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Thesis title: Nature-Based Solutions (NBS) for Flood Reduction in Rotterdam: Challenges, Implementation and Co-Benefits

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I dedicate this thesis to my ***Beloved Parents***

and

Honorable teacher ***Prof. Dr. Alak Paul***

Summary

The collective consequences of climate change and unplanned urban expansion have elevated the risk of flooding in cities. Furthermore, flooding has created a substantial number of problems for urban communities around the world. It is possible to address urban hazards like flooding through implementing a set of Natural tools, and Nature-Based Solutions (NBS) are at the center of a debate that can be applied to lessen the threat of flooding in city areas. The aspects of NBS implementation are found to be less investigated by the researchers and this has propelled the current research to focus on the implementation challenges. The central objective of this study is to assess the limitations and challenges that affect the implementation level of NBS for flood reduction in Rotterdam. Moreover, there was also an endeavor to explore the co-benefits provided by the NBS projects. For conducting this study, two NBS projects are chosen i.e. Water Square and ZOHO Raingarden, both of them are located in the *Agniesebuurt* neighborhood of Rotterdam. This research has been conducted applying the 'Case Study' strategy and primary data were collected through 8 Key Informant Interviews (purposively selected) on the experts who have worked in those projects and 100 questionnaire survey (randomly selected) on the users of the chosen projects. This study has brought to the light that a number of challenges were faced in different implementation stages of Water Square and Raingarden. It is found that there were challenges of integrating stakeholders' expectation, an uncertainty of gaining benefits from the projects, unfamiliarity of people with the NBS. Moreover, many technical problems were faced in the implementation stages which have also created some afterward impacts. Likewise, the study has also explored that both projects did not keep any fixed budget for the maintenance phase, which has raised the question of their future effectiveness. Even Water Square is found to have no proper maintenance strategy at present which has resulted in the loss of its aesthetic appeal to the people. On the other hand, Raingarden has confronted some more challenges like less involvement of stakeholders in the implementation phase and getting less priority from the authority considering its very localized impact. Moreover, this project has created a possibility of future negative impact like the spread of mosquito and it possesses some design limitations (like less sitting space inside the garden) as expressed by many respondents of this study. While looking for co-benefits, different advantages were identified from both projects. Relaxation, community gathering, good environment, aesthetic beauty are some common benefits from both projects. Again, Water Square provides facilities like sports and recreation for the people of different ages and is being used as a children's playground. Nevertheless, Raingarden has created a green environment within the neighborhood that is also somehow ensuring ecological benefits. The most notable issue unveiled by this study is that these NBS projects have not only faced challenges during the implementation but also confronting many problems after the completion of the projects. More specifically, there is still absence of workable monitoring strategy which is also affecting the success rate of these projects. The analysis of this research has exposed that implementation challenges and limitations of both projects have affected their performance levels and execution. A significant number of challenges has affected the implementation level of Raingarden and many of the experts have considered the project as 'Successfully Implemented with Some Limitations'. Contrarily, due to the smaller number of challenges and a higher number of benefits, Water Square can be termed as a 'Successfully Implemented' project. In addition, many experts have claimed the Water Square to be very successful due to its unique feature, design and participation of a substantial number of stakeholders in its application process. Therefore, it is understood that the more the prevalence of problems in an NBS project, the less successful it is. This study suggests that the authority should introduce effective maintenance strategies for both projects in order to make them as showcases for the people to raise awareness about Nature-Based Solutions.

Keywords

Nature-Based Solutions, Challenges, Implementation, Flood Reduction, Rotterdam

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Abbreviations

ADB	Asian Development Bank
CBD	Convention on Biological Diversity
CORDIS	Community Research and Development Information Service
EEA	European Environmental Agency
EU	European Union
HHSK	Hoogheemraadschap Schieland and Krimpenerwaard
IHS	Institute for Housing and Urban Development Studies
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resource Management
KII	Key Informants Interview
NBS	Nature-Based Solutions
NDMA	National Disaster Management Authority
USAID	United States Agency for International Development
UNEP	United Nations Environment Programme
UNISDR	United Nations International Strategy for Disaster Reduction
WMO	World Meteorological Organization
WVCA	Wales Council for Voluntary Action
WWF	World Wildlife Fund
ZOHO	Zomerhofkwartier

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Chapter 1: Introduction

1.1 Background

Being one of the most disastrous events, flooding in cities could result in the massive damage of infrastructure, environment, society and above all the urban economy (Ashley et al. 2007; Chang et al. 2013; Zhou et al. 2017a; Zhou et al. 2018). The vulnerability to huge loss during flooding has become greater in the cities because of the intense concentration of economic activities and the dense population there (Kaspersen et al. 2016). It is already evident that flooding in urban locals are more frequent than it used to be in the past (Shrestha 2013). Throughout the world, this urban disaster is becoming a matter of extreme concern as it might influence the destinies of many cities in the coming decades (Jha et al. 2011). Moreover, rapidly escalating urban areas are highly unprotected to the brunt of climate alteration and water-related hazards (Palazzo 2019).

Flooding has created a substantial number of problems for the urban communities around the globe (Kirshen et al. 2006; World Meteorological Organization 2012). The collective consequences of climate change and unplanned urban expansion have raised the risk of flooding in cities (Miller and Hutchins 2017; Jiang et al. 2016; Sang and Yang 2017; Zhou et al. 2018; Semadeni-Davies et al. 2008; Bouwens 2017). More specifically, cities are flooded due to the excessive rainfall, overspill from the river, effect of sea-level rise and the malfunctioning of drainage infrastructures (Mailhot et al. 2007; Ashley et al. 2005; Rana 2013). Heavy rainfall is one of the most prominent causes of flooding in cities and the vast majority of this hazard result from heavy localized rainfall (SUDA 2007; Meena and Gupta 2017). Even a little amount of rainfall might submerge the urban neighborhoods which are characterized by weakened infrastructure and inadequate drainage systems (Weber 2019). On the other hand, cities are often characterized by impervious surfaces due to the concrete infrastructures and sealed road throughout the area (Huong and Pathirana 2013; Kaspersen et al. 2016). Less infiltration creates high run-off and sometimes flooding during the high precipitation (ten Veldhuis et al. 2011; Kaspersen et al. 2016; Gaitan et al. 2016). In addition to the impervious surface, solid waste, debris, inefficient drainage system are also responsible for the urban flooding (Seto and Kaufmann 2009). Because of the warming of the global atmosphere, the increment of sea level and the ultimate climatic occurrences are becoming more frequent with passing days. If this situation continues, the risk of urban flooding will be something that's unprecedented and dangerously intense (Jha et al. 2011).

The traditional ways to manage flood are becoming insufficient to deal with its frequent occurrence and devastating impacts. Furthermore, the conventional hard engineering or 'grey' infrastructures e.g. dam, dyke, levee, flood wall etc. are not considered environment-friendly as well (Nature Conservancy 2014). Building such type of defenses to control flood may also have unanticipated consequences, for instance, the problem of flooding could shift to elsewhere that was not planned (WCVA 2018). Besides, engineering approaches are quite expensive and for which are unaffordable for many developing countries (Kourkoulis 2018). The imbalance between expenditure and effectiveness of hard measures to prevent flooding has propelled the policymakers to look for better alternatives (EEA 2017). And Nature-Based Solutions (NBS) are at the center of a debate that can be applied to reduce the threat of flooding in city areas (Kourkoulis 2018). It is possible to address urban hazards like flooding through implementing a set of Natural tools (Naturally Resilient Communities 2017). Nature-based solutions provide new and effective alternatives of infrastructural development which can deal with numerous problems of cities in a cost-effective manner (Fink 2016; Frantzeskaki 2019). The idea of Nature-based Solutions is aroused from nature itself and this notion is being implemented with

the support of nature (European Commission 2015; Frantzeskaki 2019). In recent times, urban planners and policymakers are increasingly conducting research on Nature-Based Solutions to collect and map the proof of its multiple advantages (Brink et al. 2016; Frantzeskaki 2019). This research is dedicated to discern the limitations and challenges of implementing NBS for the flood reduction in Rotterdam. Moreover, the study has had an effort to explain the relationship between the *"level of implementation"* and *"implementation challenges"* of Nature-Based Solutions in Rotterdam.

1.2 Problem Statement

Research problem springs up from the interests of the researcher or the absence of an answer to a particular question (Bwisa 2008). The motivation behind working on the issues topical to Nature-Based Solutions was the personal zone of interest of the researcher. Currently, NBS have attracted the attention of numerous researchers because of its being a sustainable solution and a flourishing concept. There are plenty of studies (reviewed in chapter 2) which have explicitly demonstrated the urban flooding as a growing concern all over the world. Furthermore, as a possible alternative to 'grey infrastructure', implementing NBS on a wider scale is becoming crucial; however, implementation aspects of NBS have not been addressed thoroughly by any researcher until the present.

A study of Paprotny and his fellows (2018) showed that the exposer of urban areas towards flooding in Europe have risen by a thousand percent during last one hundred and fifty years (Paprotny et al. 2018; Jongman 2018). Around 60 percent area of the Netherlands is prone to flooding (European Commission 2019). Rotterdam is the 2nd significant municipality of the Netherlands that has a comprehensive drainage system, however, this city still might get flooded from the Nieuwe Maas river or excessive rainfall events (Water Atlas of the Netherlands 2012). The drainage network of Rotterdam is developed based on the estimation of water that might flow over the street. Nevertheless, preventing the occurrence of all flooding events is quite unattainable (Bouwens 2017). Impermeability of the surface is one of the prominent reasons for flooding in this port city. Moreover, it was identified that most of the flood-prone areas in Rotterdam have extreme imperviousness due to the sealed ground. Several research works identified that high stormwater run-off occurs in the areas of less vegetation and highly paved surfaces (Pauleit et al. 2005; Zölch et al. 2017). In a study by Bouwens (2017) the flood hotspots of Rotterdam were identified. He found that the largest flood-prone areas include the sub-districts "Rotterdam Centrum", "Delfshaven" and "Noord of Rotterdam". Furthermore, some other flood-prone smaller hot spots are Charlois and Feijenoord. Within the municipality, the identified flood-prone clusters are Overschie, Kralingen-Crooswijk, Ijsselmonde and Prins Alexander (Bouwens 2017).

Contrariwise, Rotterdam has always remained dynamic in introducing effective tools and approaches to confronting the climate change impacts and challenges emerged from urbanization (Tillie and van der Heijden 2016). 'Water Safety' is considered as one of the paramount issues and that is why urban flood risk management has been prioritized in Rotterdam Waterplan of 2013. Some of the "Nature-Based Solutions" have already been implemented in Rotterdam including restoration of the local park, roof garden, rain garden etc. (Frantzeskaki 2019). Even after having different initiatives for improving the environmental status, NBS have not been implemented widely in Rotterdam until the present. Moreover, no such detailed study has been found so far that depicts the implementation constraints and challenges which determine the level of successful accomplishment of NBS projects in Rotterdam. Many earlier studies have mentioned diverse implementation challenges (e.g. Raymond et al. 2017a, b; Kabisch et al. 2016a, b; Balian et al. 2016; Nesshöver et al. 2017) of

NBS and pointed the lack of sufficient knowledge base focusing implementation aspects. It is discernible that the effective application of any project could contribute to solving a problem. Therefore, it's imperative to have a flawless idea about the challenges that affect the implementation of NBS for the reduction of flood risk in Rotterdam. This study aims to deal with this problem to reveal the limitations and challenges that affect the implementation of NBS in Rotterdam. Subsequently, this research could help to unscramble the fact of not implementing NBS to a larger extent in this port city of the Netherlands. Furthermore, the study has also brought to the light about current practice and offered co-benefits by NBS alongside flood reduction in Rotterdam, the Netherlands.

1.3 Research Objective

The central objective of this study is to assess the limitations and challenges that affect the implementation level of NBS for flood reduction in Rotterdam. The specific objectives are:

- **To determine the implementation level of NBS for flood reduction**
  This objective has been attained through assessing the implementation status of selected NBS projects which are planned, designed or implemented so far for reducing the flood risk in Rotterdam. Moreover, this objective has brought the implementation process to the light as well.

- **To know the limitations and associated challenges of NBS implementation.**
  The objective has revealed the main challenges of implementing chosen NBS projects. It has created an unambiguous understanding of the issues that have somehow affected the implementation or created some challenges after materializing those projects. Furthermore, a sound knowledge of the involved parties and their contribution in applying the NBS projects become known from this objective.

- **To identify the co-benefits of NBS that have been attained in addition to flood reduction.**
  This objective has ascertained the co-benefits that are offered by the existing NBS which have been implemented for flood water reduction. The co-benefits are known from the opinions of experts and the perception of the users of those projects. Moreover, a futuristic scenario has been developed regarding the possible benefits that might be obtained from NBS in the future alongside flood mitigation.

1.4 Research Questions

Research questions are formulated to attain the objectives of the research. The questions also let the researcher to specify the arguments within the broader arrangement of the conceptual framework (Sanyal 2006). Even though the curiosity in a specific topic starts the research procedures, acquaintance to the issue ultimately helps to develop precise research questions (Haynes 2006). Questions then emanate out of a defined knowledge gap within a branch of knowledge or field of study (Hulley et al. 2007). Perneger and Hudelson (2004) have mentioned that the notable attributes of research questions are (i) specificity; (ii) uniqueness; and (iii) universal applicability to an expansive scientific community. In this research, the researcher has tried to formulate the main research question along with few sub-questions based on the aforementioned criteria. These questions were tried to make more specific for the convenience of study. The main research question as follows:

"What are the existing limitations and challenges that affect the implementation level of NBS for flood reduction in Rotterdam?"

1.4.1 Sub-Questions

a) What is the level of implementation of NBS for flood reduction in Rotterdam?

This sub-question has answered whether the chosen NBS projects have been successfully implemented, partially implemented or at the piloting stage yet. This question also provides the story of implementing the chosen NBS from the conceptualization stage to final implementation and some maintenance issues as well.

b) What are the challenges faced during NBS implementation in Rotterdam?
The question has sought an enhanced understanding of what limitations of existing NBS in Rotterdam are (for flood reduction) and which factors are making the implementation procedures challenging. It has also brought to the light about the bodies or level of government who were assigned with the implementation of NBS in this city.

c) Which co-benefits are provided by NBS in addition to flood reduction in Rotterdam?
Through answering this sub-question, all the associated co-benefits from the NBS projects become known to the researcher. Alongside mitigating the flood risk in Rotterdam, all other related benefits or facilities of the project are known.

1.5 Significance of the Study

Presently, more than fifty percent of the global population are inhabiting in cities and it is anticipated that by the half of 21st century the amount will stand at 66% (ADB 2016). Urban areas possess a huge significance because of the high concentration population, assets, economic activities and administrative works (WWF 2017). Globally, the trend of urbanizing on flood plain zones is continuing, particularly in Asia and Africa (Winsemius et al. 2016). The overwhelming effects of urban flooding on the economic condition and society have drawn the attention towards possible brunt of forthcoming climate change on existing urban drainage infrastructures (Zhou et al., 2012; Chang et al., 2013; Abdellatif et al., 2015; Zhou et al. 2018). In addition, the problem of flooding will become more severe in the coming days as a high-level of ambiguity has remained pertaining to the changing scenario of global climate in future (World Meteorological Organization 2012). In a word, urban flooding has become a talked-topics that is necessary to resolve on an immediate basis. There has been a long trend of relying on the "grey" or engineering approaches to reduce the urban flood impact. These 'grey' infrastructures are usually designed as a single-purpose oriented structure, for instance, a piped drainage system is made for conveying the stormwater only. However, such drainage infrastructures are becoming abandoned due to the fast urbanization and having no alternative uses (Perales-Momparler et al. 2017; Zhou 2014). Besides, managing urban flood with the support of engineered infrastructures involves high expenditure for construction, maintenance and restoration (Hair et al. 2014). As opposed to, Nature-based solutions to flooding can provide multiple benefits alongside the mitigation of flood impact. All Nature-based strategies can offer manifold services in addition to fulfilling the prime objective (IUCN 2019). Furthermore, the construction and maintenance costs of green solutions are quite lower than the "grey" infrastructures (Sidner 2017). Undoubtedly, 'grey' approaches have prevented many cities from flooding for last two centuries and in future, such infrastructures will also have importance as well (Perales-Momparler et al. 2017; Davis and Naumann 2017).

For the city Rotterdam, numerous engineering approaches have already been implemented to prevent it from flooding, however, there always remains a question of environmental benefits from such infrastructures. Being a modern city, Rotterdam still doesn't have a significant reliance on the NBS to address different socio-environmental challenges like urban flooding.

A range of researches has been conducted to promote and ameliorate the concept of NBS. Furthermore, many pilot projects are on-going in different European countries to come up with a firmer baseline for detailing NBS. Nevertheless, there is still insufficient research concerning the implementation process and the challenges of NBS projects. Many earlier studies (e.g Kabisch et al. 2016a, b; Fernandes and Guiomar 2018; Kalantari et al. 2019) also pointed out the lack of evidence and researches on implementation aspects. Information regarding NBS implementation practices and monitoring remains inadequate (Fernandes and Guiomar 2018). More specifically, the challenges of applying NBS for flood reduction are also quite vague due to the lack of adequate research works. Having a firm knowledge base could facilitate the implementation processes in this city. Additionally, the growing threat of climate change and rapid urbanization are compelling us to think of environment-friendly development for flood mitigation. To move simultaneously with the changing scenario of urban areas and global climate, we have to be more reliant on nature to eventually make the cities resilient. This research can let the policy makers and planners figure out the possible constraints that might need to be considered while designing and implementing NBS for flood reduction-related projects in Rotterdam. Moreover, the implementation challenges are necessary to reveal so that it becomes possible to discern which type of governance can lead to the effective application of NBS in a flood-vulnerable city like Rotterdam. Lastly, as a flourishing concept, NBS is better understood from this study and this research can contribute as a knowledge base for forthcoming research endeavors.

1.6 Scope of the Study

The current study covers the issues related to the implementation of NBS in Rotterdam. Firstly, it assesses the implementation status of the chosen NBS project in Rotterdam to ascertain the level of implementation. In addition, the process or stages of implementing the projects have also been considered in this study. Secondly, the most significant part of this research is to recognize and elaborate on the existing limitations and challenges which are ultimately hindering or somehow affecting the NBS implementation. Lastly, the research has focused on ascertaining the different benefits that are being provided by NBS in this city. Altogether, the issues that have been encompassed in this study is expected to give a concrete understanding of the implementation aspects of NBS. However, this research has not covered the issues related to the effectiveness of NBS and any cost-benefit analysis of the existing projects.

1.7 Limitations of the Study

The study has been constrained by the following limitations:

- **Time limit**: Sufficient time is the most significant issue to accomplish any project, however, the time was quite limited to gather information and analysis of collected data for this research. It was a challenging task to accomplish data collection and all other sub-sequent works in just a couple of months. The researcher could have collected more detailed information on the projects, however, shortage of time did not allow him to do so.

- **Financial Constraints**: As the researcher had to bear the expenses himself, limited financial capacity might limit the scope of study especially data collection. Financial assistance from any sponsor or university could facilitate and expand the data collection.

- **Lack of Available Information**: While reviewing literatures, the researcher realized that there is insufficient information about the current or planned NBS projects in Rotterdam. It was time-consuming to gather secondary information from other sources because much

information is not available on internet sources. So, key informants were the paramount way of having detailed information on the projects.

- **Managing Interviewees**: As one of the data collection methods of this research, it has sought to interview a considerable number of experts or key informants. However, it was quite tough to get an appointment from many key informants who have been working in the field of NBS. Moreover, due to the summer holiday schedule, the researcher had to consistently contact numerous informants to get their appointment.

- **Unfavourable Weather Condition:** Because of having an unstable weather pattern in Rotterdam, the researcher had to reschedule the questionnaire survey. Mostly the rain has affected the data collection phase. Therefore, more time was spent in collecting data through questionnaires.

1.8 Organization of the Thesis

This dissertation is organized into five main chapters, begins with the acknowledgment, summary, list of figures, list of tables, list of maps, the chapters in the middle and ends with a list of bibliography and appendix.

Chapter One depicts the statement of the research problem, its significance, aims and objectives of the study, scope of the research and limitations.

Chapter Two critically elaborates the literatures regarding urban flooding and Nature-Based Solutions to come up with a concrete framework.

Chapter Three describes the research design and pros and cons of the methodological framework that has been implemented throughout the research work.

Chapter Four is devoted to analyzing and depict the findings of this study. There is a clear demonstration of result with argumentative interpretations.

Chapter Five aims to answer the research questions. Moreover, it also provides some recommendations and concludes the paper with an unambiguous summary.

Chapter 2: Literature Review

2.1 Introduction

"Making cities inclusive, safe, resilient and sustainable" is one of the Sustainable Development Goals (goal no. 11) set by United Nations (United Nations 2015) realizing the importance of ensuring a better and livable urban environment (Konijnendijk et al. 2016; Fini et al. 2017). Besides, currently there is a rising awareness for valuing the nature among the business sectors, policymakers and in societies in order to address different social, economic and environmental challenges (Daily et al. 2000; Guerry et al. 2015; Lafortezza and Sanesi 2019; Maes and Jacobs 2017; Faivre et al. 2017). Throughout the world, flooding is one of the most recurrent disasters that affect the significant number of people (UNISDR 2015) and the occurrence of floods in urban areas are more prominent (Chen et al. 2015). Consequently, urban flood risk mitigation is getting importance at each and every governance levels (Fang 2016; Mignot et al. 2019). Nature-Based Solutions (NBS) are gaining more focus to deal with different challenges with the support of Nature (EC 2015; Calliari et al. 2019). The objective of this chapter is to raise some conceptual and theoretical issues by reviewing a wide range of literatures. Different studies regarding Nature-Based Solutions (NBS) and Urban Flooding have been critically analyzed and depicted in this chapter. The concepts and scenarios associated with the study are presented along with describing the current global scenario of urban flooding. Following that several implementation issues and challenges have also been addressed. Finally, the chapter ends with expressing the research gaps and providing an unambiguous theoretical framework.

2.2 Conceptualization

2.2.1 Urban Flooding and Its Global Scenario

"Urban flooding is significantly different from rural flooding as urbanization leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times" (NDMA 2019). Again, an "Urban Flood" can also be defined as the overflowing of water over a developed area that does not typically stay under water (Shepherd 2007). While Weber (2019) stated that "*Urban flooding is caused by excessive runoff in developed areas where the water doesn't have anywhere to go*". Different authors have defined the concept of Urban Flooding from different points of view but most of them have emphasized the excessive overflowing of water that might not be predicted in a built-up area. Being one of the most disastrous events, flooding in cities could result in the colossal damage of infrastructure, environment, society and above all the urban economy (Ashley et al. 2007; Chang et al. 2013; Zhou et al. 2017a; Zhou et al. 2018).

Cities are often characterized by impervious surfaces due to the concrete infrastructures and sealed road throughout the area (Huong and Pathirana 2013; Kaspersen et al. 2016; Scalenghe and Marsan 2009; Fini et al. 2017). Consequently, less infiltration creates high run-off and sometimes flooding during the high precipitation (Kaspersen et al. 2016). Again, built-up urban areas reflect the highest possibility of experiencing colossal damages even the loss of life when a flood takes place (Willems et al. 2012; Bisht et al. 2016; Zhou et al. 2017b; Hettiarachchi et al. 2018). As urbanization creates paved surfaces, it is liable for both clogging the water over the surface and minimizing the ground water seepage in cities (Wu et al. 2017a; Wu et al., 2017b; Shen et al. 2015a, b; Xu et al. 2018). Although a substantial number of researches advocate in favour of man-made reasons as responsible for urban flooding, the changing climate has also been identified to have a considerable impact on the flooding in multiple ways. Because of the warming of the global atmosphere, the increment of sea level and the intense climatic occurrences are becoming more frequent. If this situation continues, the risk of urban

flooding will be higher in the coming days (Jha et al. 2011). Heavy precipitation is one of the most prominent reasons of flooding in cities and the vast majority of this hazard result from heavy localized rainfall (Meena and Gupta 2017). As a result, drains cannot accommodate the water from intense rainfall and create flooding in cities (Peng et al. 2015; Yazdanfar and Sharma 2015; Zhou et al. 2018). The cities that are confronting the heavy rainfall events are greater in number than those where rainfall has declined with time (Donat et al. 2013; Westra et al. 2013; Hettiarachchi et al. 2018). Researchers from different panels have demonstrated their own logic of flood occurrence in cities. The perception derived from the existing literatures justify that the occurrence of urban flooding is a combined effect of unplanned urban development, excessive rainfall (Ma et al., 2014) and the inefficiency of drainage system (Wu et al. 2017a; Wu et al., 2017b; Shen et al. 2015a,b; Xu et al. 2018).

The magnitude of damage and dimension of urban flooding have risen with the elapse of time as a huge number of people and assets are based in cities (Bansal et al. 2015). European cities have been confronting repeated and intense flooding events which are projected to become severe in coming days due to the prompt urban enlargement and climate change (Santato et al. 2013; Davis and Naumann 2017). Instead of having a significant investment for flood protection, several flooding events have caused colossal damages in Europe that worth billions of Euros (Kundzewicz et al. 2014). During the 1990s, about 1000 Km^2 of the surface were sealed every year due to the growth of urban areas, however, recently this pavement trend has been dwindled to 900 Km^2 per year. It has been estimated that the cost of environmental degradation from sealing the ground is about €45 billion/year in Europe (European Commission 2012). In Leipzig of Germany, surface runoff has become doubled within 1940–2003 because of the expansion of paved surfaces (Haase and Nuissl 2007). Likewise, in Leeds of the UK, surface runoff has increased by 12% due to the 12.6% extension of impervious areas (Perry and Nawaz 2008; Fini et al. 2017). Conversely, due to the rise of global temperature, Europe is predicted to confront a greater risk of flooding in its cities and surroundings. The flood risk will increase by 113% and 145% for the 1.5^0C and 3^0C rise of global temperature respectively (CORDIS 2018). Again, many developing countries with a high concentration of population like India and China have also been experiencing the frequent urban flooding since the last decade (Willems et al. 2012; Bisht et al. 2016; Zhou et al. 2017b; Hettiarachchi et al. 2018). About 200 urban localities of China have been suffering from flooding due to the intense rainfall (Yin et al., 2015; Lyu et al., 2018; Sang and Yang 2017; Xu et al. 2018). Therefore, it's quite obvious that the occurrence of urban flooding is propelled by the changing nature of climate and alteration of surface cover in the cities. Moreover, global cities will face an increasing prevalence of city flooding if the atmospheric temperature continues to rise in the coming decades. Using or relying on Natural elements could be a possible way to overcome the threat of urban flooding; the concept and implementation aspects of Nature-Based Solutions are discussed in the following sections.

2.2.2 Nature-Based Solutions (NBS) for Urban Flood Reduction

As a flourishing concept which is contrary to the 'grey' engineering approach (Davies and Lafortezza 2019), 'Nature-Based Solutions' (NBS) incorporates strategies that imitate the characteristics and procedures of environmental ecosystems (Faivre et al. 2017; Lafortezza and Sanesi 2019). The idea of Nature-Based Solutions is aroused from nature itself and this notion is being implemented with the support of nature (European Commission 2015; Frantzeskaki 2019). In other words, NBS is an idea which directly relates or supports the concept of ecosystem-related approach, services or adaptation (European Commission 2015; Eggermont et al. 2015; Faivre et al. 2017). Particularly, NBS have had a focus on the area of adaptation to the change of climate, ecosystem benefits and green set-up (Kabisch et al. 2016a; Kabisch et

al. 2016b). Furthermore, the NBS approach can support to deal with three types of challenges, i.e. ethical, intellectual, relational which have not been considered by other concepts till the date (Jones 2011; Hauck et al. 2013; Eggermont et al. 2015). NBS might also be implemented *"in tackling challenges such as climate change, food security water resources, or disaster risk management, encompassing wider definition of how to conserve and use biodiversity in a sustainable manner"* (Balian et al. 2014, P.5; Kabisch et al. 2016a).

On the other hand, NBS are designed to deal with diverse societal challenges through the effective use of resources with an aim to safeguard social, economic and environmental benefits simultaneously (European Commission 2015; Cohen-Shacham et al. 2016; Maes and Jacobs 2017; Albert et al. 2017; Fini et al. 2017; Raymond et al. 2017a; Faivre et al. 2017), this characteristic of NBS is referred as "multifunctionality" (Kabisch et al. 2016). In addition, some other features of NBS comprise cost-effectiveness (European Commission 2015; Keesstra et al. 2018), adaptableness (Cohen-Shacham et al. 2016), dependence on transdisciplinary perspective and evidence-based approaches (Nature 2017). Even though several expectations and benefits are described, the term 'Nature-based Solutions' still lacks a generally agreed and accepted definition (Calliari et al. 2019). Though the argument on defining 'Nature-Based Solutions' is still going on (Nesshöver et al. 2017), IUCN and the European Commission have mostly developed or elaborated the concept. IUCN has defined Nature-based Solutions as *"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"* (Cohen-Shacham et al. 2016; Calliari et al. 2019). In recent times, urban planners and policymakers are increasingly conducting research on Nature-Based Solutions to collect and map the evidence of its manifold benefits (Brink et al. 2016; Frantzeskaki 2019). NBS were initially discussed and considered by the policy and decision-makers, however, nowadays researchers of the diverse field are increasingly focusing on NBS (Lafortezza and Sanesi 2019).

Again, the term 'Nature-Based Solution' does not imply only for the green space or infrastructure, rather it also encompasses the functions that are made to address the prevailing societal challenges (Naturevation 2017). NBS utilize the natural processes and living things to accomplish the technical tasks which used to be performed using artificial ways (Eggermont et al. 2015; European Commission 2015; Fernandes and Guiomar 2018). For different functional purposes, Nature-Based Solutions exploit the natural phenomenon and ecosystem services. These solutions might entirely be 'green' or a combination of ecosystem elements and 'grey' infrastructures (World Bank 2017). Moreover, Nature-Based Solutions are undertaken to recuperate the ecological balance and to increase the resilience level through a new infrastructure in cities (Brink et al. 2016; Frantzeskaki 2019). Many research works argued that the notion of Nature-Based Solutions is not confined within the use of natural elements only, rather soft engineering approaches are also considered as part of NBS (Marton-Lefèvre 2012; van Wesenbeeck et al. 2014). Furthermore, learning from nature can better contribute to ameliorating the environmental condition rather than solely looking for strategies that are based on nature (Potschin et al. 2015). In a thematic report, Frantzeskaki (2018) narrated "*Nature-Based Solutions become a valid alternative for infrastructure development and update in cities that are considering (new) approaches and rethink their time horizon and costs in maintaining them*" (Frantzeskaki 2018, P. 2). Such statement represents the possibility of NBS to bring about a positive change as complementary to the traditional engineering measures. In sum, it can be stated that NBS is a growing concept which can potentially be used to deal with diverse socio-environmental challenges either only using the natural constituents or creating a unique hybrid design in a combination of natural products and engineering elements. Next section

elaborates different categories of Nature-Based Solutions that have been proposed or applied so far.

2.2.3 Types and Approaches of NBS

'Nature-Based solutions' has been taken into account as an umbrella concept that encompasses diverse approaches with a wide range of application (Cohen-Shacham et al. 2016). In real, NBS offer a range of technical approaches to address human necessities through the use of natural systems and procedures (Nesshöver et al., 2017; Fernandes and Guiomar 2018). NBS combine different traditional ecosystem-based approaches, like "ecosystem services", "green-blue infrastructure", "ecological engineering", "ecosystem-based management" and "natural capital" (Nesshöver et al. 2016; Nature Editorial 2017) alongside evaluating the socio-economic advantages of resource-effective and systemic solutions (European Commission 2015; Raymond et al. 2017a). IUCN has categorized the NBS approaches into five broad categories that are demonstrated in the following table (Table 2.1).

Table 2.1 Different Approaches to Nature-based Solutions.

Category of NBS Approaches	Examples
Ecosystem restoration approaches	• Ecological restoration • Ecological Engineering • Forest landscape restoration
Issue-specific ecosystem-related approaches	• Ecosystem-based adaptation • Ecosystem-based mitigation • Climate adaptation services • Ecosystem-based disaster risk reduction
Infrastructure-related approaches	• Natural infrastructure • Green infrastructure
Ecosystem-based management approaches	• Integrated coastal zone management • Integrated water resources management
Ecosystem protection approaches	• Area-based conservation approaches, including protected area management

(Source: Adapted from Cohen-Shacham et al. 2016)

2.2.3.1 Ecosystem Restoration Approaches

In the description of Cohen-Shacham et al. (2016), three major approaches have been found under this category. Firstly, Ecological Restoration is defined as *"the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed"* (Society for Ecological Restoration 2004). Though the term *Ecological Restoration* is sometimes used interchangeably with Ecosystem Restoration (Suding 2011; Baird 2005), in some cases the first one might only focus on environmental objectives. Ecological restoration can increasingly contribute to policies to reduce the extensiveness of environmental degradation (Aradottir and Hagen 2013). However, effective renovation of an ecosystem needs a thorough understanding of the weaknesses of that ecosystem (Apfelbaum and Chapman 2015). Example of this

approach might incorporate but not confined to the restoration of a contaminated river basin, renovation of a forested area that was worsened by mining works etc.

Secondly, the approach Ecological engineering is also considered as a related concept to ecological restoration (Mitsch 2012). *"Ecological engineering combines basic and applied science for the restoration, design, and construction of aquatic and terrestrial ecosystems"* (Mitsch 1996, P. 113). This approach considers both the people and environment in order to protect the people as well as their properties (Roy et al. 2011; Cheong et al. 2013). Examples of this approach includes treatment of wastewater to get rid from contamination problem (Mitsch & Jørgensen 2004; Barot et al. 2012), introducing new type of floral species to restore salt marshes (Teal & Weinstein 2002), applying a sediment trapping faunal species for shore protection (Borsje et al. 2011) etc.

Thirdly, Forest landscape restoration approach incorporates stakeholders of the affected land-use sectors and implement the participatory decision-making processes (Sabogal et al. 2015). Earlier this approach used to be defined as a "planned process that aims to regain ecological integrity and enhance human well-being in deforested or degraded landscapes" (Mansourian et al. 2005). However, the concept was refined later and shifted its emphasis from the species arrangement of the local ecosystem and its processes to adaptable service provision and numerous benefits (Maginnis et al. 2014). The implementation and investment for Forest landscape restoration approach can yield conservation benefits for many degraded and fragmented forest areas throughout the world (Sayer et al. 2003). Real examples of this approach are renovation of the forests of Shinyanga, Tanzania (Barrow 2014) and the Loess Plateau, China (Lü et al. 2012).

2.2.3.2 Issue-Specific Ecosystem-Related Approaches

Different approaches were presented by Cohen-Shacham and her colleagues (2016) pertaining to specific issues. The first one is *Ecosystem-based Adaptation* (EbA) that can be defined as *"the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels"* (UNEP 2013, P.3). This approach (EbA) was developed with an aim to specify the role of our ecosystem for moderating climate change effects on global residents (Staudinger et al. 2012; Locatelli et al. 2011). Though EbA can successfully be implemented in different scales, it generates benefits mostly at the local level (Locatelli et al., 2011; Rizvi 2014). Furthermore, community engagement has a great significance in Ecosystem-based Adaptation. Some examples of this approach can be green aeration corridors for cities, renaturation of the river for reducing floodwater runoff, planting of climate change tolerant tree species in forests etc.

Under this category, the next approach is *Ecosystem-based mitigation (*EbM) that is emerged to deal with the underlying reasons of climate change like boosting the GHG sinks (Staudinger et al. 2012; Locatelli et al. 2011). This approach can be defined as *"the use of ecosystems for their carbon storage and sequestration service to aid climate change mitigation. Emissions reductions are achieved through creation, restoration and management of ecosystems*" (Doswald and Osti 2011, P. 5). In sum, EbM is devoted to ensure pandemic benefits and prolonged effects on climate change (Locatelli et al. 2011). The next approach is known as *Climate Adaptation Services* (CAS). This approach works as a complementary concept of ecosystem services and contributes to expanding the options for climate change adaptation (Lavorel et al. 2015). Even though CAS is sometimes used as synonymous to EbA, the former one covers the broader aspects than the later one. In addition, CAS highlights the advantages

of significant modification of ecosystems and emphasize the issues that could possibly become important for human well-being in the future (Colloff et al. 2016).

The last approach under this category of NBS is Ecosystem-Based Disaster Risk Reduction (Eco-DRR). IUCN has defined that Eco-DRR is the *"sustainable management, conservation and restoration of ecosystems to provide services that reduce disaster risk by mitigating hazards and by increasing livelihood resilience"* (IUCN 2019). This approach has a prime focus on lessening the effects of disastrous events by improving the people's capability to manage and fast recovery from the post-disaster situation (Renaud et al. 2013). Some specific ecosystems like wetlands, mangroves, coral reef etc. can significantly contribute to the prevention or mitigation of hazards. For instance, forest cover on a mountain might reduce the frequencies or prevent the occurrences of avalanche and hill slides (UNEP 2019).

2.2.3.3 Infrastructure-related Approaches

This broad category of NBS consists of two notable approaches i.e. Green Infrastructure (GI) and Natural Infrastructure (NI). Even though both of these approaches are used interchangeably (UNEP 2014), they have different purposes and context of works. Green Infrastructure can be defined as *"a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services"* (European Commission 2013). In urban locals, the most commonly used green infrastructural measures include trees, green roof and rain gardens. The canopy of trees can intercept rain water before reaching the ground while the roots of trees increase the infiltration rate (Jayasooriya and Ng 2014). Armson and his co-researchers (2013) made a comparison between the surfaces covered by trees and asphalt. They concluded about the potential of trees that can minimize the runoff and eventually flooding (Armson et al. 2013). Another study of Zölch and his colleagues (2017) confirmed the increase of interception rate with an extended area of vegetation (Zölch et al. 2017). Similarly, woodland and semi-natural land cover in the upper reaches can slow down run-off rate by creating rough surfaces as well as allowing the soil to absorb more water which reduces the flood peak in the cities located downstream (Murray 2017). Green Infrastructure (GI) can significantly be cost-efficient in terms of building and maintenance. In a couple of research paper, it was stated that Green Infrastructure can reduce 30% expenditure for flood mitigation in comparison to the traditional infrastructures (Garrison and Hobbs 2011; Kourkoulis 2018). Furthermore, engineering development tends to have single purposes while green infrastructures provide a number of advantages e.g. environmental, socio-economic etc. (Sidner 2017).

On the other hand, Natural infrastructure can be considered as *"an active form of nature likely focused on the most important of these benefits. Natural infrastructure comprises an active management component aimed at providing (or conserving) the key advantages—such as climate resilience, clean water and biodiversity*" (Roy 2018). NI is a climate-smart solution as it lowers the use of energy produced from fossil fuel and helps to increase the resilience against the brunt of climate change (Quigley 2013). A "green infrastructure" approach is applied in both the urban and landscape level, however, "natural infrastructure" is only implemented at the landscape scale. Instead of having some differences, both GI and NI share many principles and objectives (European Environment Agency 2011). Furthermore, both approaches usually rely on hybrid solutions like combining both hard infrastructures with natural elements (Cohen-Shacham et al. 2016).

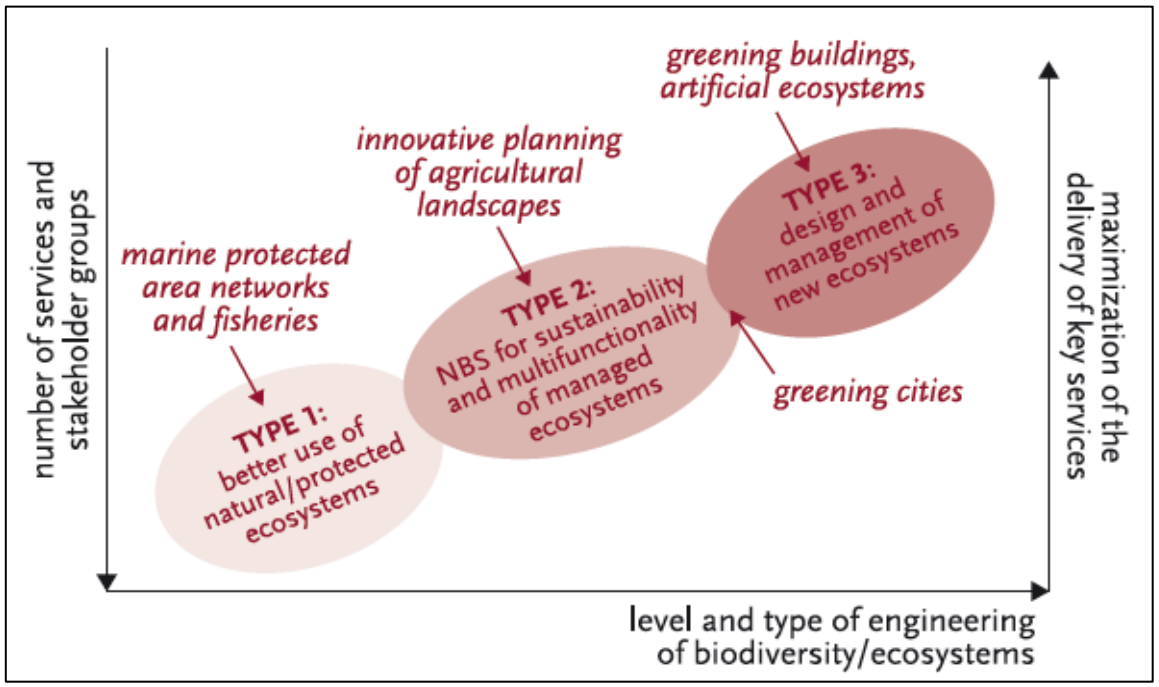
2.2.3.4 Ecosystem-based management approaches

"Ecosystem-based management is fundamentally about perceiving the big picture, recognizing connections, and striving to maintain the elements of ecosystems and the processes that link them" (Guerry 2005, P. 202). This management approach is often applied in an ecosystem and environmental management contexts. This category of NBS covers two broad approaches, namely ICZM and IWRM (as demonstrated by Cohen-Shacham et al. 2016). Though Ecosystem-based management can be of different types, it substantially focuses on marine or coastal environmental issues. Integrated Coastal Zone Management (ICZM) is a governance strategy that encompasses the legal and organizational framework that is required for the improvement and managerial aspects of coastal zones. The paramount aim of ICZM is to maximize the paybacks from the coastal belt and to diminish all the problems that might have an effect on the coastal environment and resources (Post and Lundin 1996). This Nature-based Solution of managing the coastal belt could significantly contribute to the development of the coastal zone. And the reason behind such contribution is that the region is endowed with numerous natural resources along with a concentration of huge population base (European Commission 2016a).

Contrariwise, "Integrated Water Resource Management" (IWRM) is a process that encourages the joined development and management of water and associated resources (e.g. land) with an aim of maximizing the socio-economic benefits alongside ensuring the sustainability of fundamental ecosystems (United Nations 2014). Moreover, IWRM offers a universal framework in order to deal with the demand and pressures on water resources throughout different sectors and scales. This NBS approach of managing the water resources can potentially contribute to attain the sixth SDG "ensure availability and sustainable management of water and sanitation for all" (UN Environment 2018).

On the other hand, Eggermont and his colleagues (2015) have projected a typology that characterizes the Nature-Based Solutions along the X and Y axis of a diagram. They have presented three major types of NBS (Figure 2.1).

Figure 2.1: Schematic illustration of the range of NBS approaches.



(Source: Adapted from Eggermont et al. 2015)

Type 1 includes no or negligible interference in the ecosystem alongside ameliorating the distribution of ecosystem services. For example, protecting the mangrove forest in the coastal belt in order to lessen the risk of extreme weather events and establishing a marine safeguarded area along the same coastal belt to create the opportunities and benefits for local inhabitants (Grorud-Colvert et al. 2014).

Type 2 is more related to the application of management approach that can ameliorate the sustainability and multifunctionality of ecosystems in order to eventually improve the distribution of ecosystem services in comparison to the services provided by traditional infrastructures. This sort of NBS is firmly incorporated to the concepts like "natural systems agriculture" (Jackson 2002), "evolutionary-orientated forestry" (Lefèvre et al. 2014) and "agro-ecology" (Altieri 1989).

Type 3 of NBS has an intensive focus on the management or creation of new ecosystems following an intrusive way. This category of NBS is associated to the concepts as blue or green infrastructures (Bendict and McMahon 2006). Moreover, it might be linked to an objective like renovation of highly deteriorated areas or environments. With an aim to create a bridge between "biodiversity conservation" and "landscape architecture", type 3 NBS is presently exploring the innovative approaches like "animal-aided design" (Hauck and Weisser 2015; Eggermont et al. 2015).

As Figure 2.1 demonstrates, it's quite tough to create a sharp boundary line among these three types; therefore, hybrid solutions can possibly exist along with gradient through time and space. This NBS typology of Eggermont et al. (2015) mostly responds to the NBS classification given by IUCN (Table 2.1). Here Type 1 entirely fits with the IUCN framework while the rest two types also fall under the IUCN definition and defined criteria. Furthermore, type 2 and type 3 have frequently been demonstrated by the European Commission for altering "natural capital" into a source for "green growth" as well as "sustainable development" (Eggermont et al. 2015; Cohen-Shachem et al. 2016).

In fine, it can be articulated that the types of NBS are not firmly defined within a sharp boundary, however, most of the categories utilize of ecosystem components or green materials with an aim to solve a problem alongside ensuring the multiple benefits. Presumably not all but many of the type of NBS could mitigate the flooding in urban locals. The succeeding section discusses the different stages that are needed to follow while implementing a Nature-Based Solution.

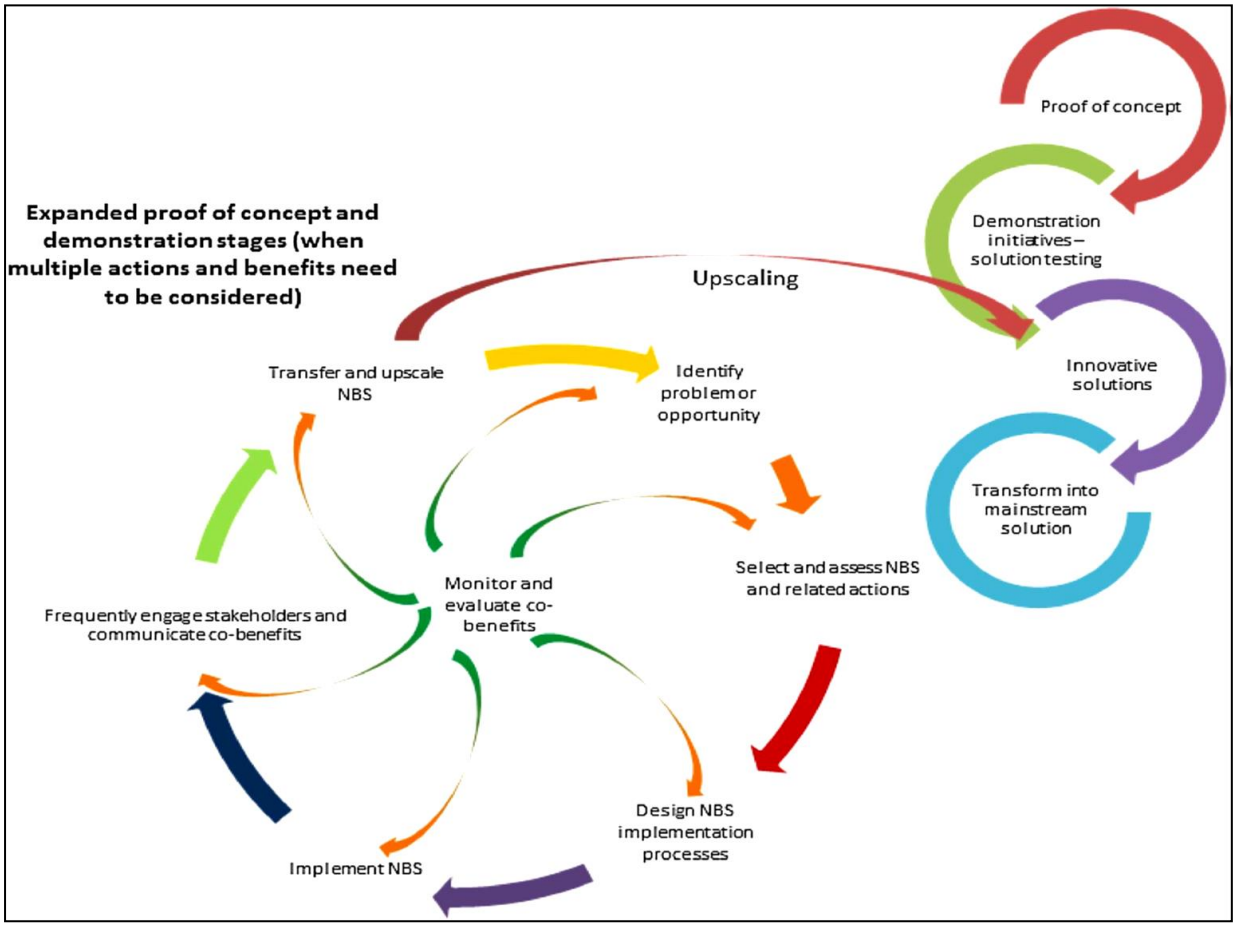
2.3 Stages of NBS Implementation

Different organizations like IUCN and The Nature Conservancy have actively been working to assimilate the NBS into policy arguments (IUCN 2012; Faivre et al. 2017). NBS and other ecosystem-related concepts have been upheld in the pronouncements of the United Nations Convention that focused on Biodiversity and Climate Change (CBD 2016). Suggestions that are made by the current EU policies focusing on climate change, disaster risk mitigation, protection of biodiversity etc. have notably supported mainstreaming of 'innovation with nature' policies in the international arena; particularly bringing the concept of nature & innovation in the UN Agenda (2030) for 'Sustainable Development Goals' (United Nations 2015). In a study of Faivre and his colleagues (2017) argued that NBS can potentially contribute to attaining a number of SDGs, even many of those goals that are not related to nature or natural processes. As more than 50% of the global population and two-thirds of EU's

people are residing in cities, by introducing NBS to address different urban challenges can lead to the achievement of SDG 11: “Sustainable Cities and Communities” (Faivre et al. 2017).

In research of Raymond and his colleagues (Raymond et al. 2017a) have demonstrated seven stages of realizing Nature-Based Solutions. The steps of implementation are demonstrated in figure 2.2 and elaborated subsequently.

Figure 2.2: Process of NBS implementation including phases of social innovations.



(Source: Adapted from Raymond et al. 2017a)

2.3.1 Identifying Problem or Opportunity

Urban environmental problems are identified based on their prevalence and the possibility of creating negative impacts on human being or resources. The problem cannot be defined too narrowly or too widely (Satterthwaite 2003). Most of the times, problems that are needed to be solved through implementing NBS seem complex and multidimensional. After recognizing the problem, the next important task is to look for the opportunity in NBS to alleviate the selected problem. Furthermore, it is also necessary to decide whether an ecosystem-based measure or a hybrid type of solution (that is combined with grey infrastructure) would respond the best to the chosen identified problem (Raymond et al. 2017a). Alongside, benefits of different NBS are also required to compare in terms of multiple benefits and cost-effectiveness. However, a cost-benefit analysis might not provide a detailed understanding of multiple benefits of NBS, therefore, Raymond et al. (2017b) have suggested the use of some new methods like “participatory assessments”, “group modelling” and “integrated sustainability assessment” (Raymond et al. 2017b). In addition, mapping the provided manifold benefits by NBS and their changes over the time span is also crucial (Xing et al. 2017).

2.3.2 Selecting NBS and Related Actions

As mentioned in the previous section, the selection of NBS depends on the nature and extent of problem to be addressed (Raymond et al. 2017a). In the second step of NBS implementation, it is important to understand necessary actions along with choosing the right NBS. While taking the actions, planners must try to lessen the use of 'grey' measures that usually result in the high expenses, rigidity and contradictory interests (Brink et al. 2016). The availability of information regarding monitoring and assessment of action might affect the action types. Moreover, it's necessary to incorporate different kinds and levels of knowledge with the actions in order to assure the acceptance of actions towards a group of stakeholders (Frantzeskaki and Kabisch, 2016; Raymond et al. 2017b).

2.3.3 Designing NBS Implementation Processes

The third step of NBS implementation is to make an effective design on how the whole process will be performed. After recognizing the problems to be solved and choosing appropriate NBS, it is quite indispensable to develop an articulated design of the implementation procedures. The Implementation processes require to ensure the support from residents, practitioners and policymakers in terms of sincerity, clarity in governance procedures and authenticity of knowledge (Crowe et al. 2016; Frantzeskaki and Kabisch 2016; Specht et al. 2016). Furthermore, the stakeholders also require to make institutional space that can promote the policy dialogues on "adaptive co-management", sharing of knowledge on "urban ecosystems" (Crowe et al. 2016; Dennis and James 2016) and empowering cross-sectoral collaborations (Krasny et al. 2014; Specht et al. 2016; Ugolini et al. 2015; Raymond et al. 2017a). Ensuring of all these issues can surely lead to the development of an operative implementation design for NBS.

2.3.4 Implement NBS

The next step is about implementing NBS as per the design developed in the previous stage. Implementation needs to consider the comparative costs and benefits of a particular action. Furthermore, it is also important to take care of complexities related to uncertainty. NBS or Green solutions could be differentiated from traditional engineering infrastructures considering their appearance and ways of services (Davies et al. 2006). Contrariwise, depending on the landscape or physical characteristics of the urban area, green solutions can be applied either alone or in a combination with 'grey' measures (Mell 2013). So, it is significant for the planners to articulately mention the spectrum of green and grey measures to be applied in an area.

2.3.5 Frequently Engage Stakeholders and Communicate Co-Benefits

Usually, involving stakeholders from diverse sectors is usually given less priority in the planning of large projects (Bragança et al. 2014). However, in a research work of Frantzeskaki and Kabisch (2016) suggested that stakeholders from different level should be engaged throughout all the project activities. Therefore, communicating with people from a different professional background and citizens are necessary. Until present, different platforms or collaborative processes (e.g. PPP, social innovation) have already been used as a suitable platform for bringing the stakeholders together. On the other hand, disseminating the information about possible co-benefits from the NBS projects could encourage the participants to contribute with their best. Reciprocally, spontaneous involvement of stakeholders can also ensure the co-benefits from a project (Jones and Somper 2014; Raymond et al. 2017a). In fine, it can be stated that involving different parties through a proper means of communication can eventually lead to assuring the co-benefits from an NBS project.

2.3.6 Transfer and Upscale NBS

After involving all the possible stakeholders in an NBS project, the later stage is to work for upscaling the implemented NBS. Upscaling can motivate the investors to continue their spending on the NBS (Cohen-Shacham et al. 2016) and to initiate the implementation of more NBS projects that can ultimately offer numerous co-benefits. Frantzeskaki and her colleagues (2017) added that upscaling of NBS can be done by the collaboration of multiple actors. On the other hand, some of the NBS provides extra co-benefits if they are up-scaled. Such criteria can be utilized to promote the up-scaling initiatives as well as their possible contribution in attaining the policy objectives (Geneletti and Zardo 2016; Raymond et al. 2017a). Therefore, it can be commented that upscaling of an NBS project could facilitate the green initiatives and can ensure overall the environmental development with numerous benefits.

2.3.7. Monitor and Evaluate Co-Benefits Across All Stages

Monitoring is involved with all other six stages of NBS implementation (Figure 2.2). There could be both long-term and short-term monitoring process for an NBS project. Furthermore, monitoring can help to develop long-term plan rather than only looking for immediate benefits (Kabisch et al. 2016). Any Nature-Based Solution is required to monitor as they are made either using the ecosystem components or combing green material with the grey elements. The prolonged monitoring process can let the planners understand about possible necessary changes from negative impacts and the issues to be considered during the upscaling of an NBS (Connop et al. 2016). For the long-term monitoring of an NBS project, it is essential to understand the indicators of effectiveness e.g. environmental performance, civil participation and health and well-being etc. (Kabisch et al. 2016 and Raymond et al. 2017b). However, sometimes authorities show their apathy for NBS project due to the cost involved with monitoring (see section 2.4.4 for further detail). So, it's obvious that monitoring is an indispensable part of implementing NBS project. Every NBS must have enough provision and focus on its monitoring so that the project becomes successful.

To summarize about the implementation stages of NBS, it can be uttered that instead of being a newly developed concept, Nature-Based Solutions are also required to implement following a few stages. Furthermore, implementing these natural solutions through different step ensures stakeholders to get involved and contribute for an effective solution to the chosen problem as well as to maximize the benefit from a project that uses the natural tools. The subsequent sections narrate the possible constraints that might be confronted in the different stages of NBS implementation.

2.4 Limitations of NBS and Implementation Challenges

While implementing Nature-Based Solutions by different actors, it is necessary to consider the financial, political and scientific challenges all together (Maes and Jacobs 2017). In addition, Experts require to think about different components of biodiversity, urban management, governance (McGinnis and Ostrom 2014) and also to incorporate the diversified knowledge base for the effective design and implementation of NBS so that these solutions get the acceptance to different stakeholders (Frantzeskaki and Kabisch 2016; Maes and Jacobs 2017; Raymond et al. 2017b; Raymond et al. 2017a). Even though NBS offer a substantial number of advantages, still those benefits are not equally applicable in varied circumstances (European Commission 2016; Naumann et al. 2011; Denjean et al. 2017). NBS cannot be argued as a collection of *"do it all"* measures because these solutions also have constraints in terms of applicability (Fernandes and Guiomar 2018). The concept of NBS is still being refined by the

European Commission using evidences that have resulted from the implementation of different projects (Faivre et al. 2017).

There are several constraints that have made the implementation of NBS challenging to address different environmental issues. The most significant challenges that are related to the application of NBS include but not limited to the Uncertainty about future benefits or value (Raymond et al. 2017a; Kabisch et al. 2016a; Kabisch et al. 2016b; Nesshöver et al. 2017), Lack of established implementation guideline for NBS (Pontee et al. 2016), "Disconnection between short-term actions and long-term goals", absence of sectoral language like traditional infrastructures (Kabisch et al. 2016a), Assuring the participation of several stakeholders, "Guaranteeing the proper application of multi and transdisciplinary knowledge" (Nesshöver et al. 2017), Unfamiliarity of NBS concept to the wider public (Kabisch et al. 2016b), Lack of political and economic will (Balian et al. 2016) and Financial constraints of individual municipality (Droste et al. 2017). In addition, NBS might not be feasible for all urban areas because these require more space than traditional grey interventions (Boelee et al. 2017). Furthermore, health problems might also result from NBS, like allergies from pollen grain or spread of any infection ailments to the residents living nearby (Keune et al. 2013; Nesshöver et al. 2017). Based on the existing literatures, these notable barriers and challenges to implementation of NBS are critically depicted in the following sub-divisions.

2.4.1 Uncertainties of Future Impacts, Benefits and Risks

Implementing NBS relates different sorts of uncertainties. Most of the times, while designing NBS projects, designers need to deal with a complicated socio-ecological system because of not knowing the definite responsibility of the management and insufficient information about the natural factors (Suding et al. 2004; Seastedt et al. 2008; Nesshöver et al. 2017). In some NBS projects, the value and paybacks that might be brought about by a Nature-Based Solution for certain stakeholders, are quite uncertain as well (Kaczorowska et al. 2016; Raymond et al. 2017a; Balian et al. 2016). In a couple of research papers, Kabisch and his colleagues have defined such uncertainties as *"fear of the unknowns".* This fear of not knowing the future risk and potential impacts may result in the changes in urban planning (Kabisch et al. 2016a, b). Moreover, there is a vagueness about which type of NBS or green infrastructures have the utmost potential to address a risk like flooding (Zölch et al. 2017). Considering the uncertainties and possible effects of NBS through time and space, there should have obligations for assessing the risks and to look for possible future alternative solutions. If not, NBS might create negative impacts rather than solutions (Eggermont et al. 2015). In a number of research works (Assmuth and Hildén 2008; Lindenmayer et al. 2008; Assmuth et al., 2010), '*adaptive management'* is mentioned as another way of dealing with uncertainty which includes *"devising flexible ways to maximize learning opportunities by applying different strategies, and the consideration of practices as experiments by ensuring that management treatments are replicated and responses are carefully monitored" (*Nesshöver et al. 2017, P. 1221). In addition, focusing on the management for increased resilience could be another way to minimize the negative consequences of NBS (Lindenmayer et al., 2008; Nesshöver et al. 2017). Due to the different nature of NBS, it is quite significant to undertake new strategies for implementing and maintaining the NBS projects than other approaches (Kabisch et al. 2016a, b). Therefore, it is understood that the uncertainty of possible future outcomes from an NBS project might create a challenge in terms of whether the project should be implemented or not. This uncertainty could be realized by the different actors who are involved for an NBS, however, bringing stakeholders from different levels for the planning or implementation of NBS is also a noteworthy challenge; the next chunk of discussion elaborates this aspect.

2.4.2 Difficulties in Involving Multiple Stakeholders

Stakeholders are usually communicated and involved in the implementation phase of different large projects (Bragança et al. 2014; Raymond et al. 2017a). In a substantial number of research works, the participation of varied stakeholders has been considered as indispensable to the implementation of NBS projects. Stakeholders' involvement can ensure "substantive" benefits (e.g contribution of knowledge or perspectives) (van den Hove 2000), "instrumental" benefits (e.g. stakeholders support or consent) (Parkins and Mitchell 2005) and "normative" benefits (e.g increasing the legitimacy of the process) (Schultz et al. 2010) in the planning and improvement of a project (Nesshöver et al. 2017). However, bringing different stakeholders in the planning and implementation is considered as one of the most notable challenges of NBS projects as well. Stakeholders can be the residents, administrations, policymakers, planners, environmentalists and many more. The process of participation can be more or less complicated depending on the matters related to the project (Fish 2011; Keune and Dendoncker 2013; Nesshöver et al. 2017). It is quite challenging to manage the stakeholders' perceptions about the long-term and short-term benefits that will be offered by the chosen NBS compared the estimated expenditures (Raymond et al. 2017a,b). Again, the absence of coordination or spontaneous support between or among the administrative bodies could result in budget failure, ineffective use of the resources, maladaptation or unnecessary investments (OpenNESS 2015). Instead of having advantages of the participatory process, in most cases, the implementation phase becomes more complex due to the involvement of stakeholders from different levels. Nevertheless, the participative approach cannot be ignored as NBS aim to ensure co-benefits alongside fulfilling the main objectives of the projects. Next section describes the necessity and issues that are faced while integrating long and short-term goals of an NBS project.

2.4.3 Disconnection Between Short-term Actions and Long-term Goals

Diverse temporal issues are incorporated to the Nature-Based Solutions which are designed and implemented to address an existing challenge. It remains vague which approach of NBS could provide an immediate benefit or which will be more effective in the long run after implementation (Kabisch et al. 2016a). Even though many pilot projects are being conducted throughout Europe to perceive the time that different NBS projects might take to become effective, uncertainty remains regarding when the project will serve for a purpose. This ambiguity of not having an exact timeline of effectiveness for NBS projects has been a post-implementation challenge. Again, there is a discontinuation between the long-term and short-term benefits of NBS. In most cases, considering the local politics and to demonstrate the immediate benefits of the projects, short-term goals are tried to achieve. However, some of these projects which were aimed to serve immediately, might not run for a long time due to the disconnection of short and long-term goals. Because to attain long-term objectives for a project, it's necessary to specify the monitoring strategies, related costs and the authority who will take care of future issues of that project (Kabisch et al. 2016b). As mentioned in the earlier section (2.4.1), the effectiveness and future impacts of NBS still remain unclear, integrating the short and long-term goals are quite challenging. This is because planners of the project might not give the assurance of what type of benefit could be attained shortly or after a long-term period. Therefore, the need for further research is recognized by focusing on this issue. In addition, specifying the immediate benefits and long-term outcomes from a project can surely attract the stakeholders to become more motivated for the NBS in addressing different challenges like an urban flood. The further section focuses on the monetary and administrative aspects of NBS implementation.

2.4.4 Financial & Political Constraints

Lack of political and economic will are noteworthy obstacles to the NBS implementation. Furthermore, there are also limitations regarding timing and financial issues (Baur et al. 2013; Hansen et al. 2015; Kabisch 2015). The problem of "somebody has to pay" has made the application of NBS projects challenging (Balian et al. 2016). The traditional infrastructures or other economic growth-related issues are prioritized and most of the times less focus, as well as funds, are given for materializing an NBS design (Kabisch et al. 2016b). Sometimes, the administration cannot define or specify who will be responsible for the expenses of the project. Moreover, NBS project relates a continuous investment for monitoring. Considering this matter, in many projects, no such defined strategies are mentioned for long-term monitoring and it is not specified how long the project will be monitored (Raymond et al. 2017a). Subsequently, financial limitations might result in the political unwillingness for undertaking Nature-Based Solutions. On the other hand, while implementing any NBS project, an individual municipality might not have sufficient fund, manpower or skills which can hamper the successful implementation of a project. However, if an NBS initiative somehow benefits more than one municipality, in that case, there could be a possibility of sharing the responsibilities and costs by inter-municipal cooperation (Droste et al. 2017). In sum, it's evident that an NBS project could be abandoned due to the uncertainty of who will pay for the project or how long the project will get funding. However, the challenge of having a fund for NBS could be solved if the decision-makers change their attitude towards NBS and prioritize these green measures as the traditional solution. Next section discusses the perception of mass people about "Nature-Based Solutions" concept.

2.4.5 Unfamiliarity or Awareness about the Concept of NBS to Mass People

The unfamiliarity with NBS concept or absence of awareness amongst the wider public about the advantages of NBS is a remarkable obstacle to the implementation (Balian et al. 2016; Kabisch et al. 2016b). The notion of Nature-Based Solutions has earned the attention of different level of stakeholders including business sectors, civil society, experts etc. Even after having an endeavor from policymaker (EC 2016; UN, 2013) and practitioners (Rizvi et al. 2015; Cohen-Shacham et al. 2016) to disseminate the aim and usefulness of NBS, the concept still remains unacquainted to the mass people (Nesshöver et al. 2016; Faivre et al. 2017). Therefore, the issue of NBS acceptability to the residents remains a question. Very few studies have been identified that reported the acceptability of NBS implementation by the local citizens (Groth and Vogt 2014; Perlaviciute and Steg 2014). In a study by Thorne et al. (2015) has mentioned the public preference towards NBS as a potential barrier to the application of NBS for flood protection. In a case study that was conducted in the Netherlands, Derkzen and his co-researchers (2016) have described that effective implementation of NBS is related to the societal preference which can be ensured by the stakeholders' involvement since the beginning of a project (Denjean et al. 2017). Therefore, ameliorating the perceptions of people about the pros and cons of NBS could support the effective implementation at different spatial scales.

2.5 Co-Benefits of NBS

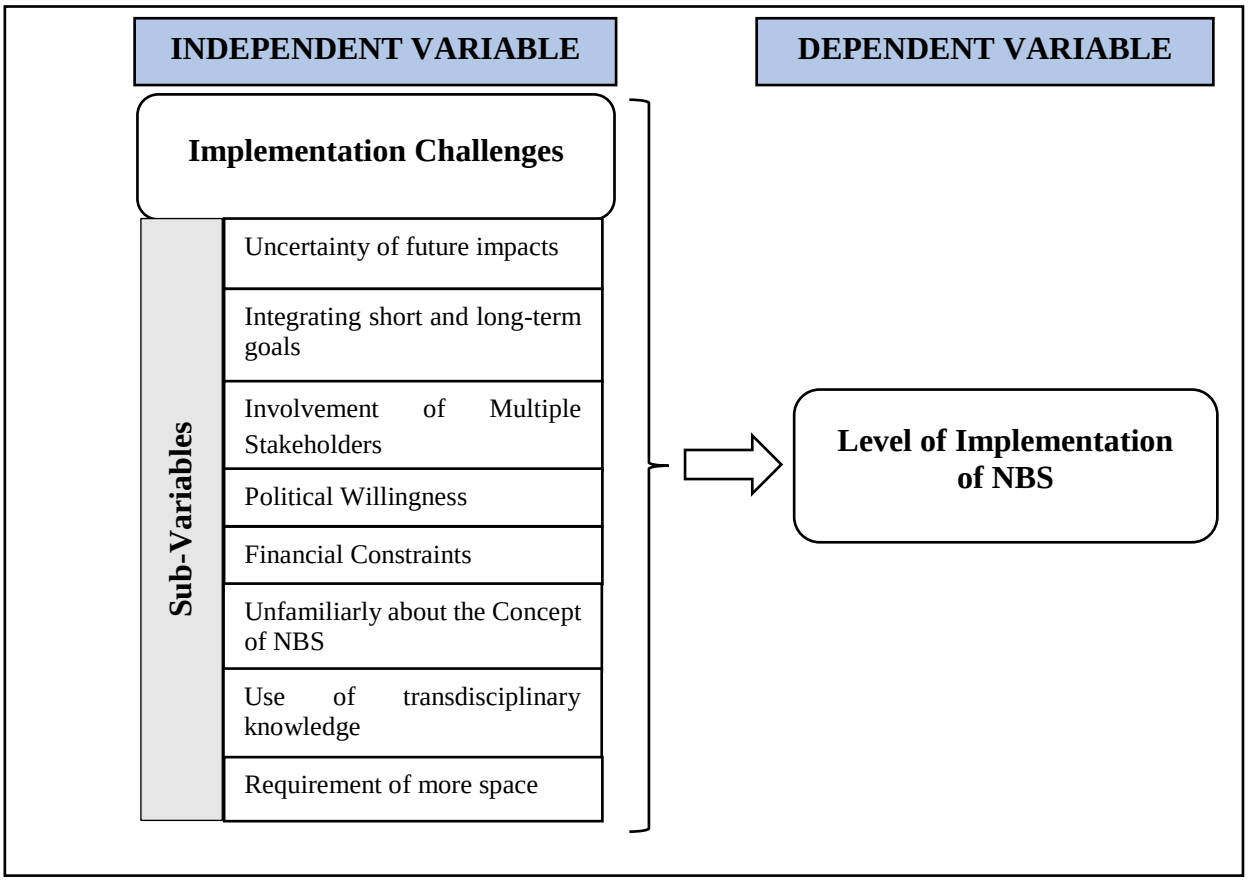
The concepts that stimulate the preservation, augmentation and restoration of biodiversity as well as ecosystems in order to address multiple issues at a time, 'Nature-Based Solutions' (NBS) is one of them (Kabisch et al. 2016a). The distinct criteria of NBS is that they become better with the elapse of time while the effectiveness of traditional grey infrastructures often declines over time (OpenNESS 2015). Moreover, as an advanced concept, it can enhance green economies and green jobs through involving stakeholders and ensuring co-benefits which would eventually create a link between social and economic interests (Kabisch et al. 2016b;

Raymond et al. 2017a, b). Alongside addressing a targeted problem, NBS offer co-benefits like ecosystem services and human welfare (Cohen-Shacham et al. 2016; Hartig et al. 2014) which are notable advantages of these solutions compared to the grey infrastructures (Pontee et al. 2016;). For instance, NBS that are designed for flood reduction can help to increase coastal resilience, promote the urban living environment (Larson and Perrings, 2013), reduction of urban heat island effect, expansion of biodiversity (McFarland et al. 2019), improving physical and mental health (Keniger et al. 2013; Hartig et al. 2014), strengthening social cohesion among citizens (Birch et al. 2010; Xiang et al. 2017), creating opportunities for recreation (IUCN 2019; Lafortezza and Sanesi 2019) and upgrading urban aesthetic beauty can consequently raise the property value through upgrading environmental quality of an area (Mitchell Polinsky and Rubinfeld, 2013; Raymond et al. 2017a). In fine, NBS have had the potentials to progress the quality of the life of urban inhabitants alongside dealing with a challenge like flooding (IUCN 2019; Lafortezza and Sanesi 2019). Considering the abundance of co-benefits that offered, NBS present a more competent and cost-efficient solution than traditional engineering approaches to deal with climate change impacts (European Commission 2015; Kabisch et al. 2016). However, these benefits of NBS could only be ensured if there is effective participation of stakeholders while implementing a project (Waylen et al. 2015a; Wyborn 2015). Different research works have tried to point out the additional benefits of NBS which can increase the acceptance of this concept towards varied stakeholders. Even after having some challenges in implementation, the versatility of Nature-Based Solutions could potentially contribute to address many socio-environmental and economic concerns in cities.

2.6 Conceptual Framework

Above discussion gives an overall idea about the research works that have been done so far focusing on Nature-Based Solutions. No such research work has been identified that focuses on the implementation challenges of NBS in Rotterdam. From the reviewed literature, a conceptual framework is drawn (Figure 2.3) consisting both the independent and dependent variables. Here ‘Implementation challenges’ is the independent variables and ‘Level of implementation’ is the dependent variable. Sub-independent variables include uncertainty of future benefits or risks, disconnection between the short and long-term objectives, confirming the involvement of multiple stakeholders, financial and political barriers, lack of people’s perception about NBS, integrating the use of transdisciplinary knowledge and requirement of more space for NBS. There lies a relation between the implementation challenges with the level of implementation of any NBS project. This framework suggests that more research works should be carried out focusing the independent variables (Figure 2.3) to better understand the implementation level of Nature-Based Solutions for the urban flood reduction in Rotterdam. Therefore, this research is an endeavor to contribute some knowledge about the limitations and challenges of implanting NBS in the Rotterdam municipality. It is expected that the study will be a step towards making the concept of ‘NBS challenges’ more articulate and will provide a base for future research initiatives.

Figure 2.3: Conceptual Framework.



Chapter 3: Research Design and Methods

3.1 Introduction

This chapter deals with the methodological aspects of the current research. It demonstrates the methods and techniques that have been applied throughout the study period to accomplish the research work. This study focuses on the implementation aspects of Nature-Based Solutions for flood reduction in Rotterdam. In addition, the research has also an aim to ascertain the supplementary benefits of NBS. The research has been designed concerning the objectives of this study. After reviewing a considerable literature in the preceding chapter, a concrete theoretical framework has been developed which has led to the further design of this research. The chapter discusses the strategies that have been adapted to materialize the research ideas, specific data collection methods to answer the research question, operationalization procedures, data analysis methods and techniques that were used for sampling. The chapter ends with explaining the reliability and validity of the collected data for this study.

3.2 Revised Research Question(s)

"What are the existing limitations and challenges that affect the implementation level of NBS for flood reduction in Rotterdam?"

3.2.1 Revised Sub-Questions

a) What is the level of implementation of NBS for flood reduction in Rotterdam?
   This sub-question has answered whether the chosen NBS projects have been successfully implemented, partially implemented or at the piloting stage yet. This question also provides the story of implementing the chosen NBS from the conceptualization stage to final implementation and some maintenance issues as well.

d) What are the challenges faced during NBS implementation in Rotterdam?
   The question has sought an enhanced understanding of what limitations of existing NBS in Rotterdam are (for flood reduction) and which factors are making the implementation procedures challenging. It has brought to the light about the bodies or level of government who were assigned with the implementation of NBS in this city.

b) Which co-benefits are provided by NBS in addition to flood reduction in Rotterdam?
   Through answering this sub-question, all the associated co-benefits from the NBS projects become known to the researcher. Alongside mitigating the flood risk in Rotterdam, all other associated benefits or facilities of the project are known.

3.3 Research Approach

This research has adopted the concept of inductive approach that starts with the specific observation of a phenomenon and consequently generates theories to draw the conclusions. The basic aim of inductive research is to support the existing knowledge and theories (Patton 1990), however, building theory is a complex task indeed (Strauss and Corbin 1998). Theories are resultant from the fieldwork, are developed and examined during fieldwork and are progressively expanded into higher levels of generalization towards the completion of data collection phase (Bryman 1996; Paul 2009). The reasons for considering the inductive approach in this research is that it considers the context where the attempt of study is active, while it is also suitable for small research units that generate both qualitative and quantitative

data. On the contrary, inductive research is most applicable when there is slightly known about the chosen problem (Thiel 2014). From the literature review (chapter 2), it has been known that there is a research gap focusing on the challenges and limitation of NBS implementation in Rotterdam. Moreover, there is no such work that has depicted the level of implementation of NBS projects in the same city. Therefore, the "inductive research approach" is found as the most appropriate to carry out this study.

3.4 Research Strategy

A research design or strategy provides a framework to gather and analyze the data (Bryman 2004) and to develop a comprehensible argument for satisfying the research question (Green and Thorogood 2004). This research has been conducted applying the 'Case Study' strategy. A case study is a research design which is conducted in a real-life situation or in the field. This research strategy can be implemented for both the inductive and deductive research (Theil 2017). Yin (1984) has defined case study as *"an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used."* (Yin 1984, P. 23). In other words, case study is an in-depth research strategy that narrows down its focus on a particular situation rather than covering vast issues like a survey or statistical analysis (Shuttleworth 2008). Most of the times, case study is conducted within a small geographical unit and on a limited number of respondents. A researcher can choose either a single case or multiple cases for his/her study, however, it relies on the research question and covered issues under the study (Zainal 2007). A case study has also been criticized by many researchers. The significant drawback of this research strategy is that outcomes of the research are quite tough to generalize as it focuses on the limited number of research units (Tellis 1997; Flyvbjerg 2006; Theil 2014). Despite having some criticisms, it's quite certain that case study often provides more detailed and realistic information than a mere numerical questionnaire (Shuttleworth 2008) and subsequently the researcher has become motivated to apply this strategy for the current research. The reasons for choosing 'Case Study' for this research are depicted in the following sub-sections.

3.4.1 Possibility of Including Unknown Variables

A case study is apposite for this because all the sub-independent variables are not known to the researcher. For the present study, some independent and dependent variables were identified after a careful analysis of the literatures. Some of the challenges that could constraint the implementation of NBS have been considered as the independent variables. However, it is still not certain whether those chosen variables are working as the constraining factors for NBS in Rotterdam or not. Therefore, it is very likely that more variables are identified with the time that are unknown to the research. Through implementing the case study strategy, it has become possible to work on several unknown variables which may not have covered under other research designs.

3.4.2 Limited Research Units

A Case study is a strategy that creates scope to collect very detail information of the limited number of research units (Thiel 2014). For this study, two different NBS projects have been chosen as two different cases. As much is not known about those cases, this research has tried to come up with the implementation aspects of those projects, more specifically, the existing challenges of implementation and the current implementation status (e.g. successfully implemented, partially implemented or in pilot stage) of the projects. 'Case study' strategy has

surely permitted the investigator to gather detailed information about the desired aspects and to explain the relationship between the dependent and independent variables of this study.

3.4.3 Making Comparison Between Cases

A case study offers the opportunity to compare and contrast the components of research. To make a comparison within a single case or among multiple cases, Case Study is the best possible strategy available. In the current research, the research question seeks to understand the implementation level of NBS in Rotterdam. However, choosing a single project or case might not let the research to incorporate underlying challenges with implementation status. Rather, the researcher aimed at selecting more than one project to create a clear comparison of the implementation level. In addition, other research strategies do not allow to create a comparison of cases with profound information. Consequently, Case Study has been found as the most appropriate strategy for this research.

3.4.4 Analysing Causal Process

Causal Process Tracing (CPT) is an essential instrument of qualitative analysis. CPT is defined as "the systematic examination of diagnostic evidence selected and analyzed in light of research questions and hypotheses posed by the investigator" (Collier 2011, P. 823). This methodological approach is predominantly appropriate to answer 'why' and 'how' questions as it emphasizes on the causal conditions, relationship and procedures which result in a possible specific outcome (Blatter and Haverland 2014). In other words, "CPT is a within-case method of analysis that concentrates on the processes and/or mechanisms that link the causes and the effects within specific cases" (Blatter and Haverland 2012). The study aimed at explaining the linkages between implementation challenges and level of implementation regarding Nature-Based Solutions that have been implemented for flood reduction in Rotterdam. However, in order to perceive the constraining factors of implementation, the research has looked at the processes of implementation to have a better understating of existing challenges. Using the CPT approach of Case study, the present research has found the causal impact of Implementation challenges on the implementation status. Moreover, case study has helped to realize the causal impacts of individual challenges. So, case study (causal process tracing) was helpful to discern the challenges that are associated with every stage of NBS implementation process.

3.5 Selection of Cases

Rotterdam is trying to come up with some efficient monitoring system that could provide assurance to obtain the co-benefits from the green solution projects in this city (Raymond et al. 2017a). Choosing the appropriate case is a significant part of the study as the project should be consistent with the goal of the researcher. The cases for research study were chosen following the mentioned steps below:

3.5.1 Reviewing Secondary Data Sources

As part of the climate change adaptation strategy, there are different NBS projects have been planned to implement in the city of Rotterdam. Many of those projects have already been materialized while some others are under the process. De Urbanisten (2016) has demonstrated their climate adaptation initiatives in their book where many on-going and completed projects in Rotterdam are described. Moreover, a thematic report by Frantzeskaki (2018) also mentioned about some of the NBS projects in Rotterdam. Both of these secondary sources of information have led the researcher to choose two appropriate NBS projects i.e. Water Square and ZOHO Rain Garden from a number of possible projects.

3.5.2 Assessing the Criteria of NBS

As discussed earlier (in section 2.2.2) Nature-Based Solutions could be something that use the ecosystem elements, imitates the natural processes or somehow supported by Nature (European Commission 2015). However, some researchers (Marton-Lefèvre 2012; van Wesenbeeck et al. 2014) expressed that NBS are not confined within the use of natural ingredients, rather soft engineering projects could also be considered as Nature-Based Solutions. Combing the aim of the current study, definition of NBS (European Commission 2015) and principles of NBS (IUCN 2019) a list of criteria is developed by the researcher for selecting the appropriate cases for current study. A few NBS projects of Rotterdam that are described by the secondary sources were assessed and finally, two projects have been selected to conduct this study (Figure 3.1). To verify the collected data and ensure the reliability of the assessment, the researcher has visited all the mentioned projects at the commencement of the data collection phase.

Figure 3.1: Assessing different projects to choose the appropriate cases.

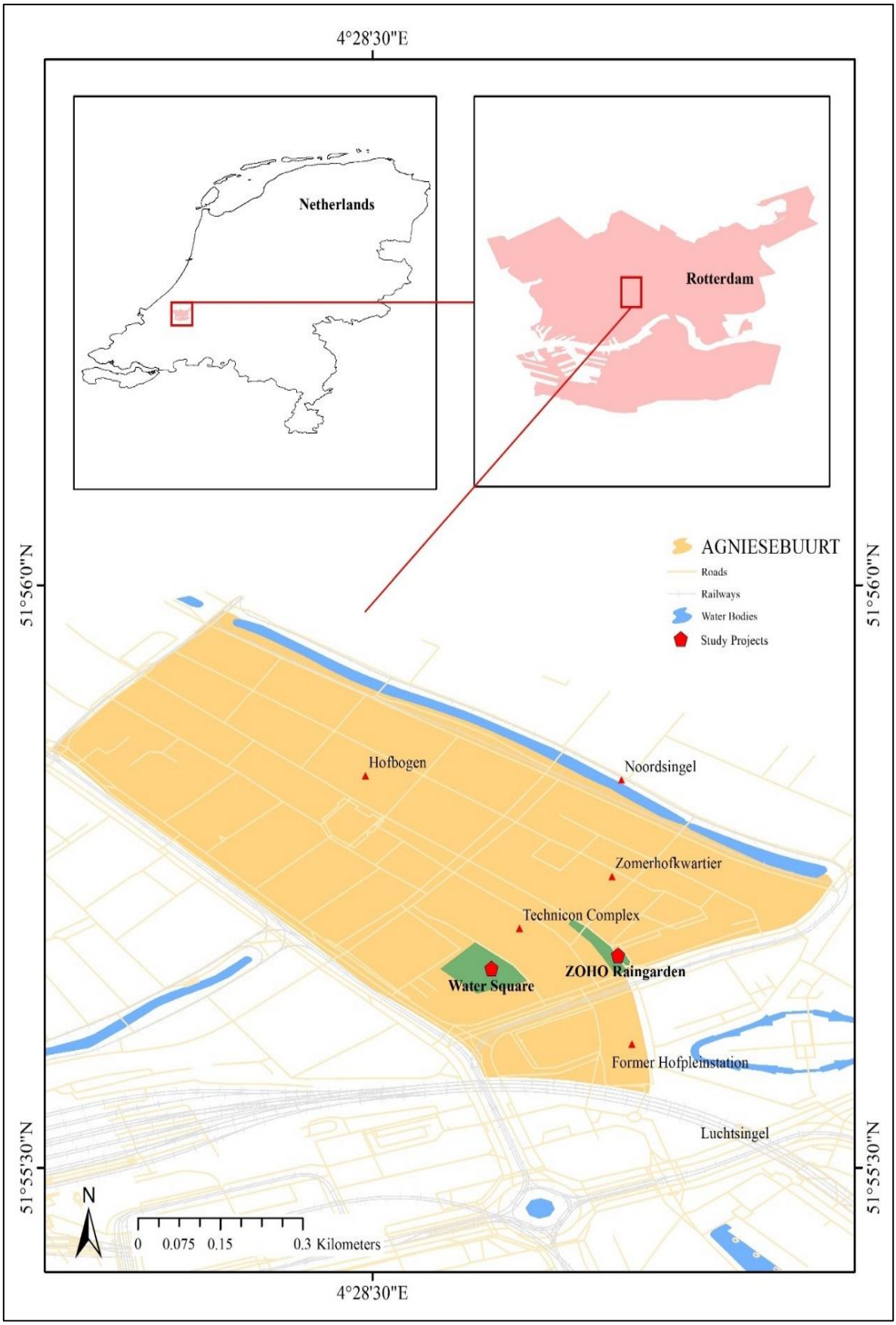
Criteria	Name of NBS Projects in Rotterdam				
	Water Square	**Boomjes promenade**	**Zoho Raingarden**	**Katshoek Rainaway Garden**	**Dakpark**
Flood Reduction	✓	✓	✓	✓	
Involvement of different stakeholders	✓		✓		✓
Multiple benefits	✓	✓	✓		✓
Addressing societal challenge	✓	✓	✓	✓	
Increasing Greenery	✓	✓	✓	✓	✓
Using, copying or supported by Nature	✓	✓	✓	✓	✓
Bottom-up approach	✓		✓		✓

(Source: Prepared by the Author)

3.5.3 Description of the Study Area and Projects

Both of the chosen projects for this study i.e. Water Square and Raingarden are located in the *Agniesebuurt* neighborhood (Map 3.1) of Rotterdam municipality. This 19th-century neighborhood is located in the Rotterdam Noord (HHSK 2019). *Agniesebuurt* is the smallest neighborhood of Rotterdam Noord having a population of 4100. Among the residents of this area, 65% people belong to the non-Dutch background. There are several schools and services are available in that area. Moreover, it considers as one of the hubs of creative entrepreneurs (Gemeente Rotterdam 2019). This urban local is characterized by less greenery space and more stony environment which has created a high risk of flooding in the area. However, there are many initiatives being undertaken by the responsible bodies in order to make the area as climate-proof in the coming days (HHSK 2019). Water Square and Raingarden (Table 3.1) are two of the climate adaptation initiatives that have been implemented to minimize the flood risk in *Agniesebuurt* area.

Map 3.1: Location of the Study Projects in *Agniesebuurt* neighborhood.



(Source: Prepared from Google Maps 2019)

Table 3.1: Description of the Cases.

Name of the Project	Description	Main Purpose
Water Square, Benthemplein, Rotterdam, The Netherlands	Water Square or Benthem Square is a floodable multifunctional square which is considered as an iconic water management structure which was constructed to hold a considerable amount of rainwater during the extreme rain events. It can help to remedy the flooding condition of its nearby areas. The construction of this project was started in 2010 and realized by 2014. Benthem square is the first water square in the world of its type that also provides numerous benefits to its users alongside flood management (Bassolino 2019).	- Water Retention - Flood Protection - Recreation
ZOHO Raingarden, Rotterdam, The Netherlands	ZOHO Raingarden is a special type of public garden that holds excessive water during the rain events. This project was initiated to modify a monotonous parking space to a greenish and unpaved surface. This project was accomplished through two different phases where Urbanisten initiated the 1st phase and the later phase was done by Rotterdam municipality. This garden receives rain water from around 3000 sq. meter of surface area alongside providing some other benefits to the local community or its users (De Urbanisten 2016).	- Water Retention - Flood Protection - Depaving surface

3.6 Operationalization: Variables, Indicators

Operationalization is the transformation of theories or concepts into measurable entities (Thiel 2014). The central concept of this research is the implementation aspects of NBS in Rotterdam. The theoretical framework that has been developed from the review of existing literatures, demonstrates both the independent and dependent variables of this research. In order to materialize the variables for the current research, it is essential to unpack the variables into measurable indicators. All the chosen variables are operationalized into sub-variables, indicators with the scale of measurement (Table 3.2). However, the measurement or scale is different for collecting qualitative and quantitative data.

Table 3.2: Operationalization of variables and indicators.

Concepts	Variables	Sub-variables	Indicators	Measurement	Type of Data	Data Collection Method
Implementation aspects of Nature-Based Solutions	Challenges of Implementation **(Independent variable)**	Uncertainty of future impacts	Expected Level of benefits	Scale 0 to 4 4 – Substantial Benefits 3 – High benefits 2 – Moderate Benefits 1 – Low Benefits 0 – No Benefits	Quantitative	Key Informants Interview (KII)
			Possibility of target achievement	Scale 0 to 4 4 – Highly possible 3 – Possible 2 – Possible with some limitation 1 – Cannot be predicted 0 – No Possibility	Quantitative	KII
			Risk level of negative effects	Scale 0 to 4 4 – Very High risk 3 – High Risk 2 – Moderate risk 1 – Low risk 0 – No risk at all	Quantitative	KII
			Reliability in terms of effectiveness	Scale 0 to 4 4 – Fully Solving the problem 3 – Can be more effective than grey infrastructure 2 – Equally effective as grey projects 1 – Less effective than grey	Quantitative	KII

				0 – Very little effective		
		Integrating short and long-term goal	Achievement of immediate benefits	Yes No If Yes – 2 – Achieved as planned 1 – Partially achieved	Quantitative	KII
			Link between short and long-term goals	Perception of the linkage between short and long-term goal	Qualitative	KII
		Involvement of Multiple Stakeholders	Spontaneity of participation	Who were the stakeholders?	Qualitative	KII and Questionnaire
				Scale 0 to 4 4 – Very Spontaneously participated 3 – Spontaneously participated 2 – Participated with some condition 1 – Only few Stakeholders participated 0 – No participation of Stakeholders	Quantitative	
			Level of contribution	Scale 0 to 4 4 – Significantly Contributed by all chosen stakeholders 3 - Contributed by all stakeholders with some limitations 2 – Supported by some stakeholders 1 – Supported by only a few stakeholders 0 – Project was abandoned due to the unsupported of stakeholders	Quantitative	KII and Questionnaire
		Financial Constraints	Availability of fund	What were the main sources of funding?	Qualitative	KII

				Scale 0 to 4 4 – Sufficient fund was available 3 – Funding was available with some limitations 2 – Funding was partially available 1 – Little funding was given 0 – No fund was available	Quantitative	
			Reliable funding sources	1 – Yes 2 – No	Quantitative	KII
			Duration of financial support	Scale 0 to 4 4 - Throughout the project including long-term monitoring cost 3 – Project investment and short-term budget for monitoring 2 – Once investment only 1 – Part of project building 0 - Project was abandoned due to financial deficit	Quantitative	KII
		Political Willingness	Level of government's involvement	Scale 0 to 4 4 – Fully supported by the national government 3 – Join venture of national and local government 2 – Only supported by local government 1 – Partially Supported by Local or National government 0 – No government support/ private initiative	Quantitative	KII

			Level of Priority	Scale 0 to 4 4 – Highly prioritized 3- Prioritized than grey projects 2 – equally prioritized as grey projects 1 – less priority than engineering projects 0 – no priority at all	Quantitative	KII
		Unfamiliarly about the Concept of NBS	Level of familiarity	Scale 0 to 4 4 – Very familiar and already involved with NBS 3 – Familiar but never got involved in NBS 2 – Heard about the concept with some idea 1 – Heard about the concept but no idea 0 – Not familiar at all	Quantitative	Questionnaire
			Understanding of uses	Perception of the uses of NBS	Qualitative	Questionnaire
			Perceived co-benefits	Benefits that they have observed so far	Qualitative	Questionnaire
			Participation in project planning	1 – Yes 2 – No	Quantitative	Questionnaire
			Perceived negative impacts	Perceived disadvantage of the NBS project	Qualitative	Questionnaire
		Use of transdisciplinary knowledge	Involvement of experts	Experts from which sectors were involved?	Qualitative	KII
			Integrating different ideas	Scale 0 to 4 4 – Very Successfully integrated 3 – Integrated somehow 2 – Integrated with some difficulties 1 – Partially integrated	Quantitative	KII

				0 – No integration of multidisciplinary knowledge		
		Requirement of more space	Availability of space	Difficulties in managing space	Qualitative	KII and Questionnaire
			Requirement of area	Scale 0 to 4 4 – Very large area required 3 – Required more space than traditional infrastructures 2 – Almost equal as grey project 1 – Less than traditional projects 0 – Project was done in a small area	Quantitative	KII and Questionnaire
	Level of Implementation **(Dependent variable)**	Successfully implemented	Materializing the design	Scale 0 to 4 4 – Perfectly implementation of design 3 – Full implementation of design with little constraints 2 – Partial implementation of design 1 – Little implementation of design 0 – Design didn't work as planned	Quantitative	KII
			Attainment of Goals	Scale 0 to 4 4 – Goals are successfully achieved 3 – Goals are achieved but not as expected 2 – Goals are about to achieve 1 – Some of the goals are achieved 0 – No attainment of Goal yet	Quantitative	KII
			Ensuring co-benefits	Scale 0 to 4 4 – Significant numbers of co-benefits are achieved even more than expected 3 - Planned co-benefits are gained only	Quantitative	KII and Questionnaire

				2 – Some co-benefits are provided 1 – Few co-benefits with difficulties 0 – No co-benefits at all		
		Partially implemented	Materializing the design	Scale 0 to 4 4 – Perfectly implementation of design 3 – Full implementation of design with little constraints 2 – Partial implementation of design 1 – Little implementation of design 0 – Design didn't work as planned	Quantitative	KII
			Attainment of Goals	Scale 0 to 4 4 – Goals are successfully achieved 3 – Goals are achieved but not as expected 2 – Goals are about to achieve 1 – Some of the goals are achieved 0 – No attainment of Goal yet	Quantitative	KII
			Ensuring co-benefits	Scale 0 to 4 4 – Significant numbers of co-benefits are achieved even more than expected 3 - Planned co-benefits are gained only 2 – Some co-benefits are provided 1 – Few co-benefits with difficulties 0 – No co-benefits at all	Quantitative	KII and Questionnaire
		Not implemented	Materializing the design	Scale 0 to 4 4 – Perfectly implementation of design	Quantitative	KII

				3 – Full implementation of design with little constraints 2 – Partial implementation of design 1 – Little implementation of design 0 – Design didn't work as planned		
			Attainment of Goals	Scale 0 to 4 4 – Goals are successfully achieved 3 – Goals are achieved but not as expected 2 – Goals are about to achieve 1 – Some of the goals are achieved 0 – No attainment of Goal yet	Quantitative	KII
			Ensuring co-benefits	Scale 0 to 4 4 – Significant numbers of co-benefits are achieved even more than expected 3 - Planned co-benefits are gained only 2 – Some co-benefits are provided 1 – Few co-benefits with difficulties 0 – No co-benefits at all	Quantitative	KII and Questionnaire

3.7 Sample Size and Selection

Sampling is the *"process of selecting just a small group of cases from out of a large group"* (Walliman 2017, P. 93). In a research work, it rarely becomes possible to work on the entire population and that's why it is required to employ an effective sampling technique for a study. To identify a representative sample, it is vital to choose a sampling strategy relevant to the theoretical framework and research questions (Miles and Huberman 1994; Punch 1998). As the present research is based on using both the qualitative and quantitative data, two different methods of sampling have been applied simultaneously pertaining to the chosen data collection methods of this study (Table 3.3). Both purposive and random sampling methods are used for this study as a mixed type of research requires to combine both probability and non-probability sampling techniques (Sandelowski 2000). Below the sample size for current research regarding different data gathering methods are demonstrated in the table and described subsequently under-sampling category.

Table 3.3: Summary of the Sample design.

Data Collection Methods	Sampling Type	Sample Size	Sampling Groups
Questionnaire Survey	Simple Random Sampling	100	Users/ Residents
Key Informants Interviews	Purposive Sampling	8	Policymakers/Planners/ Municipal Authority

3.7.1 Purposive Sampling

The purposive sampling strategy is a non-probability selection method that identifies the sampling units based on a particular purpose (e.g. knowledge, skills or expertise of respondents on the research problem) (Freedman et al. 2007). This sampling strategy is the most appropriate for qualitative data collection. To select the samples for Key Informants Interviews (KII), the purposive sampling technique is applied. Expertise on the chosen projects and knowledge on managing selected NBS will serve as the purposes of choosing a sample for Key Informants Interviews. The researcher has interviewed only those people who are involved with either the implementation or maintenance of both projects (i.e. Water Square and ZOHO Raingarden). Total 8 Key Informant interviews (4 for each case) have been conducted that include Project manager, Project leader, urban planner, Architect, Maintainer and Stakeholder. To identify suitable people for interview, the snowballing technique was very helpful, which is a chain referral sampling method extensively applied in "qualitative sociological research" (Biernacki and Waldorf 1981).

3.7.2 Simple Random Sampling

"Simple random sampling" is the modest form of probability sampling where each unit of the population has an identical possibility to be selected (Showkat and Parveen 2017). This sampling strategy is applied to conduct a questionnaire survey. The respondents were the users or people who often visit these places (Benthemplein water square and Zoho Raingarden) at different times of the day. The researcher randomly approached the people of different ages (mostly younger adults or older adults) and asked the question himself to the respondents. Sometimes, the researcher approached a group of teenagers when they were found gossiping inside the study areas. Total of 100 questionnaire interviews were taken place in both the study sites (50 in each project).

3.8 Primary Data Collection

With an aim to satisfy the objectives of this dissertation, both primary qualitative and quantitative data are gathered. Qualitative methods can be applied to investigate substantive aspects about which tiny is known (Stem 1980) like “people's lives”, “experiences”, “behaviors”, “emotions” and “feelings” (Strauss and Corbin 1998; Paul 2009). On the other hand, Quantitative research is usually taken to be represented by public surveys and by experimental inquiries (Bryman 1996). This study has applied a Questionnaire survey, Naturalistic observation and Key Informants Interview (KII) to collect the primary data. The following sub-section discusses the reasons for using both qualitative and quantitative data and elaborates the chosen primary data collection methods for this study.

3.8.1 Reasons for Choosing Mixed Approach

An increment in the implementation of the mixed-method approach are seen to magnify the scope and expand the analytic ability of the studies of the different researcher (Sandelowski 2000). Relying on a single data type might not provide an unambiguous understanding of the challenges associated with NBS and its implementation level. However, mixed research method provides more comprehensive data on the chosen perspectives (CIRT 2019b). This research will be based on using both qualitative and quantitative data. The reasons for choosing a mixed type of data use are as follows:

3.8.1.1 Wider and In-depth Data Collection

Even though a case study aims to focus more on the depth of the collected information, a questionnaire survey has also been chosen as one of the data collection methods. In this research, qualitative data has ensured the profoundness of information focusing the research problem, while quantitative data has increased the breadth of understanding of the problem which can eventually ensure the external validity of the present research. In a word, using mixed data method can assure the depth and breadth of information together.

3.8.1.2 Triangulating the Data

Triangulation in research is the application of more than one data collection approach for increasing the credibility of the research (Salkind 2010). Most of the case studies often use different data collection methods to increase the validity (i.e. accuracy and consistency) of the research. The current research was also aimed at triangulating the data in order to make the research more valid. Therefore, it is quite certain that using both quantifiable and non-quantifiable data have ensured the accuracy level and repeatability of information on different aspects.

3.8.1.3 Complementarity

The complementary use of quantitative and qualitative approaches offers a wide range of insights and aspects as well as ensures the validity of findings of the study (Maxwell 1998). As quantitative data only include numeric values, it cannot represent the people’s expression, thoughts or ideas in detail. All the required information to answer the question of this research can neither quantitative nor qualitative alone. Therefore, combining both qualitative and quantitative methods have assured complementarity of information on the co-benefits and implementation aspects of the selected cases.

3.8.2 Data Collection Methods

This study is intended to utilize three different methods to gather primary data. Combining the different data collection method can potentially raise the scope of research (Greene et al. 1989; Sandelowski 2000). Below the data collection methods (Table 3.4) and instruments are described with appropriate reasons for choosing them.

Table 3.4: Primary Data Collection Methods.

Data Collection Methods	Instruments	Data Type	Perspectives of Information
Questionnaire Survey	Semi-structured Questionnaire	Quantitative	Residents' individual perception on familiarity with NBS and co-benefits
Naturalistic Observation	Taking Notes	Qualitative	Ways of getting Co-benefits from NBS
Key Informants Interviews	Semi-structured interview questions	Qualitative	Challenges that affect the implementation level of NBS

3.8.2.1 Questionnaire Survey

Questionnaire survey is considered as the easiest way to gather data from a substantial number of people in a limited time and efficient way (Hewitt et al. 2017). Furthermore, collected data are reliable as the questionnaire helps the researcher to get repetitive information (McLeod 2018). A significant number of questionnaire survey have been conducted in this research because of its merits and to attain some quantifiable data alongside qualitative information. Perception of an individual who uses the project was gathered through implementing a semi-structured questionnaire. Before finalizing the questionnaire, it was pilot tested by the researcher to understand the necessary modification and feasibility of included questions in the list. Among the respondents, some were residents of *Agniesebuurt* neighbourhood of Rotterdam while the researcher found many others who visit these projects as they work somewhere nearby. The questionnaire mostly emphasized on collecting information about people's understanding of NBS, co-benefits that are offered by chosen NBS projects and some issue related to the implementation aspects. Total 100 questionnaire survey were held in this research.

3.8.2.2 Observation

Observation as a research method can be defined as "the systematic description of events, behaviors, and artifacts in the social setting chosen for study" (Marshall and Rossman 1989, P. 79). This is a qualitative data gathering method where a researcher utilizes his/her sense to observe the targeted people or a natural setting (Erlandson et al. 1993). For the current research, open or unstructured naturalistic observation method has been used. As the study has an endeavor to know about the resulted co-benefits of the chosen NBS projects, the researcher has observed the ways people are getting benefits from the NBS in Rotterdam. Even though the information on co-benefits was gathered through other data collection means as well, observation has let the researcher to understand the way people are being offered the varied benefits by the selected NBS projects. While conducting the questionnaire interviews, the researcher has continuously taken the notes of activities that people often do there. Furthermore, the sites were visited for several times to understand the impact of these Nature-Based projects on people. In addition, photographs were also captured throughout the time of data collection.

3.8.2.3 Key Informants Interview (KII)

Key Informant Interview is an in-depth qualitative interview with the people having keen expertise and knowledge regarding the perspective under research (Macfarlan 2014). Moreover, this data collection method is quite reliable as the information emerges from the people who possess sufficient knowledge about that field (USAID 1996). For the present

research, 5 key informants are chosen for each project, therefore, a total of 10 key informant interviews have been conducted on the selected personnel. This research method has helped to identify the existing challenges which are constraining the implementation of NBS in Rotterdam. Moreover, the implementation process and other related issues were known from KII. Because the chosen interviewees were somehow involved with the planning and implementation stage of both projects. Key informants were interviewed using a pre-set semi-structured outline. Most of the questions on the list are kept open to get detailed information on the desired aspects of this study.

3.9 Data analysis methods

The data that have been collected through questionnaire surveys are check thoroughly before processing in the computer. As the questionnaire has contained both open and close-ended questions, structured questions are categorized according to the pre-set codes. Open questions which got similar sorts of response are tried to include in some categories for the convenience of analysis. However, those open-ended questions which cannot be grouped into some categories, the researcher has considered that as qualitative information. In the processing of quantitative data Statistical Package for the Social Sciences (SPSS) 25.0 is used for the frequency and correlation analysis (Pearsons' coefficient and Spearman's rank Correlation). Along with SPSS, Microsoft Excel 2016 has been utilized to demonstrate the analyzed data through charts, graphs and diagrams. On the other hand, qualitative data are analyzed by looking for the patterns to categorize as much as possible. Furthermore, the researcher has utilized ATLAS.ti 8 as part of the qualitative data analysis. However, being qualitative information, all the collected data could not be grouped. Therefore, some necessary information also needed to present as the direct or indirect speech of the respondents.

3.10 Reliability and Validity

3.10.1 Reliability of the Research

Reliability of the research findings depends on the accurate and consistent measurement of the variables (Thiel 2014). To ensure the precision and consistency of the results, this research has applied triangulation or different methods of data collection. Through triangulating the data, there was a chance to cross-check the responses gathered from respondents. Due to the nature of an in-depth study on the chosen phenomenon, Case study often produces a huge amount of data. Sometimes the process becomes too long to gather detailed information and to manage the collected vast amount of data (Yin 1984). Considering this possible challenge, a very systematic plan can be developed to manage and organize data to increase the accuracy level of collected information. Besides, the repetition of information by varied primary data collection methods will also assure the consistency of this research.

3.10.2 Validity of the Research

Because of considering the small number of study units, the result from a case study is quite tough to generalize and, in most cases, it's impossible (Yin 1984). Moreover, choosing a single case will make it more difficult to generalize the findings (Tellis 1997). There are limited number of known NBS projects in Rotterdam. In order to overcome the limitation of external validity, two cases have been chosen and the researcher believes that the gathered data will represent the scenario of existing NBS projects in this city. As opposed to, the researcher has collected a substantial amount of data on the chosen aspects through triangulation; this could indeed certify the internal validity of the current research.

Chapter 4: Research Findings

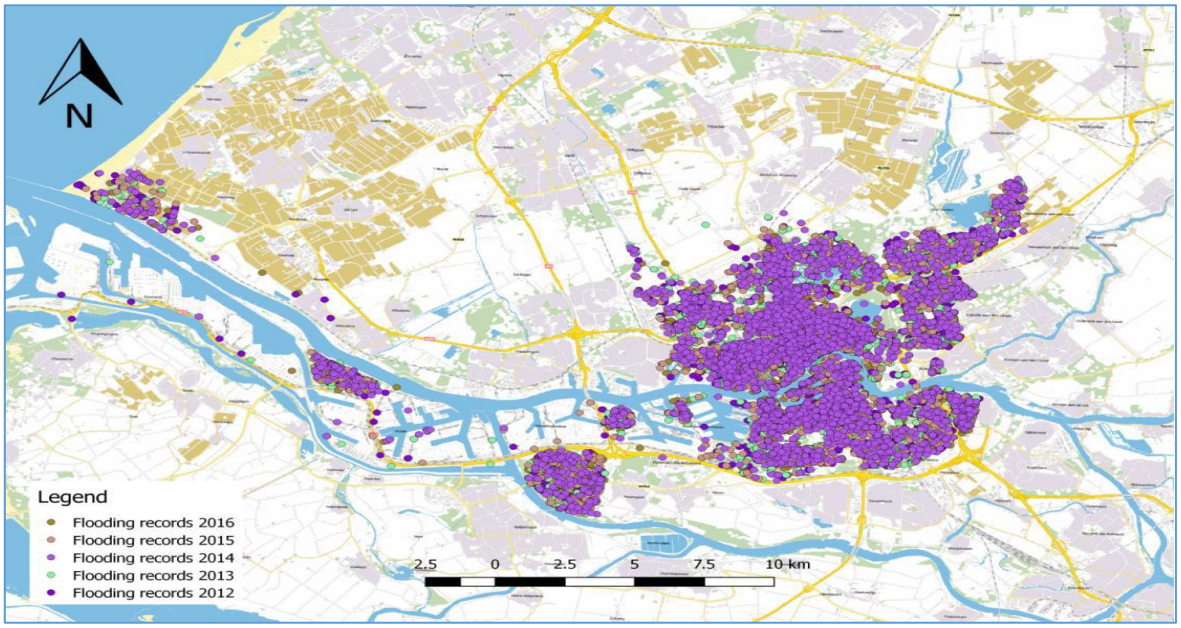
4.1 Introduction

Cities that have highly been anthropized throughout the world are badly confronting the deleterious effects of climate change (Bassolino 2019). The demand of cities to upgrade their infrastructures for ensuring the aesthetic view and sustainability have eventually propelled to introduce the new concept of "Nature-Based Solutions" (Frantzeskaki 2018). As a growing concept developed by the European Commission, "Nature-Based Solutions" (NBS) is still being analyzed and piloted in different countries to discern the possible contribution that can be made by NBS to confront the brunt of climate change in urban areas. Furthermore, different global organizations are increasingly conducting research to understand the diverse aspects of NBS. The current study has a focus on the implementation aspects of NBS in Rotterdam. This chapter describes a glimpse of flooding scenario and current NBS practice in Rotterdam, subsequently elaborates the existing challenges that are constraining the NBS implementation and identified implementation level of NBS in Rotterdam. Moreover, the chapter concludes by explaining the relation between implementation challenges and the level of implementation of the selected NBS projects.

4.2 Flooding Scenario in Rotterdam

As the 2nd largest city of Netherlands and the biggest port of Europe, Rotterdam possesses a vast water network and comprehensive drainage system to tackle the high-water flow. Even it has kept the provision for multifunctional infrastructures like underground water storage in Museumpark, Roof Park and Water Square at Benthemplein which can facilitate the draining out of the rain or flood water (Water Atlas of the Netherlands 2012). Nonetheless, Rotterdam is not free from the risk of flooding. Bouwens (2017) in his study identified that the flood hotspots of Rotterdam include the sub-districts "Rotterdam Centrum", "Delfshaven" and "Noord of Rotterdam". However, there are some other smaller flood-prone areas as well. Within the municipality, the identified flood-prone clusters are Overschie, Kralingen-Crooswijk, Ijsselmonde and Prins Alexander (Bouwens 2017). Map 4.1 demonstrates the locations of all flooding events that took place between 2012-2016 in Rotterdam Municipality.

Map 4.1: All flooding incident records for 2012-2016 in the Municipality of Rotterdam.



(Source: Adapted from Bouwens 2017)

On the other hand, heavy rainfall is a notable concern in the Rotterdam municipality and particularly in the city centre and in prewar districts (De Urbanisten 2016). The Zomerhofkwartier or shortly ZOHO is a business area located within the *Agniesebuurt* neighborhood of Rotterdam. During the heavy rain events, many of the streets, basement or backyards in this neighborhood get flooded (Barfoot 2017; HHSK 2019). The significant reason is the prominence of built-up surface area where about 75% concrete landscape is non-permeable and 50% of the paved parking space are not being used (Climate-proof Zomerhofkwartier workshop 2014). While visiting the neighborhood during the data collection phase of the present study, it was observed that there is very little green space in the area. Furthermore, it was also noticed that *Agniesebuurt* contains very few public spaces. While talking with a resident of the area about flood risk, he expressed,

> *"This is a densely populated and quite an old neighborhood where people from different cultural backgrounds are residing. It's true that the area is not green and most of the landscape is quite paved. I think such a condition of Agniesebuurt could possibly cause flooding if there is an extreme rainfall".*

Again, Barfoot (2017) reported that the number of excessive rain events is increasing, therefore an additional water storage provision is required in *Agniesebuurt* that can keep the area free from flooding. Otherwise, excessive water can affect the wooden pile or foundation of the households (Barfoot 2017). Alongside, insufficiency of infiltration space in the locality, presence of open water bodies at distant places are also factors of greater concern, which would have made the situation something different if situated closer. Furthermore, the inadequate capacity of the existing underground drainage system has made the situation complicated (De Urbanisten 2016). However, the authority has already taken varied initiatives of relying on Nature-Based Solutions in order to deal with the existing problems. The next section elaborates the current NBS practices in the *Agniesebuurt* as well as in other parts of Rotterdam Municipality.

4.3 Practices of NBS in Rotterdam

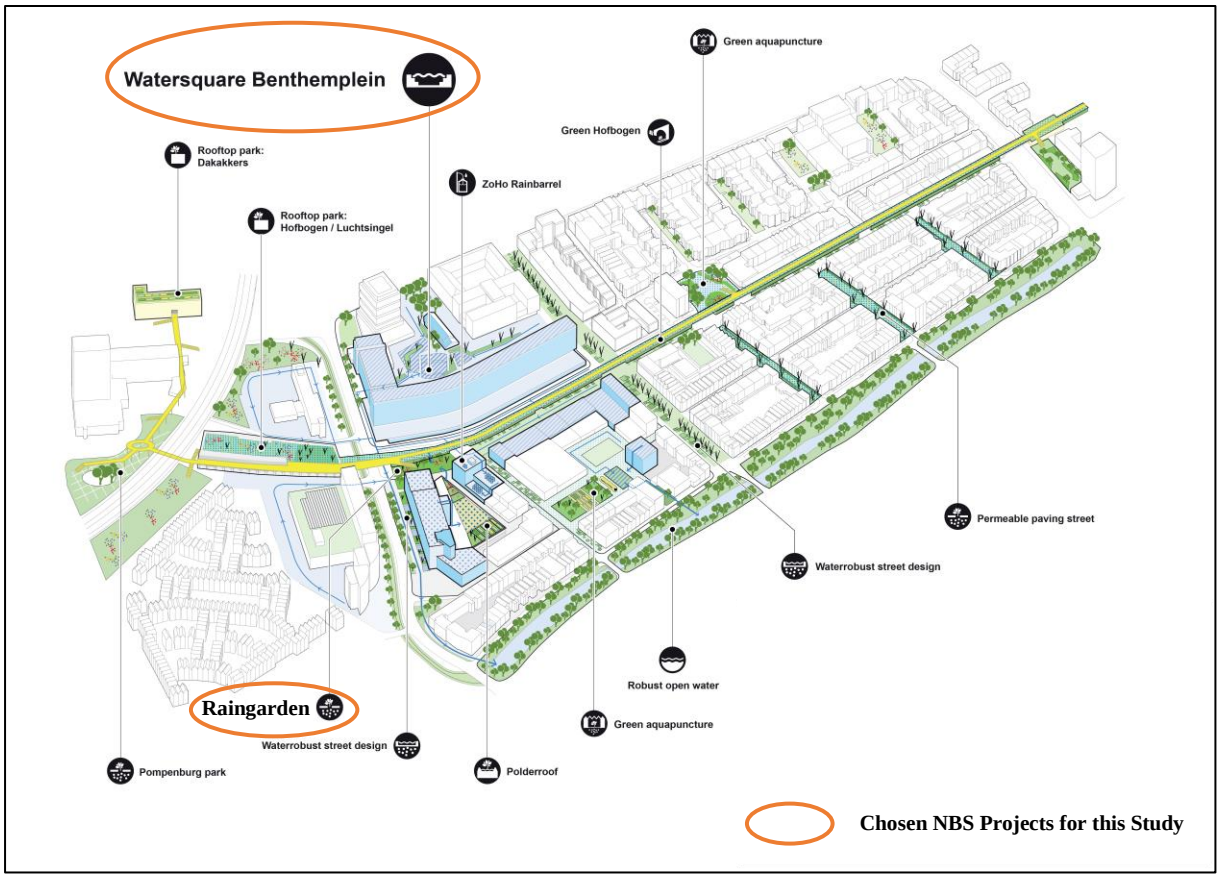
Alongside implementing the traditional infrastructures, Waterplan (2013) has also emphasized in increasing the green infrastructures (e.g. green roof) to increase the temporary storage capacity of water to prevent urban flooding. In order to make the city greener and public spaces attractive, different green solutions are initiated and many green roofs have already been made (Bouwens 2017). The city of Rotterdam has been facing transition and NBS can be lucrative for renovating the port areas which are left empty from industrial activities. Meanwhile, Rotterdam has come up with a few Nature-Based projects that represent the reclamation and regeneration of urban space (Frantzeskaki 2018). Some examples of NBS projects in Rotterdam are Dakakkers Roofgarden, Boomjes promenade, Katshoek Rain away Garden, ZOHO Raingardens etc. (Frantzeskaki 2019). Furthermore, there are some innovative and clean-tech solutions which are being implemented in Rotterdam like floating forest near the port area; to some extent, such solution can be considered as NBS as well (Frantzeskaki 2018). One of the Key Informants stated,

> *"Nature-Based Solutions can be used as something additional to the existing to Grey infrastructure. Using NBS can surely promote green development and could possibly reduce the sole reliance on hard solutions"*

Due to the high imperviousness of surface and being vulnerable to the flooding, different measures have been taken to make the *Agniesebuurt* neighborhood climate-proof (Barfoot

2017). The ZOHO district (in *Agniesebuurt)* of Rotterdam is chosen as a suitable pilot area for implementing climate adaptation strategies. The long-term ambition of increasing the permeable surface has propelled the climate-proof strategies in ZOHO (De Urbanisten 2016). As part of the climate adaptation strategies, many NBS initiatives have already been implemented and are being developed in ZOHO and other parts of Rotterdam municipality. It was known from a few Key Informants that most of the climate adaptation initiatives involve different stakeholders to ensure the best output of those projects. Figure 4.1 demonstrates different NBS projects including Water square and Rain Garden that have been initiated in *Agniesebuurt* neighborhood.

Figure 4.1: Nature-Based Solutions as part of climate adaptation strategies in *Agniesebuurt*.

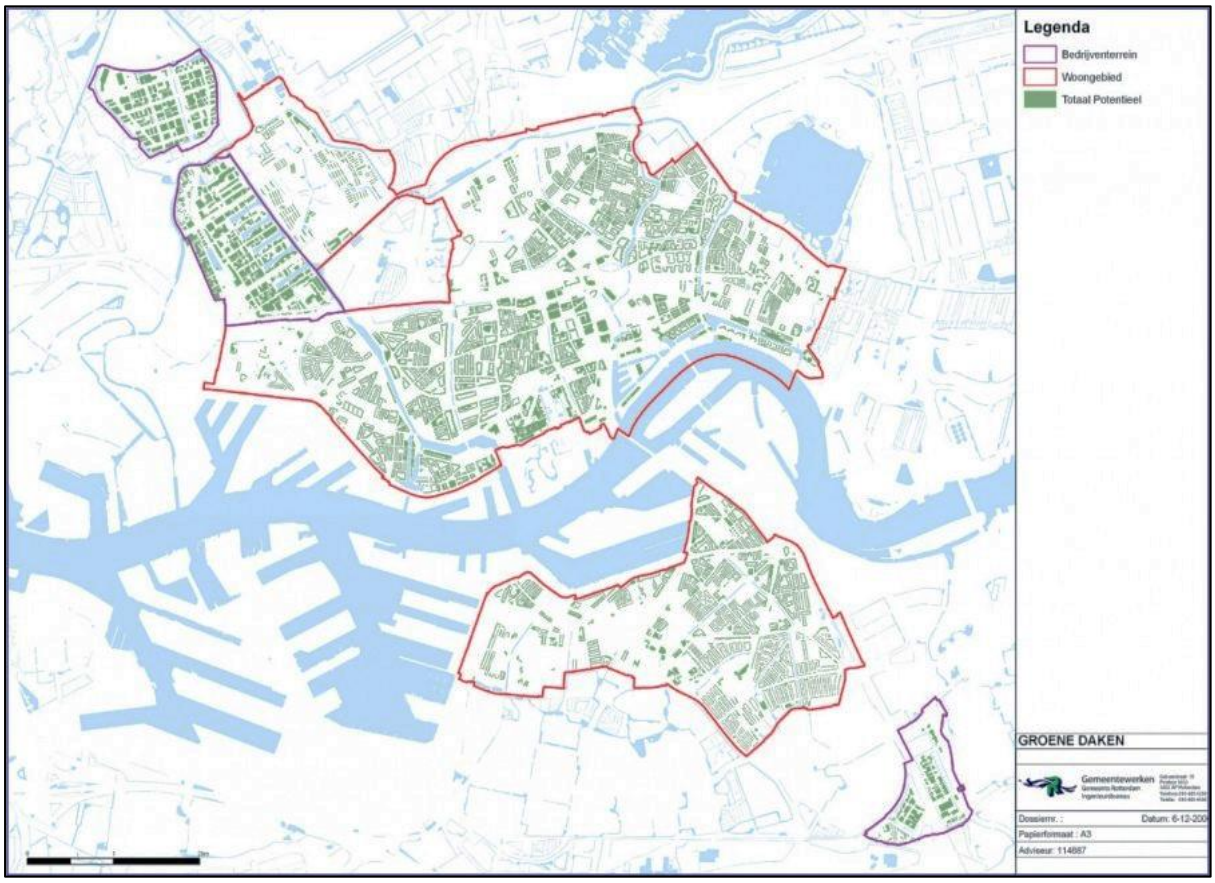


(Source: Adapted from De Urbanisten 2016)

Again, as a Nature-Based Solution, Green roofs can remarkably contribute to reducing surface water runoff during the storm (Stovin 2010; Stovin et al. 2013; Pauleit et al. 2017). In a few studies, it was determined that green roofs have the water holding capacity between 20% to 100% of the rainfall but it substantially relies on the factors like the design of the green roof, rainfall intensity or vegetation used (Czemiel Berndtsson 2010; Moran et al. 2003; Carter and Rasmussen 2006; Roehr and Kong 2010). Furthermore, green roofs along with a bio-retention system can greatly lessen the storm-water discharge rates to the pre-urbanized level (Trinh and Chui 2013). The research of Zölch and his colleagues (2017) showed that approximately 15% runoff can be lessened if all the roofs are made green and vegetation cover in cities is increased considerably (Zölch et al. 2017). The Dutch government has been working to extend the green roofs throughout the city and by 2030 it aims to achieve total 800,000 m^2 green roof in Rotterdam (Geisler et al. 2014). Map 4.2 shows the potential sites of Rotterdam where green roofs are possible to implement for stormwater reduction. The next section discusses the

people's views about the contribution made by both chosen projects in order to lessen the flood risk in the study area.

Map 4.2: Geographical scope of green roofs project in Rotterdam (Red outline is the residential area, Purple is business area).

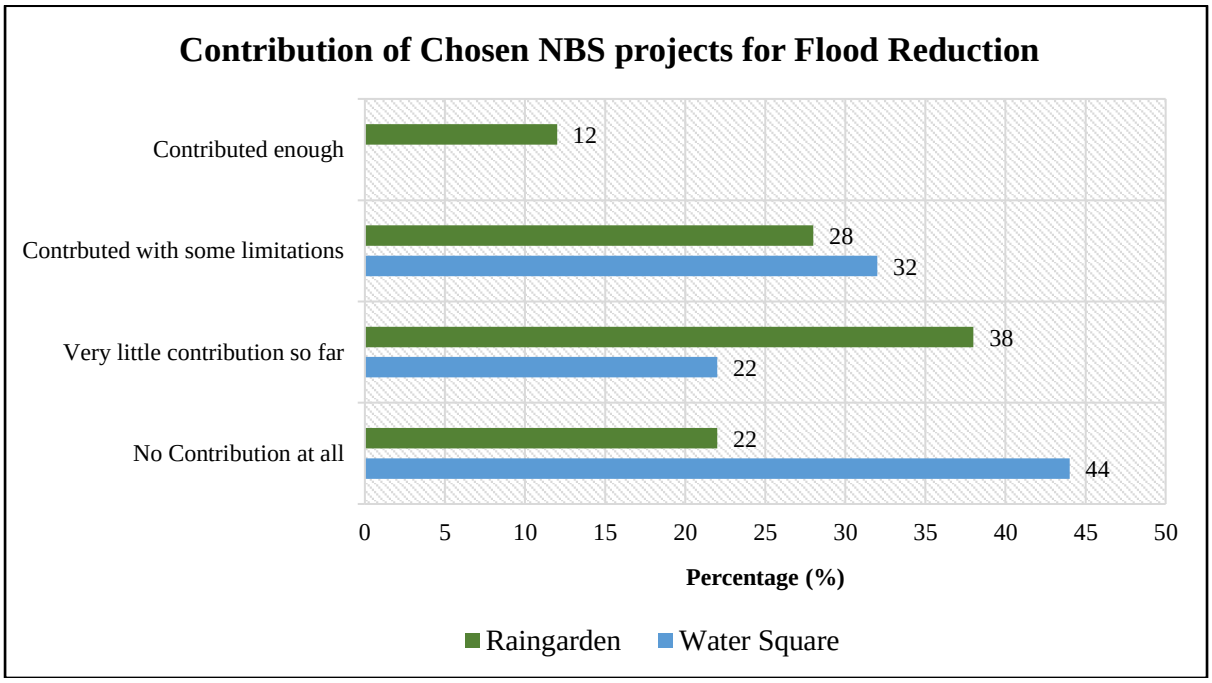


(Source: Adapted from Geisler et al. 2014)

4.4 Contribution of Chosen NBS Projects for Flood Reduction

The contribution and acceptance of NBS for reducing the flood risk on a broader scale is still unidentified and not well-documented (Schanze 2017). This study has sought the perceptions of people regarding the contribution made by both NBS projects in terms of flood risk reduction in the neighbourhood. About 30% people expressed that both Water Square and Raingarden have contributed to flood risk reduction with some limitations (Figure 4.2). They considered it because these two projects have the capacity to retain a significant volume of water during rainfall. As *Agniesebuurt* neighborhood has little green spaces than those of other areas in Rotterdam, some people think that Water Square and Raingarden are making the neighborhood secure from getting flooded. One respondent from Water Square said that even though it has enough capacity to hold a substantial amount of water, he never saw it to get fulfilled. He also added that the square might receive much water from the bigger area as it has a substantial retention capacity, however, it stores the rainwater that comes from the roof of surrounded buildings and the square itself. Therefore, it has some limitation instead of having a contribution to reducing flood risk. At the same time, 12% people of Raingarden opined that the project has contributed enough for lessening the flood risk in their area. Being the only green public space in this neighborhood, it can ease the infiltration of excessive water during rainfall.

Figure 4.2: People's perception about the contribution of Water Square and Raingarden for Flood reduction.



(Source: Field Survey 2019)

On the other hand, just less than half of the people think that Water Square has no contribution to decreasing flood risk in the area (Figure 4.2). While 22% people of Raingarden also assume no contribution from the project so far. It is understood that people's perception of the projects are somehow related to their understanding of NBS. Moreover, one Key Informant said that people mostly judge the contribution of a project depending on its visible effect. Moreover, it was said that the underlying contribution of a project like increasing the infiltration capacity of an area or performing like a sponge might not be perceived by the people. However, some of the respondents who possess a good understanding of NBS, they considered the projects as having a little contribution. Though few people expressed that more NBS projects like Water Square and Raingarden in the neighborhood can altogether put a significant contribution to minimize the flood risk in that area.

4.5 Descriptive Statistics of Independent Variables

Descriptive Statistics helps to discern the characteristics of a data set through providing an essence of the sample and measures of the data (Kenton 2019). Table 4.1 and 4.2 demonstrate the descriptive statistics for the indicators under the independent variables of this study. All the values in both tables are based on the perception of respondents. For each of the projects, 50 observations were placed in SPSS and data were analyzed for different indicators. Regarding the 'Gender' and 'Resident Status', both indicators have a minimum and maximum value between 1 and 2. Descriptive statistics for both projects (Table 4.1 and 4.2) show that most of the respondents were male. Mean value of Gender is found as 1.10 and 1.30 for the Water Square and Raingarden respectively. Furthermore, Standard Deviation (SD) for both of them presents the less dispersion of dataset from their mean values. Again, the mean value of the indicator 'Resident Status' shows that most of the respondents for Water Square were Dutch nationals (mean 1.33) while respondents for Raingarden project (Mean 1.59) are of non-Dutch background.

Table 4.1: Descriptive Statistics of Indicators (Water Square).

	Indicators	N	Minimum	Maximum	Mean	Std. Deviation
Basic Information of Respondents	Gender of the Respondents	50	1	2	1.10	.303
	Educational Qualification of the Respondents	50	1	3	2.02	.685
	Occupation of Respondents	50	1	4	2.02	.915
	Resident Status of Respondents	49	1	2	1.33	.474
Familiarity with NBS	Familiarity of Respondents with NBS Concept	50	0	4	1.20	1.125
	People's perception about the use of project	49	1	1	1.00	.000
	Perceived Uses of the Project	49	1	1	1.00	.000
Co-Benefits	Recreation	49	1	2	1.80	.407
	Relaxation	49	1	2	1.88	.331
	Community Gathering	50	1	2	1.68	.471
	Social Interaction	50	1	2	1.66	.479
	Good Environment	50	1	2	1.90	.303
	Scenic Beauty	50	1	2	1.58	.499
	Spots	50	1	2	1.22	.418
	Children's Playground	50	1	2	1.42	.499
Project's contribution	Contribution of the Project for Flood Reduction	49	1	3	1.88	.881
	Size of the Project	50	0	3	1.46	.838
	Effectiveness of NBS for flood reduction as Grey Infrastructure	49	1.00	3.00	1.7347	.75761
	Valid N (listwise)	43				

(Source: Field Survey 2019)

Descriptive statistics for Water Square project (Table 4.1) presents that some indicators have higher standard deviation while rest indicators are not much dispersed from their mean. Even all the responses for a few indicators are found to be located at the mean value; for instance, all the respondents replied positively regarding their acquaintance on the uses of Water Square. Therefore, the Standard Deviation for two consecutive indicators is zero. Regarding the indicators stating co-benefits of the project like Recreation, Relaxation, Community Gathering and Good Environment have the minimum and maximum value between 1 and 2. The mean value for these indicators is found mostly close to the maximum value, which means most of the people did not mention these benefits from Water square project. In addition, the Standard Deviation for all of these co-benefits are between 0.3 to 0.5, that reflects the less spread of the data set from their mean values. Though the minimum and maximum value for 'Familiarity of Respondents with NBS Concept' are between 0 and 4, the mean value 1.20 shows the people's less familiarity with the NBS. However, the data set of this indicator seems scattered as it possesses a higher standard deviation (1.125). Again, regarding the effectiveness of the Water

Square as compared to the Grey infrastructures, mean value is 1.7347 and SD is 0.757 which presents that people responded mostly about the less or moderate effectiveness of such NBS project. Likewise, in Table 4.2, mean value 1.80 for Raingarden effectiveness exhibit identical type of responses from the people.

Table 4.2: Descriptive Statistics of Indicators (Rain Garden).

	Indicators	N	Minimum	Maximum	Mean	Std. Deviation
Basic Information of Respondents	Gender of the Respondents	50	1	2	1.30	.463
	Educational Qualification of the Respondents	49	1	4	2.10	.963
	Occupation of Respondents	49	1	5	2.47	1.209
	Resident Status of Respondents	49	1	2	1.59	.497
Familiarity with NBS	Familiarity of Respondents with NBS Concept	50	0	3	.56	.812
	People's perception about the use of project	50	1	2	1.20	.404
	Perceived Uses of the Project	48	1	6	2.52	2.021
Co-Benefits	Relaxation	50	1	2	1.40	.495
	Community Gathering	50	1	2	1.80	.404
	Social Interaction	49	1	2	1.69	.466
	Ecological Benefits	50	1	2	1.20	.404
	Good Environment	50	1	2	1.10	.303
	Scenic Beauty	50	1	2	1.40	.495
	Green Environment	50	1	2	1.10	.303
	Children's Playground	48	1	2	1.69	.468
Project's contribution	Contribution of the Project for Flood Reduction	50	0	3	1.30	.953
	Size of the Project	50	0	2	.40	.670
	Effectiveness of NBS for flood reduction as Grey Infrastructure	50	1	3	1.80	.881
	Problems from Raingarden	48	1	3	2.71	.683
	Valid N (listwise)	0				

(Source: Field Survey 2019)

Contrariwise, Respondents of Raingarden project were found to have little familiarity with NBS which can be understood from the mean value of indicator 'Familiarity of Respondents with NBS Concept' (Table 4.2). Where the min. and max. values are between 1 and 3, mean is determined as 0.56 that shows to the tendency of most people to answer about their little acquaintance with the NBS concept. However, the dataset for this indicator seems to remain scattered from its mean which is reflected by the Standard Deviation (0.812). Regarding the uses of Raingarden project, the people's responses are found to be highly dispersed (SD 2.021) than its mean value. On the other hand, descriptive on 'Co-benefits from Raingarden' are a bit different than that of Water Square. The dataset shows that most of the responses (mean) are closer to a minimum value which reflects that the vast majority of respondents mentioned about

those co-benefits like Green Environment, Ecological Benefits, Good Environmental Condition and Relaxation. Moreover, the observations for these indicators show the propensity of staying closer to their mean because Standard Deviation for all of them are between 0.3 and 0.5.

4.6 Pearson's Correlation Test of Independent Variables

Pearson correlation (r) refers to a linear association between two variables. It is expressed through a value between +1 and -1. The sign of r (correlation coefficient) refers to the trend of a connection. However, the magnitude of r (correlation coefficient) refers to the intensity of the relationship (Kent state 2019). In statistical analysis +1 means perfect positive linear relation, 0 means no relation and -1 means perfect negative correlation. On the other hand, 0.1 < | r | < 0.3 means "small or weak correlation", 0.3 < | r | <0 .5 means "moderate correlation" and 0.5<| r | means "strong correlation" (Cohen 1988). For the purpose of this study, Pearson's correlation test is performed (Table 4.3 and Table 4.4). In order to discern the relationship status among the chosen indicators of Independent variables, Pearson's test is applied for both data set i.e. Water Square and Raingarden. Table 4.3 demonstrates that indicators have different correlation coefficient among themselves, while the value of r is found to vary from negative to positive for the varied indicators.

The highest correlation coefficient (r=0.701) is identified between the indicators 'Contribution of the Project for Flood Reduction' and 'Community Gathering', which shows the positive strong relationship between them. Presumably, as a Nature-based project community support to this project has somehow increased its contribution towards flood risk reduction in the neighborhood. However, the relation can be seen reciprocally as well, where reduction of flood risk in that area has motivated the community members to get together in the square considering its benefits and significance to them. In addition, it was known from the respondents that Water Square is a perfect place for community gathering. Alongside reducing the flood risks it facilitates social interaction among people. Therefore, the highest correlation value reflects the actuality of relationship regarding these two indicators. At the same time, 'Good Environment' and 'Recreation' possess a positively moderate strong correlation (0.666). Possibly the nice environment of Water Square attracts many people to visit the place for recreation purpose. Moreover, this NBS provides a considerable number of recreation facilities which was observed by the researcher during the fieldwork. In like manner, a strong positive correlation (0.603) is seen between 'Size of the project' and 'Children's playground' that means the optimum size of the Water Square project has created sufficient space for kids playing over there. Even many users of Water Square also reported that the spacious area of this Square has facilitated the playing of kids. Moreover, the project being secure for children, it encourages many parents to bring their kids in the square.

A positive weaker and moderate correlation are present among numerous indicators (Table 4.3), for instance, the correlation between 'Educational Qualification' and 'Familiarity with NBS' (0.154), between 'Community Gathering' and 'Occupation of the Respondents' (0.489) etc. Regarding the first two indicators, apparently, to a little extent, the familiarity with the concept of NBS depends on a person's educational qualification. While less educated people might have a slight acquaintance with this recently developed concept. Regarding 'Community Gathering' and 'Occupation of the Respondents', the coefficient value shows a moderate positive relation. During this study, it was observed and known that mostly students and teachers from nearby schools spend their time on Water Square. Though few people were also identified having different professions, all of them somehow related to the institutions located around the Square. However, it was informed by a resident that people from the neighbourhood rarely visit the place. Most of the users are either students or the professionals working around.

Table 4.3: Person's Correlation Test for Water Square project.

	Gender of the Respondents	Educational Qualification of the Respondents	Occupation of Respondents	Resident Status of Respondents	Familiarity of Respondents with NBS Concept	Recreation	Relaxation	Community Gathering	Social Interaction	Good Environment	Scenic Beauty	Spots	Children's Playground	Contribution of the Project for Flood Reduction	Size of the Project	Effectiveness of NBS for flood reduction
Gender of the Respondents	1															
Educational Qualification of the Respondents	-.010	1														
Occupation of Respondents	-.376**	-.033	1													
Resident Status of Respondents	-.208	-.720**	.499**	1												
Familiarity of Respondents with NBS Concept	-.359*	.154	-.421**	-.571**	1											
Recreation	.171	.385**	.565**	-.181	-.369**	1										
Relaxation	.126	-.534**	.008	.267	.061	-.194	1									
Community Gathering	-.486**	-.043	.489**	-.010	.316*	.187	-.260	1								
Social Interaction	.239	-.352*	.249	.508**	-.554**	.187	.536**	-.492**	1							
Good Environment	.111	.010	.376**	.235	-.539**	.666**	-.126	-.229	.464**	1						
Scenic Beauty	-.392**	.025	.019	.136	-.138	.073	-.323*	-.149	-.183	.392**	1					
Sports	-.177	.412**	.522**	.147	-.312*	.272	-.694**	.364**	-.230	.177	-.037	1				
Children's Playground	.392**	-.683**	-.422**	.396**	-.189	-.585**	.323*	-.285*	.183	-.392**	-.097	-.452**	1			
Contribution of the Project for Flood Reduction	-.339*	.175	.162	-.169	.299*	.004	-.479**	.701**	-.297*	-.384**	-.355*	.412**	-.169	1		
Size of the Project	.217	-.230	-.225	-.010	-.143	-.019	-.237	.122	-.162	-.217	.228	-.236	.603**	.216	1	
Effectiveness of NBS for flood reduction	.569**	-.029	.399**	.206	-.590**	.494**	-.135	.102	.028	.330*	-.183	.449**	.031	-.173	.079	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

(Source: Field Survey 2019)

Table 4.4: Person's Correlation Test for Raingarden project.

	Gender of the Respondents	Educational Qualification of the Respondents	Occupation of Respondents	Resident Status of Respondents	Familiarity of Respondents with NBS Concept	People's perception about the use of project	Perceived Uses of the Project	Relaxation	Community Gathering	Social Interaction	Ecological Benefits	Good Environment	Scenic Beauty	Green Environment	Children's Playground	Contribution of the Project for Flood Reduction	Size of the Project	Effectiveness of NBS for flood reduction	Problems from Raingarden
Gender of the Respondents	1																		
Educational Qualification of the Respondents	-.303*	1																	
Occupation of Respondents	.479**	.381**	1																
Resident Status of Respondents	.462**	.088	.510**	1															
Familiarity of Respondents with NBS Concept	-.076	-.284*	-.404**	-.563**	1														
People's perception about the use of project	.327*	-.051	.436**	-.095	.025	1													
Perceived Uses of the Project	.240	.139	.545**	.231	-.072	.498**	1												
Relaxation	.356*	-.525**	.195	-.155	.295*	.102	-.180	1											
Community Gathering	-.218	.054	-.386**	-.421**	.286*	.250	-.226	-.102	1										
Social Interaction	-.070	.089	-.440**	-.570**	.470**	-.213	-.445**	.074	.257	1									
Ecological Benefits	.218	.211	.827**	.421**	-.348*	.375**	.750**	.102	-.375**	-.762**	1								
Good Environment	.364**	-.036	-.132	.248	.182	-.167	.252	-.272	.167	.224	-.167	1							
Scenic Beauty	.000	.354*	.021	-.155	-.213	.102	-.326*	-.250	-.102	.529**	-.408**	-.272	1						
Green Environment	.509**	-.390**	.149	.280	-.149	-.167	-.259	.408**	-.667**	.198	-.167	-.111	.408**	1					
Children's Playground	-.418**	.077	-.308*	-.063	-.307*	-.208	-.297*	-.373**	-.324*	.053	-.252	-.506**	.570**	.230	1				
Contribution of the Project for Flood Reduction	-.208	.281	-.234	-.387**	-.011	-.477**	-.382**	.000	-.106	.668**	-.424**	-.106	.563**	.247	.438**	1			
Size of the Project	-.132	-.226	-.495**	-.453**	.293*	-.302*	-.115	.123	.302*	.406**	-.302*	.302*	-.185	-.201	.044	.511**	1		
Effectiveness of NBS for flood	.401**	-.096	.285*	.265	-.011	.688**	.723**	-.281*	.172	-.393**	.401**	.459**	-.281*	-.306*	-.398**	-.705**	-.208	1	
Problems from Raingarden	.158	-.345*	.065	.149	-.070	-.234	.035	.240	-.221	-.299*	.221	.147	-.430**	.147	-.308*	-.150	.071	-.012	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

(Source: Field Survey 2019)

Some indicators are also found to be negatively correlated (Table 4.3) with each other. Contrarily, the highest negative strong relation (-0.694) is determined between 'Sports' and 'Relaxation'. Though such correlation seems somewhat impractical. Because the researcher has found that sports are considered as a part of relaxation by some of the respondents. Such negative correction is also found between 'Occupation' and 'Gender of the Respondents' (-0.376), 'Familiarity of Respondents with NBS Concept' and 'Gender' (-0.359), 'Familiarity of Respondents with NBS Concept' and 'Occupation of Respondents' (-0.421), 'Children's playground' and 'Occupation of the respondents' (-0.422). Again, some other indicators even possess the correlation coefficient very close to 0, which means the absence of any sort of relationship between these indicators; for example, the indicators 'Good Environment' and 'Educational Qualification' possess almost no relation with each other (r =0.10). Though in real some highly educated people were found who have considered that Water Square possess a good environment. A similar relationship is also presented by the r value between the indicators 'Contribution of the Project for Flood Reduction' and 'Recreation' (0.004). This r value reflects a real relationship because there is no such reason to have any link between contribution of the project for flood reduction and recreation facilities from this project. Moreover, some other indicators like 'Size of the project' and 'Resident status of the respondents' (r= -.010), 'Relaxation' and 'Occupation' (0.008) are also found to have almost no correlation.

As opposed to, the Dataset of Raingarden Project (Table 4.4) exhibits that different level of correlation exists among the indicators. The highest correlation co-efficient (r) is determined as 0.827 which reflects a strong positive correlation between the indicators 'Occupation of the Respondents' and 'Ecological Benefits'. The possible thing is people who are working somewhere related to Environment or whose occupation somehow create a sense of natural benefits, may be they have mentioned the Ecological benefits from Raingarden project. Moreover, some experts of the project also mentioned about ecological benefits from Raingarden; it supports the positive relationship between perception of ecological benefits and profession of the respondents. Likewise, respondents who commented about the uses of Raingarden, seemingly they have also realized the ecological benefit from this project that can be understood from a positive correlation (r=0.750) between the indicators 'Perceived uses of the project' and 'Ecological Benefits'. While observing the project during this study, the researcher also assumed a positive contribution of Raingarden for biodiversity improvement and greening the area although it's in a very local level. Likewise, such positive correlation (0.688) is encountered between 'Effectiveness of NBS for flood' and 'people's perception about the uses of project'. As questions were asked regarding both of the indicators, people who possess the idea about uses of Raingarden possibly also realize its effectiveness in terms of flood risk reduction in the area. Similarly, 'Contribution of the project for flood reduction' shows a moderate positive relation (r= 0.668) with the indicator 'Social Interaction'. However, no such relation was identified from the responses of experts or while observing the project.

On the other hand, there are many other indicators (Table 4.4) that show the weaker positive or negative correlation. For instance, the coefficient (r) of 'Community Gathering' and 'Familiarity with NBS' is calculated as 0.286 that reflect a weaker positive correlation between them, though in reality no such link was identified between these two indicators. Similarly, such relation exists between 'Green environment' and 'Contribution of the project for Flood reduction' (0.247). A negative lower correlation (r = -0.208) is encountered between 'Effectiveness of the Project' and 'Size of the project', however, based on the explanation of experts it was understood that the bigger the project, the more effective it is.

Again, some indicators show the absence of any relationship (Table 4.4) between them where the coefficient is 0; like between 'Gender of Respondents' and 'Scenic Beauty', between 'Contribution of the project for Flood reduction' and 'Relaxation'. Regarding the Water Square (Table 4.3), there was a positive moderate correlation between 'Size of the Project' and 'Children's Playground'. However, in the case of Raingarden project, these two indicators show almost no relation between them. Possibly, the reason for having a smaller space of Raingarden compared to Water Square. Furthermore, the researcher observed that there is hardly any large open space in the Raingarden where kids can play. Conversely, the strongest negative correlation (-.0762) exists between 'Ecological Benefits' and 'Social Interaction'. This aspect of relationship creates a sense of having less social interaction when there are high ecological benefits from the project; presumably, this is because Raingarden provides less space and scope to the community people to get there together. In addition, it was observed that there is less sitting space inside the garden, therefore, it's quite certain that the project has less scope for community gathering instead of having a high ecological benefit.

4.7 Spearman's Rho Correlation Test of Independent Variables

A Spearman correlation coefficient is usually indicated either by the Greek letter rho (ρ), or r_s. Similar to the other correlation analysis, Spearman's rho determines the strength of connection between two variables. In comparison to the Pearson's correlation test, the Spearman correlation does not need "continuous-level data" (interval or ratio), because it applies ranks rather than assumptions regarding the distributions of the two variables (Statistics Solutions 2019). Its interpretation almost identical to the Pearson's test because the value varies between +1 and -1, where the relationship can be understood from the score as 0 - 0.19 "very weak", 0.20-0.39 "weak", 0.40-0.59 "moderate", 0.60-0.79 "strong" and 0.80-1.0 "very strong" (Statstutor 2019). This study has also applied the Spearman's Rho correlation test to understand the relationship of indicators under Independent variable. As there are some ordinal variables in the data set, to make the correlation analysis more reliable, Spearman's Rho test is used alongside Pearson's correlation analysis. Table 4.5 and 4.6 present the Spearman's correlation coefficient for the indicators of Water Square and Raingarden respectively.

Regarding Water Square (Table 4.5), the highest positive correlation ($\rho = 0.715$) is found between the indicators 'Contribution of the Project for Flood Reduction' and 'Community gathering'. Likewise, the Pearson test has also found a strong positive correlation ($r = 0.701$) between these indicators. Both of the correlation tests support the positive link between them. At the same time, another ordinal variable 'Effectiveness of NBS for flood reduction' shows a positive correlation ($\rho = 0.516$) with 'Gender of Respondents'. Presumably, the response regarding the effectiveness level of Water Square was somehow related to Gender as most of the respondents were male. That is why the answers of male participants dominated the overall response scenario about the effectiveness of this project. Nevertheless, a counter relationship ($\rho = -0.641$) is determined between the indicators 'Effectiveness of NBS for flood reduction' and 'Familiarity with NBS concept'. This strong negative relation has resulted due to people's less familiarity with NBS. Possibly, respondents who have less familiarity with NBS have considered Water Square as highly effective without assessing its real contribution level for flood risk reduction. Contrarily, people having a clear perception of NBS have probably rated the Water Square to be less effective. However, in reality there were very few respondents identified who possess a clear understanding of NBS concept.

Table 4. 5: Spearman's Rho Correlation Test for Water Square.

	Gender of the Respondents	Educational Qualification of the Respondents	Occupation of Respondents	Resident Status of Respondents	Familiarity of Respondents with NBS Concept	Recreation	Relaxation	Community Gathering	Social Interaction	Good Environment	Scenic Beauty	Spots	Children's Playground	Contribution of the Project for Flood Reduction	Size of the Project	Effectiveness of NBS for flood reduction
Gender of the Respondents	1															
Educational Qualification of the Respondents	-.013	1														
Occupation of Respondents	-.436**	.022	1													
Resident Status of Respondents	-.208	-.717**	.404**	1												
Familiarity of Respondents with NBS Concept	-.410**	.207	-.385**	-.616**	1											
Recreation	.171	.384**	.654**	-.181	-.374**	1										
Relaxation	.126	-.538**	-.057	.267	0	-.194	1									
Community Gathering	-.486**	-.046	.522**	-.010	.280*	.187	-.260	1								
Social Interaction	.239	-.351*	.200	.508**	-.575**	.187	.536**	-.492**	1							
Good Environment	.111	.013	.436**	.235	-.494**	.666**	-.126	-.229	.464**	1						
Scenic Beauty	-.392**	.033	.153	.136	-.063	.073	-.323*	-.149	-.183	.392**	1					
Spots	-.177	.412**	.449**	.147	-.307*	.272	-.694**	.364**	-.230	.177	-.037	1				
Children's Playground	.392**	-.681**	-.486**	.396**	-.255	-.585**	.323*	-.285*	.183	-.392**	-.097	-.452**	1			
Contribution of the Project for Flood Reduction	-.346*	.152	.224	-.137	.252	.014	-.469**	.715**	-.278	-.374**	-.355*	.424**	-.161	1		
Size of the Project	.273	-.160	-.183	-.069	-.176	-.038	-.297*	.123	-.220	-.273	.161	-.167	.601**	.257	1	
Effectiveness of NBS for flood reduction	.516**	-.033	.343*	.201	-.641**	.521**	-.192	.161	-.034	.348*	-.100	.461**	.013	-.133	.179	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

(Source: Field Survey 2019)

Table 4.6: Spearman's Rho Correlation Test for Raingarden.

	Gender of the Respondents	Educational Qualification	Occupation of Respondents	Resident Status of Respondents	Familiarity of Respondents with NBS	People's perception about the use of project	Perceived Uses of the Project	Relaxation	Community Gathering	Social Interaction	Ecological Benefits	Good Environment	Scenic Beauty	Green Environment	Children's Playground	Contribution of the Project for Flood Reduction	Size of the Project	Effectiveness of NBS for flood reduction
Gender of the Respondents	1																	
Educational Qualification of the Respondents	-.280	1																
Occupation of Respondents	.459**	.486**	1															
Resident Status of Respondents	.462**	.040	.517**	1														
Familiarity of Respondents with NBS Concept	-.031	-.296*	-.447**	-.569**	1													
People's perception about the use of project	.327*	0	.328*	-.095	.075	1												
Perceived Uses of the Project	.237	.210	.409**	.209	.037	.532**	1											
Relaxation	.367**	-.341*	.060	-.199	.175	-.020	-.174	1										
Community Gathering	-.218	.047	-.478**	-.421**	.310*	.250	-.208	-.080	1									
Social Interaction	-.100	.002	-.353*	-.542**	.510**	-.240	-.474**	.103	.283*	1								
Ecological Benefits	-.017	.213	.309*	-.100	-.076	.320*	.457**	.202	-.120	-.310*	1							
Good Environment	-.044	.065	-.106	-.183	.200	-.300*	.091	.080	.000	.194	0	1	.					
Scenic Beauty	-.035	.238	.076	-.165	-.134	.040	-.248	-.126	-.040	.428**	-.116	0	1					
Green Environment	-.048	.031	.154	.101	-.076	-.218	.098	.105	-.327*	-.168	.157	.218	-.211	1				
Children's Playground	-.545**	.000	-.278	-.184	-.245	-.296*	-.352*	-.361*	-.277	.183	-.145	-.096	.488**	-.053	1			
Contribution of the Project for Flood Reduction	-.190	.223	-.087	-.355*	.002	-.490**	-.432**	.182	-.136	.639**	-.076	.211	.418**	.036	.439**	1		
Size of the Project	-.085	-.121	-.509**	-.426**	.326*	-.323*	-.101	.233	.323*	.414**	0	.361**	-.078	-.028	-.017	.508**	1	
Effectiveness of NBS for flood reduction	.371**	-.026	.166	.297*	.074	.661**	.760**	-.295*	.142	-.436**	.174	-.098	-.228	-.132	-.427**	-.749**	-.171	1
Problems from Raingarden	.175	-.319*	-.028	.108	-.077	-.200	.067	.349*	-.229	-.294*	.079	.116	-.410**	.158	-.272	-.211	.133	.041

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

(Source: Field Survey 2019)

Again, a positive relation (ρ = 0.666) has been found between the indicators 'Good Environment' and 'Recreation'. They possess a strong positive correlation. It was known from the field that the good environment of Water Square attracts many people and because of its recreational facilities (e.g. sports), people often spend their quality time in the square. Moreover, the unique design of Water Square has created a nice environment that facilitates different recreational activities. During the data collection period, some students were seen to practice dancing in the largest reservoir while skating was found to be very common recreational work in most of the times. Though 'Sports' and 'Relaxation' were identified to have a positive relationship in the real, Spearman's analysis shows a strong negative correlation (ρ= -0.694) between these indicators. As an ordinal variable 'Familiarity of Respondents with NBS Concept' presents a strong negative correlation with 'Resident Status of Respondents' (ρ= -0.616). Similarly, Pearson's correlation test also showed a negative relation (r = -0.571) between these two variables (Table 4.3). However, no such pattern of response was noticed from the Dutch or non-Dutch people pertaining their acquaintance to NBS concept. Rather, an affinity of people's familiarity was determined with the educational status and profession of the respondents. Therefore, the results from both correlation analysis do not support the real situation of these indicators. Conversely, Table 4.5 shows that there are some indicators that either has no correlation or very weak relationship according to Spearman's analysis. Regarding Water Square, the indicators 'Relaxation' and 'Familiarity with NBS' do not possess any correlation with each other Respondents' (ρ = 0). Likewise, 'Community Gathering' and 'Resident Status' (-0.010), 'Effectiveness for flood reduction' and 'Children's playground' (0.013), 'Educational Qualification' and 'Gender of Respondents' (-0.013) are also found to have very negligible relationship as shown by the Spearman's Rank correlation test.

On the contrary, Spearman's Rho values for Raingarden indicators (Table 4.6) are found to have some similarities with the outcome of Pearson's analysis. The strongest positive relation (ρ = 0.76) is identified between 'Effectiveness of NBS for flood reduction' and 'Perceived uses of the project' which reflects a good correlation of the indicators. For these two indicators Pearson correlation coefficient (r) was 0.723. Both correlation test show almost similar result for these indicators. Similarly, the Rho correlation coefficient for 'Contribution of the Project for Flood Reduction' and 'Social Interaction' present almost identical value to the Pearson' test for them. Though no positive relation was discerned between these indicators from the perception of people, both correlation analyses have found a strong positive relationship for them. In like manner, 'Social Interaction' is also positively correlated relation (ρ = 0.639) with 'Contribution of the Project for Flood Reduction'. Contrariwise, a strong negative correlation is determined between 'Contribution of the Project for Flood Reduction' and 'Effectiveness of NBS for flood reduction', though they are found to be very related to each other because an effective project can put significant contributions towards solving a problem.

A number of indicators are showing no correlation among them (Table 4.6). The Rho value is found 0 between 'Educational Qualification' and 'Perception of Uses of the Project', 'Good Environment' and 'Ecological Benefits', 'Scenic Beauty' and Good Environment', 'Size of the project' and 'Ecological Benefits'. However, in real all these indicators are somehow linked to each other. Even many experts and respondents have mentioned about the reciprocal affiliation of these indicators. Again, many of the indicators of Raingarden show a negligible positive or negative connection. For instance, 'Community Gathering' has a very weak connection (ρ = 0.047) with 'Educational Qualification', which reflects the reality as no such reason was identified from the field to explain a relation between these two indicators. In fine, though some contrasts are found between the actual scenario and the result of Correlation analysis, both Pearson and Spearman's coefficient have provided an overall scenario of relationship among the indicators.

4.8 Implementation Scenario of NBS

A number of stakeholders e.g. citizens, financiers, De Urbanisten, the water board of Schieland and Krimpenerwaard (HHSK), housing association Havensteder and Gemeente Rotterdam have come up together with the identical intention of making Rotterdam a climate-proof city. Such goal of the stakeholders has propelled them to 'depaving' the stony outdoor surface and introducing different Nature-Based Solutions in the city (Barfoot 2017). To address the water problems like flooding in the coming days, *Agniesebuurt* requires more spaces to temporarily accommodate the rainwater (HHSK 2019). 'Depaving' will raise the infiltration capacity and could make a significant contribution for ground water recharge, controlling the temperature of public space and expanding storm water retention capacity (De Urbanisten 2016). Water Square and ZOHO Rain Garden are two of such initiatives that have already been implemented to increase the rainwater holding capacity of the neighborhood so that flood risk in this locality can be minimized. Though both of the projects have similar purposes, the implementation strategy, stages and duration were different for them. Following subsection analyzes the implementation processes of Water Square and Raingarden mentioning the stages followed.

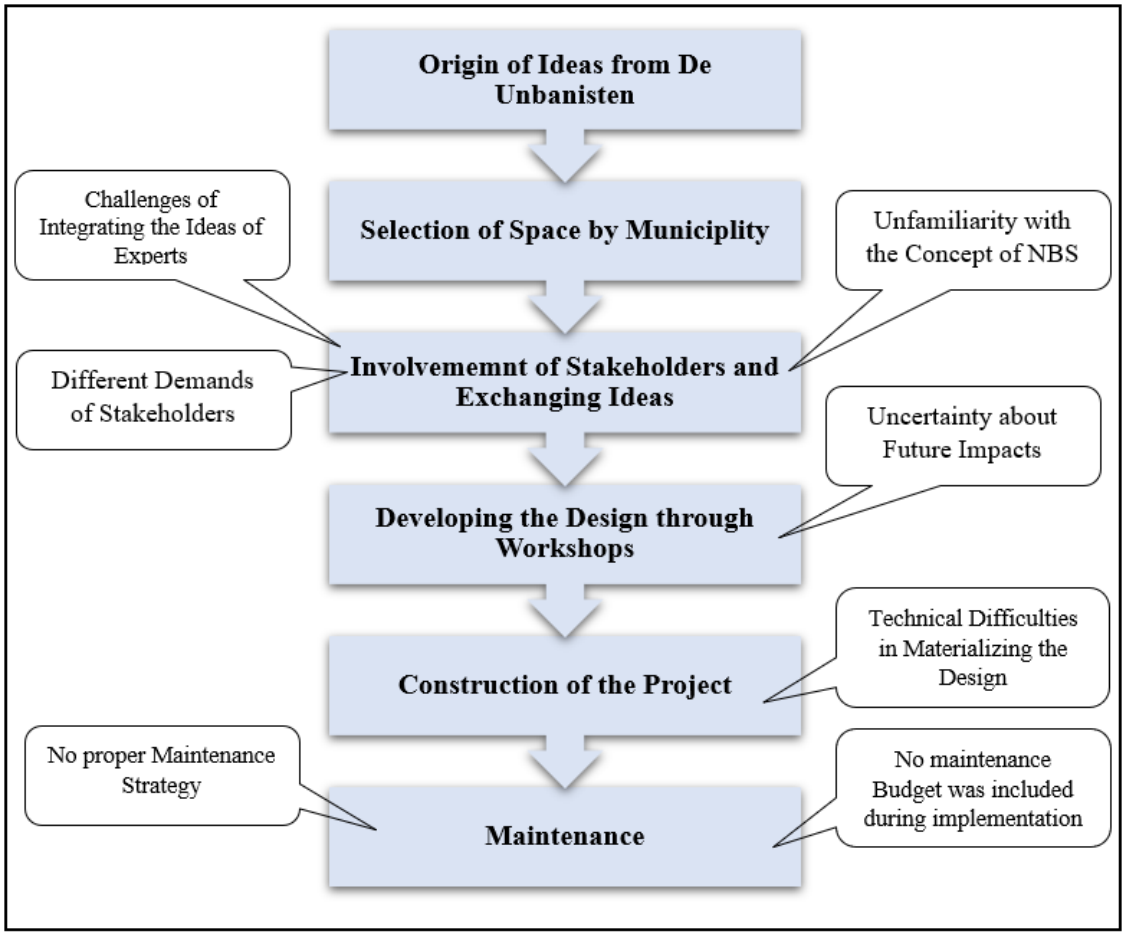
4.8.1 Implementation Processes and Associated Challenges in Different Stages

Raymond et al. (2017a) have mentioned seven major stages of implementing NBS project. However, the implementation processes of Water Square and Raingarden were known from the Key Informants of this study. The present research has tried to investigate the challenges associated with different stages of implementation. Regarding the chosen projects, Implementation stages have been developed in a bit different way than Raymond and his colleagues presented in their study (reviewed in chapter 2).

4.8.1.1 Implementation Process of Water Square

The origin of the idea for Water Square came from a Bienal on architecture and urbanism, called 'the flood'. The Water Square was pitched as a possible solution on how to deal with excessive rainfall events in cities. From there a pilot project was initiated, although that eventually could not be materialized for several reasons. At the same time, the Municipality was also looking for an innovative idea to deal with the excessive rain water management. Since the municipality was very interested in the idea, a new location was determined, and the concept was further developed there. This is a kind of coincidence happened with the municipality. Because some students from a school of Benthemplein wanted to change their square as they don't like the grey, stony open space that they used to have before Water Square was constructed. They were already looking for finances to change the Benthemplein into something very attractive while the Municipality was also looking for a perfect location for the Water Square. The municipality had an intention to make a square to hold excessive water while students wanted to have a nice place for hangout. So, based on the willingness of both parties, the ideas were combined, which is 'Water Square'. A devoted team of designers, municipal officials, water management experts and many others were working closely together to realize the plan. An extensive participation trajectory was set up to generate support from local stakeholders such as the adjacent school, sports-facility and inhabitants. The design was developed through the participation of stakeholders in three consecutive workshops. The implementation procedure is demonstrated in the following diagram mentioning all the challenges faced.

Figure 4.3: Implementation stages of Water Square with respective challenges.

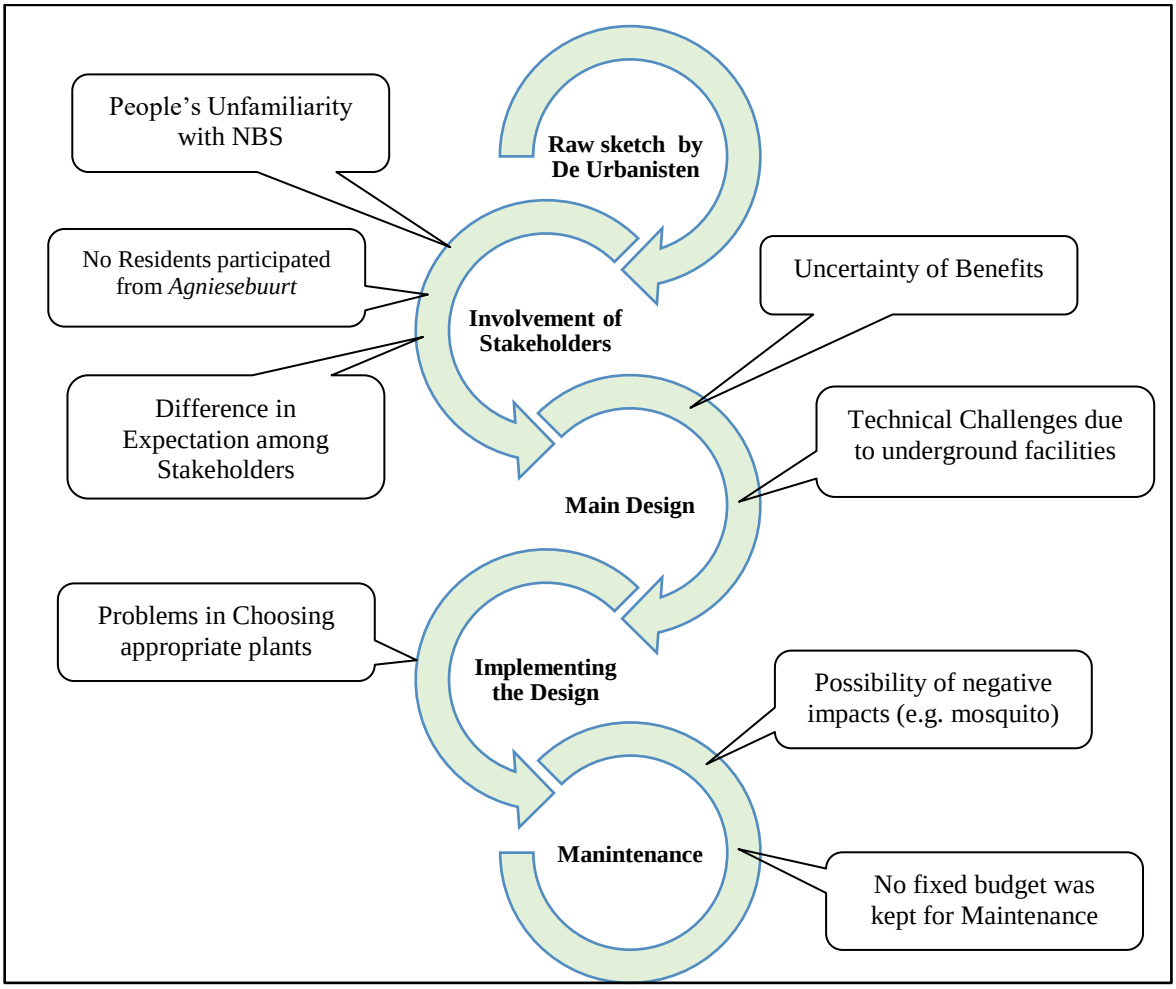


(Source: Prepared by the Author)

4.8.1.2 Implementation Process of Raingarden

Raingarden project was something different than the Water Square, even a bit more complicated. It was the result of an idea also initiated by De Urbanisten. The project was implemented in two phases where the first one was done by the initiator and later one was completed by the Municipality. In the first phase, De Urbanisten made a Raingarden in ZOHO district over a small area. They were working on the project without any commission or client, which means it was solely their own initiative to move ahead with this project. It was done with a lot of people by the way, Urbanisten didn't do it alone. However, that was a small Raingarden and it was beginning of the process which finally left to the constructed now. In the second phase, the project was designed and built by the municipality itself. But De Urbanisten organized the money, awareness and the will of people to make this garden. Before constructing the Raingarden, the place was a stony surface and used to be a parking space. In the later phase, the time was limited, so the project had to be finished quite in a hurry. Urbanisten made the raw sketch of the idea of the Rain Garden and the detail sketch was made by the municipality later. To know the people's consent about developing a Raingarden there, ZOHO citizens or entrepreneurs of the area were invited. Consequently, different stakeholders were involved, and their ideas have been integrated to make the final design. The project took almost two years to be realized.

Figure 4.4: Implementation stages of Raingarden with respective challenges.



(Source: Prepared by the Author)

4.9 Challenges of NBS Implementation (Independent Variable)

'Challenges of NBS Implementation' is the independent variable of the current study. During the operationalization phase, this variable has been further divided into sub-variables and indicators based on what the primary data are collected. The present study has developed an articulate understanding of the 'Challenges' faced during the implementation of Water Square and Raingarden project from the opinion of Key Informants and to some extent including the perception of respondents as well. The following sub-sections will elaborate on the specific challenges of implementing the chosen NBS projects.

4.9.1 Uncertainties of Future Impacts, Benefits and Risks

A few research works (e.g Kaczorowska et al. 2016; Raymond et al. 2017a; Balian et al. 2016) have mentioned about the uncertainties of 'Pay backs' from NBS projects. A number of research papers (reviewed in Chapter 2) have emphasized on the uncertainty of future risks and potential benefits from a Nature-Based Solution. This study has assessed the 'Uncertainty' aspects of chosen NBS using four indicators i.e. 'Expected Level of benefits', 'Possibility of target achievement', 'Risk level of negative effects' and 'Reliability in terms of effectiveness'. Key Informants opinion and people's perception were gathered to analyse the aforementioned indicators.

4.9.1.1 Expected Level of Benefits

While interviewing the Key Informants, most of them have uttered about the significant number of attained co-benefits from both projects. However, there was a difference in perception among them regarding the expected benefits and gained benefits from the projects. Half of the informants of Water Square said about attaining expected benefits from this project whilst the other two participants claimed that there are more achieved benefits from Water Square than they expected before implementing it (Table 4.7). On the other hand, experts of Raingarden were also positive in their responses while talking about the attained benefits of the project. Most of them said that though they were not sure to what extent the benefits could be ensured from Raingarden, after accomplishing the project they have gained planned benefits. However, one Key informant expressed that this NBS has ensured some more added benefits than expectation. Based on their responses, it's quite certain that at least benefits from this project are gained as expected although there always remains uncertainty in achieving benefits from the NBS (Nesshöver et al. 2017).

Table 4.7: Expected and Gained Level of Benefits from Water Square and Raingarden.

Expected and Gained Level of Co-benefits (Scale 0 to 4)	Water Square	Raingarden
4 – Significant numbers of co-benefits are achieved even more than expected		
3 - Planned co-benefits are gained only		
2 – Some co-benefits are provided	-	-
1 – Few co-benefits with difficulties	-	-
0 – No co-benefits at all	-	-

(Source: Field Survey 2019)

4.9.1.2 Possibility of Achieving Project Target

'Possibility of target achievement' is another indicator of understanding the sub-variable 'Uncertainty of future impacts'. As both 'Water Square' and 'Raingarden' were realized a few years earlier (De Urbanisten 2016), the researcher wanted to know whether the projects could fulfill their main target of water retention. Almost all interviewees have confidently opined in favor of the target achievement of both projects. According to them, Water Square and Raingarden projects are working in way they expected and anticipated. However, as both the projects are applied for the first time in Rotterdam, surely there was an uncertainty in achieving the goal. An interviewee of Water Square said,

> *"Since the square is supposed to store rainwater that normally is discharged into our underground system and this had not been done before, there were uncertainties on its functionality. To overcome these uncertainties a close collaboration between the spatial designers and the water management experts was required. Fortunately, we overcame the uncertainty and make the project happen. Moreover, the square is functioning well that let us to achieve the target"*

In the case of Raingarden, the main uncertainty in achieving the goal was related to the performance of plants in the garden. This is because of the complex design and difference of moisture condition even within the garden and considering the difference of rainfall throughout the times of the year. An expert mentioned that the garden was found too wet or too dry due to the excessive rainfall or dry season respectively. Such situation had created an uncertainty of whether they can store sufficient water alongside maintaining the plants well. However, the target has been achieved despite the uncertainty in goal attainment and persisting problems. Therefore, regarding Water Square and Raingarden, it is certain that both projects have overcome the difficulty of uncertain future impacts in terms of provided benefits.

4.9.1.3 Reliability in terms of Effectiveness

Another indicator for measuring the 'Future Uncertainty' is the Reliability of the project in terms of their effectiveness. Key informants were given the scale of 0 to 4 to rate the reliability of either project in terms of their effectiveness. If a project is effective, it would reliable and will surely have positive impacts. Even though most of the participants in interviews considered both projects as reliable due to their effectiveness, the majority of them preferred not to make any comparison of effectiveness with the Grey infrastructure. One of the co-designers of Water Square said,

> *"I would not rate its effectiveness against grey infrastructure. I would rather say it's an addition to existing grey infrastructure".*

Another Key person of Raingarden uttered that she doesn't consider the project highly effective because of its inability to hold water for a longer period. Therefore, plants are not much benefitted. The researcher asked all the key informants about the effectiveness of both projects compared to the exiting engineering projects in order to understand the reliability level. Nevertheless, another leading person from Raingarden project explained the difference between 'grey' and 'green' projects in terms of their reliability and effectiveness. He stated,

> *"For the grey, we cannot do any experiment, we need to make sure its effectiveness. However, we are still doing many experiments and piloting with the NBS. In the case of Raingarden, it is handling a very little risk in comparison to a dike. Prioritizing the safety issue, Grey infrastructure has always been got a great focus. Nevertheless, if there are excessive rain events in the coming days, then Nature-based projects like Raingarden will have higher contribution and it will also get a high priority. Because that time everyone will tell that they need something to deal with the water from high rainfall. So, realizing the importance and having a visible effect is an important aspect while making a comparison of NBS with the traditional engineering projects".*

The discussion with interviewees about this aspect has made it clear that though both projects are effective so far, they are not reliable as grey infrastructures. Therefore, despite having numerous benefits from each of Nature-Based Solutions, flood control is still highly reliant on 'grey' infrastructural measures (Jongman 2018).

4.9.1.4 Risk of Negative Effects

The chosen experts for interview have defined the risk level from Water Square and Raingarden project. They have mentioned the future risk level to range from 'Moderate' to 'Low' risk category. Alongside, people's perception was gathered to understand whether there is any current risk from the projects. A respondent of Water square said that due to the continuous settling of dirt in the main reservoir, the place sometimes gets slippy that might cause accidents for the kids who often play soccer or basketball there. About 19% people told about the

deposition of dirt in Water Square while 12% mentioned the unhygienic condition due to nasty stagnant water (Figure 4.5). In addition, the biggest reservoir of Water square has been observed to be dirty and found full of litters many times while visiting the site during data collection. Conversely, a municipality officer claimed that the square is cleaned on a regular basis. But a Key informant has informed that right now this project lacks an efficient maintenance program for which sometimes contamination or negative aesthetic impact on the environment are visible. He further added that holding such contaminated water for long might eventually lead to enormous health hazards and give birth to numerous unprecedented diseases. Again, the users of Raingarden (12%) have also mentioned the mosquito problem arising out of the project and a small number of respondents (4%) expressed concern about the spread of worms and tiny creatures from the garden (Figure 4.6). One of the respondents said, *"there are more flies nowadays than it used to be".* It is most problematic for the people who have an allergic problem or be afraid of flies. A couple of research paper (Keune et al. 2013; Nesshöver et al. 2017) also mentioned about the possible health problems from NBS projects. Almost all the Key informants are found to be aware of problem of mosquito due to this project. However, all of them have denied the prevalence of mosquito due to Raingarden. One Key Informant said that some residents have reported about the increase of mosquito since the time of realizing the Raingarden. She added that few citizens correlating the presence of mosquito with Raingarden.

Figure 4.5: Problems from Water Square

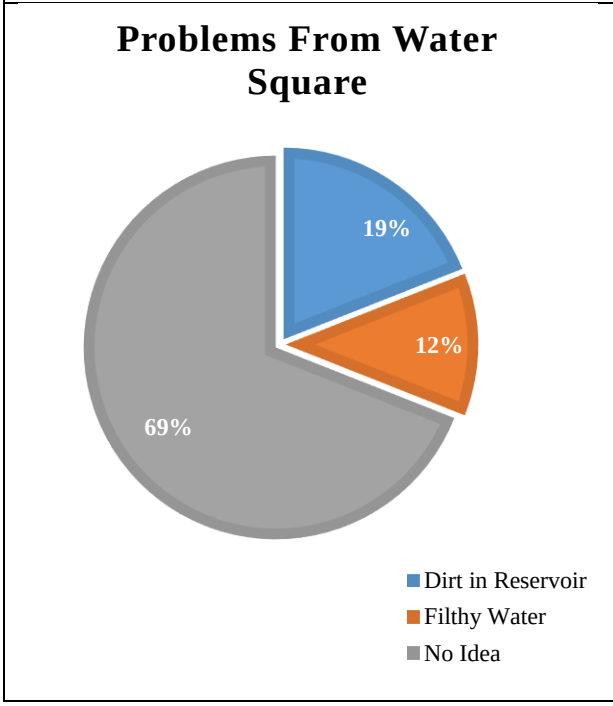
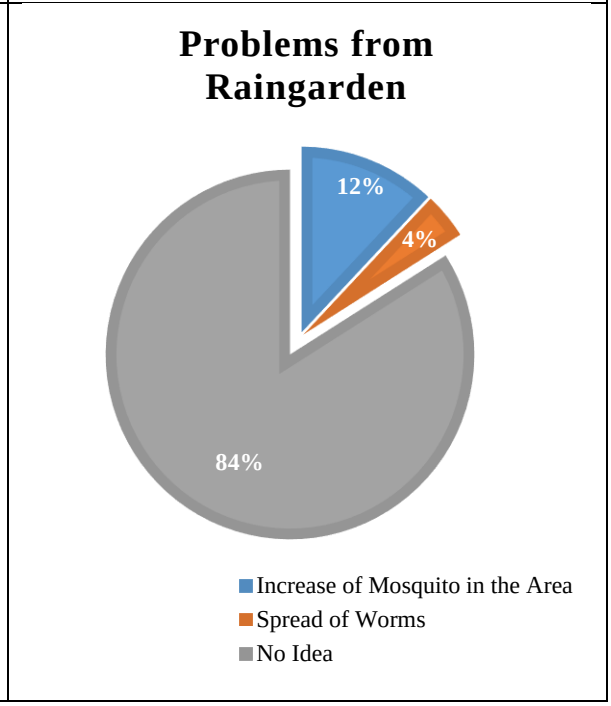


Figure 4.6: Problems from Raingarden



(Source: Field Survey 2019)

The negative impact of Raingarden is that some people are afraid of mosquitos. Again, another expert of Raingarden considered it to have future risks as people claimed to see more mosquito nowadays. He uttered,

> *Of course, there is a risk. Though I don't know to what extent it's true. What if mosquito starts to hatch from this garden? And if there's a spread of tiger mosquito from this garden for any reason, it might cause diseases which is, of course, a risk. If there is a consistent hot summer like last year for few more in the next, I am quite sure it would*

cause to flourish tiger mosquito there. We need to be more careful but the way we keep the water it's all risky.

Based on the perception of people who use the projects and responses of experts it is understood that both Water Square and Raingarden have negative effects that might create risk related to the health of people. Though the number of people who mentioned the problems is quite a few, the risk of having a future problem like diseases cannot be neglected.

4.9.2 People's Perception of Familiarity with NBS

Some researchers (e.g. Balian et al. 2016; Kabisch et al. 2016b) have mentioned the lack of awareness or unfamiliarity of people with the NBS concept as a notable barrier to the wide implementation of Nature-Based Solutions. The present study has tried to assess the people's acquaintance with the NBS concept. People's familiarity was evaluated through using two main indicators i.e. 'Level of familiarity', 'Perceived Uses of the Project'

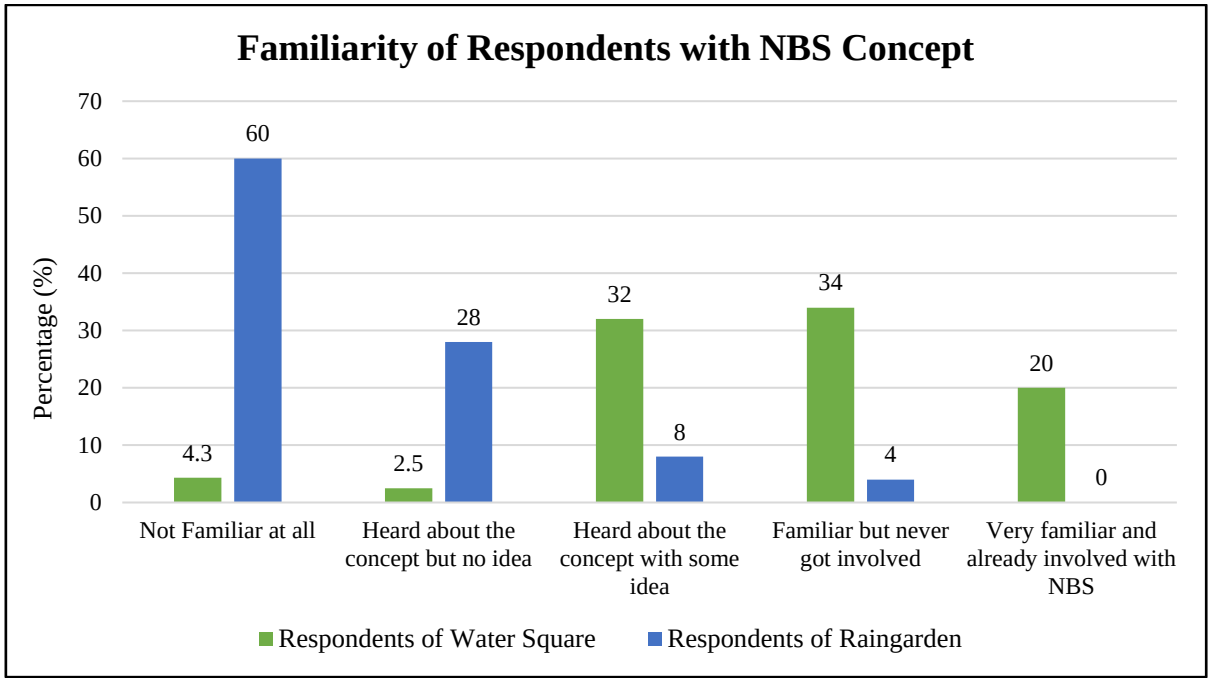
4.9.2.1 Level of familiarity with NBS

Respondents from Water Square and Raingarden projects were asked about their understanding of NBS. Though the questions were the same for the respondents of both cases, people's perception and their acquaintance with the NBS are found quite different. Figure 4.7 presents the responses of people regarding the level of their familiarity with the NBS concept. About one-third respondents who were found to visit Water Square on a regular basis, do not possess any idea about Nature-Based Solutions. While talking about this concept, many of them even heard it from the researcher for the first time. Contrariwise, almost 60% of respondents from Raingarden are not familiar with the notion of NBS at all. Even though Raingarden is a public space that is green enough and solely based on using the natural elements, many people who often visit the place even don't know that it's Nature-Based Solution for flood risk reduction in this neighborhood. An older person who was passing through the Raingarden stated that she walks in the garden almost every day, but she thought that it's a public garden like many others located in Rotterdam. She also added that there is no such widespread discussion of NBS that can make the people more aware of it. Approximately 28% of respondents in Raingarden were found who have heard the concept of NBS somehow but do not have detailed knowledge about it. In the case of Water Square, about 34% of its user have acquaintance with the term 'Nature-Based Solution', though they have no further idea of how it works (Figure 4.7). While one-fifth of people from Water Square possess some idea about the NBS, that number is only 8% in the case of Raingarden respondents. In both cases, people having some idea of NBS are found to be either students or professional like a teacher.

On the other hand, some people from both NBS project have been found who understand the NBS concept well but never participated in any NBS project as a stakeholder. As the respondents were chosen randomly from the users of both projects, none of them were found to be involved in the implementation of either project. However, only one person from Water Square was identified among 50 respondents who participated in a different NBS project and possess a good understanding of this concept as well. He uttered,

"I didn't participate in the planning or implementation of water Square because it's been a long time the project was realized and I do not live in this neighborhood; I visit this square as I work nearby. However, last year I was involved in a workshop of Nature-Based project which is mainly about developing a green roof in my neighborhood. I was enthusiastic to be part of that project and I would like to join in such nature-based initiatives if there's an opportunity in coming days".

Figure 4.7: People's familiarity with the concept of 'Nature-Based Solution'.



(Source: Field Survey 2019)

Therefore, it is understood from the responses of people that although NBS is a growing concept which is being implemented in different corners of Europe, the vast majority of the people under this study were found to have very little or no acquaintance with 'Nature-Based Solution'. Moreover, instead of visiting the Water Square and Raingarden on a regular basis, many people do not even know that these are the ideal examples of Nature-based Solution. In fine, it can be commented that the lack of people's familiarity with NBS could be a significant reason for not having a widespread reliance on Nature-Based projects in Rotterdam. Because awareness among mass people about NBS could possibly instigate the authority to think of implementing the concept widely to address different challenges like flooding.

4.9.2.2 Perceived Uses of the Project

People's knowledge about the uses of two selected cases is considered to understand their familiarity with the Nature-Based projects. Interestingly, almost all the respondents of Water Square around found to know the use of this project. Though many of them were not really aware of the NBS concept at all (see the previous section). The main purpose of Water Square is to hold huge volume water during the rainfall (Photo 4.1) so that the nearby area doesn't get flooded in the event of excessive rainfall. People are found quite aware of retention purpose of Water Square (Table 4.8).

Table 4.8: Perceived Uses of Water Square.

Uses		Frequency	Percent
Valid	Rainwater Retention	49	98.0
Missing	999	1	2.0
Total		50	100.0

(Source: Field Survey 2019)

Photo 4.1: Storing of Rainwater at Water Square.

(Source: Field Survey 2019)

On the other hand, there were variations in the perception of people regarding the main purpose of Raingarden. Though the vast majority of the people (58%) know about the main purpose of Raingarden, many others responded to something different than the garden is really made for (Table 4.9). While the main use of this project is to increase the rainwater retention capacity, people opined some other uses that are exactly not the primary purposes of this project. About 14% of people uttered that the main aim of this project was to increase the greenery in the neighborhood. The same number of people are found who do have an exact idea of why the project was built. Though no such people from Water Square was identified who don't know the use of that project. Again, a minority number of questionnaire respondents (8%) have considered the Raingarden as a public space only. They do not think that this garden might have a different purpose other than creating a space for the mass people.

Table 4.9: Perceived Uses of Raingarden.

Uses		Frequency	Percent
Valid	Holding Rain Water	29	58.0
	Making the place better	1	2.0
	Greening the Space	7	14.0
	Public Garden	4	8.0
	No Idea	7	14.0
	Total	48	96.0
Missing	999	2	4.0
Total		50	100.0

(Source: Field Survey 2019)

The perceptions of people helped to discern their understanding of the purposes of both projects. Even though people from Water Square possess a good understanding of the project, many respondents of Raingarden could not recognize the main purpose of that project yet. Being a green solution, people thought Raingarden as a common green space or a public place like other gardens in Rotterdam. In fine, it can be uttered that both the Indicators under the sub-variable 'People's familiarity with NBS' reflect the shortage of people's understanding about the Concept of Nature-Based Solution and their uses.

4.9.3 Stakeholders' Participation

Citizens participation is considered as a significant aspect for the NBS projects not only to create a "fit-to-context" design but also to use "social inclusive approach" to develop them (Frantzeskaki 2018). Citizen and other stakeholders' involvement in the Water Square and Raingarden project are evaluated in this study based on the perception of experts and participants of both projects.

4.9.3.1 Stakeholders of The Projects

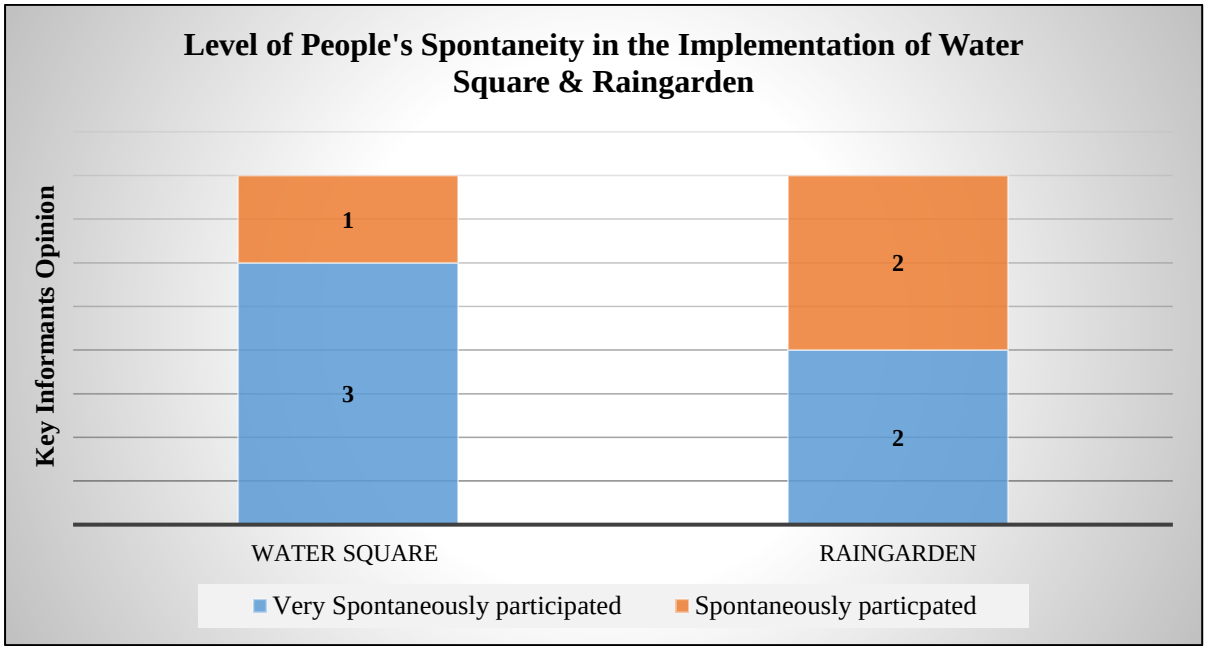
Based on the description of Key Informants, there were a different group of stakeholders participated in the implementation process of both projects. In the Water Square the major stakeholders were Municipality of Rotterdam, Water Board (HHSK), Church community, Zadkine College (Students and teachers), Sports Club (David Lloyd), Engineering Bureau Rotterdam, ACO (who made the gutters), Arnold Reijndorp (feedback), Anouk Vogel (design of the well), Graphic Lyceum Rotterdam (school) and people from *Agniesebuurt* Neighborhood. These significant number of participants have worked together to implement the Water Square. On the other hand, Raingarden project involved Municipality of Rotterdam, Water Board (HHSK), Owner of Hofbogen, Companies from ZOHO and Studio Bas Sala (who designed the ZOHO letter). These are the major stakeholders participated in the projects.

4.9.3.2 People's Spontaneity of participation and Contribution in the project

Key informants from both projects were asked about the spontaneity of the stakeholders who participated in the implementation process. The interviewees from both projects have mentioned it differently in their conversation. Regarding Water Square, three experts have mentioned that all the stakeholder were 'Very Spontaneous' in the implementation process of the project. At the same time, one Key informant mentioned that all the participants of the projects were 'Spontaneous'. As a Nature-Based Solution, Water Square was something very new to the people that made them enthusiastic to contribute their ideas and expectation during its implementation. Furthermore, their highly spontaneous involvement was a reason for creating an iconic design and materializing it. A student from Zadkine college who participated in the implementation of Water Square said *"the government was the most spontaneous. They really loved the idea of participants. And everyone put their best effort, so I think all the participant were spontaneous enough in this project".* On the other hand, two Key informants of Raingarden have opined that all the stakeholders including ZOHO companies were 'very spontaneous' while participating in the discussion (Figure 4.8). Likewise, the same number of experts expressed the participation of people as 'Spontaneous'. Though there was no resident from the neighborhood, many entrepreneurs of the area came and enthusiastically joined in the planning and implementation of Raingarden. It was known that the companies or ZOHO citizens were eager about this project because there was an awareness about the issue among them already. *"If we were making the Raingarden in another part of the area, I imagine we would have more problems. Because the level of awareness of people in other places would not be as of ZOHO. However, as people have seen this Raingarden already, hopefully, it will*

be easier to make such project elsewhere in the neighborhood" – said by a co-designer of this project.

Figure 4.8: Level of People's Spontaneity in the Implementation of Water Square & Raingarden.



(Source: Field Survey 2019)

Even though stakeholders from different level came up with dissimilar ideas, most of them have 'contributed enough' as said by the key informants of both projects. A key informant of Water Square stated that three workshops were organized to obtain and integrate ideas from the stakeholders and all of them have positively impacted the workshops and subsequently to develop the design. *"participants have contributed even more than our expectation",* he added. Contrarily, while conversing with some interviewees they expressed that there was no resident in the Raingarden procedure rather Companies from that area were there. Because companies or entrepreneur from an area can organize something better and they really came up with interesting ideas like ZOHO letters set in the garden. One of the companies designed that letter in a way that it could store rainwater for using it later. So, overall the stakeholders have made significant contributions to the project.

4.9.3.3 Integrating Stakeholders Expectation

Integrating stakeholder's expectation was a great challenge in the implementation of both projects. Mostly in the case of Water Square, it was more difficult to integrate and consider the expectation and ideas of all participants. As presented in the previous section, there was more participants in Water Square project than that of Raingarden. One Key informant of Water Square said that most of the participants came up with different ideas that made the whole process complicated. Many of them claimed to include their demanded feature in the design. Due to the non-identical ideas of people, the designer of the project had to face a great challenge of making an appropriate design that could satisfy all. For instance, the people from the Church wanted a provision in the square to sell food while neighborhood people didn't want the basketball court there because this might create noise. To make the people happy, designers tried their best to come up with an integrated and comprehensive design and they became successful to come up with an innovative design. To facilitate the design process, four groups were made splitting all the participating equally. But design became so complicated that it has

resulted in some later impacts (discussed in section 4.10.1). Nevertheless, Frantzeskaki (2018) mentioned her report that involvement of residents has modified the preliminary design of the project which has made it more multifunctional. Again, most of the Key Informants have claimed that the design of Water Square is something very unique and introduced for the first time in the world. Moreover, the participation of a higher number of stakeholders positively influenced to make an iconic Water Square.

On the other hand, there were fewer stakeholders participated in the Raingarden project. Presumably, less number of stakeholders were involved as the project was smaller than Water Square. However, a Key expert of Raingarden expressed that they have invited all the relevant people for the project. Actually, no residents of *Agniesebuurt* neighborhood was involved in the project. Rather there were the entrepreneurs from ZOHO district who called themselves as ZOHO citizens. Another interviewee uttered that they have included a few people because it's a lot easier than having a huge number of participants. He added that if they wanted to reach a lot of local people, the process might become complicated while with the few numbers it was easier to tell them about the plan, getting inputs from participants, modifying the design etc. It was known that some residents from the area were invited to join in the table of discussion for Raingarden, however, they didn't join. Again, an expert of the project said, *"We have considered other stakeholders' expectation in the form of design but not in the functionality"*. Even though the designers of Raingarden said that they have made a good design of this project considering the ideas of local companies, the design of this project has not been considered as unique like Water Square. This is possibly due to the involvement of fewer people in Raingarden.

Therefore, stakeholder's participation in both projects can be considered as fruitful in terms of their contribution and development of ideas. However, the level of innovativeness is perceived as higher for Water Square project than that of Raingarden. This is possibly due to the greater number of participants were in the Water square project than Raingarden. Moreover, residents of *Agniesebuurt* were less prioritized considering that Raingarden is located in a business district while users of this project are found mostly the inhabitants of this neighborhood.

4.9.3.4 Involvement of Transdisciplinary Experts

Assuring the proper use of multi and transdisciplinary knowledge is a challenge of implementing NBS projects (Nesshöver et al. 2017). However, it is a requirement to bring experts from a diverse background in order to develop a successful project. Both Water Square and Raingarden have involved multidisciplinary experts. In the case of Water Square, there was a project team including a project leader from the municipality and they were in charge. There was an expert on hydrology, hydrodynamics, an expert on technical elements of sewage, drainage, sometimes they had an expert on traffic but not all the time, people from the health service to advice on public health, an expert on communication, financial experts etc. However, the design was mainly developed by the Architects and Urban Planner in close collaboration with the Engineering Bureau of Rotterdam. All of these experts have integrated the ideas of stakeholders more technically into the design of Water Square. Due to the technical requirement of the project, it was necessary to incorporate the people having a different type of expertise. However, it was a challenge and time-consuming task to integrate the ideas of people. One key informant said that though the process went well it was a very complicated work to develop the design because there was a continuous need of the different type of professionals with different experiences. On the other hand, Raingarden also required to use the transdisciplinary knowledge. Like the Water Square, the municipality was the leading body of Raingarden. They have their own experts including Project Manager, Architects, Designer,

Urban Planner etc. Moreover, there were other professionals like contractor (a part for realization of project), botanists (who helped to choose the right type of plant for this Raingarden), ground water expert etc. Even though both projects have confronted difficulties in integrating the experts' ideas and knowledge, there was more complexity faced in the Water Square project.

4.9.4 Decision Making and Prioritization of the NBS projects

It was known that both Water Square and Raingarden projects were handled by the local government i.e. Rotterdam Municipality. As both projects are part of the climate-adaptive strategies, the municipality took the lead in both cases. However, there were some other supportive bodies (e.g. Water Board) who are not the part of the municipality rather central government. Basically, the projects were initiated and managed by the city authority.

In order to understand the priority level of Nature-Based Solutions, perceptions were sought from the Key Informants. They were asked whether NBS gets the priority as a grey engineering project. They have opined almost similarly with some differences. Regarding Water Square, half of the Key Informants said that it was prioritized almost equally as a grey infrastructure project. Because the municipality was very willing to invest in a project that will be unique in design and feature. Simply, municipality liked the idea of Water Square that's why they were looking for a suitable place to materialize the idea. At the same time, two other interviewees expressed that Water Square cannot really perform as a Grey project as the intention of this NBS is to increase the rainwater retention of this area. Therefore, two experts opined that the project has got less priority (Table 4.10).

Table 4.10: Level of Materializing the design based on Key Informants' Perception.

Level of Prioritizing the Projects (Scale 0 to 4)	**Water Square**	**Raingarden**
4 – Highly Prioritized	-	-
3 – Prioritized than Grey project	-	-
2 – Equally Prioritized as Grey project		-
1 – Less Prioritized than Grey project		
0 – No Priority at all	-	-

(Source: Field Survey 2019)

As opposed to, all the Key participants of Raingarden stated that the project was less prioritized than the traditional grey infrastructure development. While answering whether the Raingarden got equal priority to Grey or not, a landscape architect of the project said,

> *"Not really, because when it's about grey infrastructure like dikes it's about safety. Because, if there's a crack in a dike it will flood all the area. However, if we didn't make Raingarden, I don't think it would make such an impact. For the grey projects, higher investment is made as those infrastructures deal with higher risk but NBS is not made in that way to handle high-risk issues. Raingarden was prioritized in a way that*

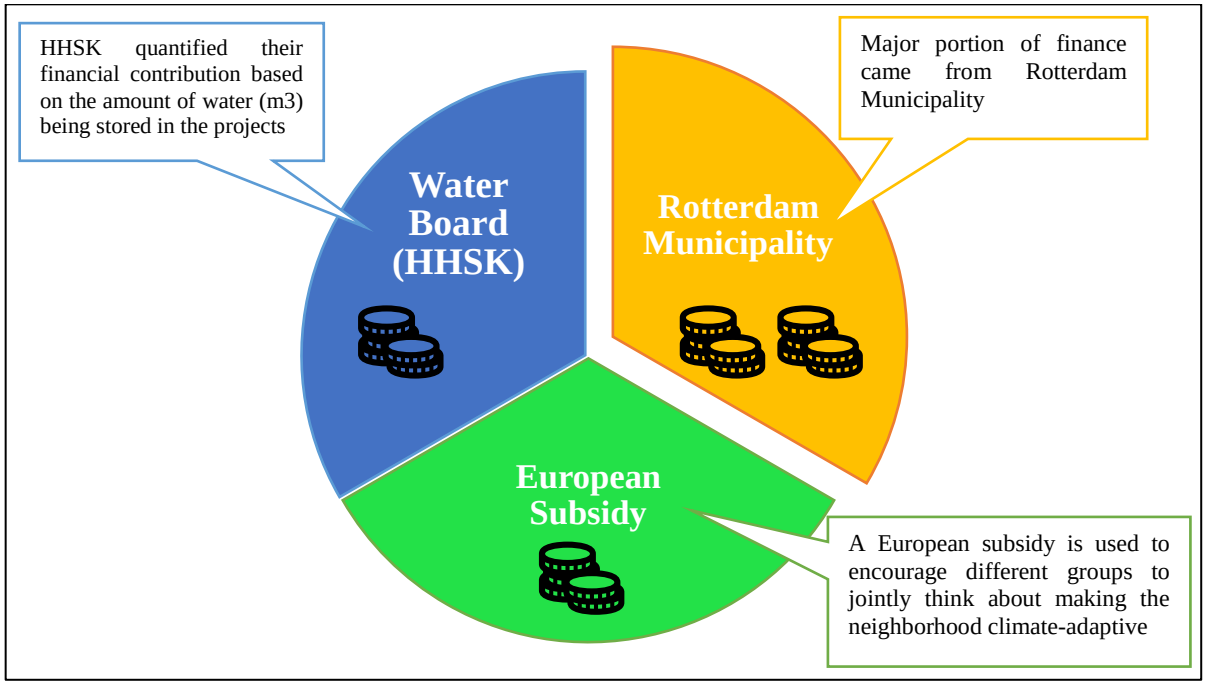
we wanted to have a showcase. In that way, it was prioritized. Moreover, such NBS project was also about the experiment as it was something made for the very first time in the Netherlands, but Grey infrastructure is about providing security to the people; so, the later one has more priority of course".

In fine, the research unveiled that because of the less reliability of NBS compared to the Grey projects, Nature-Based projects still get less priority. Though Water Square was said to be considered having enough focus from the authority, Raingarden has been given less priority due to its very local effect of working. Getting such less priority could be a hindrance to the implementation of NBS project.

4.9.5 Financial Availability for the Projects

One of the paramount aspects of implementing a project is financial support from the authority. Both projects were implemented in the financial collaboration of three main parties. While the Rotterdam Municipality was the major financier, Water Board (HHSK) and European Subsidy were also the sources of funding for Water Square and Raingarden (Figure 4.9). European subsidy was provided in order to make the *Agniesebuurt* as a 100% percent rain water proof area (HHSK 2019). One expert of this study revealed an interesting aspect of Water board. He said that the water board usually finance a project after quantifying its possible contrition in terms of water retention. In the case of Water Square, Waterboard has funded according to the volume of water that can be stored by the project.

Figure 4.9: Financial Sources of Water Square and Raingarden project.



(Source: Field Survey 2019)

The intention of this study was to know if there was any deficit of funding while implementing the projects. Moreover, also to explore the duration of financial support from the sponsors. All the Key Informants from both projects have mentioned that 'Funding was sufficiently available'. The estimated cost of Water Square was 4 million Euros while about 250,000 Euros was spent on the Raingarden (De Urbanisten 2016). However, while asking the interviewees about the duration of financial support, all of them said that the budget was made for all expenses until the realization of the projects. That means in the budget of both chosen projects

there was no provision kept for the maintenance and monitoring after their completion. One Key Informant of Water Square expressed that their responsibility was to complete the project and hand it over to another department who will take care of it, he didn't know how the project will be financed for its maintenance purpose. Again, another expert of the same project uttered that because of being a very complicated project, Water Square requires high maintenance, but right now it doesn't have an appropriate strategy to manage it perfectly. Therefore, Water Square seems aesthetically unappealing and dirty nowadays. On the other hand, Raingarden also didn't have any advance budget for its maintenance. Though now it's being maintained by two women from a nursery, it is not certain how long the fund will be available to take care of this project.

So, it is found that although the projects were done without facing any financial deficit, there's no fixed budget given for their maintenance. Because of not having enough security for funding the maintenance, it's not certain how long the projects will be financed by the responsible authority. Moreover, being Nature-Based Solutions, both projects require special maintenance and extra money which is a headache for the authority indeed. Therefore, the financial deficit might affect the monitoring of these NBS projects which is already visible from the condition of Water Square.

4.9.6 Technical Challenges of the Projects

Technical problems could affect any project in its implementation. This study has unveiled some technical challenges that were faced while implementing Water Square and Raingarden. More or less those technical issues have affected the process of materializing the projects. The Key Informants have shared their experiences regarding technical issues that they have confronted throughout the projects' work. Designing both the projects was a significant technical challenge because for the very first time such type projects were implemented in Rotterdam, even in the case of Water Square, it was the first time in the world of its typology. An expert from Water Square uttered that they needed to combine a lot of disciplines to make an effective design, that was a technical challenge indeed. It was also a challenge to make sure that everything is working well. Again, there was a requirement to bring about the changes in design consistently because people wanted it differently and due to the technical challenges afterward the design was changed as well. Because for collecting the rainwater, the design needed to use the roof of schools, but they hadn't given them permission to use; so, the designers made little changes in the design. Another Key Informant said that the project is a very complicated one and this was a challenge to materialize the design. He also added,

> *"The drawback I think about this project is if they want to do something new with this project, it will be a lot of work. Any modification of this square would take longer time than another square".*

On the other hand, while implementing Raingarden, there were some technical difficulties. Experts have mentioned about a few technical challenges related to the design and materializing it. One of the key informants said,

> *"The main challenge was underground. In the Netherlands, all the facilities like sewage, water pipes, electricity etc. are running below the ground. Likewise, some underground pipes were passing through the place we have chosen for Raingarden. For instance, the authority said that to prevent the pipe of gas or water for any sort of leakage, we need to have at least 60 cm of thick soil layer over it. So, it was an issue that we faced, and we had to make the design accordingly. Another problem we faced is the groundwater level because it affects the infiltration rate. Then we made some holes so that the water goes faster".*

Some other experts expressed that the challenge of the project is to retain the water and trying to infiltrate it slowly. Making an appropriate bed for the garden was a critical issue to deal with. Another person added that functioning the harder part of Raingarden is a challenging task. It was also known that stakeholders of the project wanted to make the pedestrian path (next to Raingarden) more organic rather than using concrete, but designers have to make it like as it is now due to the technical limitation. On the other hand, there was a problem in choosing the right type of plants for the garden. The lower part of the Raingarden is used to store water and there are plants on it. Sometimes the lower part is very wet while many times of the year it remains very dry. So, the experts were looking for the right types of plant that can survive under the dissimilar type of weather or moisture condition. Moreover, the plants have shades from the trees, so there is less sunshine which a matter of concern was how the plants can survive flourish in a shady environment. This was the most difficult part in realizing this project as expressed by an interviewee. Again, it was observed that instead of being a public garden, Raingarden has very limited sitting facilities. Even it has no provision for people to sit inside the garden. Though the authority claimed that it is due to save the plants from people's stepping over, lack of sitting space has been considered as a design limitation by many of the respondents. Furthermore, an Architect said that the current design of the Raingarden doesn't succeed in integration with street function, therefore, it is difficult for the people to go through the bike or wheelchairs. In addition, there is an inconvenience in using the street between the bar and garden because bikers need to pass through the street close to the bar where there are even some chairs for the customers. That could be a drawback of the design as well.

In sum, it is perceived that both projects have faced some technical difficulties. In the case of Water Square, making the design and implementing it was the most challenging task. Moreover, due to the complex design, there is not enough technical flexibility to introduce any further changes in Water Square. Conversely, while implementing Raingarden, the experts have faced the challenges of dealing with existing underground facilities and choosing the right type of plants for the project. In addition, lack of sitting space inside the garden was opined as a design limitation of Raingarden although designers of the project didn't consider it as a drawback. Because the design was intended to be integrated as a garden and paths. However, people with bike and wheelchair cannot pass through the garden, which is a limitation that cannot be ignored. The following section will highlight the Challenges aroused after completion of the projects.

4.9.7 Challenges Related to Maintenance of the Projects

In a research paper, Raymond and his colleges have considered monitoring as a significant part of NBS implementation stating that monitoring is involved with all the stages. Furthermore, they have also mentioned the maintenance of the NBS as a challenge because it incorporates financial issues (Raymond et al. 2017a). The Key Informants of both projects have uttered about some challenges that they are experiencing in the monitoring or maintenance of Water Square and Raingarden. Experts of Water Square revealed a few issues that the current concerns from this project. Firstly, the designing and building the project went fine, but the problem aroused afterward when it was completed because they had to hand over the project to a department who even did not know the whole process and its complexity. So, it was a great challenge indeed. Secondly, the project is very complicated. So, it needs extra maintenance, and extra maintenance means extra money. Moreover, it takes a lot of extra effort to clean it. As it's complicated, it is needed to be monitored by the experts to make sure it's working in the right way. Alongside, people have made the maintenance difficult because they through different trashes in the square. Though Rainwater is generally considered relatively clean, the flow of water in the Water Square transports substantial amounts of street litter (cigarettes, tree

leaves, soda-cans, mud etc.) (Photo 4.2). Such a condition has made the maintenance more critical. One Key person from the project expressed,

> *"Well, the water square was a very interesting and a successful project, but I don't want to make another one like this again, I would say never. Because, it is very complicated, requires too much maintenance. The project got complicated in monitoring or maintenance".*

Photo 4.2: Tree leaves in the Water Square (a notable problem in its maintenance).

(Source: Field Survey 2019)

Likewise, a co-designer of the project said that there is one thing always critical about water square and that is the Maintenance which is still of a negative issue of this project. *"You cannot blame the design though"* – he added. On the contrary, some issues were also explored that are related to the maintenance of Raingarden. It was said that the Raingarden is quite tough to maintain because there is a variety of plants including many flowing species as well. As mentioned in the earlier section, choosing the right type of plants remains a problem even in the maintenance phase of Raingarden. Because, if plants are found to have less growth or not surviving under the prevailing condition, they are required to be replaced with an appropriate species. Another fact is most of the public space have mono-culture, the plants are mostly separated according to their type. However, there is a mixed type of plants in Raingarden so it's complicated to look after these. Again, as similar to Water Square, people also through different rubbish inside the garden, that have made its cleaning complicated. Trashes like water bottles, plastics, butt of cigarette etc. were observed in different corners of the Raingarden (Photo 4.3).

Photo 4.3: Trashes (Bottle) thrown in the Raingarden. (Source: Field Survey 2019)

4.10 Level of Implementation (Dependent Variable)

The only dependent variable for this research is 'Level of Implementation' that includes some sub-variables in order to discern the implementation level of chosen NBS projects. To gather a very articulate idea about the implementation status of Water Square and Raingarden, only the perceptions of Key Informants are considered. As all of them have directly participated or worked in both projects, only they could provide a reliable answer about the implementation level of these projects. All the experts have opined about 'implementation level' though the perceptions varied among the Key informants. Furthermore, to understand the implementation level, 'materializing of design', 'attainment of goals', and 'ensured co-benefits' are assessed based on the experts' opinion and perception of the respondents. Out of the four Interviewee of Water Square, all of them have considered the project as 'successfully implemented' (Table 4.11). More specifically, one of them has emphasized that it's a very successful project that was implemented for reducing flood risk so far. The Key informant has described the reasons for considering this as very successfully implemented project. He narrated,

> *"First of all, we were able to make the first water square in the world. The typology of water square we built was not made before anywhere. So, it was an innovation I would say. As innovation takes time and after implementing our innovative ideas, it was successful indeed. Secondly, it is working as an alternative water management feature. It keeps 1700 cubic meter of water and combined sewer that is a huge volume I would say. Because we have reduced the risk of sewerage overflow along with this project which is contributing to manage the local flood water. From the socio point of view, this square is contributing to actively using the space in comparison to it used to be. It's not being used weekly or daily, rather I would say almost all day by different groups of people. Looking at the economic perspective, as Rotterdam is an iconic and resilient city in terms of flood management, this square is attracting many international delegates to visit which is really a commercial or economic benefit. I think it's a great benefit for us".*

Table 4.11: Perception of Key Informants about the Implementation level of Water Square and Raingarden.

Water Square		**Raingarden**	
Key Informants	**Implementation Level**	**Key Informants**	**Implementation Level**
Interviewee 1	Very Successfully Implemented	Interviewee 1	Successfully Implemented
Interviewee 2	Successfully Implemented	Interviewee 2	Successfully Implemented with Some Limitation
Interviewee 3	Successfully Implemented	Interviewee 3	Successfully Implemented with some limitations
Interviewee 4	Successfully Implemented with some Constraints	Interviewee 4	Successfully Implemented with some limitation

(Source: Field Survey 2019)

Other Key informants have also justified the reasons for considering Water Square as a successful project. An expert of Water square said that she considers this as a successful project because technically it's worked well, it is exactly what they wanted, it looks attractive for not only the for the people living around it but also for the professionals. She also added that it was a good integration of interesting ideas and most importantly people were happy with that. On the other hand, another participant has considered the project as Successful with some constraints. The person has argued that the project has created some problem afterward mostly related to the maintenance. Moreover, as it was a very complicated project, some issues were not thought that much which came to the light at the later stage of implementation.

As opposed to, only one Key Informant of Raingarden has mentioned 'Successful Implementation' of this project. One of the most influencing people of Raingarden project expressed,

> *"I think it's a successful project because a lot of people visit this Raingarden and sometimes people come there in groups and some students are even doing research on it. Moreover, for the first time, we have made the lower part of a garden (that stores water) not by grasses but by plants. And I think we have used the right plants for this project. Considering the strategy and details, this can be considered as a successful project. Of course, it could be made better, but I am really proud of the project".*

His argument of considering Raingarden as successful were mostly focusing on the co-benefits from the project. In addition, like Water Square, the Raingarden project was also the first of such Nature-Based Solutions in Rotterdam. There was no Raingarden project implemented before had done in *Agniesebuurt.* Therefore, initiating something different than the traditional with multiple benefits was a notable reason behind the success story of Raingarden. However, most of the experts said the project has few limitations instead of being successful. One of them stated that the design of Raingarden could be made better and may be the garden could have made over an extensive area. They do not consider the project successful as Water Square due to the limited effect of Raingarden. The following sub-section interprets the significant parameters of assessing the implementation level of both projects.

4.10.1 Materializing the Design

Materializing the design of a project is a significant indicator of the successful implementation of a project. This research has tried to assess the Implementation Level of both the chosen project and 'Level of Materializing the Design' of the project is one of the sub-variables developed in the operationalization stage. The Key Informants of Water Square and Raingarden were asked to choose a value from the scale of 0 to 4 and to justify the reason for choosing a particular value in the scale. Concerning Water Square, all the interviewees have chosen 3 in the scale (0 to 4) that stands for the Full implementation of design with little constraints (Table 4.12). Being a very complex and comprehensive project, it was quite challenging for the experts to come up with an appropriate design and materializing it. Because never had before this project any Water Square was made anywhere in the world possessing the same criteria. Instead of having little limitations, all the experts claimed the design was well implemented. One of the co-designers of Water Square said,

> *"I think the design as we imagined, has been materialized very well, even to the minor details. Lots of work went into detailing the elements that would transport and store water. The precision that went into detailing these elements (drawings, 3d, models etc.) was a necessity to ensure the functioning of the square and thus had to be exactly made the way it was designed".*

Table 4.12: Level of Materializing the Design based on Key Informants' Perception.

Level of Materializing Design (Scale 0 to 4)	Water Square	Raingarden
4 – Perfect implementation of design		
3 – Full implementation of design with little constraints		
2 – Partial implementation of design	-	-
1 – Little implementation of design	-	-
0 – Design didn't work as planned	-	-

(Source: Field Survey 2019)

The main challenge was to re-adjust the design many times. Moreover, there was a need to consider some other issues that have made the design process complicated. A Key Informant said that as design processes are usually very fluid and flexible, changes were made during the project. Many alternative designs have been made, tested and judged by the people who got involved. Moreover, concerning materialization of the square, the decision was made to use the typical 'Rotterdamse Stijl' paving on all areas that did not deal with rainwater, whilst the water-related parts (the basins, gutter, etc.) were realized using more special materials. Though there was a good level of materializing the design, the experts preferred not to consider this as 'perfect' realization. Because after implementing this project, the complex design of Water Square has created a few problems for the authority in terms of operation and maintenance.

Conversely, three out of four Key Informants told that the design of Raingarden was well implemented with some limitations. One of them said that it was quite tough to create an underground or lower portion of Raingarden that holds the water. Because there was already some underground infrastructure like sewerage, water pipes etc. which has made the materializing of design challenges. He added that they made some changes in the design of Raingarden bed due to the existing underground facilities. So, it was not possible to make evenly thick sand or soil layer throughout the garden. In the middle of Raingarden, the thickness of the bed is less than its other parts, which is a limitation of this project as he considered. At the same time, another Key Informant mentioned that the limitation of materializing the design of Raingarden is introducing the change of its working process at the later stage by the authority. She expressed,

> *"When rainwater comes down from the railway bridge (hofbogen), it goes into the garden. But the water doesn't stay long in the Raingarden, possibly for 12 hours I guess. In the beginning, the water used to stay for longer, however, the authority has made some big holes/pipes with stone to facilitate the drainage of water quickly. Because before the water even stayed there for 2-3 days but that's not allowed as long-term logging of water can cause the spread of insects or mosquitos. So, they had a problem with staying water too long. Therefore, they decided to make pipe holes through the thick layer and they filled it out with stone for the fast removal of water.*

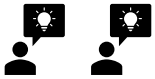
Now the problem is the water drains out too quickly which is depriving the plants in Raingarden to get enough water".

However, another chosen expert of this project opined that the design of Raingarden was materialized perfectly. He argues that the garden is working as expected so the score can be given as 4 in the scale (0 to 4). In sum, it can be stated that the design of both Water Square and Raingarden was materialized quite well instead of having some challenges. Though the limitations remain even after implementing a good level of design, both projects are working efficiently. The next section discusses the attainment of goals of both chosen projects, which is an important parameter to measure the Implementation Level of the present study.

4.10.2 Attainment of Goals of the projects

Achieving the goal is the most paramount part of implementing a project. As an indicator of the dependent variable of this study, the level of achieving goals for Water Square and Raingarden were assessed based on the perception of Key Informants. Regarding Water Square, three interviewees mentioned the 'Successful Achievement' of goals. This is because the main goal of Water Square was to make provision for retaining a substantial amount of rainwater. As the authority has successfully managed to make a reservoir that can hold 1700 cubic meter of water, it has fulfilled its primary target. In addition, the project has created multiple opportunities for people, which were the secondary goal of Water Square that are also fulfilled. Considering these reasons, majority of Key Informants have given score 4 in the scale (Table 4.13). However, one Key informant chose score 3 in the scale (0 to 4) stating that instead of having the volume for water storage, Water Square hardly gets filled with water. He added that although the goals are achieved, it's not holding the amount of water from rainfall as they expected.

Table 4.13: Level of Attainment of Goals based on Key Informants' Perception.

Level of Attainment of Goals (Scale 0 to 4)	**Water Square**	**Raingarden**
4 – Goals are successfully achieved		
3 – Goals are achieved but not as expected		
2 – Goals are about to achieve	-	-
1 – Some of the goals are achieved	-	-
0 – No attainment of Goal yet	-	-

(Source: Field Survey 2019)

On the other hand, half of the Key informants from Raingarden scored the achievement of its goal as 4 while the rest two interviewees scored the goal attainment as 3 (Table 4.13). Like Water Square project, experts of Raingarden have also presented the benefits that are achieved so far. They said that as a Nature-Based Solution, Raingarden has ensured a considerable number of benefits alongside retaining rainwater. These benefits reflect the successful

attainment of project goals. Nevertheless, a Key Informant has uttered something different, he said,

> *"It's true that Raingarden has successfully implemented, and the major goal of this project has been achieved. But I think all the goals are not fulfilled as it was expected. Because water drains out quickly due to the recently made holes that are filled with stones. It would be more effective when water retains for longer so that it can support all the plants of this area. That's a pity and that could be made better".*

Therefore, it is perceived that instead of having some limitations, the main goals of both Water Square and Raingarden are achieved. Furthermore, the attainment level of project goals is understandable from the offered benefits by these NBS. The next section will elaborate on the perceived co-benefits of Water Square and Raingarden project.

4.10.3 Co-Benefits of the Projects

The multifunctionality of Nature-Based Solutions is a noteworthy criterion that ensures different benefits and services for urban residents and for the cities itself (Frantzeskaki 2018). As NBS projects, Water Square and Raingarden provide some other benefits that are identified from the responses of people who use these projects and Key informants who have worked in the planning and implementation of both projects. As mentioned earlier, the paramount goal of either project is to expand the water-retaining capacity of *Agniesebuurt* neighborhood in order to lessen the flood risk during high precipitation. Alongside providing the water retention benefit, both NBS projects offer a number of advantages for the residents of this area. However, provided co-benefits by the chosen projects are a bit different than each other. Key Informants of the study have given their opinion about the level of achieved co-benefits from both projects. All the informants were asked to choose the level of co-benefits from the Water Square and Raingarden project on the scale of 0 to 4 (Table 4.14). Regarding Water Square, three out of four key informants selected 4 in the scale. Which means they claimed that the project is providing a substantial number of benefits to its stakeholder. Moreover, some benefits from this project are added to the plan to the expectation of designers. At the same time, one expert of Water Square opined that the project has only ensured the benefits which were expected by the authority before implementation. Contrarily, two experts of Raingarden chose the highest level (4) on the scale (Table 4.14). According to them, Raingarden has created multiple opportunities for the people in different ways although it was mainly constructed to increase the rainwater retention capacity of the area.

On the other hand, Respondents perceptions were gathered through the questionnaire survey to list the co-benefits from both projects. The vast majority of respondents (78%) from Water Square mentioned the Sports facilities as a significant benefit from it (Figure 4.10). The design of Water Square includes a Basketball court and a skating ground (Photo 4.4). Many young people were seen to skate over the square, though the researcher has rarely seen someone to play Basketball. Some respondents told that sports center use the Basketball court sometimes while some kids reported that they often play soccer there. Furthermore, some students were observed to practice dance over the Basketball court. In addition, about 58% people said that the square is a nice playground for the children. As opposed to, no sports facility is provided by Raingarden and none of the respondents is mentioned about such co-benefit from this project, though children were seen to play in Raingarden as the design allows the kids to do some interesting tasks like jumping over smaller sized concrete blocks. Moreover, one-fourth of respondents from Raingarden mentioned the facility of Children's playground as a benefit of this project.

Photo 4. 4: People are playing Basketball (left) and hanging out (right) at Water Square.

(Source: Field Survey 2019)

About one-third of the respondents said about the scope of Community Gathering (32%) and a nice place that can facilitate Social Interaction (34%) as benefits from the Water Square (Figure 4.10). Almost all Key Informants have mentioned the 'Hanging out' of young people in the square, and most of them are students. Such get-together opportunity somehow helps to improve social cohesion as said by many of them. Respondents from both projects have expressed that these places are suitable for Relaxation while few people see indirect health benefits from these NBS project. One of the Key informants uttered that Water Square gives the opportunity for sports and relaxation while Raingarden can impact people's mind positively with its green environment; both projects indirectly offer health benefits to the people. Nature-Based Solutions are designed in such a way that these could provide support to nature and can assure the benefits for the mental health of people. Precisely, NBS can create the scope for residents to get relaxed and recover from the mental stress that eventually leads to the well-being of those people (Ambrey and Fleming 2014; Carrus et al. 2015; Frantzeskaki 2018).

Table 4.14: Level of Achieved Co-Benefits based on Key Informants' Perception.

Level of Co-Benefits (Scale 0 to 4)	**Water Square**	**Raingarden**
4 – Significant numbers of co-benefits are achieved even more than expected		
3 - Planned co-benefits are gained only		
2 – Some co-benefits are provided	-	-
1 – Few co-benefits with difficulties	-	-
0 – No co-benefits at all	-	-

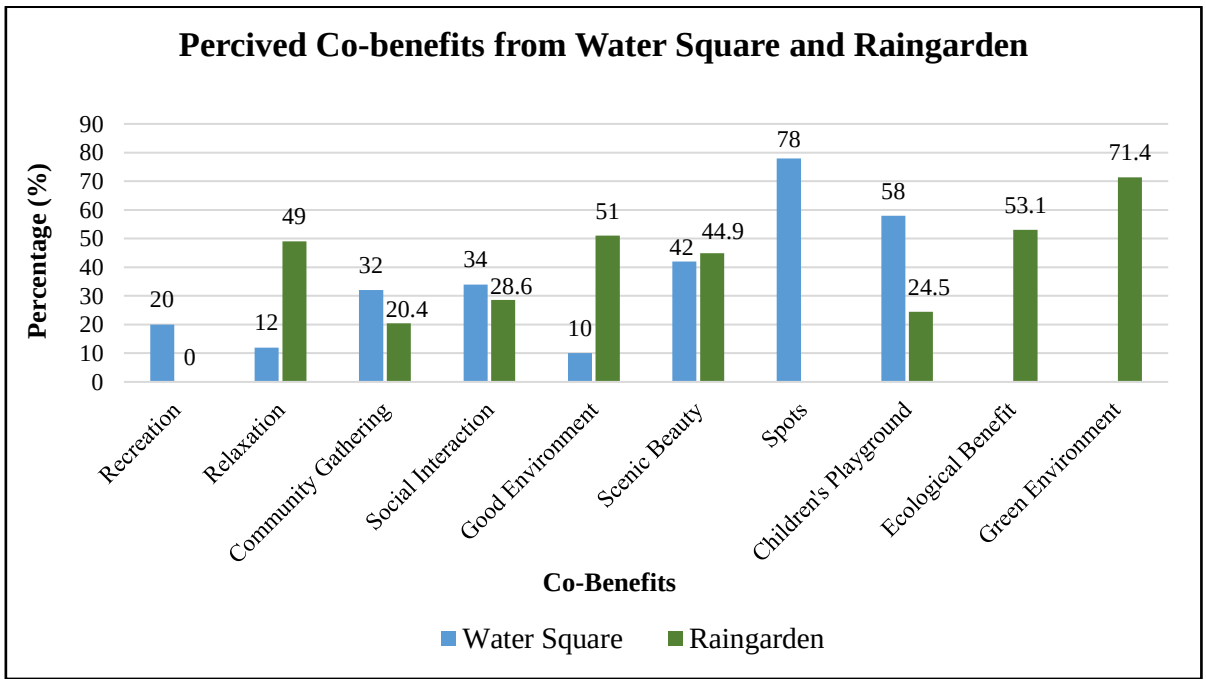
(Source: Field Survey 2019)

Again, more than 40% users of both projects have mentioned Aesthetic beauty as an advantage from these NBS (Figure 4.10). A coordinator of Water Square project said that the unique

design of this project is attracting many people to visit the place regularly, even many professionals from other countries often come to have a look of this. Similarly, another Key Informant of the same project said,

> *"This is the first water square of its type in the world, so it has an iconic value that attracts tourists and experts to see the project. I think it is somehow benefiting the Dutch experts due to its design and working strategy. Furthermore, it has created a commercial value of such project as many other cities are now trying to make water square due to its multifunctionality".*

Figure 4.10: Perceived Co-benefits from Water Square and Raingarden.



(Multiple Responses are Considered) (Source: Field Survey 2019)

On the other hand, people who expressed aesthetic beauty as a benefit from Raingarden mostly said that natural beauty attracts them to walk through this garden. About 71% of respondents stated that Raingarden has created a green environment in the neighborhood. A respondent added that as *Agniesebuurt* neighborhood has very little greeneries, Raingarden is a green place where people feel better to walk through and spent their time. Montgomery (2013) pointed out in his research that green spaces create new experiences between people and nature. In addition, two of Key Informants have mentioned the term 'Social Cohesion' while talking about the benefits of this project. They said that Raingarden is a place where people of different age groups visit regularly, however, they emphasized that the garden is a nice place for older people to spend their quality time. The opportunity of people's interaction in this public space can surely improve social cohesion among them (Photo 4.5). In a word, Raingarden is being used as urban green common alongside its main purpose of holding rainwater; Frantzeskaki (2018) also mentioned that NBS creates urban commons for the people living around it. A Key Informant of Raingarden project stated,

> *"It has health benefits as it provides a nice environment for the citizen because nature can somehow affect the happiness of people. And the entrepreneurs of the area are really pleased with this garden. People really love to walk through the garden, mostly*

residents with pets prefer to walk through this Raingarden. Some people also told me that they love the place since it was changed".

Again, three out of four Key informants of Raingarden have mentioned the 'Ecological Benefits' of this project. Likewise, just above half of the respondents also talked about the ecological benefits of this project. A Key informant, who is also a biological expert said that this garden has also benefited the tiny animals, giving them shelters and helping to maintain the ecological balance of that area. In like manner, one of the designers of Water Square told about the indirect ecological contribution of the project. Furthermore, another common expected benefit from both chosen NBS is the raising of people's awareness about using nature. In the earlier section (section 4.9.2), people's familiarity with NBS is described where it is found that a substantial number of people are still not aware or acquainted with NBS. Key informants of both projects expect that Water Square and Raingarden could consider as 'Showcase' for the people to understand the nature and green infrastructure.

Photo 4.5: People walking with pets (left) and sitting (right) next to Raingarden.

(Source: Field Survey 2019)

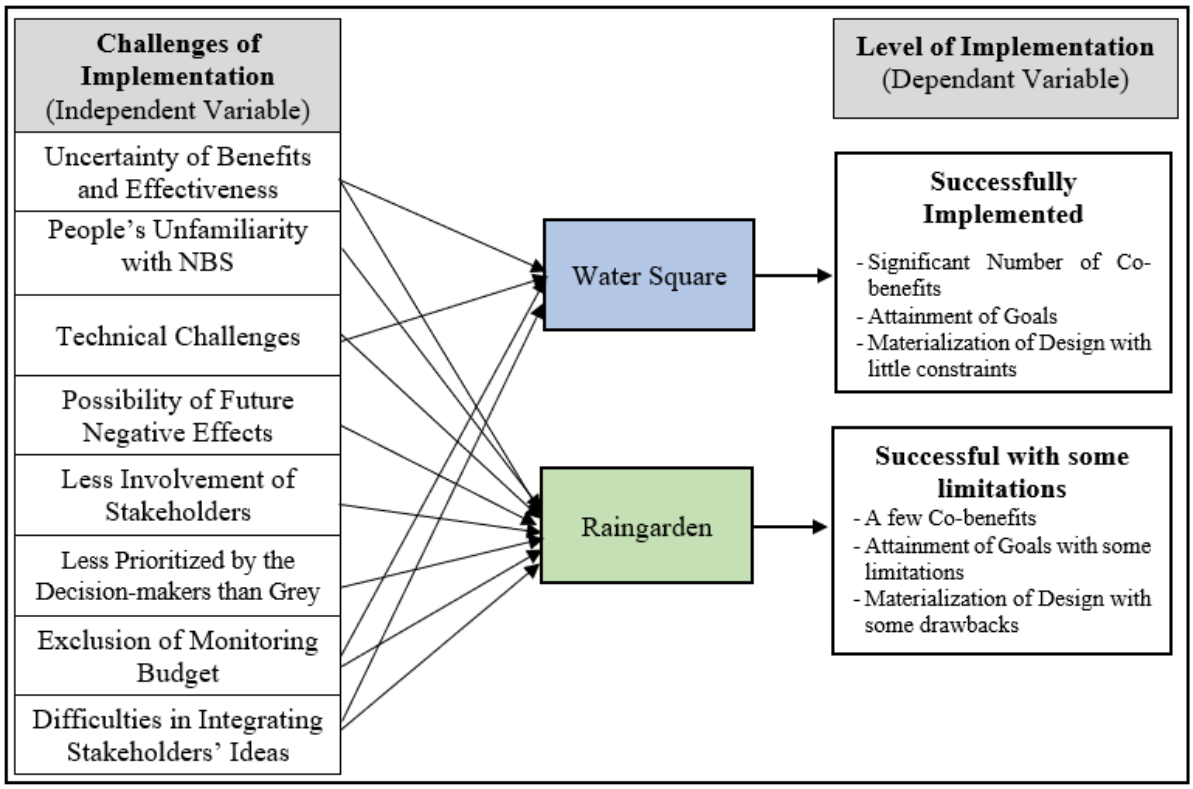
In fine, it is well perceived that being Nature-Based Solutions, Water Square and Raingarden are providing a substantial number of benefits alongside their main purpose of rain water retention. Though Water square mostly offers the relaxation and sports facilities, Raingarden is more appreciated by the people for its aesthetic view and green environment. Furthermore, both projects could make the people more acquainted to NBS, as expected by the Key informants of this study. The next section explains the relationship between 'Implementation Challenges' and 'Level of Implementation' of the chosen projects.

4.11 Implementation Challenges and Level of Implementation

The main focus of this study was to explain the relationship between existing challenges of implementing NBS and level of implementation of the chosen projects. This research has identified many challenges pertaining to the different stages of implementation. Though a framework was developed based on the theoretical review, in the field the researcher realized that all the sub-variables (independent) didn't get the answer. Moreover, as a case study research, the present study has included a few new sub-variables under the Independent variable. Due to the modification in sub-variables, a revised theoretical framework is presented here (Figure 4.11). The framework demonstrates the relationship between Independent and Dependent variables for Water Square and Raingarden project.

From the revised framework (Figure 4.11) it is visible that a total of eight challenges were identified that are related to the implementation of both projects. Water Square had four notable challenges that affected its implementation level somehow. Being the first Water Square in the world, it had the uncertainty in terms of its benefits and effectiveness. As experts said about the issue of uncertainty, they could not provide assurance of a considerable number of benefits from the project. Moreover, it was not certain whether the project is going to work according to the design and plan. However, the dexterity of experts and the unique design of the project ultimately ensured the effectiveness of the project. And for this reason, Water Square is considered as a 'Successfully Implemented' project by the participants. Again, there were technical difficulties while making the design. It was known that due to the complicated design of Water Square, it will be very tough to make any changes in the future. Such technical complexity represents the rigidness of the project. The intricacy of its design has even made maintenance as a tough task for the responsible authority. Furthermore, the higher expenditure and requirement of specialized maintenance were reported by the Municipality and other chosen experts of this project. Presumably, such complications in maintenance has created an apathy for the authority to maintain it regularly as the square has been observed to remain filthy for a long time period during this study. It was known that the aftermath of this project was not foreseen or assumed by the experts and even they did not expect to have a complicated scenario for its maintenance. Even a prime expert of this project uttered that they would not make Water Square of its type anymore because it's a lot of work to deal with during and after the implementation. The technical difficulties have limited the success rate of the project to some extent, otherwise, Water Square could be considered as a 'Very Successfully Implemented' project.

Figure 4.11: Revised Theoretical framework showing the relationship between variables.



At the same time, there was a challenge of integrating stakeholders' ideas because everyone came up with different concepts. Being a participatory process, everyone tried to contribute with their best and they expressed their expectations from the project. The spontaneous

participation was an advantage of the project as it has resulted into a unique design for Water Square but the dissimilarity of people's expectation from the project has somehow affected the integration process and made the procedure critical. So, it was a challenge to consider everyone's idea and make a comprehensive design that would reflect participants' expectations. However, experts claimed that they have managed the challenge well that lead to the success of water Square. Conversely, although the money was sufficiently available throughout the project, no fixed budget has been available regarding the maintenance of Water Square. If there was a budget included in the implementation cost, the project would be more secure. Because the afterward difficulties of the project already created a concern of its maintenance and if the monitoring cost increases with the time for any reason then the authority might not invest the money for proper maintenance of this project. Moreover, another concern remains of prioritizing the maintenance compared the Grey projects, as the effectiveness issue of NBS has not been investigated yet. It is not certain how long it will be well maintained and remain effective. Therefore, the success status of Water Square could be changed in the coming days, if not well maintained. Overall, the project is considered as a 'Successfully Implemented'. Even though there were some limitations, those challenges were tackled well by the experts except the maintenance issue.

On the other hand, Raingarden project has confronted a significant number of challenges throughout its implementation. Many of them have affected the implementation level of Raingarden. The perception of people about the familiarity of NBS (Figure 4.7) presents that most of the users of Raingarden have very less or no familiarity with the NBS concept. This shows a situation of people not having sufficient knowledge about NBS. Moreover, possibly due to the lack of familiarity, many people of *Agniesebuut* could not exactly tell about the purpose of the Raingarden. From the Key informants of Raingarden, it was known that no resident from the neighborhood was involved in the implementation process, rather ZOHO companies were invited to join the process considering that ZOHO is a business area and companies can contribute better than the residents. Due to the involvement of a fewer number of stakeholders, possibly, the design of Raingarden is not unique as Water Square. If people of that area had more familiarity with the NBS, possibly they would have been invited to join in implementation process. And their participation could result in the integration of more expectations of the people in Raingarden. As local residents were not in the planning and implementation, many of them have expressed the limitations of this project as it couldn't fulfill their expectation to some extent. The Raingarden has been considered as a less successful project by many of its users. Subsequently, people's unfamiliarity with NBS concept had an impact on the success rate of the project. Again, Raingarden has also had some technical challenges. Firstly, existing underground facilities have made the process complicated and experts needed to make design accordingly. So, the soil bed in Raingarden was not made uniform throughout the area. Secondly, to drain out the water quickly, some pipes were introduced in the design so that water doesn't stay longer. However, an expert said that plants of the area are not getting benefits from such strategy of quick infiltrating the water. Which can be considered as a limitation and made the project less successful. Thirdly, the design of this project didn't include sufficient sitting space inside the garden. This could be a possible reason of fewer users of Raingarden than Water Square. Moreover, involvement of the resident during its implementation could raise such expectation by them, it has not happened possibly due to their absence. The next Challenge aroused from the project is the spread of mosquito. Though some experts refused such allegation of the inhabitants, the prevalence of mosquito might cause health problems, even dengue. Such possibility of future negative impact from the project has limited the success rate of Raingarden. Moreover, if any negativity happens from this project, this will discourage the authorities and stakeholders to initiate such project in other places.

Again, it was known that there was a priority issue from the decision-making body. Raingarden project was not really prioritized due to its local level of effectiveness compared to the Grey projects. However, an expert said that Water Square was equally treated as a traditional engineering project because there was something unique about the project that made the decision-makers to prioritize it. Another similar challenge of Raingarden to Water Square is the exclusion of monitoring budget. Therefore, uncertainty remains of future benefits from Raingarden as the maintenance level would define the further effectiveness of this project. So, it is understood that because of having several challenges associated with the Raingarden project, this couldn't be considered as successful as Water Square.

To conclude then, it can be stated that the Water Square project is more successful than that of Raingarden because the higher number of challenges have somehow affected the success rate of Raingarden. Moreover, the indicators under dependent variable (Figure 4.11) also describes the implementation level for which Water Square is found as a 'Successfully Implemented' project and Raingarden is identified as 'Successful with some limitations'.

4.12 Concluding Remarks

This research has unveiled numerous challenges that could affect the implementation process of Nature-Based Solutions in Rotterdam. The requirement of involving multiple stakeholders, ensuring a significant number of co-benefits and most importantly utilizing the concept of natural process have made the NBS projects quite different than tradition grey infrastructures. Subsequently, a number of challenges arise in the implementation of Nature-based projects. Moreover, a connection has been identified for such challenges with the implementation level of NBS and the causal relationship is explained in this study. The research came to the conclusion that the higher the number of challenges faced in the implementation process of an NBS project, the less successful the project is. All the implementation challenges along with the existing problems of an NBS project could limit the scope of its effectiveness and therefore the success rate. The next chapter specifically answers the research questions and recommends future possible initiatives.

Chapter 5: Conclusions and Recommendations

5.1 Conclusion

The progressive effect of climate change could possibly affect the cities with more intense and devastating events like flooding. As urban flooding is already evident in numerous global cities, it is becoming a concern to undertake effective measures to make the cities resilient. The present research has analyzed the implementation aspects of Nature-Based Solutions. The current scenario of NBS implementation in Rotterdam, more specifically the existing challenges, assured co-benefits and the linkage between Implementation challenges and implementation level are tried to understand from this study. Using a mix method approach within a case study framework, this research has brought different issues of NBS to the light in order to answer the research questions. The following sections answer the research questions that have been formulated for the current study.

5.1.1 Sub-Question 1: What is the level of implementation of NBS for flood reduction in Rotterdam?

This question has been answered mostly based on the perception of Key Informants from both projects. Three indicators are used to assess the Implementation Level of Water Square and Raingarden i.e. Attainment of Goals, Materialization of Design and Assured level of Co-benefits. Firstly, regarding the achievement of the goals, both projects have attained major goal though Raingarden is said to have some limitations. This is because of the technical challenges as the design of Raingarden that could not fulfill the expectation of people and even of experts. However, Key informants have claimed that the main goal of retaining rain water was achieved for both projects. Secondly, the design was well implemented for both chosen projects. Nevertheless, experts have mentioned some technical issues that hindered the perfect martializing of their design. Lastly, both of the projects have ensured a number of co-benefits alongside fulfilling its goal of increasing the water retention capacity of the neighborhood. The interviewees of the study have opined that Water Square has attained co-benefits even more than expected. Being the first Water Square in the world, it has attracted many people to visit and has ensured some facilities to its users. Contrarily, Raingarden has also ensured a few benefits for the people. Though it could have provided some more benefits as opined by the people of that area. Again, all of the Key Informants were asked about the implementation level other than chosen indicators. In the case of Water Square, only one person has mentioned the 'Successful with some limitations' while others have expressed the 'Successful Implementation' of the project. On the other hand, pertaining to Raingarden, most of the experts have mentioned that the project is 'Successful with some limitations'. Therefore, based on the assessment of indicators and experts' opinion, the Implementation level of Water Square is '*Successfully Implemented*' while Raingarden can be considered as '*Successfully Implemented with Some Limitations'*.

5.1.2 Sub-Question 2: What are the challenges faced during NBS implementation in Rotterdam?

Rotterdam Municipality has initiated and handled the implementation of Both of the projects. This research has identified several challenges that are related to the different stages of implementing NBS. Some of those challenges are applicable for both Water Square and Raingarden while a few challenges are different for the later one. The current study has revealed that in the planning or initial stage of implementing both projects there were challenges like 'Uncertainty of Benefits or Effectiveness' and 'Lack of People's familiarity with the NBS

Concept' has also hindered the project somehow. Kabisch and his colleagues have defined such uncertainties of benefits and effectiveness as *"fear of the unknowns"* (Kabisch et al. 2016a, b). On the other hand, some other researchers have considered the 'People's Unfamiliarity with NBS' as a significant barrier to its implementation (Balian et al. 2016; Kabisch et al. 2016b), this issue has also been identified in the present research. Moreover, there was a challenge of 'Integrating the Ideas of Stakeholders' because a different group of people came with dissimilar ideas, which was a tough task to develop a design considering everyone's expectation. A few numbers of research works (e.g. Fish 2011; Keune and Dendoncker 2013; Nesshöver et al. 2017) have considered that bringing all stakeholders together is one of the complicated tasks in NBS implementation process, however, this study found the problems of integrating participants' ideas rather than bringing them together. At the same time, both projects have experienced some technical challenges. In Water Square, the technical difficulties were faced while making the design and implementing it. However, the technical problem that affected the Raingarden design was existing underground facilities of that area; which made the implementation difficult and imposed some changes in the design. Furthermore, there was a technical change brought by the authority for quick infiltration of water because if the water retains in Raingarden for more than a day, it could possibly result in the growth of mosquito. However, some respondents have also reported the prevalence of mosquito from this project. Which is a current challenge from the Raingarden as it might result into 'Negative Health Effects' on the residents of this area (such health problems were also said by Keune et al. 2013 and Nesshöver et al. 2017). Again, the complicated design of Water Square has created some present challenges in the maintenance of the project. Moreover, it was known that the design of Water Square has very little possibility to allow any modification in the future, which is indeed a future challenge that might affect the project. On the other hand, it was expressed by the Key Informants, the budget of both projects did not keep any financial plan for the maintenance, which might result in uncertainty of maintaining the project effectively. Droste and his co-researcher also mentioned about the financial constraints of the municipality for NBS projects. (Droste et al. 2017). In fine, it is understood that the major challenges related to the projects are the uncertainty of benefits, technical issues, involving and integrating stakeholder's ideas, possible negative effects in future (from Raingarden), lack of people's familiarity with the project purpose and NBS concepts, and exclusion of monitoring budget. Moreover, there was an issue of less prioritizing the Raingarden project compared to the traditional engineering projects, which has been considered as a hindrance to the implementation of NBS in many earlier research works (e.g. Nesshöver et al. 2017).

5.1.3 Sub-Question 3: Which co-benefits are provided by NBS in addition to flood reduction in Rotterdam?

Co-benefits from the projects were identified and listed through the perception of respondents, opinion of Key Informants and using observation. Both Water Square and Raingarden has ensured a number of benefits that are added to their main purpose of Rain Water retention to eventually reduce flood risk in the area. Though the number of benefits provided by either project is different, both of them have some similar co-benefits for the people. Relaxation, Community Gathering, Increasing Social Interaction are some common benefits from both projects. People often visit the projects and spend their quality time considering these as nice places. It was said by some people that such NBS project is helping to ameliorate the social cohesion (also mentioned by Birch et al. 2010; Xiang et al. 2017) among the community by creating public commons. Frantzeskaki (2018) has also mentioned the benefits of NBS in creating urban commons. However, Water Square is providing some recreation and sports facilities that are not offered by Raingarden. People of different ages mostly the teens were seen to play soccer and skating there. Moreover, there is also a basketball court where students

or people from the sports centre sometimes play basketball. The court was also seen to be used as a dancing practice ground while visiting the site during the data collection phase. Moreover, Water square is observed to be used as a playing ground for the children where very few kids were seen to play in the Raingarden. Some children prefer to play using the cubic blocks made in Raingarden, they jump from one to another. Research works (e.g. IUCN 2019; Lafortezza and Sanesi 2019) have also stated that NBS ensures different recreation and relaxation facilities for the people. In addition, the most notable benefit from Raingarden is that it has made the area Green and ensured a good environment for the people living nearby. Furthermore, Raingarden is ensuring ecological benefits (also mentioned by McFarland et al. 2019; Cohen-Shacham et al. 2016; Hartig et al. 2014) and has improved the aesthetic view of the area. Therefore, it is understood that both projects are providing different co-benefits to the people though Water Square is found to offer more facilities than Raingarden.

5.1.4 Main Research Question: What are the existing limitations and challenges that affect the implementation level of NBS for flood reduction in Rotterdam?

This research has identified several challenges that were experienced during the implementation of Water Square and Raingarden. The challenges are found regarding different stages of implementation. Both projects have faced some common challenges including the difficulties of integrating stakeholders' expectation and unfamiliarity of people about the NBS. Moreover, there was an uncertainty regarding the attainment of benefits and effectiveness of either project. There were a number of technical challenges for both projects. In the case of Water Square, it was quite challenging to materialize its complex design while the underground facilities have affected the design of Raingarden. Such difficulties have affected the implementation level of both projects. This study has found from the analysis that Water Square has been considered as 'Successfully Implemented' project due to its limited number of challenges faced. Moreover, some experts opined that the challenges were managed with their dexterity, therefore, the implementation process of Water Square went well, and the project has ensured a significant number of co-benefits. Hence, because of the limited effect of challenges, Water Square is a successfully implemented project. However, there are some more limitations found for Raingarden. It was known that instead of the involvement of many stakeholders, there was no resident in the implementation of Raingarden. Due to a smaller number of people's involvement, the design of Raingarden doesn't reflect the expectation of inhabitants from the neighborhood. The Key Informants have claimed that as a business district, there are few residents nearby the Raingarden, that's why they have invited the local entrepreneurs to be part of the implementation process. Nevertheless, it is found that the main users of this project are local residents instead of the companies. This is a notable limitation of the project. Moreover, Raingarden has created a possible future negative impact i.e. Spread of mosquito. This has resulted in fear among some people, though experts have denied such allegation. Furthermore, there are some more limitations in the design like not having enough sitting provision inside the garden and lack of adjustment of the path in the Raingarden with the main street, which doesn't allow any person to pass through with wheelchair. Based on the limitations and challenges faced during and after implementing Raingarden, the project can be considered as 'Successfully implemented with some limitations'. The reason behind some success rate is the offered co-benefits from Raingarden for the people of *Agniesebuurt*. Therefore, this study has found that 'Implementation Challenges and Limitations' affect the 'Implementation Level' of Nature-Based Solution projects.

5.2 General Recommendations

From the experience of this study, some general recommendations are made that could enrich the literatures focusing Nature-Based Solutions.

- This study has provided a sound experience of investigating Nature-based Solutions. From this research, it is understood that NBS projects are complex and takes time to investigate thoroughly. It is suggested that long-term projects could be introduced to evaluate the drawbacks and the effectiveness of Nature-Based Solutions.

- The research realized that there is insufficiency in the monitoring process after implementing the NBS projects. Consistent monitoring of the projects could ensure effective outcomes from NBS.

- In order to integrate the NBS into policy measures, detailed research works are required that can reveal the effectiveness of Nature-based projects. The present study has found that existing literatures are not sufficient for the decision making about NBS, so more assessments are necessary for this field.

- The findings of this research could be used to carry out further work on the implementation aspects of NBS. All the effort of this study will be fruitful if the findings are considered in the policy measures and to prolong this work.

5.3 Specific Recommendations

This study has identified different implementation issues and unveiled diverse benefits that are currently provided by Water Square and Raingarden. Based on the findings and analysis, the current study recommends that the following measures should be taken into consideration by the authority.

5.3.1 Recommendation for Water Square

- The project is found to be unique in design, but presently it doesn't have an effective maintenance strategy. During the data collection phase, it was observed as dirty and sometimes with filthy water. People expect to see the square clean and tidy. This study suggests that the square could be made cleaner and better if the users are somehow involved in the maintenance strategy. Therefore, a participatory maintenance strategy could be lucrative for the authority to operate the square easily and to reduce the monitoring expenses.

- People are often seen to through the trashes (soda can, butt of cigarette etc.) which have made the place less attractive. However, some interesting posters could be made and demonstrated in different location of the square to raise awareness among people to keep it clean.

- Water Square has the capacity to store 1700 cubic meter of rain water. However, people of the area reported that they have rarely seen the square to be filled with water. This reflects the additional capacity of the project to hold more water than only from its surrounding buildings. The authority can make provision to bring more water from the nearby buildings to increase the impact of this project.

- The main reservoir has lost its appeal to the people due to the incessant deposition of dirt. As an iconic project, the reservoir needs to be refurbished to increase the aesthetic beauty that would represent Nature-Based projects in a better way to the people.

- Some people stated that this square should have more greeneries. Moreover, it was also seen that the project has no shady space. It is suggested to increase the greenery of the projects and planting more tree to create more shady space for relaxation.

5.3.2 Recommendation for Raingarden

- Though the project involved some stakeholders while planning and implementation, there is no such way to participate in the maintenance of Raingarden. The authority can involve the communities to take of care of plants and maintaining the garden. Such scope will attract many people to spend their time in community gardening. Moreover, this Raingarden could be made a showcase of different species of plants and herbs that could be learnable for the kids.

- Some residents of *Agniesebuurt* neighborhood mentioned about the prevalence of mosquito possibly due to the Raingarden. So, the authority should take the issue into consideration.

- Many people expressed the limitation of Raingarden of not having any sitting chair inside the garden. Keeping a consistency to the current design, some organic sitting space (e.g. log of tree, wooden chairs etc.) might be introduced in the garden. This would surely attract more people.

- The path inside the garden doesn't allow someone to pass through with a wheelchair. Therefore, disabled or older people who cannot walk have a low possibility to visit the place. This path inside the garden should be adjusted to the main street.

- An expert claimed that the quick infiltration of water in this garden deprives the plants to get enough water. So, this matter should be considered to bring about a possible change so that all plants in the garden and nearby areas can get adequate water.

- Raingarden is a great way to introduce people to Nature-Based Solutions. Hence, it is suggested that some informative posters could be used in the garden to inform about NBS to the visitors including kids.

5.4 Future Research Scope

This study was a little endeavor to analyze the implementation aspects of Nature-Based Solutions. It has only focused on the existing challenges and its relation to the implementation level. Moreover, the study has identified the co-benefits as well. However, the researcher thinks that there's a vast scope for the future study to investigate the implementation issues. Implementation challenges could be investigated for more projects to generalize the NBS limitations. More specifically, future research work can be conducted on the limitations of NBS for all the existing projects to understand their effectiveness level. In addition, no such research has been found so far that compares the effectiveness of NBS project with the Grey infrastructures. It is possible to investigate the effectiveness of NBS in terms of cost-benefits, contribution and risk reduction of a possible hazard. Therefore, this research suggests the individual researcher or organizations to carry out more research work to reveal the effectiveness level of NBS that would certainly motivate the authority to consider NBS projects in lieu of traditional Grey infrastructures.

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Annex 1: Research Instruments and Time schedule

Questionnaire on

"Nature-Based Solutions (NBS) for Flood Reduction in Rotterdam: Challenges, Implementation and Co-benefits"

(As part of MSc. Thesis of Master's Student, Institute for Housing and Urban Development Studies (IHS), Erasmus University Rotterdam, the questionnaire will be used to collect information at field survey. The collected information will solely be used for research purposes and confidentiality of all information will be preserved)

Instructions for the Interviewee/ Respondents

1. This research is about the Nature-Based Solutions (NBS) in Rotterdam. The aim of this research is to know your perception about challenges, benefits and implementation level of NBS. We have chosen two NBS project in Rotterdam. So, you can answer the questions regarding anyone or both projects. However, there are some general questions as well that you can answer even if you don't know anything about those chosen projects.
2. Please Carefully read each of the questions and choose your answer from the given options
3. Choose your answer based on your own opinion
4. If you don't agree with the given choices of answers, you can tick the 'Others' and please write your comment on it
5. If you don't want to reveal any Basic information (like name, income etc.), you can leave it blank
6. Please, make sure that you have put the tick mark for all the questions
7. For the questions that **don't have any option to choose**, please write your own comments/answer yourself. Your opinions are really matter for this research.

- Please Choose the Project You are familiar with (please choose one)

• **Water Square**, Benthemplein Rotterdam, The Netherlands	• **Raingardens**, Rotterdam, The Netherlands

A. Respondent's Basic Information

Name: Age:

Gender: | Male | | Female | |

Educational Qualification: a. Higher secondary b. Honors/Degree/Bachelor

c. Master d. Others …….

Occupation: . . . . . .

Duration of living in this Neighborhood: Years

Resident Status: | Local | | Non-Local | |

Monthly Income: ……. **Email**:

Name of Neighborhood:

B. Information on Nature Based Solutions

i) **How familiar you are with the concept of "Nature-Based Solutions (NBS)"?** (put tick in one answer)

Scale 0 to 4
4 – Very familiar and already involved with NBS
3 – Familiar but never got involved in NBS
2 – Heard about the concept with some idea
1 – Heard about the concept but no idea
0 – Not familiar at all

ii) **Do you know what are the Purpose/uses of chosen NBS project** (Water Square/Raingarden)?

1 – Yes 2 – No

If yes, please mention them
…….

iii) **Did you participate in the planning or implementation stage of the NBS project?**

1 – Yes 2 – No

If **Yes**, what was your role there?.....

Were you able to contribute your knowledge or experience for that project?

1 – Yes 2 – No

Do you think all stakeholders (who were involved) were equally prioritized?

1 – Yes 2 – No

Was everyone Spontaneous in participating that project?

1 – Yes 2 – No

Was there a good integration of ideas/expectations from stakeholders?

1 – Yes 2 – No

Do you think, the project was developed as all stakeholders expected?

1 – Yes 2 – No

iv) **What are the benefits have you realized/obtained so far from this project (Water Square/ Rain Garden)?** (You can choose more than one option if necessary)

1. Recreation
2. Relaxation
3. Community Gathering
4. Social Interaction
5. Good Environment
6. Scenic Beauty
7. Sports
8. Children's playground
9. No benefits at all
10. Others……..

v) **Do you think this project has contributed to flood water/ flood risk reduction in the neighborhood somehow?**

1 – Yes 2 – No

If Yes, then what is scale of contribution-

Scale 0 to 4
4 – Very High contribution for flood reduction
3 – Contributed enough
2 – Contributed for flood reduction with some limitations
1 – Very little contribution so far
0 – No contribution at all

vi) **Do you think NBS project can reduce flood risk like Engineering infrastructures (for example: Dam, dike etc.)?**

1 – Yes 2 – No

vii) **Do you know any disadvantage or problems that are created by the NBS project** (Water Square/Raingarden)?

1 – Yes 2 – No

If Yes, please mention them

…….....

viii) **What do think about the area/space that is occupied by this project?**

Scale 0 to 4
4 – Very large area required
3 – Required more space than engineering infrastructures (like dam, dike, bridge etc.)
2 – Almost equal as engineering projects
1 – Less than engineering projects
0 – Project was done in a small area

Thanks for Your Cordial Support and Time

Interview Outline for the Key Informants

This is an interview outline for the Master Thesis on "*Nature-Based Solutions (NBS) for Flood Reduction in Rotterdam: Challenges, Implementation and Co-benefits*"

Name of the Project/Case: Water Square/Rain Garden Date:

Name of Key Informant:

Occupation and designation:

a. What was your role in this project?.....

b. How long you were/have been involved with the project?.....

c. How you got to know or involved in that project?.....

Implementation Processes

d. Could you please briefly tell the implementation process of this project?

e. What is level of implementation of the project?

1. Successfully implemented
2. Partially Implemented
3. Piloting stage

If Number **1 or 2**, Why are you considering this project as successfully implemented or partially implemented?

f. How well the design of the project was Materialized?

Scale 0 to 4
4 – Perfectly implementation of design
3 – Full implementation of design with little constraints
2 – Partial implementation of design
1 – Little implementation of design
0 – Design didn't work as planned

g. Was there any necessity to bring about any changes in the design? If Yes, then why?

h. **What were the challenges faced during the implementation of this project?**

i. How the challenges of this project were overcome?

j. Do you think those issues or challenges have prolonged or constrained the project somehow?

Stakeholders Involvement

k. Which Level of government was involved with the project?

Scale 0 to 4
4 – Fully supported by the national government
3 – Join venture of national and local government
2 – Only supported by local government (municipality)
1 – Partially Supported by Local or National government
0 – No government support/ private initiative

l. Which stakeholders were involved for this project?

m. How Spontaneous stakeholders were in participation?

Scale 0 to 4
4 – Very Spontaneously participated
3 – Spontaneously participated
2 – Participated with some conditions
1 – Only few Stakeholders participated
0 – No participation of Stakeholders

n. Which type of experts have worked in this project?

o. How well the ideas of experts were integrated?

Scale 0 to 4
4 – Very Successfully integrated
3 – Integrated somehow
2 – Integrated with some difficulties
1 – Partially integrated
0 – No integration of multidisciplinary knowledge

Achievement of Goals

p. Was there any uncertainty regarding the achievement of goals of the project?

q. To what extent the goals of this project was achieved?

Scale 0 to 4
4 – Goals are successfully achieved
3 – Goals are achieved but not as expected
2 – Goals are about to achieve
1 – Some of the goals are achieved
0 – No attainment of Goal yet

r. What was the short-term and long-term goals of this project?

s. Do you think short and long-term goals are well integrated for this project?

If Yes, how? If No, then why?

t. **Do you think that this project might create any negative effects**?

1. Yes 2. No

If yes, what is the Risk level of negative effects?

Scale 0 to 4
4 – Very High risk
3 – High Risk
2 – Moderate risk
1 – Low risk
0 – No risk at all

u. What is the reliability level of this project in terms of effectiveness?

Scale 0 to 4
4 – Fully Solving the problem
3 – Can be more effective than grey infrastructure
2 – Equally effective as grey projects
1 – Less effective than grey
0 – Very little effective

Financial Issues of the Project

v. What were the main sources of funding for the project?

w. How available the funding was?

Scale 0 to 4
4 – Sufficient fund was available
3 – Funding was available with some limitations
2 – Funding was partially available
1 – Little funding was given
0 – No fund was available

x. What was the total cost of this project?

Achievement of Benefits

y. To what extent the co-benefits from this project were ensured?

Scale 0 to 4
4 – Significant numbers of co-benefits are achieved even more than expected
3 - Planned co-benefits are gained only
2 – Some co-benefits are provided
1 – Few co-benefits with difficulties
0 – No co-benefits at all

z. Could you please mention the co-benefits provided by this NBS project?

aa. What do you think about the size or area required for this project?

Scale 0 to 4
4 – Very large area required
3 – Required more space than traditional infrastructures
2 – Almost equal as grey project
1 – Less than traditional projects
0 – Project was done in a small area

bb. Did u face any challenge while managing the space for this project?

1. Yes 2. No

If Yes, please mention the challenges-

cc. Do u think, Nature-Based Solutions like Raingarden could be effective as traditional Grey infrastructure?

dd. To what extent Raingarden is contributing for flood reduction in the Neighbourhood?

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