project despite that the numerous participants are from different villages and might have conflicts of interests:

> JSPP, EIA report p. 267: “The project presented in the hearing was met positively with encouragement and wishes for its success and implementation. Most of the participants openly expressed their support to it.”

This is a striking contrast when compared to another large-scale project which is the construction of the Bisri dam:

> Bisri Dam EIA report volume 1 p. 253: The overall attitude of all four audiences was strongly opposed to the construction of Bisri Dam. At Aamatour, barely has the introduction to the session been completed when for several minutes the meeting descended into uproar as attendees stood and shouted their opposition

It can be concluded form this preliminary analysis that projects where the whole ecosystem and surrounding areas is considered and where the benefits reach a wide variety of people are more welcomed by communities. While a project like Bisri dam would benefit hundreds of thousands of people, but its immediate impact on the surrounding area will still be seen negatively by the population. On the other hand, creation of wetlands and focusing on watershed management options would still strengthen the water resources while bringing ecosystem benefits to the immediate surrounding. This was well noticed where such projects took place in Lebanon:

> 11:11 “There’s Ammiq wetland, where the restoration of the wetland had huge beneficial impacts on the groundwater from QabElias 7 km away to Kefraya 7km on the other side where the wells are still full, and the wetland had a huge positive impact of them. the wetland is holding a lot of water and helping the area. Moreover, the ecosystem itself improved in the area, birds, pigs and rabbits numbers increased in the area.”

This is all reinforced by the literature which indicates that the majority of people will welcome nature based solutions and the added benefits they bring (Faivre, Fritz, et al., 2017b).

5.3.5.3 Financial Factors

In a developing country with very limited resources, availability of money for any project is the controlling factor usually. Most large-scale projects completed in the water sector are based on grants and international funding.

It is not yet clear from the literature weather the initial cost of NBS is lower or higher than the cost of conventional grey solutions. But what is sure is that when accounted for, co-benefits brought on by NBS will tip the scale towards adopting NBS (Browder, Ozment, et al., 2019).

In all the conducted interview the financial aspect was mentioned as a barrier. But what stands out, is that when finances are secure all actors will welcome NBS projects such as the case of the ACTED project in Beirut's suburb:

> 3:16 "that's why people are open to new ideas and because it's an NGO... I've been waiting for everyone to say no, but I've seen great acceptance. Maybe because I've been working with everyone for a long time. Even CDR when I told him about the project, he was interested to hear about it after we get results."

The other aspect to note is the fact that many organizations funding water related projects in Lebanon have issued guidelines and reports concerning NBS (Raymond, Frantzeskaki, et al., 2017b, ADB, 2016, Browder, Ozment, et al., 2019, UNESCO, 2018). It is left to be determined why none of these organization is pushing towards NBS solutions in Lebanon or at least pushing towards starting the discussion on NBS vs grey engineering. Answering this question is outside the scope of the current research.

5.4 Analysis of Data and Discussion

5.4.1 Governance of the water sector towards NBS integration

The urban water sector is another layer in the complex system of urban governance. Adding on top of that the challenges of climate change, ecosystem deterioration, political and security instability in the region, it becomes clear that Beirut and Lebanon in general did not have the governance dynamics needed to adapt and make the water sector resilient to these challenges.

Because of all that, all levels of governance are slowly adapting to the growing water challenges which have reached alarming level of surface and groundwater pollution and resources scarcity. From amending governing laws and strategies to small scale NBS projects, the water sector is trying to respond.

Reviewing the current water law 77/2018 and the water sector strategy from an NBS support point of view it can be concluded that the current regulatory framework does not offer enough support to push for NBS. In the first clause of the law there are no definitions given for

ecosystem services, green infrastructure or nature-based solutions. Furthermore, throughout the text the law calls for the protection of the important watersheds and aquifers, but the focus is always on controlling wastewater and point sources pollution. There is no mention of the importance of forests and green areas as key resources to improve surface and groundwater availability and quality. Furthermore, although the water sector strategy envisions 200 million m^3 of water coming from groundwater recharge by 2020, the law does not set the rules that govern recharge of groundwater. In addition, recharge of groundwater can contradict with some of the articles in the law which define collected water as private water but groundwater as public right. Further analysis of the law 77 indicates the absence of focus on stormwater management neither as a source of fresh nor for any use other than local irrigation. This is becoming a focus now as flooding events are increasing in urban agglomerations which was the driving force for the ACTED project covered in this research. The law still offers opportunity for adoption of new technologies, solutions, and thinking methodologies mainly through calling the creating of a National Water Body which contains all actors in the water and who's role will be to set the guiding regulations in the water sector. This body, and as it contains the ministries of environment and agriculture, can issue the needed guidance for local bodies and municipalities to push towards the adoption of NBS as a key to solve water challenges among others.

This research can be a first call towards the incorporation of nature as a part of the landscape vision through laws and strategies. This is also a call to better direct the strategic governance level towards creating a value or identity for the water sector. Especially in Beirut which is suffering the most in Lebanon with water issues (Browder, Ozment, et al., 2019, Thaxton, Shames, et al., 2017). Long term thinking needs to be injected into the water sector, and realistic strategies need to be part of the direction towards sustainable development.

All the question asked to interviewees about water management in Beirut were referred back to the Beirut Water Establishment. It looks like the municipality is almost completely not involved in water management of the city. Therefore, it comes as no surprise that there is no water sector plan or program specific for Beirut. Beirut's resilience plan (of which only a power point presentation could be obtained) barely mentions actions in the water sector, while Beirut Water Establishment and the MoEW do not have any plan to rehabilitate the deteriorated Beirut River, and neither of them have any plans to augment the benefits coming from Horsh Beirut Park. Even the ministry of environment is almost excluded form water management as it is outside its mandate; but included in that mandate is wastewater management.

Government silos are in full effect in Lebanon. The lack of coordination, sharing of knowledge, and unification of programs and policies is adding to the hardships of water management. Nature-based solutions and due to their cooperative nature can be the driving force towards more collaboration, towards creating interagency mechanisms and towards embracing and strengthening the localized NBS initiatives which are rising in Lebanon (Browder, Ozment, et al., 2019, Thaxton, Shames, et al., 2017). With the correct initiatives from the central government, at the tactical level of governance, NBS can be the first steps towards a true integrated water management policy in the country. For example, NBS can offer an opportunity

towards the decentralization of water and wastewater services. Moving into focusing on strengthening local water reserves instead of building large dams projects and moving to focusing on localized constructed reed beds for wastewater treatment instead of large-scale wastewater treatment plants. This will further benefit the understaffed water establishment by relieving them of some of the burdens which is a point brought up frequently during the interviews.

Due to the lack of a central vision at the strategic level, the actions taking place at the operational level cover a broad range of water management initiatives. From an NGO working on NBS for stormwater management in Beirut's suburb, to the Beirut Water Establishment working on desalination of water wells, to adoption of constructed reed beds for wastewater treatment in several locations across Lebanon. These are some of the initiative that seemingly do not converge towards one plan. What appears to be happening, is that whenever the resources are made available for a project, the project is implemented without being part of a larger scale plan. This could be one of the reasons why implemented NBS pilots around the country are not spreading despite being successful (Loorbach, 2010).

At the reflexive level, although the pertinent laws and strategies are being updated, I believe there is a need to integrate the results of the ongoing NBS into those regulations. Therefore, the current update should aim to include the well-known basic of NBS in the water sector through a revision to contextualize the recommendations from the various agencies (IUCN, EU EKLIPSE, UNWWDR, and the World Bank among others). But to truly benefit from the process of reflexive governance, there needs to be studies to extract lessons learnt from the projects already being implemented and build policies based on them (Loorbach, 2010) as these projects and their outcomes are already contextualized to the Lebanese environment.

5.4.2 Looking for a champion

Under the rising model of governance worldwide, collaborative governance and bottom-up governance are becoming essential especially when dealing with complex (wicked) problems (Batty, 2008, Guerrero, Bodin, et al., 2015). In Lebanon this approach is lacking, participatory planning is weak, and decentralization is still at its infancy (Makhzoumi and Al-Sabbagh, 2018).

The literature identifies "individual ambitions, entrepreneurial skills, or promising innovations" (Loorbach, 2010) as an important part of the operational level of governance. And indeed, in Lebanon the field of NBS in the water sector is teeming with such innovators whom are introducing new technologies and ideas into the field. The ACTED NBS project, the green roof at the top of the central bank, and the introduction of constructed wetlands into the wastewater treatment landscape all have champions whom had to overcome multiple hurdles to implement their projects.

On the other hand, further literature notes the crucial importance of having a policy champion with a governmental body to complete the integration of NBS solutions into the strategic level of governance. This policy champion was critical in the implementation of several NBS

projects such as a mangrove project for coastal erosion protection in Vietnam (Browder, Ozment, et al., 2019) which had a champion with a ministry. A river rehabilitation project in Cambodia had the new governor as a champion (ADB, 2016), and Malmö in Sweden where several actors inside the municipality championed various flagship projects for open stormwater management (Wamsler, Niven, et al., 2016) are further examples.

This research could not pinpoint the presence of a policy champion in Lebanon. To the contrary, interviews indicated the absence of incentives for government employee to innovate, and lack of complete engagement from government employees in the reviewed projects.
To that point, NBS initiatives determined in Lebanon were started by non-governmental players who have chosen to seek the chance to bring new technologies into Lebanon trying to fill the void in the water management sector.
The case of constructed wetlands for wastewater management can be used to drive the importance of the presence of a policy champion in Lebanon. This technology has been recently introduced in Lebanon (exact date couldn't be determined) as an alternative to the conventional wastewater treatment techniques due to several technical benefits such as low maintenance, low expertise needed, very low electricity required and decentralized application. Now, a few years after its introduction and after several pilot projects have been completed this technology is always parts of the discussions about wastewater treatment and is even being considered as part of wastewater strategies in Lebanon (evidence from interviews). This partial success can be contributed to the fact that one of the pioneers of this technology in Lebanon, Dr. Nabil Amacha, used to be an employee of the central government and now moved to work in the non-governmental sector. His previous connections at the central government level could be one of the drivers that pushed towards a wider adoption of constructed wetlands. He was the link between the operational and the tactical levels of governance.

The current method of governance in Lebanon is leading to an opportunity loss whereby piloted projects and ideas remain as such without getting a chance to integrate into the larger strategic level due to a severed link in governance practices. This could be the single biggest wicked barrier towards the integration of NBS in the water management sector in Beirut.

To overcome these issues is not simple. Non-governmental actors need to aim at finding a champion for their projects on the government level. This could be done through reaching out and implementing a participatory approach that includes local governments as well as the central government bodies whom need to know that NBS projects are successfully implemented with multiple co-benefits. This is already happening to some extent in Lebanon as this research has shown that multiple partnerships are being formed around the implementation of NBS projects.

The second and more important part to solve this wicked problem should be taken by the government. Now that the water policies in Lebanon are going through a renewal cycle, it is necessary that the new laws work to empower non-governmental actions, to foster them and to empower civil society to increase its participation in the management of this sector.

Furthermore, the new policies need to encourage NBS as an option to be considered by water establishments and planners (OECD, 2016, Browder, Ozment, et al., 2019).

5.4.3 Role of International Organizations

International donors play an important role in funding and planning projects in many states that have limited resources and Lebanon is not an exception. The world bank, USAID, and others all have set strategies for the water sector in Lebanon and how they plan to contribute. Figure 11 shows the carious donors that are contributing to projects or training in the water sector in Lebanon. These donors increased in number after the Syrian refugees' crisis in 2011 forced Lebanon to request more assistance and aid.

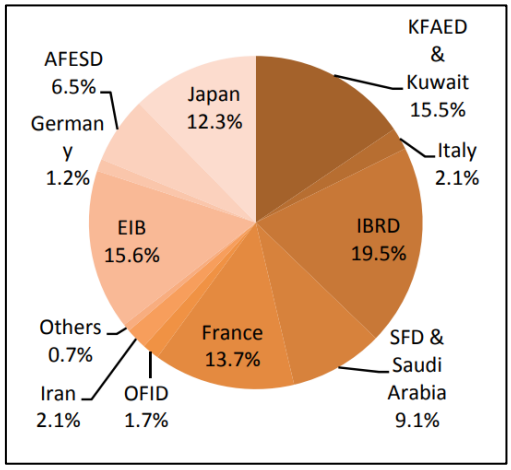

FIGURE 11 VARIOUS DONORS CONTRIBUTING TO THE WATER SECTOR IN LEBANON (1992-2008) (WORLD BANK, 2010)

Although the government in Lebanon is highly dependent on these international organization but their goals have not always been in sync (Kunigk, 1999). In addition, Kunigk's (1999) analysis proves the involvement of Lebanese politics in the water sector which is further strengthened by Comair's (2009) analysis. While this research found no impact of short political cycles on NBS's adoption (section 5.2.4.6), this could now be explained by the fact that politicians affecting the water sector would not have long term plans or targets.

Seeing the role on international organization, it can be argued that these organizations can be a strong driver towards adoption of the new concept of NBS. These non-state actors have been shown to focus on innovation and new experimentation (Chan, van Asselt, et al., 2015) while at the same time they would hold states accountable when they fail to reach targets set in international accords (Van Asselt, 2016). This role is already active in Lebanon through USAID which funded constructed wetlands projects around Lebanon (ReWater MENA, 2019) and through the ACTED NBS project in Beirut's suburb.

Therefore, this should encourage local NGO, consultancies, or government employees to propose NBS based projects to the international organizations working in Lebanon aiming to obtain funding.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

This research set out to study nature-based solutions in the water management sector in Beirut, Lebanon with a focus on governance barriers and drivers to further integration. A study to the importance of the largest park in Beirut vis-à-vis groundwater quality around it was conducted. While 15 actors at various levels of water sector were interviewed to determine processes, interventions, and conclude the drivers and barriers needed. These interviews, in addition to analyses of laws, regulations, and project documents helped in answering the proposed research questions as presented below.

6.1 ANSWERS TO RESEARCH QUESTIONS:

6.1.1 RQ1: WHAT ARE THE NBS THAT ARE NOW USED IN BEIRUT AND LEBANON FOR WATER MANAGEMENT?

Using the NBS typology presented by Cohen et al. (2016) it was demonstrated that the use of the present ecosystem in Beirut is weak as the Horsh Beirut park and other smaller green areas are not given the attention they require to fulfil their full potential in water management. While the plan to manage the watershed of Jeita springs gives an indication to a change of approach. But this approach is still in its infancy and has not spread yet. While the creation of new ecosystems is still not considered in strategies or public plans.

Several small scale NBS were found around the country indicating that NGOs are starting to show interest in this concept, some NBS found:

1- Pilot project in a large suburb of Beirut using NBS for stormwater management and collection
   - Serving as a trial for wider implementation
   - Was championed by an NGO, ACTED
   - Faced no resistance from government and local actors
2- Pilot project in Bekaa region aiming at groundwater recharge
   - Failed to launch due to political and technical conflicts
   - Formed major partnership across the water sector due to the novelty of the idea in Lebanon and the importance of the idea
3- Several projects using wetlands for WW treatment
   - Benefits of this approach is becoming apparent to the central government
   - Offers a simple, cheap, and decentralized method for WW treatment

6.1.2 RQ2: How does governance in the water sector affect NBS integration (drivers and barriers) in water management in Beirut?

Most governance related barriers as mentioned by interviewees:

- Low priority given to nature-based projects in planning
- NBS project compete for resources with grey engineering projects and NBS ends up deprioritized
- The absence of clear laws and regulation pushing for NBS

Most governance drivers as mentioned by interviewees:

- Strong partnerships created around NBS project
- Presence of support from local governing bodies
- Presence of support from the public
- Strong staff capacities and awareness related to NBS benefits

6.1.3 RQ3: What are the technical drivers and barriers towards NBS integration in water management in Beirut?

Technical drivers and barriers were discussed with some of the interviewees whom had experience in completing NBS in Lebanon, in addition some project documents were reviewed to inform this answer.

The major drivers concluded are:

- Need for new approaches in the water sector as previous methods have proved to be incompatible with the current Lebanese context and hardships,
- Presence of a few NBS pilots can push towards further adoption,
- Low energy needed to operate constructed wetlands is a major driver due to the intermittent electricity supply in Lebanon,
- Low maintenance and low expertise needed after the set-up of the project.

The major barriers are:

- Lack of technical expertise about these topics in Lebanon where most of NBS projects are applied in cooperation with international expertise,
- Large footprint of NBS projects but note the presence of various impactful NBS that can be applied at a smaller scale starting at the neighborhood level,
- Topology of Lebanon that includes steep features and a lack of planes even in cities.

6.1.4 ANSWER TO MAIN RESEARCH QUESTION

What is the current role of nature-based solutions in the water management system of Beirut, and what are the drivers and barriers to further integration?

This research provided a first look into the application of the new concept of nature-based solution in Beirut, Lebanon. Field analysis of groundwater samples collected around the largest park of Beirut showed the positive role of this natural landmark. In addition, management plans for the watershed of the largest spring supplying water to Beirut, showed the importance of the natural ecosystem around Beirut in providing water for the city. Furthermore, some new initiatives are aiming at increasing the dependence on natural solutions as a multi-benefit solution for the water crisis in Beirut and Lebanon.

Operating in the complex environment of cities and trying to introduce new concepts into a complex sector such the water sector will undoubtedly present barriers to entry on the path to integration. But every new concept has risen because it offers new ideas to solve complex problems hence presenting drivers to integration.

In addition to the drivers and barriers presented in the response to the sub-questions above, some cross-cutting governance drivers and barriers were concluded from analysis the water sector in Beirut using the literature on NBS integration as a guide. These are presented in table 13 below:

TABLE 13 GOVERNANCE CROSS CUTTING DRIVERS AND BARRIERS FOR INTEGRATION OF NBS INTO THE WATER SECTOR IN BEIRUT, LEBANON

Cross-cutting Governance Drivers	Comments
NBS are an attractive and innovative idea for international organizations	International organizations have an impact on the planning and financing of projects, and they are attracted to innovative solutions
NBS offer a step towards a much-needed decentralized governance model in Lebanon	Central government organizations are overwhelmed and unable to deal with challenges present in many sectors
NBS offer a way to integrate bottom up governance in the water sector	Bottom-up governance in Lebanon is still very weak

Cross-cutting Governance Barriers	Comments
Absence of long-term visions by the central government	Lack of a central vision is causing the rise of several pilot projects without a unified direction
A disconnect between the operational, tactical, and strategic levels of governance	Government strategies are not adopting innovations happening around the country
Absence of a champion for NBS inside the government	This could be caused by lack of incentives for government employees to innovate, and causes a disconnect between governance levels

These findings were based on the analysis of some NBS projects in Lebanon in view of the theoretical framework that was presented in chapter 2 of this work. Hence, it is fitting to present the main findings for the major projects in relation to the theoretical framework as shown in figure 12.

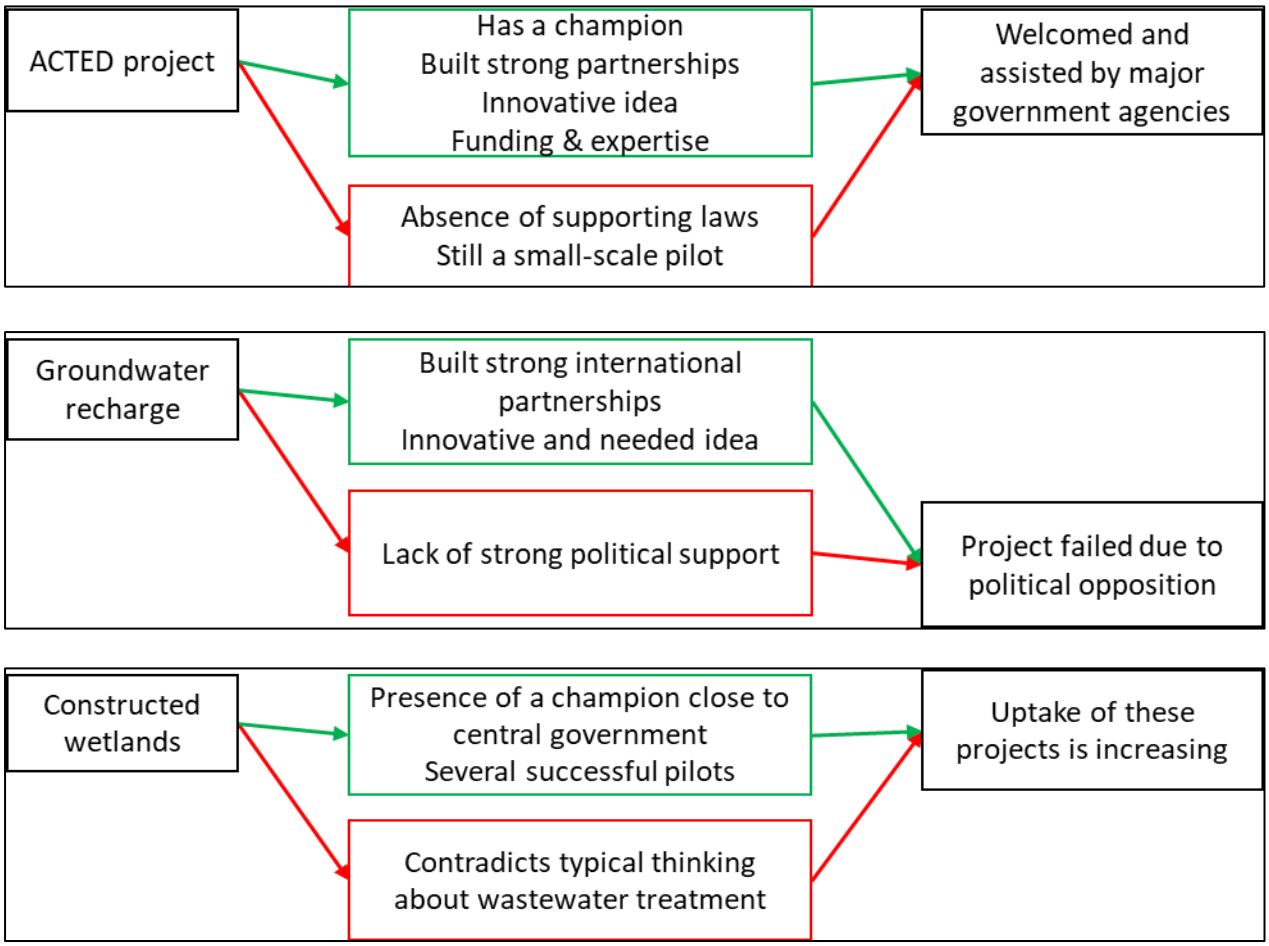

FIGURE 12 NBS PROJECTS, MAJOR DRIVERS (GREEN), MAJOR BARRIERS (RED), AND OUTCOME

6.2 RECOMMENDATIONS:

Based on the data collection period work and literature analysis I came up with some recommendations towards the inclusion of NBS to strengthen water management in Beirut.

6.2.1 TRANSITION MANAGEMENT FOR BEIRUT AS A WAY FORWARD

Transition management has been prescribed as an effective governance method to integrate ecosystem services and valuation into cities (Loorbach, 2010). Furthermore, transition management is considered a method to move governance beyond the classical top-down approach which is still prevalent in Beirut and all of Lebanon (Frantzeskaki, Bach, et al., 2018). This research has shown that both of these are barriers to the success of NBS projects.

This "radical transformation towards a sustainable society, as a response to a number of persistent problems confronting contemporary modern societies" (Ehnert, Frantzeskaki, et al., 2018 from Grin, Rotmans, et al., 2010 p. 1) is highly needed in the water sector in Lebanon. Ehnert et al (2018) showed through a comparative analysis that accelerating urban sustainability is highly dependent on local initiatives because they create new relations and interact with existing institutions. This can be seen as a driver towards change in Lebanon where local initiatives were found to be common and more advanced than initiatives led by the central government.

Transitioning green infrastructure projects in Rotterdam into strategy level was accomplished by resulting neighborhood level meetings while giving local initiatives room to grow. The role of the policy makers was to provide a platform for community's ideas and to assist in the flow of information (Tillie and van der Heijden, 2016).

It is now up to the central governance to adopt a contextualized transition management framework aiming at transforming the water sector into a sustainable sector.

6.2.2 TECHNICAL GUIDELINES FOR THE IMPLEMENTATION OF VARIOUS NBS IN BEIRUT

To tackle the technical aspect of NBS adoption, one of the prominent interviews conducted stressed on the importance of having NBS technical guidelines available for the local governments and water bodies. These technical guidelines will serve the purposes of placing NBS in the discussion for any water management project because they will ease implementation. Furthermore, they will act a knowledge driver to make actors aware of the presence of NBS and their co-benefits. In addition, the presence of easily and publicly accessible technical guidelines will serve a pressure tool that the community can use to push local government into adopting NBS.

Therefore, some technical guidelines will be proposed for some NBS. This is meant to start the conversation and it is left up to the government to create the technical committees necessary to contextualize such guidelines into the Lebanese context.

6.2.2.1 Green roofs:

The guidelines by EPA (Tolderlund, 2010) issued for design and maintenance of green roofs in the semi and arid areas of Unites States of America may be a good starting point as the climate in those areas is similar to Beirut's climate. Furthermore, Talhouk et Al (2012) assessed several plant species for possibility to use in green roofs in Beirut under different conditions, so their findings need to be taken into account.

6.2.2.2 Green walls:

Green walls are an option to introduce greenery into the city at a lower capital thank green roofs while maintaining some of the benefits. The Growing Green Guide (Francis, Hall, et al., 2014) offers technical advice for the design and implementation of those solutions and can be a great starting points for professionals to issue guidelines for this sector in Beirut.

6.2.2.3 Urban rain gardens / water parks:

Improving retention and slowing down storm water will be crucial to reduce the occurrence of flooding cause by the reduction of permeable surfaces. Furthermore, these can also play a role in improving the quality and quantity of groundwater.

Urban Design London (2018) is a not-for-profit organization which released technical guidelines for improving stormwater management in the cities. The guide referenced here (Urban Design London, 2018) is to assist cities in designing rain gardens in existing streets and offers further online free resources.

6.2.2.4 Green permeable paving:

Another method to better manage storm water and increase infiltration is to transform the large areas of paving around cities to permeable pavement with better water management potential.

The Minnesota Pollution Control Agency has created a wiki which is constantly updated with clear design guidelines for permeable pavement (Minnesota Pollution Control Agency, 2019).

I believe that these topic should be the starting point towards including more NBS in Beirut as they are relatively simple to apply and are visible to people therefore would increase knowledge about the topic.

6.2.3 Using green roofs in Beirut for groundwater recharge

From this originates my unique idea of installing green roofs in Beirut and directing the flow from their drainage into each building's well or specially designed infiltration basin aiming to artificially recharge the underground water and stop seawater intrusion.

From a water management point of view, green roofs offer many benefits and I believe that they can play an important role in Beirut. Various designs of green roofs have been found to

reduce stormwater runoff by retaining on average 34% of rainfall and up to 57% making them and attractive stormwater management technique (Stovin, 2010). In addition, further research has determined that the different types of vegetation present on the green roof would not affect the quality of the runoff water where the levels of nitrogen and phosphorus would remain within EPA set limits even if fertilizers (when correctly matched to the type of vegetation) were used on the roofs (Whittinghill, Rowe, et al., 2015) which leaves the door open to look into re-using this run-off.

One of the uses I envision for this run-off is to direct it into the artesian wells present in almost every building in Beirut. This might help improve the quantity and quality of underground water which is heavily used in Beirut as discussed previously.

Recharge wells are a well-known method to induce artificial recharge in aquifers. When unfavorable geological conditions exist, wells are dug that reach the confined aquifer below, then water is pumped into those wells. This method bypasses the unfavorable geological layers to reach directly to the aquifer. But, at the same time, this presents a greatly increased risk of pollution as water is not being filtered through the geological layers. Furthermore, these wells are usually 40% to 60% less efficient in returning water into the aquifer than they are in pumping out water. Overall, use of recharge wells remains attractive in cases where the aquifer is already exploited through wells therefore most of the structures are already available (Bhattacharya, 2010).

Beirut offers an advantage where many wells are already present, and they go dry at the end of the summer and in autumn. This technique has not been referenced in the literature and I have not found any projects that have used the outflow of green roofs to recharge wells. Therefore, this could be an opportunity to determine the feasibility and possibility of such a technique especially now that NBS and groundwater recharge projects are beginning to be implemented in Beirut.

6.2.4 CONSTRUCTED REED BED FOR WASTEWATER TREATMENT ON THE SHORES OF RAMLET EL BAYDA

As discussed earlier constructed wetlands are becoming more prevalent in Lebanon and can be considered on the most successful NBS so far in terms of market penetration.

In Beirut, Ramlet El Bayda beach is the last open and free accessible stretch of sandy beach, the rest of the coast was overtaken by private resorts or is inaccessible due to rocky nature. On that stretch of sand, two outlets are constantly disposing raw sewage that goes on the sand into the beach as shown in figure 13.

Figure 13 Ramlet El bayda beach and the wastewater outlets in red

The idea I am proposing is to use unused plots on that beach and install constructed wetlands that would treat the sewage water. Although the amount of wastewater emitted from those outlets is unknown, I envision two locations where constructed beds can be installed as shown in figures 14 and 15.

Figure 14 FIRST PROPOSED LOCATION OF CONSTRUCTED WETLAND WITH 15000M2 AREA

FIGURE 15 SECOND PROPOSED LOCATION FOR A CONSTRUCTED WETLAND WITH AN AREA OF 18000M2

The benefits brought on by this project are:

- Improvement of swimming water quality for this important beach, and help Lebanon with its commitments to reduce the pollution of the Mediterranean Sea,
- Proving that out of the box thinking can find enough space to apply NBS in congested city of Beirut.
- As the government is the only side who has the right to use this land, this project can indicate a change in direction towards NBS by the central government,
- This project can serve as a prototype for other establishments present on the coast of Beirut and who are known to dispose of their wastewater directly into the sea.

6.3 PROPOSING A FRAMEWORK FOR NBS INTEGRATION INTO THE WATER SECTOR

To complete this research and to link the governance perspective with the technical perspective a framework will be proposed which is built on the literature about transition management, sustainable development and NBS integration as shown in figure 16.

The proposed framework is based on the efforts of Calliari eh al (2019) whom presented a framework for implementing and assessing the effectiveness of nature based solutions. The strength of the framework comes from the integration of grey and green technologies to be considered as possible solutions, which I believe is needed early on in the transition. Furthermore, the framework, in the quantification phase, considers the potential negative effects that can be brought on by NBS which is added as cost or co-costs to the solution. This aspect was omitted in other reviewed frameworks.

Although Calliari et al (2019) do mention setting the baseline and determining weaknesses as a step of the visioning process, I believe more focus should be given to this step in Lebanon. System analysis thinking needs to be adopted to determine the current potential and capabilities in the water sector in Lebanon. As discussed in chapter 3, there is no clear understanding and determination of the water resources that are serving the city of Beirut. Furthermore, there is no qualitative or quantitative research to the role that the natural areas in and around Beirut play in water management.

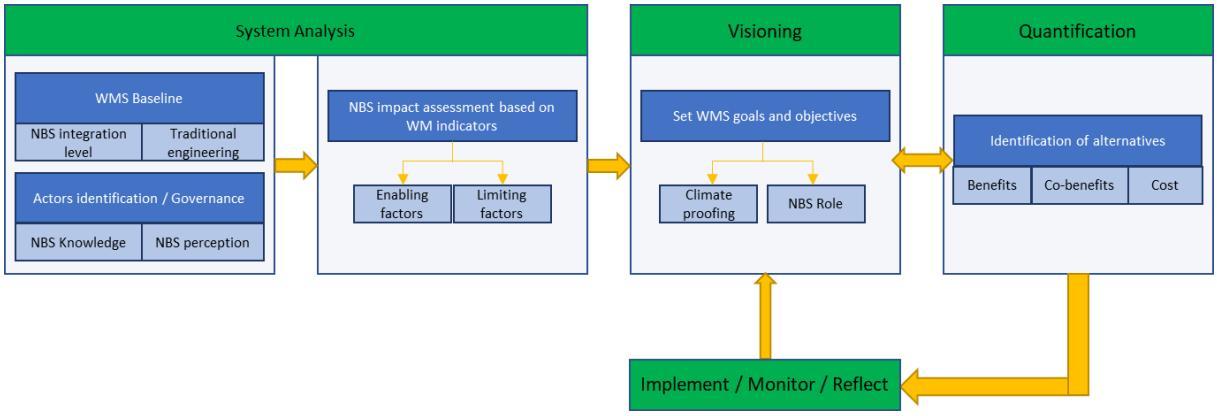

FIGURE 16 PROPOSED FRAMEWORK FOR MANAGING TRANSITION OF THE WATER SECTOR IN BEIRUT, LEBANON

In my framework, system analysis would induce a shift in how various water sources are handled. The link between stormwater and fresh water, the importance of re-using wastewater, and the role of nature in water management would be highlighted.

This would help kick off the visioning step where the link between the strategic governance and technical planning should take place. In this step, future goals in the water sector should be determined as well as the role that NBS is envisioned to play in the future. This step would include how to prepare and react to the coming threats such as climate change or any political instabilities.

In the next step named “quantification”, the tactical and operational levels of governance aim towards determining and implementing the best solutions. A methodological thinking approach needs to be adopted to set the criteria based on which proposed solution would be ranked. The literature offers many possibilities and combinations of indicators that can be used, notable of which the assessment matrix used by Liquete et al (2016) in their effort to evaluate the role of NBS in water pollution control (table 12).

TABLE 14 ASSESSMENT MATRIX TO DETERMINE THE VALUE OF VARIOUS WATER MANAGEMENT OPTIONS (LIQUETE, UDIAS, ET AL., 2016)

Indicators
Peak flow reduction (%), return time of 10yr
Reduction of flooding downstream (m3), return time of 10yr
Load reduction of dissolved organic carbon (t/yr)
Load reduction of nitrogen (t/yr)
Expert judgment about biodiversity
Landscape diversity (Shannon's diversity index)
No. of visitors/users
Frequency of visits
Value of wood production (profit from harvest in EUR)
Total construction costs (EUR)
Total maintenance costs per 20yr expected lifespan (EUR)

Finally, at the reflexive level of governance, the implemented solutions would be monitored and assessed, and the lessons learnt would contribute to the development and evolution of policy and technology in the water sector.

6.5 CONCLUSION

This research provided a first look into the application of the new concept of nature-based solution in Beirut, Lebanon as no previous research into this subject was found.

Field analysis of groundwater samples collected around the largest part of Beirut showed the positive role of this natural landmark, but it was only a small experiment and opens the doors towards further testing to determine the full benefits of the Horsh Beirut park.

While the interviews with actors resulted in an analysis of the current situation of the water sector in Lebanon with results that could be reliably linked back to the literature about governance of NBS. These can also be expanded by targeting several actors at each governmental and non-governmental level hence covering various experiences at each level.

The analyses presented managed to highlight a missing from the framework presented in chapter 2. During analysis, it became apparent that the projects being implemented in the sector can have a major impact on the governance of sector. This link was not highlighted to study as obvious by the lack of an arrow going back from “Existing NBS” to “governance”. This has been amended in the proposed framework in chapter 6 by focusing on the reflexive level of governance and the interdependence of all levels.

In the end, the recommendations given are proposed based on the field research, the interviews, and literature. These recommendations are presented as ideas which require further analysis, but they could be a starting point for more technical research.

Various topics that came up during this research were not mentioned because they either did not fit into the scope or because they were too big to discuss. Chief amongst these topic is the discussion about water rights in Lebanon. Various laws and regulation tackle this issue, but introduction of NBS can further complicate this calling for further research into water rights and usage under new technologies.

ANNEXES

ANNEX 1 SEMI-STRUCTURED INTERVIEW GUIDELINE

Introductory comments:

Thank you for taking the time to participate in this interview which is a part of my MSc thesis research.

My name is Ahmad Damaj and I am currently completing my MSc in urban management and development at Erasmus University Rotterdam.

Purpose:

The purpose of this interview is to discuss the application of nature-based solution in the water sector in Beirut. Especially focusing on the barriers and drivers in the governance dynamics.

Confidentiality:

The data collected from this interview will be used for the purpose of my thesis research and/or any research arising from it. You may choose to remain anonymous and you can end the interview anytime you want. The interview will be recorded and later transcribed as part of my thesis. The transcribed interview will be sent to you for your approval and validation.

Duration:

The interview is expected to last around one hour.

How the interview will be conducted:

We will go over a power point presentation showing some applications of nature-based solutions in the water sector from around the world. After this, we will go over the open-ended questions which are part of the interview guide.

Name and Signature Date

تعليقات تمهيدية:

شكرا لأخذك الوقت الكافي للمشاركة في هذه المقابلة التي تعد جزءًا من بحث أطروحة الماجستير.

اسمي أحمد دمج وأنا حاليًا أكمل شهادة الماجستير في الإدارة والتطوير المدني بجامعة إراسموس روتردام.

الهدف:

الغاية من هذه المقابلة هو مناقشة تطبيق "الحلول القائمة على الطبيعة" في قطاع المياه في بيروت. مع التركيز بشكل خاص على الحوكمة في هذا القطاع.

السرية:

سيتم استخدام البيانات التي تم جمعها من هذه المقابلة لغرض بحث أطروحة و / أو أي بحث ناشئ عنها فقط لا غير. يمكنك اختيار عدم الكشف عن هويتك ويمكنك إنهاء المقابلة في أي وقت تريده. سيتم تسجيل المقابلة وإعادة كتابتها لاحقًا كجزء من رسالتي. سيتم إرسال المقابلة المنقولة إليك للموافقة عليها والتحقق من صحتها.

المدة الزمنية:

من المتوقع أن تدوم المقابلة حوالي الساعة.

كيف سيتم إجراء المقابلة:

سأعرض عليكم بعض الصور التي تظهر بعض تطبيقات "الحلول القائمة على الطبيعة" في قطاع المياه من جميع أنحاء العالم. بعد ذلك، سنتطرق إلى الأسئلة المفتوحة والتي تعد جزءًا من دليل المقابلة.

الامضاء التاريخ

Interview guide for project proponents / participants:

Drivers and Barriers Towards Nature Based Solutions for Water Management in Beirut, Lebanon

Technical

Can you quantify the benefits brought on by this project for the water sector in the area?
Can you quantify the co-benefit brought on by this project in the area?
What are the technical barriers and drivers that were faced during the implementation?

الشق التقني:

هل يمكنك تحديد (بشكل كمي) الفوائد التي يجلبها هذا المشروع لقطاع المياه في المنطقة؟
هل يمكنك تحديد المنافع المشتركة الناجمة عن هذا المشروع في المنطقة؟
ما هي الدوافع والحواجز التي واجهتكم أثناء تنفيذ هذا المشروع؟

Governance

From a policy/regulation point of view, what are the drivers and barriers that were faced during the implementation of this project
Do you think there needs to be a shift in policies/strategies for improving the adoption of such projects?
What are the policy instruments that you believe are essential to improve adoption of NBS projects for water management?

الحوكمة:

من وجهة نظر السياسات / القوانين، ما هي الدوافع والحواجز التي واجهتكم أثناء تنفيذ هذا المشروع؟
هل تعتقد أن هناك حاجة لنقلة في السياسات / الاستراتيجيات لتحسين اعتماد مثل هذه المشاريع؟
ما هي أدوات السياسة التي تعتقد أنها ضرورية لتحسين تبني مشاريع "الحلول القائمة على الطبيعة" لإدارة المياه؟

Social

How do you describe the involvement of the community in this project?

الجانب الاجتماعي

كيف تصفون مشاركة المجتمع في هذا المشروع؟

Interview guide for institutional actors:

- Can you please describe your role at this institution?
- How is your institution involved in the water sector?
- How is / can be your institution involved with nature-based solutions
- How do you see the current laws, regulations, and strategies' influence on the adoption of NBS projects for water management?
- Do you think there is a need for a shift in laws, regulations, strategies to influence the adoption NBS projects for water management?
- Do you know any NBS projects for water management in Beirut/Lebanon?
- Do you have any firsthand experience with NBS projects for water management?
- What are the existing/needed instruments that could facilitate adoption of NBS projects for water management?
- What do you think are the barriers and drivers in technology/policy/governance/finance for the adoption of NBS projects for water management?

- هل يمكن أن تصف مهامك في هذه المؤسسة؟
- ما هو الدور التي تلعبه مؤسستك في قطاع المياه؟
- كيف / يمكن أن تكون مؤسستك معنية "بالحلول القائمة على الطبيعة"؟
- كيف ترى أن القوانين واللوائح والاستراتيجيات الحالية تؤثر على تبني مشاريع "الحلول القائمة على الطبيعة" لإدارة المياه؟
- هل تعتقد أن هناك حاجة إلى تحول في القوانين واللوائح والاستراتيجيات للتأثير على تبني مشاريع "الحلول القائمة على الطبيعة" لإدارة المياه؟
- هل تعرف أي مشاريع "الحلول القائمة على الطبيعة" لإدارة المياه في بيروت / لبنان؟
- هل لديك أي تجربة مباشرة مع مشاريع "الحلول القائمة على الطبيعة" لإدارة المياه؟
- ما هي الأدوات الحالية / اللازمة التي يمكن أن تسهل اعتماد مشاريع "الحلول القائمة على الطبيعة" لإدارة المياه؟
- ما رأيك في الحواجز والدوافع في التكنولوجيا / السياسة / الحوكمة / التمويل لاعتماد مشاريع "الحلول القائمة على الطبيعة" لإدارة المياه؟

Furthermore, a presentation was used to introduce actors to the concept of NBS when needed:

Nature Based Solutions for Urban Water Management

الحلول القائمة على الطبيعة لإدارة المياه في المناطق الحضرية

1

What are Nature-Based Solutions (NBS)

- Nature-Based Solutions (NBS) are solutions to societal challenges that are inspired and supported by nature, which are cost-effective, provide simultaneous environmental, social and economic benefits, and help build resilience.
- Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.
- Thus they simultaneously provide benefits for biodiversity and human well-being (Cohen-Shacham et al. 2016, p3)

2

ما هي الحلول المستندة إلى الطبيعة

- الحلول المستندة إلى الطبيعة هي حلول للتحديات المجتمعية مستوحاة من الطبيعة، والتي تتميز بفعالية التكلفة وتوفر فوائد بيئية واجتماعية واقتصادية متزامنة، وتساعد على بناء القدرة على مواجهة آثار تغيُّر المناخ.
- توفر هذه الحلول ميزات وعمليات طبيعيّة وطبيعية أكثر تنوعًا في المدن، من خلال تدخلات ملائمة محليًا وكفاءة في استخدام الموارد.
- بالتالي فهي توفر في الوقت نفسه فوائد للتنوع البيولوجي و الإنسان.

(مترجمة عن Cohen-Shacham et al. 2016, p3)

3

Sustainable urban drainage
الصرف الحضري المستدام

https://www.susdrain.org/delivering-suds/using-suds/suds-components/swales-and-conveyance-channels/swales.html

https://wwtonline.co.uk/features/getting-to-grips-with-suds

4

Creating artificial water bodies for short term water storage

إنشاء مسطحات مائية اصطناعية لتخزين المياه على المدى القصير

https://www.asla.org/2018awards/454005-Urban_Aquatic_Health.html

5

Increasing the use of vegetation in cities
زيادة الغطاء النباتي في المدن

https://phys.org/news/2019-06-pop-up-big-benefits-small-spaces.html

6

Creation of wetlands in river-basins

إنشاء الأراضي الرطبة في أحواض الأنهار

https://www.wired.com/2016/08/7-cities-transforming-rivers-blights-

7

Watershed restoration

ترميم الاحواض

http://documents.worldbank.org/curated/en/634871468291375668/pdf/E29240EA0P124904B0AFR0ESMF0P124905.pdf

8

River shed management

إدارة احواض الأنهار

http://www.buildingwithnatureinthecity.com/practice/#2

9

Coastal protection/restoration

حماية السواحل / ترميمها

https://magazine.boskalis.com/issue03/boosting-dutch-flood-defenses

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ANNEX 2 DETAILED DESCRIPTION OF INDICATORS

1- Impact evaluation methods (Raymond, Berry, et al., 2017)

– Monetary assessment
- Estimation of avoided damages and costs
- Avxoided costs from wastewater diverted from treatment plant
- Cost benefit assessment

– Non-monetary assessment
- GIS assessment for the reduction in risk to urban infrastructure

– Environmental assessment
- Run off coefficient compared to precipitation (mm/%)
- Flood peak reduction modeling
- Increase in absorption capacity of structures
- Water and ground water quality and quantity changes

– Integrated approaches
- Service provided by the introduced vegetation
- Co-benefits brought on the social level

2- Public policies should generally include these elements to facilitate a transition into green infrastructure (Browder, Ozment, et al., 2019):

- Incorporate sustainable landscape vision into strategies and policies: a shared vision with multiple goals which is embedded into strategies and policies.
- Harmonize sectoral plans to incorporate multiple goals for harnessing natural systems: is interagency cooperation and coordination encouraged when dealing with projects which are cross-sectoral?
- Create incentives for local actors to participate through policy and public finance: public funds for green infrastructure or national payments for ecosystem services.
- Encourage or require decision makers to consider green infrastructure options in planning process: are projects forced to evaluate green options, do building codes or zoning laws require dedicating space for green elements.
- Empower civil society to build partnerships: policy focuses on relevant local stakeholders and empowers and encourages to participate in the local decision-making processes.
- Recognize land and resource rights and responsibilities: enforcing local systems of rights and responsibilities and compensate landowners for the ecosystem services they provide.
- Develop a regulatory framework that supports green infrastructure: land zoning reflects landscape goals; provide resources of enforcement; and create cross sectoral policies (is NBS encouraged as a mechanism to comply with regulations and requirements)
- Participate directly in NBS partnerships: hosting stakeholders' meetings, bridging inputs from various agencies; raising public awareness; and support multi-stakeholder platforms.
- Build knowledge and technical capacity to implement NBS: baseline data on ecosystem services through data collection programs and provide information on implementation of this type of projects.

ANNEX 3 FIELD WORK SCHEDULE

	June					July						
	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	26	27	28	29	30	1	2	3	4	5	6	7
Regulation and projects data collection & interviews												
Projects site visits												
Interview with Actors	MoE	MoEW				CDR	Beirut Municipality	Beirut WE	Litani WE	Higher Council		
Data review/validation				Interview guide review								

	July											
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
	8	9	10	11	12	13	14	15	16	17	18	19
Regulation and projects data collection & interviews												
Projects site visits												
Interview with Actors	Consultancies / Various actors									Validation of data with actors		
Data review/validation								Validation of data with actors				

	July											
	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday
	20	21	22	23	24	25	26	27	28	29	30	31
Data review/validation												
Further online interviews if needed												

ANNEX 4 QUANTIFYING THE IMPORTANCE OF HORSH BEIRUT PARK ON GROUNDWATER QUALITY

Introduction

One of the major impacts of urban sprawl is the reduction of green spaces in cities (Zölch, et al. 2017). Parks, green roofs, and urban water bodies provide critical ecosystem services. Moreover, they contribute to the physical, psychological, and social well-being of the urban population (Wolch, Byrne and P.Newellc 2014) (Eshtawi, Evers and Tischbein 2016). Another important role of urban green spaces is maintaining the hydrological cycle; for example, a linear relationship was demonstrated between the change in urban area and the corresponding change in surface runoff or percolations (Eshtawi, Evers and Tischbein 2016). In the case of Beirut, alteration of the surface cover (fig. 2) is causing an increased rate of run-off and disrupting the hydrological cycle in the city. This coupled with a continued increase in demand for water and over-pumping of widely spread artesian wells had devastating effects on the groundwater quality. Beirut is at a stage where almost each building depends on a private well, usually dug next to the building, to fulfill their water needs.

It has been estimated that Beirut contains around 3000 water wells (MOE/UNDP/ECODIT 2010), most of which are unregulated, over pumped and have now experienced irreversible saltwater intrusion (MOE/UNDP/ECODIT 2010). Hence, Constantine et Al (2017), found that 85% of the wells they tested in Beirut contained TDS and Cl^- levels that exceeded drinking water quality standards. And upon further analysis, they attributed that to saltwater intrusion which is exacerbated by over pumping.

One of the causes of this is the lack of an integrated and sustainable urban water management thinking in the city. This approach is needed to transfer the water sector into a sustainable sector where resource management moves from a linear path into an integrated approach. This would require a shift of institutional management, into a management with multiple actors involved from various sectors (Brown and Farrelly, 2009).

Liquete et al. (2016) proved throught a valuation framework that green urban areas provide better water management, purification and flood protection than equivalent grey solutions. This is only one of many studies showing such benefits.

Study area

As with many cities around the world, the formal source of water on which Beirut relies are outside the city borders. In addition, green and blue areas are almost non-existent in Beirut as shown in figure 1 which only exacerbates the problems. The major sources (table 5) are the Jeita springs situated at around 30 km north of Beirut and provide an estimated three quarters of the current fresh water supply to Beirut. The water extracted from this source is treated at the Dbaye water treatment plant around 10 Km north of Beirut. The watershed for the Jeita springs covers a large area where multiple jurisdictions apply, and a large number of people

are served. A plan has been put in place aiming to protect this watershed aiming to conserve the water quality (BGR, 2013).

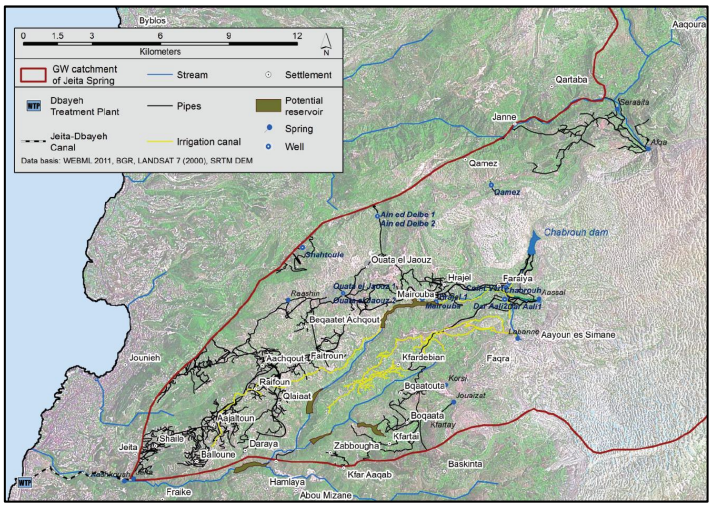


Figure 1 Jeita watershed (red limits) serving beirut and mount lebanon (BGR, 2013)

The other one third of the formal freshwater delivery is provided by wells situated around 15 km to the south of Beirut on the shores of Damour. These wells were first dug in the 1970s and have been in constant use since. The area around these wells has been progressively urbanized which is putting pressures on the wells leading to a decrease in the quantity and quality of the water provided (Khadra, 2017).

On the informal side of water delivery, Beirut's residents have resulted to various solutions to compensate the shortage caused by the lacking government services. The most used and impactful of those methods are artesian water wells dug in almost every building. Another source on which Beirut's residents highly depend is private water tankers. These tankers depend on spring and artesian wells to provide an estimated 33,0000 m3/day for their customers (Constantine, Massoud, et al., 2017).

The common problem between formal and informal water services is that the residents do not trust their quality, so they do not use them for drinking. For that, they resort to bottled water services and Lebanon is ranked 8th worldwide by bottled water consumption (Semerjian, 2011).

Table 1 Sources of Water for Beirut

Source	Size	Reference
Naameh wells	25% of water supply	(Khadra, 2017)
Jeita springs	75% of water supply	(BGR, 2013)
Private wells	Unknown	
Bottled drinking water	111 L/capita/year	(Semerjian, 2011)
Water tankers	~32,600 m3/day	(Constantine, Massoud, et al., 2017)

It was challenging to obtain any quantification of the importance of green areas in Beirut from desk research. The ministry of energy and water as well as the water establishment

in Beirut did not provide measurements or indicators as to what is the role of green areas in water management in Beirut. Therefore, there was an attempt to try and quantify the importance of the largest (and arguably only) green area inside the city of Beirut which is Horsh Beirut Park (fig. 2).

FIGURE 2 HORSH BEIRUT PARK (PICTURE TAKEN BY ME)

This park is slowly deteriorating, its area decreasing, and not enough attention given to it, therefore disease is spreading in the trees (fig 3). In 2017 it was once again struck with a disease and closed to public only after a brief period of being open (Beirut.com, 2017).

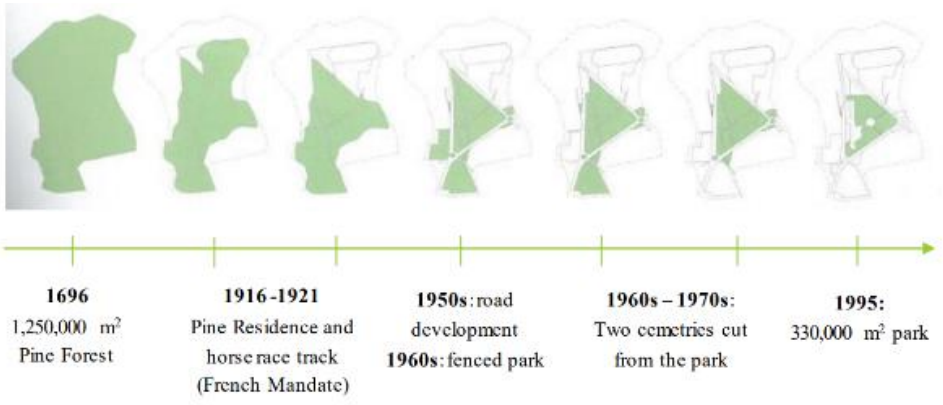


Figure 3 Development of Horsh Beirut Park through the years (Arbid, 2010)

Methodology

One of the benefits of green areas in urban environments is to maintain and improve the quality and quantity of underground water. To test that hypothesis and aiming to quantify the benefit from Horsh Beirut park, the conductivity of the water from wells adjacent to the park was measured and compared to data obtained from a larger sample across all of Beirut. Conductivity was the chosen indicator to measure because it can be measured by a portable equipment and higher conductivity is a common indicator of sea water intrusion (Hayashi, 2004). An attempt was made to prove that/if the water quality deteriorates as we move further away from the park.

Inhabited areas around the park were visited and residents of buildings asked if there is a well in the building. Conductivity was only measured when it was possible to extract water directly from the well. When that was possible, water was left to run for one minute then a sample was taken and measure on the spot. SevenGo Duo pro water quality meter (Mettler Toledo) was used for the measurement of pH, temperature, and conductivity. The device was calibrated once before beginning field work.

The most detailed geological map of Beirut that could be found was used to delimitate the geological layer to which Beirut park belongs. It was defined that only in this layer the benefits caused by Horsh Beirut park can be measured.

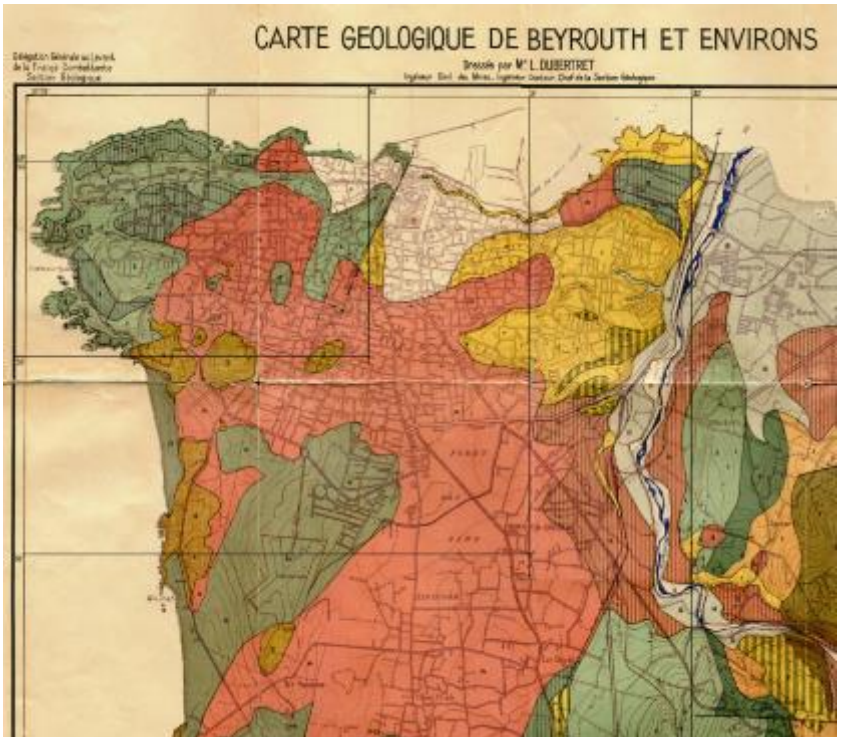
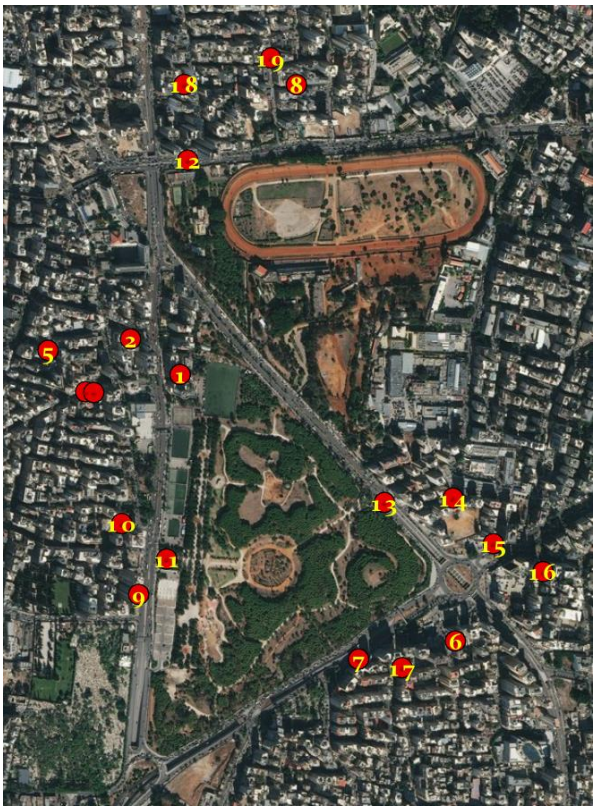


Figure 4 Geological map of Beirut (Source: Communications with Dr. Wissam Khadra)

Results

Table 2 shows the results of the tested wells and figure 5 shows their position on the map.

Well	X	Y	Cond	pH	Depth
1	35.5079	33.87437	766	7.42	80
2	35.5068	33.87503	950	6.72	Unknown
3	35.5058	33.87405	992	6.58	65
4	35.50598	33.87404	859	7.05	80
5	35.50497	33.87482	1028	6.68	Unknown
6	35.51402	33.86944	1541	6.57	Unknown
7	35.51187	33.86911	1106	5.78	Unknown
8	35.51049	33.87973	891	7.29	Unknown
9	35.50698	33.8703	730	6.5	Unknown
10	35.50661	33.87161	541	7.05	Unknown
11	35.5076	33.87096	726	7.24	Unknown
12	35.50807	33.87833	2520	6.59	Unknown
13	35.51245	33.872	757	7.16	100
14	35.51397	33.87208	815	6.71	20
15	35.51487	33.87124	597	7.07	100
16	35.51597	33.87072	734	6.84	100
17	35.51284	33.86895	2150	6.19	6
18	35.50799	33.87973	386	7.38	Unknown
19	35.50992	33.88022	1210	7.06	Unknown



A discussion of the results is presented in chapter 5 of the thesis

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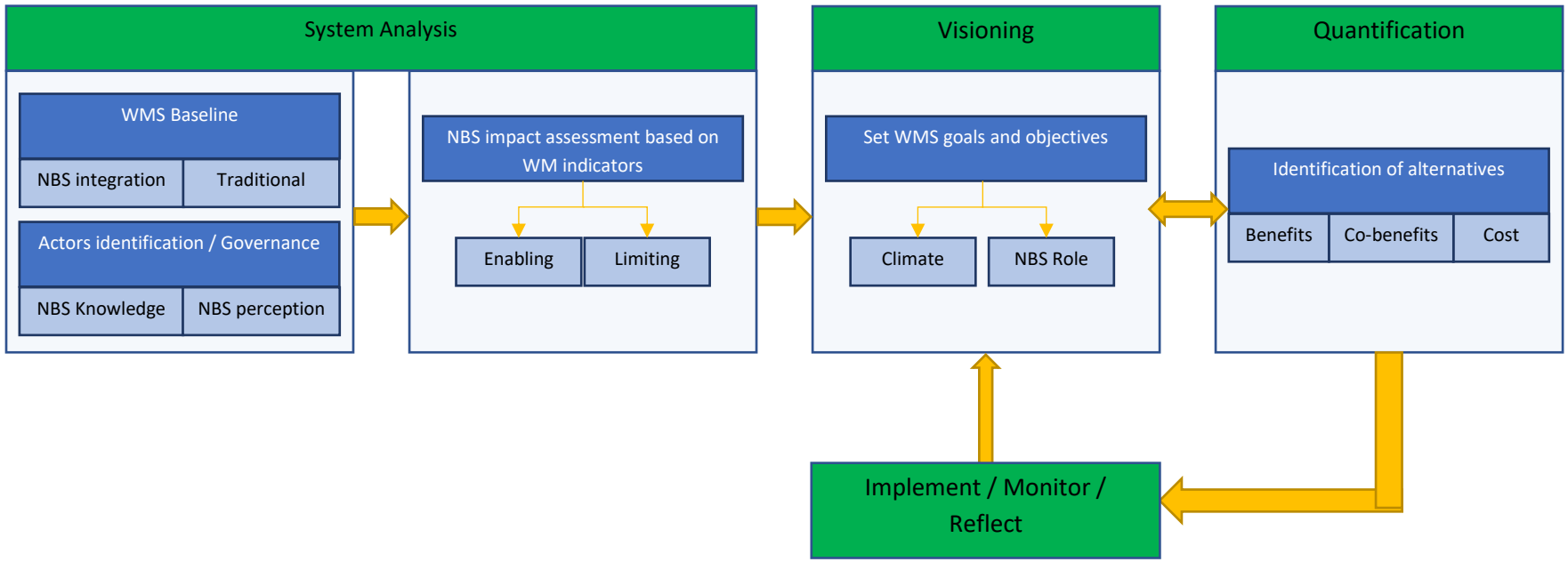
ANNEX 5 CODE BOOK

Code	Comment
B-competes with grey	Indication that NBS competes with grey engineering for resources
B-gvt silos	Different government bodies following different policy objectives and working to different time scales.
B-low priority	De-prioritization of NBS in favor of business as usual alternative
B-no laws	Absence of regulation supporting NBS
Bottom-up	A mention of bottom up way of governance
B-political cycle	When the long-term goals of NBS contradict with the short political cycles of 4-6 years
B-staff capacities	When staff capacity is lacking and hence a barrier to adoption of NBS
B-t	Technological challenges which are considered a barrier
Climate change	Mention of climate change related issues
Complementary green/gray	Mentions of adoption of green and grey together as complementary solution
D-champion	Presence of a champion for a certain idea/project
D-co-benefits	When co-benefits of NBS are a driver to implementation
Decision makers	Mentions of the role of specific decision makers
D-government support	Presence of support for an NBS project from the central government
D-local support	Presence of support for an NBS project from the local government
Donors	Role of international donors
D-public support	Presence of support for an NBS project from the public government
D-quick application	Quick application of NBS as a driver for adoption
D-SDGs	Complying with SDGs as a driver
D-staff capacities	When staff capacity showed to be a driver to adoption of NBS
D-t	Technological drivers
Incentives	Mention of any incentives and their role in the water sector
Landscape vision	Long term vision for the sector
Local actors	Role of local actors
Multiple goals	The co-benefits of NBS
Partnership	Partnerships created around the projects
Pilot project	Pilot projects and their impacts
Regulatory framework	Determining the laws and regulations in the sector
Strategy/policy	Determining long term policies and strategies mentioned
Water rights	Mention of water right and their role/impact

ANNEX 6 PROPOSED FRAMEWORK



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