RETROFITTING SUSTAINABLE DRAINAGE SYSTEMS (SUDS) IN PUBLIC BUILDINGS IN THE UK: A COST BENEFIT ANALYSIS MODEL

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ABSTRACT

In a changing climate with an increased risk of flooding, developing a resilient and sustainable approach to flood management is paramount. The retrofit of Sustainable Drainage Systems (SuDS) has been applied successfully to properties and has proven to be a cost-effective solution to help mitigate future flooding and to deliver other benefits to properties, such as improvements in air and water quality, economic benefits, educational benefits and improved business reputation. Despite these benefits, there has been a relatively low uptake of SuDS in new developments and even less so in the opportunities for retrofitting SuDS in existing buildings. This research presents a cost-benefit appraisal of the retrofit of SuDS in three classes of existing public buildings to understand the decision-making process of SuDS retrofit, the flood perception around these properties, and significantly, the costs and the benefits accrued within a period of 10years.

A synthesis of flood risk management and SuDS retrofit literature is used to inform the development of a conceptual cost-benefit analysis model for the retrofit of SuDS, focusing on the potential for improved flood risk mitigation in the context of individual properties. A qualitative study was carried out comprising a series of interviews/ focus group sessions with stakeholders to the properties, an analysis of documentary evidence and observations carried out on site. Presentations were made at regional Environment Agency meetings including individual visits to professionals. This informed the possibility of gaining access to the most appropriate case study sites which were able to meet up with the requiremnts of this research.

The findings of this research demonstrate the importance of stakeholder engagement during the decision-making process in helping to overcome many of the known challenges and the inclusion of expert(s) particularly the landscape architect to facilitate the implementation of these schemes. The Willingness-To-Pay (WTP) process was used effectively to value the tangible and intangible benefits arising from these schemes. The installation at each of the case

study sites would provide net value to the client of well over £100,000 over 10 years versus the installation costs and return on investment would be achieved in less than 3 years. Having a stakeholder who is speicifcally involved in modeling the funding procedure of the scheme is essential. Community engagement is also a very important output of the research.

The findings highlight many of the apparent barriers that need to be overcome when installing retrofit schemes and demonstrate the importance of the intangible benefits derived. It is recommended that these are given full consideration at the decision-making stage and in supporting the uptake of the retrofit of SuDS.

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DEDICATION

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LIST OF ABBREVIATIONS

CBA	Cost Benefit Analysis
CIRIA	Construction Industry Research and Information Association
CMM	Choice Modelling Method
CVM	Contingent Valuation Method
FCERM	Flood and Coastal Erosion Risk Management
FRM	Flood Risk Management
NFM	Natural Flood Management
NPV	Net Present Value
ROI	Return on Investment
SPM	Stated Preference Method
SuDS	Sustainable Drainage System
SWMO	Senior Water Management officer
UK	United Kingdom
WTP	Willingness to Pay

GLOSSARY

Choice Modelling Methods – Is a family of survey-based methodologies for modelling preferences for goods, where goods are described in terms of their attributes and of the levels that these take. Respondents are presented with various alternative descriptions of a good, differentiated by their attributes and levels, and are asked to rank the various alternatives, to rate them or choose their most preferred. By including price/ cost as one of the attributes of the goods, willingness to pay can be indirectly recovered from people's rankings, ratings or choices.

Contingent Valuation Method – The contingent valuation method (CVM) is used to estimate economic values for all kinds of the ecosystem and environmental services. It can be used to estimate both use and non-use values, and it is the most widely used method for estimating non-use values. The contingent valuation method involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services.

Cost-Benefit Analysis – This is an analysis of the cost-effectiveness of different alternatives to see whether the benefits outweigh the costs.

Stated Preference Methods – Can measure the total economic value; that is, SPM incorporates both non-use value and option value. this characteristic has far-reaching potential as it implies that SPM can be used to value potential future or hypothetical (but realistic) goods and interventions.

Sustainable Drainage Systems (SuDS) – SuDS is a generic term that refers to various measures used to control the effect of surface water runoff in the environment.

Sustainable Drainage Systems (SuDS) Retrofit – This is a stormwater management process which is aimed at addressing urban water quality and the problems associated with flooding.

Retrofit is used when SuDS are proposed for the replacement or augmentation of an existing drainage system.

Tangible Benefits – These are the benefits that can be expressed in monetary terms such as reduced cost of infrastructure, improved aesthetic value.

Intangible benefits – These are the benefits which are not easy to express in monetary terms such as reduced loss of life, habitat for wildlife.

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CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND OF THE RESEARCH

Flooding is among the most significant perils in the world. It poses a considerable threat to the sustainability and function of urban infrastructure – road, rail, electricity, housing and water supply, sewage networks and the lives of those who live in urban areas all over the world (Juan, 2017). Annual reports suggest that this curve is continuing, so flood risk management (FRM) becomes ever more significant (Salathé Jr et al., 2014). In urban cities where flooding events are much more experienced, the impacts of flooding can vary, but their consequences are similar (Hallegatte et al., 2013). Sites close to drainage canals, rivers and dams are more liable to the risks of flooding (Downs and Gregory, 2014). Impacts include damage to infrastructure, disruption of movement that could end up in diverted routes, destruction of dwelling places, unhealthy environments, damage to agricultural farmlands and livestock and destruction of educational facilities (Castaneda and Simpson, 2013).

Flooding events have increased significantly in the UK since 2000 to date (Kay et al., 2021). One of the primary reasons for this evolution is climate change, making the UK significantly warmer (Intergovernmental Panel on Climate Change, 2014). This suggests that reduction in flooding events will not stop but will continue to increase, and therefore a pragmatic approach is essential for built resilience to flooding. In the UK, the population is expected to increase significantly by 2050 and has the potency to put around three times more people at risk from pluvial flooding (Kundzewicz, 2014). In 2007, above 55,000 dwellings and businesses were affected by inland flooding affecting many parts of England and Wales. Between November 2015 and January 2016, the highest ever rainfall occurred, which caused the most extreme events within the UK in the last 100years (Council, 2017). The summer floods happened due to 223% of intermediate precipitation (based on an average between 1971-2000) from the commencement of May to the end of July (Pitt, 2008). Roughly one-third of the flood events were due to river flooding, while the remainder resulted from surface water flooding drainage failure.

In recent times, flooding events in the UK have been very concerning, with various sites experiencing varied shapes of impact (Johntson et al., 2021). Flooding is often a consequence of urbanisation due to installing pipe-based drainage systems and increased impermeable surfaces (Charlesworth et al., 2003). Pipe based conventional drainage efficiently directs water to an outflow, resulting in large outpourings of runoff in a short period. This reduces the natural 'lag time' or the time it would typically take for water to research a stream through groundwater flows (Lashford, 2016).

The Pitt Review aimed to address the severe and widespread flooding occurrences recorded in 2007 (Crick et al., 2016) and outlined the lessons learned during the review. An emphasis was made on the need for environmental agencies and councils to strengthen their technical capability to lead local flood risk management (Pitt, 2008). This has resulted in various initiatives by the environment agency and local councils in setting up policies such as the SuDS manual, which acts as a guide for delivering any SuDS retrofit scheme within the council. Other government agencies such as the Department for Environment, food and Rural Affairs (Defra), Internal Drainage Boards, Coastal protection authorities, highway authorities are working closely with the Cabinet Office, the Department for Communities and Local Government (for land use and planning policy) to prepare policies that can manage the effect of flooding events. A prevailing concern of every citizen of the UK is to see an environment where the risk of flooding and its impact is reduced (Geaves and Penning-Rowsell, 2016). However, it appears that the response of the government in this respect is relatively slow. Local authorities keep coming up with various options for managing flooding events within their locality, suggesting that there should be a consolidated effort by the central body, Defra, to put a working system in place (Srivastava, 2020).

1.2 RESEARCH PROBLEM

The Pitt review created a list of recommendations for the government, focusing on improving flood defences through a 25-year plan. These recommendations included a commitment to make SuDS and the retrofit of SuDS more useful in FRM by resolving who should be responsible for their ownership and maintenance (Pitt, 2008). SuDS have been successfully delivered in various parts of the world and have effectively managed flooding events in flood-prone areas and have also proven to provide sustainable development, which has improved places and spaces where people live. SuDS is a concept that includes long term environmental and social factors in decisions about drainage. It considers the quantity and quality of runoff and the amenity and aesthetic value of surface water in the urban environment. However, the uptake of the retrofit of SuDS has been low (Ossa-Moreno et al., 2017; Stovin, 2010). Stovin (2010) attributed the low uptake of the retrofit of SuDS to various reasons such as significant stakeholders undervaluing the scheme due to the complexity of the monetisation and quantification of the broader benefits, the fear of the high cost of implementing the scheme and the fear of the cost of maintenance.

1.3 AIM OF THE STUDY

This research aims to develop a cost-benefit analysis (CBA) model of the monetary and non-monetary costs and benefits of SuDS retrofit for public buildings in the UK.

1.4 OBJECTIVES OF THE STUDY

To achieve this aim, the following six objectives have been outlined;

1. To critically review SuDS retrofit's effectiveness in managing flooding events in the UK towards identifying the benefits and opportunities alongside the barriers and obstacles to its adoption.
2. To critically review the literature on CBA in order to identify its potential application to the study of SuDS retrofit in the UK.
3. To develop a CBA conceptual model, aligned explicitly to public buildings in the UK, of the costs and benefits of installing SuDS as a retrofit, based on integrating the existent literature.
4. To elicit the actual value of the costs and benefits of the retrofit of SuDS through a willingness-to-pay (WTP), including reducing flood risk from a sample of case study sites in the UK.
5. To analyse the costs and benefits of SuDs retrofit schemes and explore the decision-making process towards refining the conceptual CBA model and its relevance for practical application in future public buildings.
6. To draw conclusions from the findings to provide a basis for proposing implications for FRM as it affects the installation and uptake of SuDS as a retrofit and make recommendations for further studies.

1.5 RESEARCH METHODOLOGY

The motive for choosing a research methodology in any research is not the advantages or disadvantages of the method (Creswell, 2009). The factor that drives the choice of one approach above another is the nature of the study problem or objectives (Creswell, 2009; Ormston et al., 2014). If a concept is to be understood, a qualitative research approach should be employed because less research has been carried out. This research adopted a qualitative paradigm to investigate the CBA of SuDs retrofit. The qualitative concept suggests that the research concept is significantly inductive, which involves developing a framework before its application through a case study research, which will then inform the general conclusions that will be useful for further research (Gunter, 2002).

This research includes a comprehensive literature review consisting of relevant journals, books, internet articles, and thesis. This is essential to distinguish the knowledge gap in the study of FRM related to the uptake of SuDS retrofit in public buildings, to understand the monetary and non-monetary value of the costs and benefits accrued and the maintenance process of the scheme. Particular emphasis was laid on quantifying the benefits accrued on these properties with the WTP process and incorporating it into a CBA framework for the future decision-making process of the installation of SuDS.

Given the nature of investigation associated with this research, a case study approach involving a process of triangulation of evidence involving focus groups/interviews, documentary enquiry and observations was employed. This helped obtain relevant information that formed the final recommendations and conclusions reached in this research. Three case study properties were purposively selected being of different use and relevance to the community where they are located. From the stakeholders at these properties, various information was obtained, including the decision-making process of installing the scheme, the costs and benefits from installing the scheme and the maintenance process.

Choosing or deciding on the number of ideal cases for qualitative research could be pretty challenging, considering that the case study options must provide the expected depth to inform the standard from an investigation into the value of the costs and benefits of the retrofit of SuDSs (Yin, 2017). In choosing these case studies, various parameters were considered and examined. Many of these points have been outlined in chapter 5 of this thesis. However, the fact that there were limited numbers of retrofitted sites in the UK and that these cases have been able to meet up with the conditions outlined for the final choices of these cases made it possible to decide to settle with three case study options.

1.6 BENEFICIARIES

Originality is demonstrated by developing a CBA model for the retrofit of SuDS. Although CBA has been applied to other flood interventions at the various property level, this is the first time a study of this nature will be applied to the retrofit of SuDS. SuDS have been used successfully on different properties globally; however, the uptake has been low in the UK. A literature review reveals that the knowledge of the monetary and non-monetary value of the benefits from SuDS retrofit has been a setback to its uptake. This study's uniqueness is the WTP process that has been applied to quantify the intangible benefits accrued from the retrofit of SuDS. Quantifying intangible benefits has been significant difficulty in studies that require CBA application. By focusing on the CBA of the retrofit of SuDS, it is anticipated that stakeholders will be able to appreciate the monetary and non-monetary value of the benefits accrued from the installation of the retrofit of SuDS and use the framework as a CBA tool to work out the decision-making process of delivering SuDS and the cost-effectiveness of the scheme.

FRM professionals and government agencies could use the framework developed by this study to make effective policies that will contribute to the successful uptake and delivery of SuDS retrofit. Subsequent research could consider applying the CBA model to other property types and FRM schemes such as NFM to understand it’s usefulness in different research types.

1.7 THESIS STRUCTURE

This thesis is presented in ten chapters. Chapter one detailed the study's context, including the aim and objectives and the research questions. The research methodology to address these questions is outlined; the fundamental limitations and benefits are also discussed.

The literature review for the study was broadly sectioned into two parts, each forming a chapter. Chapter two presents the literature review on SuDS and SuDS retrofit, including the barriers and opportunities to its uptake in the UK. Chapter three presents the CBA concept, while the initial development of a framework is given in Chapter four, which is followed by a detailed research methodology in Chapter five. The chapter further incorporates a justification of the chosen approach. It also outlines and justifies the data collection and analytical methods to be used.

Chapters six to eight provide the data analysis, while Chapter nine presents a detailed discussion of the study's findings. Chapter ten presents the conclusions of the research and final recommendations.

1.8 SUMMARY

This chapter has detailed the context in which the research is established and the justification for this study. This chapter has shown that flood risk management is an essential issue in the UK and globally and needs every attention available. The increasing effects of climate change and the developing pressures of flooding events have increased the importance of more research that cannot be overstressed, especially the research in SuDS retrofit. This research is timely in that there has not been any study that clearly outlines the monetary and non-monetary values of the retrofit of SuDS and there is the emphasis from the Pitt review on property owners taking responsibility for FRM within their properties.

The study aims to develop a CBA model of the monetary and non-monetary costs and benefits of SuDS retrofit for public buildings. Based on this aim, objectives were set out, and the critical research questions have been outlined, and the study's contribution was stated together with the limitations of the study. Chapter one has, therefore, laid a foundation for the thesis on this foundation, the thesis proceeds with a detailed discussion of the research.

CHAPTER 2: LITERAUTRE REVIEW - SUSTAINABLE DRAINAGE SYSTEMS

2.1 INTRODUCTION

Sustainable Urban Drainage Systems (SuDS) have been proposed to mitigate the results of flooding at various locations prone to flood hazards and as part of an integrated approach to flood risk management (Jenkins, 2016). SuDS has been successfully applied in cities worldwide and have proven to be a cost-effective solution to manage flood risk whilst also delivering a range of other benefits (Smith and Mijic, 2016). Today, almost all SuDS implementations have been carried out on new developments; however, the retrofit of SuDS offers many benefits, but the uptake until now has been somewhat limited (Stovin, 2010). This research seeks to investigate the monetary and non-monetary value of the costs and benefits of the retrofit of SuDS in the UK as part of an integrated approach to flood risk management. This chapter presents a critical review of the effectiveness of SuDS retrofit in managing flood events in the UK, emphasising the benefits and opportunities alongside the barriers and obstacles to its adoption are presented in this chapter. The chapter also presents one of the primary objectives of this research, which sought to critically review the literature on the effectiveness of SuDS retrofit in managing flood events in the UK, emphasising the benefits and opportunities alongside the barriers and obstacles to its adoption.

2.2 IMPACTS OF FLOODING ON PROPERTIES IN THE UK

The impacts of flooding or the implication of flooding events depend on the nature of the area's experiencing it. Flood experiences could either be mild or deeply impacting; they could be complicated or versatile (Amadi et al., 2015). Flooding events can cause distressing and severe cases like loss of life and personal injury, including the destruction of properties and businesses. Whatever the severity, the outcome from the people affected can be devastating and often complex. Flood occurrences often cause considerable damage to properties, demanding huge financial sums for repairs, and in some cases, it could lead to relocating families and businesses to alternative accommodations (Proverbs and Soetanto, 2004).

An example can be seen in the 2007 summer flooding event in the UK, which had a significant impact on the lives of many residents and their businesses. According to research, this is one of the most devastating experiences in recent history in the UK (Joseph et al., 2014; Sefton et al., 2021; Haslett & Wong, 2021). Another example is the flooding event between November 2015 and January 2016, named storm Desmond (McCarthy et al, 2016). This flooding event is said to be the wettest that happened within three months after 1920. Several indicators in the latest UK state climate report show that the UK’s climate is becoming wetter. For example, the highest rainfall totals over five days are 4% higher during the recent decade (2010 – 2020) compared to 1961 – 1990 (Saddique et al., 2020). The change in climatic conditions is constantly experienced in the UK, and it requires proactive intervention.

2.3 SUSTAINABLE DRAINAGE SYSTEMS (SuDS)

SuDS is a generic term that refers to various measures used to control surface water runoff's effect on the environment (Locatelli, 2016). It is the method most often mentioned concerning possible actions that homeowners can take. Hence, SuDS is seen by many as an essential contribution to urban climate change adaptation (Baron and Petersen, 2016.). SuDS replicates the natural drainage processes of an area by using vegetation-based interventions such as swales, water gardens, and green roofs, which increase localised infiltration, attenuation and detention of stormwater. Hence, SuDS improves flood alleviation capacity in any community. In all SuDS, the most used and well-known examples are soakaways, green roofs, swales, rainwater beds and permeable surfaces, and open drainage waterways and reservoirs for excess rainwater (Baron and Petersen, 2016). All these solutions aim to absorb, evaporate and channel rainwater, so it does not end up in the sewage system.

2.4 RETROFIT OF SUSTAINABLE DRAINAGE SYSTEMS (SuDS)

SuDS retrofit is a stormwater management process aimed at addressing urban water quality and the problems associated with flooding (Walsh, 2016). Retrofit is used when SuDS is proposed to replace or augmentation of an existing drainage system (Smith, 2016). There is limited experience of retrofitting SuDs in the United Kingdom, and there are no well-established procedures for evaluating the feasibility, value or cost-effectiveness of doing this. However, there remains growing interest in introducing this technology (Stovin, 2013), and stakeholders and researchers have developed modalities on making SuDS more acceptable and relevant within the UK (Carboni, 2016). Examples of retrofitting SuDS can be seen in installing green roofs, the diversion of roof drainage from a combined sewer system into a garden soakaway, the conveyance of road runoff via roadside swales into a pond sited in an area of open space (Ellis, 2013). These represent alternative ways of influencing the water downstream's quality and its problems, thereby providing a more effective, resilient and sustainable approach.

2.5 BENEFITS AND BARRIERS TO THE IMPLEMENTATION OF THE RETROFIT OF SuDS IN THE UK

Several benefits that cut across various positive improvements in housing schemes and people's lives have been identified. Malulu (2016) found that a standard SuDS intervention scheme, one of the essential benefits of SuDS, entails the carrying out of works to rivers to increase their capacity to carry flood flows. Friberg et al. (2016) identified how the scheme is carried out, which are by channel maintenance or enlarging the channel cross-section and thereby increasing the flow of surface water by extending the wider capacity. The mitigation of the heat island effect and noise, the improvement in air and water quality and the provision of sites for recreation or urban amenities are various ways by which the ecosystem is sustained through SuDS retrofit (Demuzere et al, 2014; Ellis 2013; Kazmierczak et al 2010).

Other benefits of SuDS retrofit is in the reduced cost of infrastructure by the introduction of green infrastructure. Ellis (2013) argues that conventional drainage systems cannot provide the expected solution to any flood mitigation process but an extended approach based on the introduction of retrofit SuDS, in the likes of micro-and Meso-vegetative SuDS systems into a wider green infrastructure(GI) framework, can effectively address on-site and catchment urban surface water issues.

Health Improvements from the use of SuDS is also an essential benefit to every citizen. Lamond et al. (2015) affirm the importance of an improved flood risk management system to manage the growing pressure of flooding events on the health of the occupants of any community. Greenough et al. (2001) address the health effects of flooding, which are typically associated with disasters. These are direct morbidity and mortality and secondary or indirect health impacts.

A direct impact includes an impaired public health infrastructure, reduced access to health care facilities, and psychological and social effects. An indirect impact could alter ecologic systems, resulting in land covers being damaged and the abundance and distribution of disease-carrying insects, rodents and some other vectors (Pongsiri et al. 2009). An improved health system through the application of SuDS retrofit helps to address these health issues.

Economic growth can be stimulated by SuDS retrofit, through the attractiveness of an area to new businesses, creation of jobs from the installation and maintenance of SuDS, and improved productivity of workers when the environment is positively impacted by aesthetics, improved health conditions, improved air quality and many others (West et al 2009; Kruger, 2014).

Carpenter (2012) found that an aesthetically improved environment with the installation of SuDS and tourist attraction, recreation, and research tends to attract visitors from different locations, both locally and internationally. Green infrastructure has been credited in the UK with a significant impact on job creation (Chegut et al., 2014). Also, in the United States, shoppers tend to stay longer when visits are made for business purposes, owing to green structures (Yi, 2014).

Also, in projecting the cost of installing SuDS retrofit and the future effect on a community, most notably when considering a value-oriented structure, a conducive whole life costing (WLC) is guaranteed. Lamond (2016) explains whole life costing as a methodology that gives a systematic economic consideration of all costs associated with SuDS retrofit. Considering this methodology, some factors are measured – finance, business costs and income from the land sale, and user costs. All these factors are essential when gauging the economic implication in terms of the cost-effectiveness of SuDS retrofit in a community in other to deliver the best value for money.

However, despite the increased flooding events in the UK, the uptake of SuDS retrofit as a flood risk management measure is still mainly being ignored (Ossa-Moreno et al., 2017). The lack of experience and trust in some of the approaches is a significant setback for implementing SuDS retrofit (Backhaus et al., 2016). Convincing stakeholders about a new scheme could be quite tricky when consideration is given to failed flood risk management schemes (Kundzewicz et al., 2017).

Flood risk management in England and Wales is currently seen differently in water supply and water quality management terms (Kangalawe, 2017). This hinders the possibility of collaborating efforts and budget across these regions to maximise the available output, through major solutions that can manage existing challenges in a cost-effective way (Cousins, 2017). Damming is traditionally considered safe because it has been built according to high technical standards. However, many dams constructed decades ago do not meet the current state-of-the-art dam design guidelines (Marsden, 2017). This has resulted in the collapse of these structures and increased the failure of the SuDS tool in mitigating flooding.

The responsibility of the cost of maintaining and implementing of SuDS retrofit is also being shifted because of fear of the high cost of maintaining such schemes (Ashley et al. 2010). SuDS tend to be undervalued by stakeholders owing to the complexity of the monetisation and quantification of its wider benefits, with major stakeholders. Agwuele (2013) attributes this to the avoidance of the implications of the possibly high financial effect and the management of the future costs of implementation. The fragmented nature of systems resulting in the assessment of the retrofit proposal from varying angles makes it difficult to appreciate the full advantages (Zeunert, 2017). Due to the reluctance in the uptake of SuDS retrofit in the United Kingdom, direct and indirect incentives are low; therefore, the number of private investors prepared to invest in the scheme is limited.

2.6 CRITICAL REVIEW OF THE BeST TOOL

The BeST (Benefits Estimation Tool) tool was developed by the construction industry research and information association (CIRIA) to guide blue-green infrastructure valuation. It is said to assess the benefits of blue-green infrastructure easier without the need for full-scale economic inputs. The BeST tool was first developed in 2015 and has gone through three stages of updates, with the latest update in 2019. The tool's current version follows a simple structure that begins with coarse screening and qualitative assessments to identify the benefits to evaluate quickly. However, it does not have any process for assessing intangible benefits. The latest version has now been incorporated with the NFM, which is an example of a blue-green infrastructure that was not included initially.

The latest version of the tool includes 15 monetised and 3 non-monetised benefit categories indicating the inadequacy of this tool to incorporate the intangible benefits identified in the literature. Another gap in this tool is the non-inclusion of most of the SuDS retrofit requirements; hence, it cannot meet the needs of stakeholders willing to use the tool to consider the decision-making process of the installation of SuDS retrofit.

2.7 SUMMARY

This chapter has investigated the feasibility of SuDS implementation and precisely the benefits of retrofit of SuDS. The most relevant benefits provided by SuDS are flood risk reduction, rainwater harvesting, reduction of surface water charges and amenity, air and water quality, improved health and conducing a whole life costing approach. However, barriers such as the lack of trust in these schemes, the lack of clarity regarding the responsibility of the cost of maintenance, the complexities of monetising their full value, and the experience of similar approaches will need to be addressed before there becomes a better acceptance of SuDS retrofit in the UK.

The further implementation of policies that have successfully promoted large-scale SuDS implementation schemes worldwide should continue to help promote the use of SuDS and lead to a more assertive flood risk management approach (Feng and Tan, 2017). However, other developments and further research will be needed to promote and support SuDS retrofit use. Specifically, further research is recommended to help develop a fuller appreciation of the true costs and the monetary and non-monetary benefits of SuDS as part of an integrated approach to flood risk management.

CHAPTER 3: LITERATURE REVIEW - THE CONCEPT OF COST-BENEFIT ANALYSIS

3.1 INTRODUCTION

This chapter presents a review of the theory around cost-benefit Analysis (CBA). This is in line with objective 2, which is to critically review the concept of CBA and its application to the study of SuDS retrofit. CBA is significantly developed; however, applying it to life events and activities is not always easy. The aim of this research is to develop a CBA model of the monetary and non-monetary costs and benefits of SuDS retrofit for public buildings. Therefore, considering the CBA theory with particular reference to decision-making and investment appraisal is essential and relevant to this study. Furthermore, the quantification of the intangible benefits of the retrofit of SuDS will require different cost estimation methodologies to develop comprehensive costs and benefits model.

3.2 COST-BENEFIT ANALYSIS (CBA) CONCEPT

At specific periods in our daily commitments, we are bound to make decisions that are meant to positively or negatively influence our lives. Such a decision could be installing SuDS retrofit as a tool to mitigate flooding events within a property. In making such an important decision, a course of action is then required to attend to the requirements of the problem at hand decisively. This course of action may result in asking a question such as, ‘Is it worth it?’ This is important because, at the end of the process, the aim of embarking on the action is for a satisfying result. A method of this nature could be referred to as using cost-benefit Analysis (CBA).

In the current realities of the world's increasing complexity and an augmenting concern of the necessity of integrating environmental aspects into societal and organisational planning, there is a need for a powerful and efficient tool that will facilitate a better understanding and evaluating of the economic, technological and environmental system (Leitao et al., 2002). A critical purpose of such tools is to provide relevant and structured information in decision-making processes.

CBA is a broad economic valuation method with a wide scope compared to other financial tools (Drummond et al., 2015). It converts costs and benefits into monetary terms. Therefore, it is not restricted to the healthcare sector but can also be used to make decisions both within and between different sectors of the economy (Weatherly et al., 2009). Snell (2011) described CBA as a formal technique adopted for a straightforward, systematic and rational decision-making process, especially when faced with complex alternatives or uncertain data. Also, Nas (2016) defined CBA as a procedure for estimating all costs involved and possible profits derived from a business opportunity or proposal. Cost-Benefit Analysis is described or depicted differently, depending on what it is to be applied to. Still, a unifying understanding could conclude that CBA is a decision-making tool that, when rightly used, helps solve complex decision-making by taking into account economic processes related to monetary or non-monetary values (Argyrous, 2009).

CBA is a useful tool in accounting for quantitative and qualitative factors to analyse the value for money for a particular project or investment opportunity (Sartori et al., 2014). Hockley (2014) and Vickerman (2017) think that CBA is essential for a more decisive result for a reliable future and that it contributes to understanding by giving a formal description of the subject and examining the theoretical basis for some of the techniques that have become the accepted tools of decision-making around the world. CBA aims to provide a consistent procedure for evaluating decisions regarding their consequences (Nas, 2016). CBA offers clear guidelines for evaluating government decisions in such varied fields as tax, trade, or incomes policies, the provision of public goods; the distribution of rationed commodities; or private investment licensing (Forsth et al., 2016).

CBA appears to be a challenging tool to apply to real-life situations. Snell (2011) described it as a technique adopted for explicit, systematic, and rational decision-making, especially when faced with complex alternatives or uncertain data. Environmentalists generally oppose cost-benefit Analysis (CBA), and regulated industry generally supports it (Masur and Posner, 2017; Cole, 2012). Both sides have attorneys with extensive experience lobbying for regulatory outcomes favouring their constituents' interests and know a great deal about the regulation process (Pinto et al., 2012). CBA estimates and totals up the equivalent money value of the benefits and costs to the community of projects to establish whether they are worthwhile (Dwyer, 2012). These projects may be dams, highways, or training programs and even health care systems.

In concluding as to the desired output of a project, all aspects of the project, positive or negative, must be expressed in terms of a typical unit, which can also be referred to as the project's bottom line (Haavaldsen et al., 2014). This significant and most common unit could be referred to as money. This means that all benefits and costs of a project should be measured in terms of their equivalent money value. A project or program may be projected to provide benefits that are not directly expressed in terms of money, but there is a level of financial commitment the recipients of the benefits would consider just as good as the benefits of the project (Hanley et al., 2009; McKinnon, 2010).

CBA as a technique has been suggested for use by some research organisations, one of which is the Canadian Institute for Research in Construction, owing to its usefulness in economic justification for any floodproofing measure among floodplain residents (Rotimi et al., 2014; Owusu, 2014). In applying CBA to a project, an overview of the distribution of a project or its resources, alternatives, and uncertainties is inherent; this is because the project's overall assessment or the costs associated with it requires full information (NAS, 2016). Therefore, all costs and effects are considered when the project appraisal is carried out.

3.3 CRITICISM OF COST-BENEFIT ANALYSIS (CBA)

The relevance of CBA as a project appraisal tool cannot be overstressed. This is obvious in the volume of impact and its criticism by different researchers in various fields where it is applied. Many of these views and thoughts are similar and well-articulated; however, it may be challenging to expound on every idea which may have been expressed in different disciplines. It is, however, important to highlight those points which are relevant to this research.

Wegner and Pascual (2011) argue that when CBA is applied to public ecosystem services, the theoretical assumptions that underlie economic valuation and CBA fail to fully acknowledge the multiple dimensions of human well-being, the plural forms of value articulation, the complex nature of ecosystems, the distributional biases of markets and the fairness implications of Spatio-temporal framing. Joubert et al. (1997) asserted that the concept of CBA demands the quantification of all costs and benefits in monetary terms, even when not all benefits are traded in the market, therefore, posing problems to economists in the evaluation stage.

Another example that is closely related to the study of SuDS retrofit is the submission made by Ackerman (2008) that the costs and benefits of public policies do not always occur simultaneously. The benefits of installing SuDS as a retrofit goes beyond the present results, but it is more futuristic than its costs. Therefore, in addition to presenting all costs and benefits in monetary terms, CBA follows the standard economic practice in discounting future benefits, converting them to their equivalent value today (Brent, 2007; Kumar, 2010). The economist, therefore, concludes that whenever the span between the benefit and costs is so great, the analogy to an individual investment decision breaks down (Mun 2002). However, Heal (2017) suggested that consideration should be given to a very low-level allocation to the cost to derive a well-enhanced benefit in setting a discount rate for a project.

3.4 ORIGIN OF COST-BENEFIT ANALYSIS

The CBA tool is relatively primitive with its useful record in various sectors that are evident with the writings of Jules Dupuit (Pearce, 1998). The origin of CBA dates back to the 1840s as a concept by Jules Dupuit, a French engineer and also an economist, and it was formalised in subsequent works by Alfred Marshall (Bouleau, 2013). Jules introduced the concept to weigh up project costs and benefits to determine the viability of government projects (Adler and Posner, 1999). Jules' interest was how to make public choices about investment, not majorly of a commercial focus but more environmentally impacting, especially investments that had no necessary commercial returns, such as roads and bridges (Nhial, 2012). CBA gained popularity in the 1950s with an established notion which is today called 'consumer's surplus, the consumer's net benefit from consuming something and measured by the excess of willingness to pay over the cost of acquiring the good owing to the achievements recorded on the projects it was applied on (Moosa and Ramiah, 2014). A significant achievement was made with the Corps of Engineers in the US initiating the use of CBA after the Federal Navigation Act of 1936 which required the use of the CBA for the proposed federal waterway infrastructure project at that time and the Flood Control Act of 1939 which was important to establish the CBA as a federal policy which demands that 'the benefits to whoever may accrue must not be more than the estimated costs of the control measure being proposed' (Lambert and Bray, 2012). Long before this period, the practice and the theory of CBA remained divergent; however, with the application of the approach by the US Corps of Engineers in the late 1930s, more importance was given to the fact that costs and benefits should be compared when dealing with water-related investments (Zerbe, 2017).

A significant need arose after World War II with the requirement of some government efficiency. This was important, owing to the need for a clearer and well-detailed understanding of public funds' utilisation in every investment made by the government. This led to the joining together of the CBA theory and the practical decision-making process (Birkland, 2014). It is observed that since the 1960s, CBA has been enjoying much recognition within different sectors of various organisations and also government bodies over the world (Glasson et al., 2013). It is now recognised as the major appraisal technique for public investments, and its application continues to gain relevance in various sectors in different parts of the world. An example can be seen in the application of CBA in the US for water quality, recreation travel and land conservation, which led to the development of the concept of the option value to represent the non-tangible value of preserving resources such as national parks and recreation centres (Pearce et al., 2013). Further use of the CBA theory led to the need to address intangible and tangible benefits of public policies relating to health, education and chemical waste policies.

In the United Kingdom, CBA began in the 1960s for use in the transportation sector. This was later extended to other areas like water resource management, motorways, airports, forestry and several urban investment projects (Knowles and Ferbrache, 2014).

CBA has always been a tool that helps to give a clearer understanding of the relationship between benefits and costs (Snell, 2011). Since its inception, CBA has involved the addition of the benefits of a course of action and its comparison with its associated costs. Therefore, this informs the relationship CBA that has results in what is referred to as the three major arms of CBA: Economic, Financial and Social CBA.

3.4.1 Economic Cost-Benefit Analysis

An Economic CBA concerns the welfare of a defined group of people, usually a nation. In most cases, market prices and the flow of money acts as the starting point for the quantification of costs and benefits; however, they are considered to be an imperfect representation of the group's best interests, and they are therefore manipulated in various ways for a more acceptable value such as shadow pricing. Snell (2011) thinks that these adjustments are often necessary due to efficiency in pricing, which corresponds to the required perfect market concept, which aims to achieve the best allocation of resources by the relationship between supply and demand. It can be deduced that economic pricing seeks to adjust the market pricing to correct the abnormalities that may have been caused by political actions, monopolies, taxes and subsidies and many other factors, and arrive at the prices that any different perfect market would arrive at.

In discussing issues relating to FRM and investment in significant flood risk management schemes, economic CBA is an effective means of assessing national financial losses caused by floods and their indirect consequences (Rees, 2017). Therefore, this would form a significant aspect of the discussion around the CBA of SuDS retrofit in later chapters.

3.4.2. Social Cost-Benefit Analysis

Social CBA is a very distinct form of CBA, which refers to cases where the project is carried out as a broad impact across society and for this reason, it is carried out by the government (Mouter et al., 2013). In Fujiwara and Campbell (2011), HM Treasury described social CBA as a way of expressing the value of a proposed government policy to society. It seeks to unleash the full social costs and maximum social benefits of policies in monetary terms so that the consequences of a diverse range of policies can be compared using a standard metric (Fujiwara and Campbell, 2011). In a social CBA, prices by which costs and benefits are valued are adjusted by the analyst to reflect priorities and policies that no market would reflect, especially the perfect market (Snell 2011). In practice, there is no clear distinction between economic CBA and Social CBA; both kinds, in most cases, are being referred to as financial Analysis.

3.4.3. Financial Cost-Benefit Analysis

Snell (2011) identified that the primary focus in financial CBA is the financial position of a person, firm or organisation. This is a very fundamental aspect of the study around the CBA of SuDS retrofit. This is important because both costs and benefits are measured in terms of money spent or received by the parties involved in a business transaction, whether the prices are a good reflection of true value. This type of Analysis is not concerned about price distortions, but they include taxes and subsidies (Merkhofer 2012).

Financial CBA is derived from the perspective of a person, group, or unit involved in a project under appraisal (Bojö et al., 2013). In a SuDS retrofit project, the property owner’s financial commitment and the benefit of the project to the homeowners are what is being considered for Analysis. In the financial CBA application, the actual money involved is evaluated alongside the property owner's gain or loss.

3.4.4 The decision-making perspective

The purpose of carrying out CBA is to guide decision making on the most cost-effective way of achieving a common goal. According to Preez (2004), there are three techniques used in decision making. These are Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR). The choice of criteria to use in decision making depends on the purpose for which the CBA was carried out; however, one or more of these criteria can be used for decision making (Preez, 2004). For this research, only one of the requirements will be discussed (NPV); this is because BCR and IRR are not relevant to the study because they cannot provide a consistent outcome that will help define a sound output for the study.

Net Present Value

Net Present Value is the difference between the present value of all of the flow of benefits and the current value of the flow of costs (Penning-Rowsell et al., 2005), otherwise expressed as the sum of discounted net cash flows over the period. When properly calculated, the NPV is a relatively objective method of determining national wealth improvement resulting from a proposal (CASA, 2007). One of the criteria for reducing benefits and costs to a unique value is the net present value (NPV) or ―net benefits‖ criterion (Penning-Rowsell et al., 2005).

Harrison (2010) argued that the higher the net present value, the more valuable the project. Where budget constraints exist; however, the criteria become more complex. The NPV measures profits only and has drawbacks, such as the selected discount rate (Penning-Rowsell et al., 2005). This shortcoming is somewhat irrelevant in this research because the choice of discount rate can be flexible, thereby allowing users of the model to decide on the appropriate discount rate to use.

3.5 SUMMARY

This chapter has considered the origin of CBA and its development over several decades, with particular attention to the application of CBA to the study. The criticisms around using CBA were reviewed and considered and how it affects the application within the research on the CBA of SuDS retrofit. The quantification of the costs and benefits of the retrofit of SuDS can help improve the information available to explore the opportunities in the decision-making process of the delivery of SuDS retrofit.

CHAPTER 4: CBA CONCEPTUAL FRAMEWORK OF THE RETROFIT OF SUSTAINABLE DRAINAGE SYSTEMS AND THE APPLICATION OF THE WILLINGNESS-TO-PAY PROCESS

4.0 INTRODUCTION

This chapter describes the framework developed in light of the literature review on the installation of SuDS retrofit and its application to public buildings. This is an answer to objective four: to develop a conceptual framework aligned explicitly to public buildings in the UK of the costs and benefits of installing SuDS retrofit, based on integrating the explicit literature review. The chapter further evaluates the costs and benefits of SuDS retrofit and explains the WTP process of evaluating intangible benefits.

4.1 COST-BENEFIT ANALYSIS APPROACHES

In approaching real-life problems, several decision-making tools have been developed, such as Cost-benefit Analysis (CBA), cost-effectiveness analysis, cost-utility Analysis, risk-benefit Analysis, economic impact analysis, fiscal impact analysis, and social return on investment (SROI) analysis (Greco et al., 2005; Snell, 2011).

Cost-effectiveness analysis (CEA) is an economic analysis tool, distinct from CBA, which assigns value to the measure of effect. It compares the relative costs and outcomes of different actions (Price, 2018). CEA is applied to the planning and management of many types of organised activities. It is used in many aspects of life, including the health sector, where it may be inappropriate to monetise health effects. Campillo-Artero and Ortún (2016) defined CEA as a measure of health that developed countries use in making funding decisions, which is aimed at publicly funding health technologies that produce the most significant health gain at a given cost. CEA has faced some setbacks because it reflects mistrust of the underlying methods or the parties' motives conducting the analyses, or a desire on the part of many to deny or downplay the underlying problem of resource scarcity in health care due to the ethical difficulty in monetising health effects. However, CEA is widely accepted as a useful tool for resource allocation. CEA is also not applicable in the context of this research. Brock (2004) opined that there are important ethical and value choices in constructing and using CEA; these choices are not merely technical, empirical, or economic, but moral and value choices. These moral choices explain why it may be difficult to quantify health issues' outcomes and its suitability for a cost-benefit analysis model.

Cost-utility Analysis (CUA) is similar to CEA; it is mostly used in pharma economics, especially health technology assessments (HTA). It estimates the ratio between the cost of a health-related intervention and the benefit it produces in terms of the number of years lived in full health by the beneficiaries. CUA estimates health outcomes and costs of competing alternatives and is widely accepted as a useful tool for resource allocation. Health outcomes are commonly summarised as quality-adjusted life-years (QALY), a combination of quantity and quality of life (Kuntz, 2016). There are continuing controversies about the QALY unit, which is used to measure the outcome of the findings from CUA. One essential aspect of the CUA is the term ‘quality’. Richardson (1994) identified the fact that there are varieties of meanings to the ‘quality’ aspect of CUA, with different scaling techniques and concepts, making CUA inappropriate as an ideal economic tool. A similar principle that governs CEA's ethical and moral implication in this research context is also applicable to CUA because of the difficulty associated with monetising its outcomes.

Risk-benefit Analysis (RBA) seeks to quantify the risk and benefits by employing the ratio of the risk of an action to its potential benefits (Guo et al, 2010). RBA for a clinical trial is provisionally based on the preclinical phase of the medicinal product. The sponsor-investigator team needs to evaluate the toxicological tests and results and submit the data to the competent health authorities, with a projection of all the possible risks for the proposed trial subjects (Fortwengel, 2011). This tool does not have the facility to determine the cost of a product required under the determination of the cost-effectiveness of SuDs retrofit because it is not a financial-based tool. Therefore, this is outside the scope of the research on the cost and benefit of the installation of the retrofit of SuDs.

Furthermore, the economic impact analysis (EIA) examines the effect of an event on the economy in a specific location; this ranges from a single neighbourhood to the entire globe. EIA measures changes in business revenue, profits, and personal wages, leading to the suggestion of policies and laws that could improve the economy. Drucker (2015) described the EIA method as an analytical technique predicated on economic stability, yet commonly applied to situations that violate this condition with little consideration of the implications. EIA is a useful tool for the wider economy of a nation and in determining political and economic stability.

Fiscal impact analysis (FIA) is a tool used to compare project or policy change and governmental costs changes against governmental revenue changes. Moore (2015) describes the FIA tool as a revenue-to-cost relationship that explains the implication of a proposed revenue to be generated from new development in any location. This can either be positive or negative, depending on whether the income generated is more significant or lower than the cost. For example, Town A is a major residential development project that requires new services and facilities such as fire and police protection, libraries, schools, parks, and others. At the same time, Town A will receive new revenues such as property tax revenues, local sales tax revenue, and other taxes and fees. FIA, therefore, compares the total expected costs to the total expected revenues to determine the net fiscal impact of the proposed development on Town A.

The CBA approach has been selected in this study to undertake an economic appraisal of the monetary and non-monetary benefits of the uptake of SuDS retrofit. The CBA approach suggests that any new initiative or investment decision should only be adopted if its expected benefits (political, social, environmental and moral) exceed its costs (Wildavsky, 2018).

Joseph (2014) successfully applied the CBA concept to property level floor adaptation (PLFRA) measures, incorporating recognition of the intangible benefits. This provided a robust mechanism for decision making on investments in property level floor adaptation (PLFRA) measures by homeowners. This model was designed to advise homeowners of the potential benefits of investing in property level floor adaptation (PLFRA) efforts. Another example can be seen in the Analysis carried out on the report on the cost-benefit Analysis of Western Cape climate change response (Parmesan, 2006). The Western Cape Government (WCG) recognised the risks posed by climate change to its economy, population, ecosystems and infrastructure and sought measures to mitigate its effect by using the CBA model. The use of the CBA model helped lead to a better and more informed implementation process of economically valuable activities in reducing climate change risks.

The CBA tool enables an exact monetary comparison of the costs and benefits of the installation of SuDS, thereby facilitating the decision making process and appreciating the cost-effectiveness of the range of alternative solutions. A unique feature in this study is the application of the Choice Modelling Method (CMM). The CMM Method is to be employed to elicit willingness to pay (WTP) values from property owners to obtain the non-monetary benefits of installing SuDS retrofit. The advantage of using CMM is that respondents are presented with various alternative descriptions of non-monetary benefits, differentiated by their attributes and levels, and are asked to rank the various alternatives, rate them, or choose their most preferred (Hanley et al., 2001). By including price/cost as one of the attributes of the non-monetary benefits, willingness to pay can be indirectly recovered from people's rankings, ratings or choices.

4.2 EVALUATION OF THE COSTS AND BENEFITS OF SuDS RETROFIT

One of the Pitt's (2008) review's essential recommendations was to encourage property owners to take up the responsibility of reducing the effect of flood events on their properties by the uptake of available flood risk measures. Although the uptake of SuDs remains challenging owing to the complexity of its monetary and non-monetary benefits, there is continuous growth in the public interest (Ossa-Moreno, 2017). The proposed CBA conceptual framework has considered the key components associated with the cost and benefits of SuDs retrofit and could help support further uptake.

4.2.1 The Costs of SuDs Retrofit

In developing the CBA conceptual framework, the method for estimating additional costs of the measures adopted is to proceed stage-by-stage from the beginning to the end of the estimation activity. While time-consuming, this method tends to be the best because it outlines a detailed and more informed process in handling the breakdown of the costs of installing SuDS.

Figure 4.1 represents the stages that a typical SuDs retrofit installation is expected to go through to determine the full costs (and benefits). These stages include the preliminary stage, the implementation stage and the maintenance stage.

According to Merz et al. (2004), in estimating the cost of flood adaptation measures, the ability to categorise the flood mitigation measures by building design and construction process in the required order has the potential to lead to a better outcome. The decision to invest in SuDs as a retrofit is determined by the type of property, and the level of impact flood events have had and will have on the property. Therefore, it is essential to consider the impact of flood characteristics in this evaluation process.

According to Proverbs and Soetanto (2004), the damage caused by flood events on any property is a function of variables, including flood characteristics such as the depth of floodwater, velocity, history, duration, probability, and source flood. Among these characteristics, flood depth, duration, probability, history, velocity are essential because they play significant roles in the extent of damage experienced by any property. They also help determine the additional costs before installation due to damage and the repair work required.

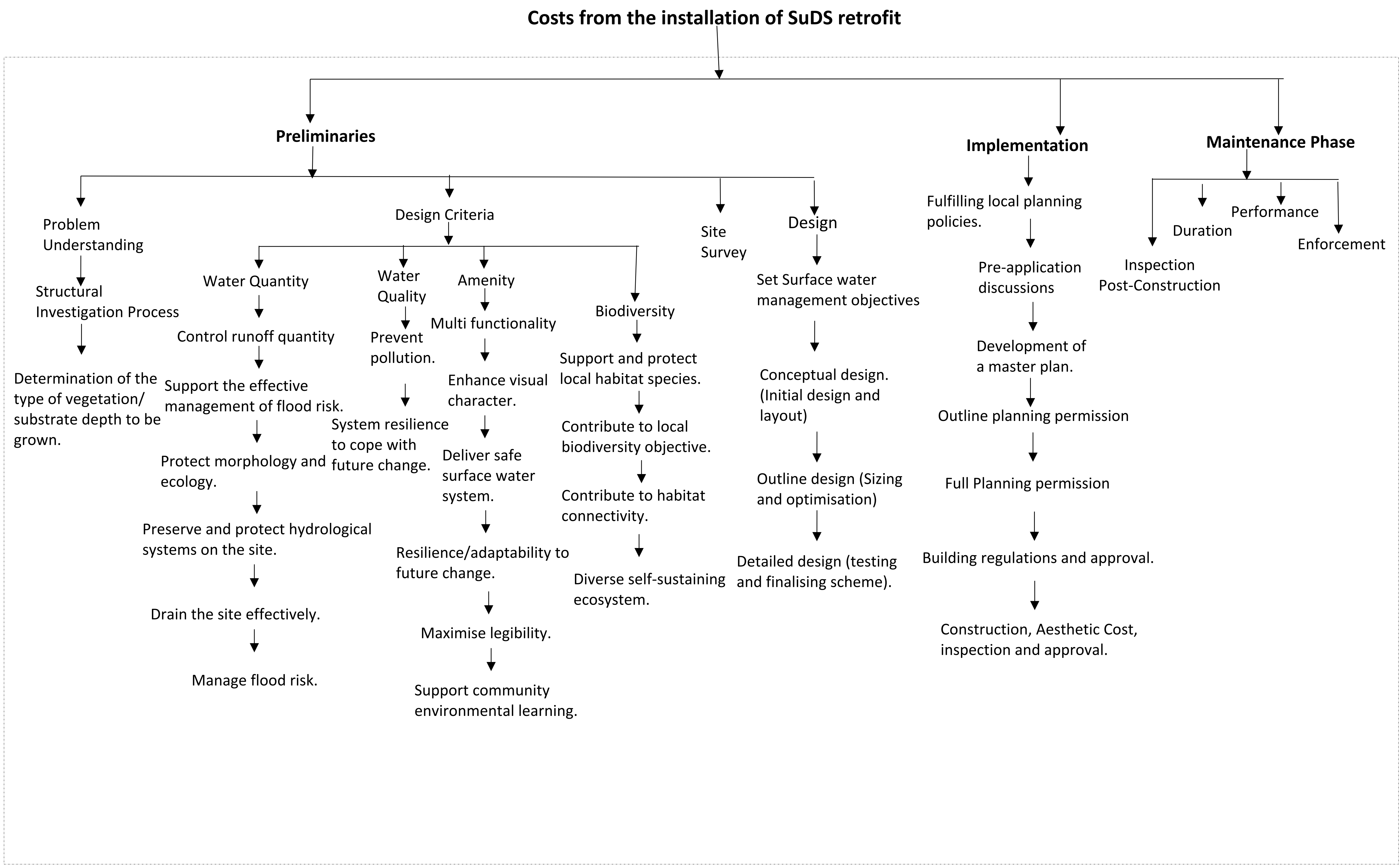


Figure 4.1: Cost for the installation of SuDS retrofit

4.2.2 THE BENEFITS OF SUDS RETROFIT

The uptake of SuDS as a retrofit could benefit different stakeholders, including property owners and users, insurance companies, flood management professionals and the government. The benefits of SuDS retrofit can be grouped into tangible benefits (Monetary) and intangible benefits (non-monetary) as shown in Figure 4.2.

To evaluate these benefits, several considerations need to be involved, such as taking into account the benefits accruing to and the cost incurred by the property owner (Penning-Rowsell et al, 2005); selecting appropriate prices for evaluating the benefits and costs in monetary terms and adjusting the future prices of benefits to present values to make them comparable with the costs (Joseph, 2014). This means that even though the benefits and costs are from different sources, it is essential that a systematic procedure is established to allow the proper evaluation of every parameter.

Bozman et al. (2015) described tangible benefits as quantifiable, especially monetarily; these are identified as reduced cost of infrastructure, improved aesthetic value, reduction of surface water charges, flood risk reduction and enhanced market value of the property. While intangible benefits are the benefits that cannot be touched, felt or measured in monetary form (Nurhayati, 2021). The intangible benefits are subdivided into the benefits accrued by the property owner and the wider community's benefits. For the accrued benefits by the property owner, this includes rainwater harvesting, reduced post-flood recovery inconvenience, the security of business reputation, reduced interruption to business activities, reduced cost of business assets and values, reduced insurance claim, increased property protection, reduced/elimination of property content evacuation and reduction in energy usage.

In terms of the benefits accrued by the wider community, this includes economic improvements, air and water quality, reduced loss of life, reduction/elimination of diseases, reduction

/elimination of infections, reduction/elimination of muddy part ways, reduced loss of ecological and cultural values, reduction/elimination of depression, reduction/elimination of anxiety, reduction /elimination of stress, reduction of G.P. visits, habitat for wildlife.

Figure 4.2 shows the stages in evaluating the value of benefits that will accrue with the uptake of SuDS. These are in two forms, the actual market data for tangible benefits and the WTP values on the intangible benefits. This is important because the application of the concept of CBA requires that both the costs and benefits have to be in the same unit of measurement before any decision can be made on whether a project is cost-effective or not (Joseph, 2014).

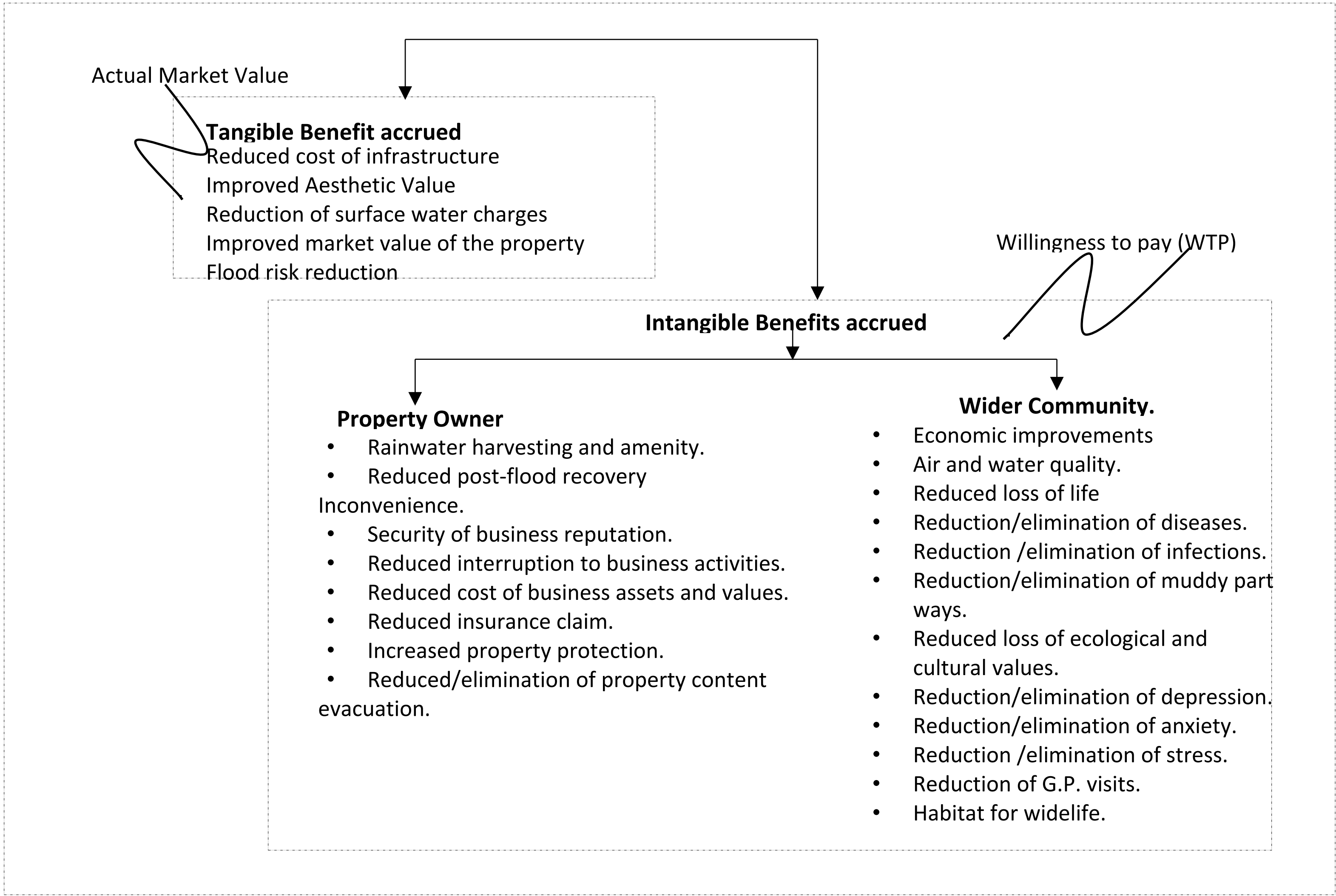


Figure 4.2: Benefits Accrued

4.3 WILLINGNESS TO PAY (WTP)

The WTP process is defined as the maximum price a customer is willing to pay for a product or service (Yang et al., 2021). In this case, the price stakeholder is willing to pay to have a SuDS retrofit scheme installed within a property. By their subjective nature, intangible benefits are difficult to quantify and are said to be more personal to the victim of a flood event (Joseph, 2014). This impact depends on the individual's relationship to the loss or damage experienced from the flood. Therefore, ignoring the intangible benefits of SuDS retrofit can lead to an incomplete understanding of the full benefits. Non-availability of locations where intangible benefits of flooding are considered makes its evaluation more difficult (Joseph, 2014; Markantonis and Meyer, 2011); this is why it is usually left out of the CBA appraisal for flood adaptation measures.

The intangible benefits of SuDS retrofit can be evaluated by using one of the stated preference methods (SPM) of valuation referred to as choice modelling method (CMM), this can be used to elicit WTP estimates from property owners.

4.3.1 Choice modelling method (CMM)

The CMM is a family of survey-based methodologies for modelling preference for different options of choices. CMM gives more detailed options to respondents enabling a more explicit understanding of their needs. With the choice modelling method, respondents are presented with various alternative descriptions of the intangible benefits with different financial commitments that would then be ranked from most preferred to the less favoured. By including price as one of the rankings, willingness to pay can then be indirectly recovered from the ratings or choices (Snell, 2011).

In a typical CMM technique, individual preferences are uncovered in the survey by asking respondents to rank the options presented to them, score them, or choose their most preferred. These different ways of measuring preferences correspond to other variants of the CMM approach. There are four major variants: choice experiments, contingent ranking, contingent rating and paired comparisons (Olazak et al., 2018).

An example of the application of CMM in the context of this study is shown in Table 4.1

SuDs retrofit type (Green Roof)	Intangible Benefit	WTP value (£)
1. 20years maintenance 2. 15years maintenance 3. 5 years maintenance 4. 2 years maintenance 5. 1-year maintenance	Economic Improvement	20,000 15,000 5000 2000 1000

Table 4.1: Example of the application of the CMM to intangible benefits (Oladunjoye et al., 2019).

4.3.2 Discounting

Considering the value of the benefits accrued from the installation of SuDS retrofit, it is essential to apply a discount rate to both cost and benefits. Szekeres (2011) argues that it is useful to address how the discounting paradigm fares, in the long run, significantly as it affects climate change and environmental policy, to see if it suffers from any notable limitations that need to be taken into account. Ackerman and Heinzerling (2001) described discounting as a CBA tool to compare the present costs and benefits and the implication for the future. This reduces the value of future costs or benefits at a pre-specified rate, which depends on its temporal distance from a typical time.

Given the value of money, a pound is worth more today than it would be worth tomorrow. Therefore, discounting is the primary factor used in pricing a stream of tomorrow's cash flow. Very often, decisions have to be made about whether to incur costs in the present, in return for benefits in the future, as in investing in SuDS retrofit. Every investment requires this type of decision at one point or the other.

Since individuals and organisations have their preference regarding receiving benefits or incurring costs, time preferences also have to be accounted for through the process called discounting. The advantage of discounting is that it enforces consistency and it makes the assumptions explicit (Charness et al., 2013).

In presenting the costs and benefits of SuDS retrofit in monetary terms, CBA follows the standard economic practice in discounting future benefits and converting them to their equivalent value today or present value. In the Economist view, when the period is extended and different generations are required to be involved in the costs and benefits of a particular project, the analogy to an individual investment decision breaks down (Keynes, 2018). Ackerman (2001) suggested that when setting a discount rate for a project, it must be set to a shallow level to generate an enhanced benefit.

4.4 FLOOD PROBABILITY

One major factor in determining the cost-effectiveness of SuDS retrofit is flood probability (flood return period). Destro et al. (2018) described it as the estimate of the likelihood of a flood event occurrence. It is a critical determining factor in the installation of SuDS retrofit, affecting the accrued benefits. A study by Thurston et al. (2008) determined that a flood resistance measure could be said to be worth an economic value for properties with a 50 year return period. However, for properties that experience flooding events more than once every ten years, the benefits outweigh the up-front investment. Also, Joseph et al. (2014) found that the adoption of resilience measures will be more economical for properties located in areas with up to 25 years return period. However, properties that experience flooding events more than once every five years, the benefits are said to outweigh the up-front investment. Therefore, considering the accrued benefits from repeat flooding in high-risk areas, flood probability (flood return period) is an important variable that should be included in the CBA conceptual model.

4.5 THE CONCEPTUAL FRAMEWORK

Figure 4.3 represents the CBA framework for comparing the costs and benefits of SuDs retrofit in public buildings. This CBA framework gives a detailed description of the monetary and non-monetary value of installing SuDs retrofit in public buildings. Oladunjoye et al. (2017) identify this as a gap that has resulted in a reluctance towards the uptake of SuDs retrofit to mitigate flood risks, hence the need for a detailed framework that will give a robust understanding of the monetary values.

The framework is represented by a pivoted depiction representing the implications of the impact costs and the benefits accrued from a typical SuDs retrofit. Stovin (2013) and Lamond et al. (2014) opined that when considering the decision for the uptake of an element like SuDs retrofit, it is essential that if the cost of installing SuDS retrofit is less than the benefit, then investment in it is advised but if it is otherwise, it is not advisable to go ahead with its uptake.

In a typical CBA model, costs and benefits must be well defined. Snell (2011) described CBA as a formal technique adopted for explicit, systematic, and rational decision-making, especially when faced with complex alternatives or uncertain data. Hence a detailed CBA model will make it easy for clarity and a sensible decision to be attained. Although CBA is a well-established tool, its application in this context is unique. In this framework, in a bid to derive a robust outcome, consideration was given to the involvement of indirect property users in terms of the benefits accrued from the installation of SuDs retrofit.

The framework is divided into two parts: firstly, the details of the costs of installing a typical SuDs retrofit for public buildings and, secondly, describing the accrued benefits. The CBA conceptual framework is developed by introducing required elements of the costs versus the tangible and intangible benefits as it affects public buildings and reflects the hypothesised relationship between costs and benefits of a typical SuDS retrofit installation. The costs and benefits of the SuDs retrofit are linked together to produce a CBA conceptual framework that incorporates all necessary parameters.

An exact and well-detailed process of installing a typical SuDs retrofit has been employed to form the framework. This framework represents a contribution to the study of SuDs retrofit in the context of public buildings. In terms of the benefits accrued, these are considered in the context of both direct and indirect users of public buildings. This is important because consideration is needed to be given to both the property owner and other property users such as customers, employees and suppliers.

Included in the framework are the flood characteristics, which influence the cost of installation and the benefits. Flood duration, depth, velocity, probability and history are vital determinants in determining the outcome of installing SuDs retrofit. Soetanto et al. (2004) opined that the damage caused by any disaster is highly dependent on the scale and nature of that disaster. In this context, the damage caused to a public building is dependent on the flood characteristics.

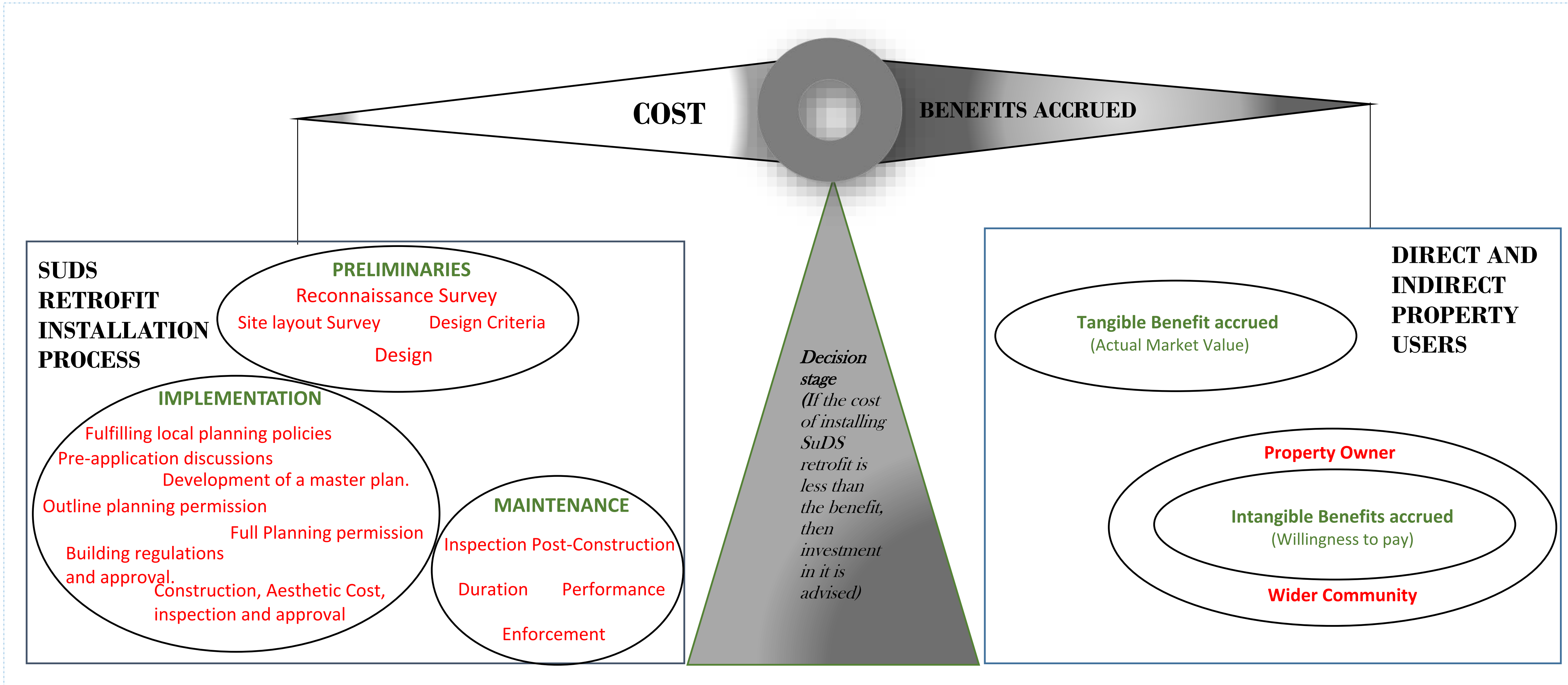


Figure 4.3: CBA Conceptual Framework for comparing the costs and benefits of SuDS retrofit in Public Buildings

4.6 SUMMARY

The development of a CBA conceptual framework for the costs and benefits of SuDs retrofit has been discussed and presented. This framework highlights the essential elements of the costs and benefits of SuDs retrofit, which need to be examined in the context of public buildings. The CBA framework provides an in-depth means of assessing the actual cost and benefits of installing SuDs retrofit. By combining the relevant elements in each section of the framework, the full costs and benefits of retrofitting SuDs can be established. This would help in the decision-making process when faced with choosing to invest in any type of SuDs retrofit.

The conceptual framework presented gives the much-needed understanding of the cost-effectiveness and benefits of installing the retrofit of SuDs which is previously lacking in the literature. The framework draws on the various approaches used in estimating costs and benefits of SuDs retrofit, which will help decision-makers and end-users decide how best to reduce the impacts of flooding.

A full understanding of the costs and benefits of retrofitting SuDs will help inform better decision making in choosing the most appropriate and cost-effective means of retrofitting SuDs for any given location. The proposed model is expected to be used by flood risk management professionals, property professionals and public building owners for the potential benefits of investing in the installation of SuDS. This study will help develop our understanding of the full costs and benefits accrued from the retrofit of SuDs and lead to an increase in uptake. Also, details about the benefits accrued by indirect users of public buildings will inform a robust understanding of the advantage that these users will derive from the uptake of SuDs retrofit. The model developed here is specifically for public buildings, but many of the principles applied would be equally relevant to other property types.

However, one major challenge with this research is quantifying the intangible accrued benefits from installing SuDs retrofit. Putting value to these parameters are very important but challenging for most professionals to accomplish. Quillin (2010) described intangible benefits as hidden jewels that need to be accepted as valid. However, being able to validate these parameters stands as a significant difficulty.

CHAPTER 5: RESEARCH METHODOLOGY

5.0 INTRODUCTION

This chapter considers the methods available to collect the evidence needed to develop and test the framework. The research design adopted for the empirical investigation is mainly qualitative. The justification for choosing this approach, the research paradigm that informed this approach's choice, and the data collection procedures are also presented and discussed. This chapter addresses the fifth research objective in terms of eliciting the actual value of the costs and benefits of the retrofit of SuDS, including reducing flood risk from a sample of case study sites in the UK.

5.1 RESEARCH PARADIGM

The term paradigm has been interpreted and understood in different ways by various scholars. Dean (2018), Bunniss et al. (2010) and Pollack (2007) explained that the research paradigm comprises of three elements: a belief about the nature of knowledge, a methodology and criteria for validity. Pollack (2007) further refers to this paradigm as a collection of assumptions, values and concepts within a community, which constitutes a way of viewing reality. According to Creswell (2018), these assumptions are philosophical worldviews guided by the researcher's actions or premises and originates research and some good level of thinking. It is the set of thoughts and beliefs about the research topic, how it fits together, how we enquire about it and how we interpret the findings (Johnson et al., 2007). These assumptions relate to the nature of reality (ontology) and the extent to which these realities can be known (epistemology) (Neuman, 2000; Creswell, 2003). They shape the research strategies and methods adopted by researchers, and it is essential to identify them.

Mackenzie and Knipe (2006) classify paradigms as positivist, transformative, interpretivist, retroductive, pragmatism and deconstructivist. In explaining interpretivist research, positivism is often placed in dichotomy with interpretivism approach. Such can be seen in the study that deals with numbers and discourse, generalisability versus situatedness (Dean, 2018). In the positivist paradigm, the philosophy is determined by cause and effect (Creswell, 2003). In contrast, interpretivist researchers understand the world in terms of human experience (Thanh and Thanh, 2015). Taking account of various researchers, it is theoretically understood that the interpretive paradigm allows researchers to view the world through the participants' perceptions and experiences (Wahyuni, 2012). In seeking out answers to the research, the investigator who follows the interpretive paradigm uses those experiences to construct and interpret their understanding from the data which have been gathered.

At the moment, interpretivist paradigm is not a dominant model of research, but it is gradually gaining relevance because of its ability to accommodate multiple perspectives and versions of truth (Thanh and Thanh, 2015). Interpretivists believe that an understanding of the context in which any form of research is conducted is critical to interpreting data gathered (Wahyuni, 2012). According to Willis (2007), interpretivism usually seeks to understand a particular context, and the core belief of the interpretive paradigm is that reality is socially constructed. Therefore, an understanding of the phenomenon helps to inform the data retrieval process and the research outcome. Positivism assumes that a phenomenon obeys natural law and can be subjected to quantitative logic. In contrast, interpretivism assumes that a phenomenon does not obey natural laws but is interpreted based on peoples' conviction and understanding of the phenomenon's reality (Bailey, 1987; Walliman, 2001). The positivist paradigm is linked to the ontological position of fact being static and fixed while the interpretivist is connected with the ontological status of reality being subjective and changing, thereby resulting in the understanding that there is no single ultimate truth but a multiple, therefore it is experienced differently by everyone (Angen, 2000).

These choices have implications when conducting research. Positivism does not necessarily require the physical presence of the researcher for findings to be developed. However, with interpretivism, the researcher must be physically involved in the research process for detailed and first-hand data collection (Silverman, 2006). Furthermore, to achieve robust outputs with positivism, a large sample size of statistical conclusions are required. Simultaneously, with interpretivism, the focus is usually on small samples towards an in-depth understanding (Nandhakumar and Jones, 1997).

However, there are critics of the interpretivist paradigm, which tend to be more philosophical. Yanow (2006) opined that interpretivism does not hold a concrete hypothesis before any fieldwork being carried out. Schwartz-Shea and Yanow (2013) highlighted the volume of data required to develop findings, and the lack of generalisability and objectivity are also significant issues. Table 5.1 outlines further implications between positivism and interpretivism.

Table 5.1 Implications between positivism and interpretivism

Comparison Item	Positivism	Interpretivism
Reality	There is one reality that is static and fixed.	Reality is subjective, multiple and socially constructed.
Observer	The observer may be independent	The observer is part of the study.
Established theory	The theory is established deductively.	Uses inductive reasoning.
Type of method	Tends to use quantitative methods	Tends to use qualitative methods
Number of cases	Requires large sample selected randomly	Requires a few numbers of cases chosen based on some criteria
Analysis	Unit of Analysis should be reduced to the simplest terms	Unit of Analysis may include the complexity of whole situations

Understanding of the research	Demonstrates causality	The aim is to increase the general understanding of the phenomenon
Research progress	Research progresses through hypothesis/prior formulation	Research progresses through gathering rich data

(Source: Bunniss and Kelly (2010); Dean (2018))

5.1.1 Adopted Paradigm

The research phenomenon being considered and the critical research questions influence the type of paradigm that has to be adopted (Remenyi et al., 1998; Pollack, 2007). The conceptual framework of a phenomenon is strategic in informing which paradigm to follow (Miles and Huberman, 1994). The interpretivist paradigm has been considered to frame this research. From the research questions posed in Chapter 1, the research into the installation of SuDS retrofit is still relatively new in the UK, and it is evident that there exists a very low uptake of SuDS retrofit, which has therefore led to a lack of knowledge about the monetary and non-monetary value of the installation of SuDS retrofit. It is expedient that a study route beyond a surface inquiry process is employed into the knowledge of the monetary and non-monetary value of the installation of SuDS retrofit. Interpretivist paradigm is known to aid the researcher through a well-detailed progression towards a rich data retrieval. This is supported by the detailed breakdown of the cost and accrued benefits of installing SuDS retrofit in a commercial property which has been systematically detailed in the framework.

According to Thanh and Thanh (2015), every stakeholder must be included in the data retrieval in considering the interpretivism paradigm. This is to achieve a robust and balanced view of the parties involved in any given phenomenon. This is applied to the delivery of SuDS retrofit, especially because various stakeholders are involved from the preliminary stage to the maintenance stage. At different stages of the delivery of SuDS retrofit, various professional impacts are required from these stakeholders for decision making. Therefore, it is good to understand their level of involvement in delivering SuDS retrofit and how much they will be interested in the monetary and non-monetary value.

An interpretivist paradigm sits well towards a detailed form of data retrieval process for developing a deeper understanding of the monetary value of SuDS retrofit and a form of promoting the uptake of this phenomenon. By employing an interpretivist paradigm, the views, perceptions and experiences of the present users are expected to inform further details necessary for data collection as it affects the wider community.

By adopting interpretivism, the possibility of retrieving the required data that will inform the intangible benefits accrued through the use of an interview process of data collection will be explicit. This will help to educate the knowledge gap about the understanding of the present users about the phenomenon. Assessing the value of intangible benefits in installing SuDS retrofit in public buildings which requires a systematic process called the willingness-to-pay (WTP) method. Obtaining first-hand information to understand the response to the WTP concept on installing SuDS retrofit in public buildings cannot be adequately obtained through any other means other than interpretivism.

5.2 RESEARCH STRATEGY

Apart from the research paradigm adopted in research, researchers also consider adopting a research strategy and method that is important for data collection and analysis (Johnson et al., 2007). The research strategy provides the required direction for procedures in any research design; after a good understanding of the theoretical components involved in the literature of the phenomenon, the choice of route and the route's approach is derived (Creswell, 2009). The three common research strategies are qualitative, quantitative and mixed-method strategies.

Several strategies for conducting research and the literature on research methods exist with various submissions regarding the appropriate strategy for a given research problem (Barro et al., 1997; Runeson, 1997; Dainty, 2008). Creswell (2009) defines research design as the plan and procedures to conducting research involving the intersection of three elements: philosophical worldview (i.e. methodological paradigm), strategies of inquiry (i.e. research strategy), and specific methods (i.e. research methods). Figure 5.1 is a representation of the framework for the delivery of research.

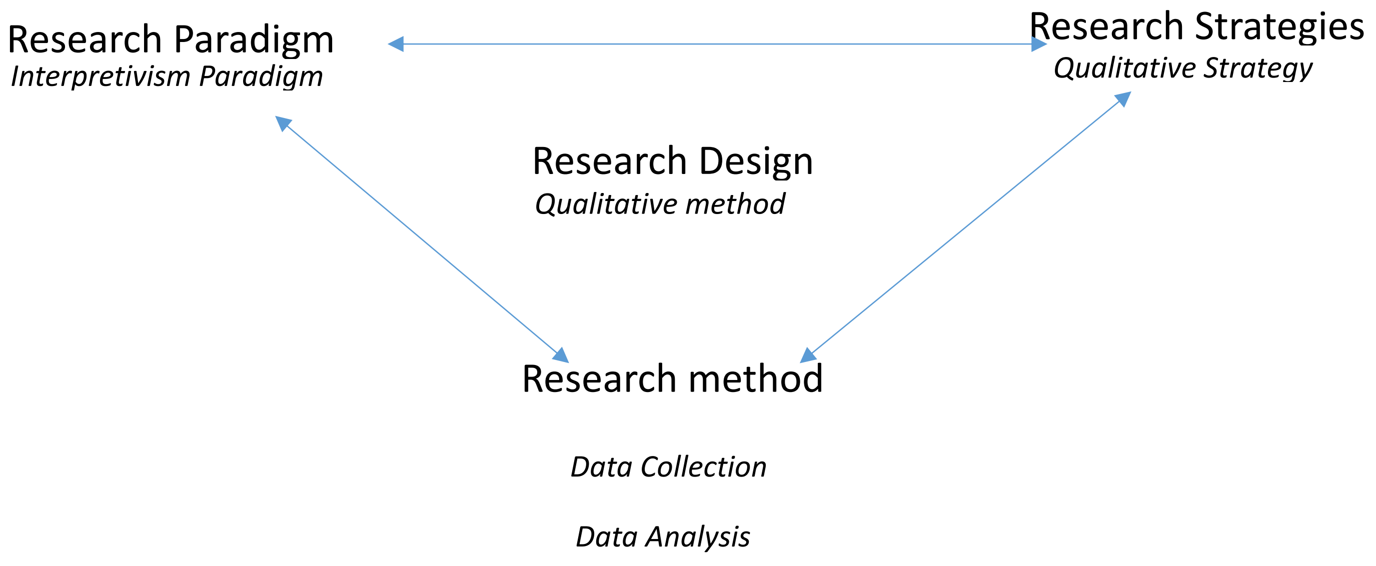


Figure 5.1 Framework for the delivery of a research design

5.2.1 Qualitative research and methods

Qualitative research provides a means of exploring and understanding the meaning individuals or groups ascribe to a phenomenon (Creswell, 2009). It helps to answer research questions that relate to "how" and "why" a phenomenon is delivered (Fellows and Liu, 2008). It enables the researcher to investigate the meanings people attribute to their behaviour, actions, and interactions with a phenomenon. The qualitative research process is inductive concerning theory and literature and is mostly rooted in the interpretivist philosophical position (Sutrisna, 2009). It involves emerging questions and procedures, data typically collected in the participant's setting, data analysis building from particular to general themes, and the researcher making interpretations of the data's meaning (Creswell, 2009).

Qualitative researchers collect four kinds of data: interview data, observation data, document data, and audio-visual data. The common forms of data analysis used in qualitative strategies are text analysis and image analysis. The samples collected are often small as the focus is obtaining in-depth meaning and not a generalisation. Despite the usefulness of qualitative research in providing an in-depth sense of phenomena, researchers have not escaped criticisms. According to Bryman (2004) and Yin (2014), critics of qualitative research argue that it is too impressionist and subjective and the findings are based on unsystematic views about what is important and significant. Another critical theory identifies qualitative research as difficult to replicate because it relies on unstructured data. There are hardly any standardised procedures to follow, the quality depends on the researcher's ingenuity. It is also believed that it lacks transparency due to the difficulty that sometimes arises from establishing what the qualitative researcher did and how the study conclusions were arrived at.

Despite these criticisms, reliability in qualitative research can be achieved by following suggested reliability procedures such as thorough checking of transcripts to ensure they do not contain mistakes and making sure there is no drift in codes' definition (Gibbs, 2007). Validity can also be provided by following procedures such as establishing themes based on converging several sources of data or perspectives from participants, allowing participants to comment on the findings, and using peer debriefing (Creswell, 2009). However, there are several qualitative research strategies; however, Creswell (2009) identified five of these strategies: ethnography, Grounded Theory, case study, phenomenological research, and narrative research. Among these five strategies, case study research is the strategy being employed. This is important because ethnography is a strategy that uses the study of social interaction and culture groups. These groups may be defined by societies, communities, organisations or teams. Although this strategy is flexible and typically evolves contextually in response to the field setting's lived realities (LeCompte and Schensul, 1999). It is exploratory, which means that the ethnographer goes into the field to explore a cultural group and explore specific social interactions outside this particular research scope.

Furthermore, another example of these strategies is grounded theory. This is a strategy where the researcher derives an abstract or general idea of a process, action, behaviour or interaction grounded in the views of participants in the study (Creswell, 2009). This process involves multiple data collection stages and the refinement and interrelationship of categories of information (Strauss and Corbin, 1990). In a case study strategy, an in-depth study of a phenomenon (e.g. a program, or a process and one or more individuals) is mostly achieved. This is carried out by typically using various data sources and procedures (Stake, 1995; Yin, 2003). These cases are bounded by time and activity, and researchers collect detailed information over a sustained period (Creswell, 2003). Therefore, research into the Cost and benefit of SuDS retrofit is mostly involved in this form of research method because of the ability to retrieve a detailed output within a specified time frame which is essential. Like phenomenological research and narrative strategy, other types of techniques are either concerned with the essence of human experiences about a phenomenon or used to describe participants' combined views towards biography or history production.

5.3 RESEARCH METHODS

A significant element useful in a research approach is the specific methods of data collection and analysis. The research method is used to consider the full range of possibilities for data collection in any study (e.g. SuDS retrofit). The choice of methods by a researcher turns on whether the intent is to specify the type of information to be collected in advance of the study or to allow it to emerge from participants in the project. In this study, a case study method is considered and discussed below.

5.3.1 CASE STUDY METHOD

Considering the choice of the ideal number of cases, factors that include description and explanation of the issue are very important. When we have multiple cases, the idea is to get contrasting situations. For example, in a situation where the phenomenon being studied occurs in one option and another where it did not occur, some further explanations will further give an in-depth understanding of the phenomenon. Yin (2017) opined that cases are not supposed to duplicate each other but should be contrasting to highlight differences. However, Yin (2017) did not identify the number of samples required for case study research.

A conceptual framework that attempts to explain the installation process and accrued benefit of SuDS retrofit was presented in the previous chapter. To understand the cost implication of installing any SuDS retrofit, it is necessary to obtain the corresponding documents (survey plan, drawings, BOQ) that show these details. The records retrieved from these organisations will further inform the knowledge of the cost involvement that may have been made during the installation process, including the SuDS retrofit's ongoing maintenance. Furthermore, in understanding the intangible benefits accrued from installing SuDS retrofit, an interview process is necessary. This process will help understand the views of the different stakeholders involved as it affects the non-monetary value obtained from the installation of SuDS retrofit. Interviews vary in their nature and can be structured, semi-structured or unstructured (Patton, 2002; Legard et al., 2003).

Another aspect of the data retrieval process is observation. Observation, as the name implies, is a way of collecting data through observing. SuDS retrofit is a phenomenon that is discussed in writing and is also physically present in specific locations; therefore, it is essential to observe the existing structure. To understand the level of the application of this phenomenon and generate a useful and informative record, a visit to the current project is advised. The researcher must immerse himself in the setting where her respondents are located, and there is direct access to the research phenomenon.

These different forms of data retrieval are essential in this research to achieve the required depth and richness the study is aiming to discover. This helps to form a well-balanced understanding of the phenomenon being studied, which is the monetary and non-monetary value of SuDS retrofit. This can allow the limitations from each method to be transcended by comparing findings from different perspectives. Figure 5.3 below gives a pictorial idea of the triangulation of the data retrieval process of the research.

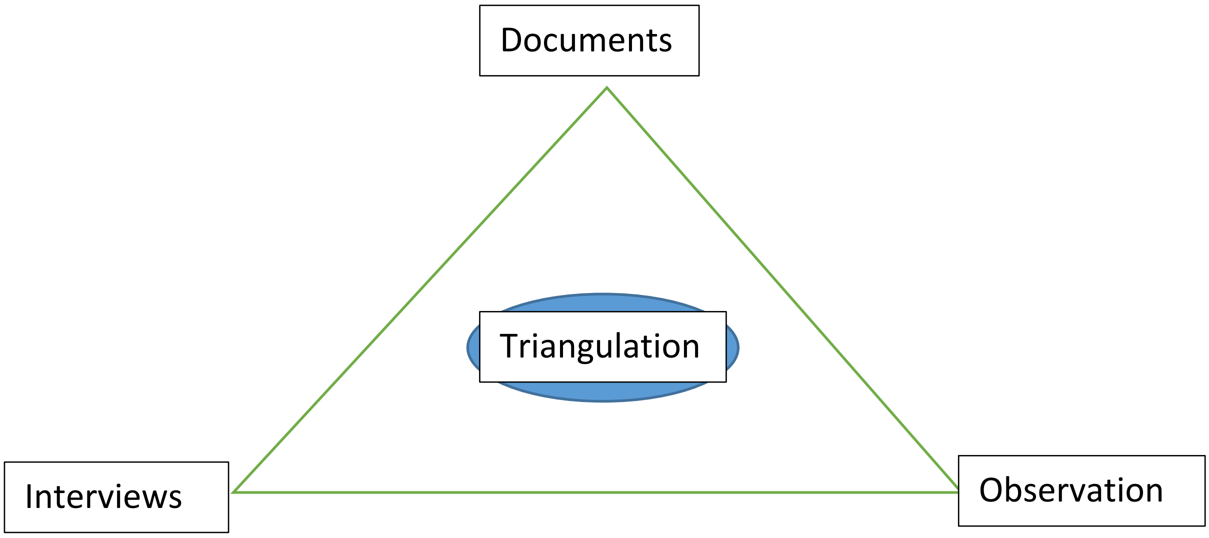


Figure 5.2: Triangulation of the data retrieval process of the research

5.3.1.1 Case Selection

In selecting cases, the process must clearly state the reasons why a specific group of cases are needed (Yin, 2017). This is the usual process in case study research to identify the participants who are likely to contribute the data required to answer the research questions and detailed framework (Oliver, 2006). This involves establishing the criteria against which the cases are screened to determine if the cases meet the study criteria. Table 5.2 outlines the requirements developed for the selection of cases.

Table 5.2: Case selection criteria

No	CASE SELECTION CRITERIA	JUSTIFICATION
1	Type of public building	The framework suggests a typical installation of SuDS retrofit in public buildings. This is because there is less research into the cost and benefit of the installation of SuDS retrofit in public buildings and this has informed the general focus of the research study.
2	The type of installed SuDS retrofit	The literature suggests that the choice of the SuDS retrofit has been used to determine the framework. Although this is not a limitation in any way, it gives a detailed process of an ideal SuDS retrofit installation.
3	Year of property and SuDS retrofit scheme	It is important that the SuDS scheme being considered should be a retrofitted or argumented and not installed when the property was being built. This is because a SuDS retrofit is meant to augument or replace an existing drainage system.

4	Involvement of the wider community on the property	The literature suggests that the intangible impact on the wider community is yet to be determined. This is to be elicited with the CMM. A component breakdown of the benefits including the WTP values will help to retrieve this information from the property owners.
5	Location of the property- Urban, Suburban and rural.	The framework suggests that flood-prone areas are essential to this research. The data about the flood probability, velocity, depth, duration and history of the case study site is essential to the research.
6	Size of the property and installed SuDS retrofit	For proper analysis and manageable research work, the size of the property is a major determinant. This informs the viability of the research for proper data collection. A medium-sized project that can answer many of the research questions is necessary to be considered. This is important due to the time required for the research.
7	Flood Risk	The literature suggests that flood characteristics are a very important aspect of the research. Therefore, this needs to be considered when selecting the ideal site.
8	Professional involvement	The literature suggests that professionals have varying views about SuDS retrofit and its application to properties. It is important to be able to obtain information from these professionals based on their involvements on the delivery of the SuDS retrofit scheme.

Considering the type of SuDS retrofit to be selected, it is important to introduce different examples where possible. Yin (2017) suggests that in selected multiple examples of cases, the results' eventual outcome can give a true picture of what applies to the phenomenon. Therefore, a balance of the reality of the outcome is achieved. Since the focus is on public buildings, choices from different case study sites will help a more informative knowledge of how the decisions were made in other locations.

There are various types of public buildings; these include office buildings, learning institutions, medical centres, hotels, malls, retail stores, farmland, multifamily housing buildings, warehouses, and garages. These are some examples of the various public buildings that will be considered for case study research. The type of SuDS retrofit is also significant for consideration. In the design of the conceptual framework, reference was made to a SuDS retrofit installed within a public property. This is to aid the systematic analysis of the output of the research.

Furthermore, in considering the wider community's role and how it affects the intangible benefits accrued, it is necessary to have a component breakdown of the benefits, including the WTP values, which will help retrieve the required information from the property owners. This is the core of the research, which forms the contribution to knowledge. Therefore, some detailed results are expected through this exercise. Another critical aspect of the study is the location of the project being studied. It is essential to understand the factors considered to determine the need to install the SuDS retrofit project. This will further clarify what drives the need for an installation of this nature and the occupants' perception of its installation. Through this means, the flood characteristics within these sites can be determined and understood.

5.3.1.2 How the case study sites were selected

Identifying the suitable cases was challenging due to limit in the number of retrofitted SuDS schemes in the UK. Calls were made to organisations and individual professionals, with some applicable identifying links to other areas that may be helpful. Presentations were made to professionals at regional meetings of the EA at the west midlands and at the Water, Research community workshop at BCU, which hosted various professionals from diverse groups and organisations. These steps were beneficial in creating the leads, which eventually resulted in the options that were considered. This does not mean that all the cases identified were easy to adopt. One of the options, which had good potential for the required depth of research, declined later to a further meeting. A visit to one of the sites informed the possibility for a third case study option due to the keen interest one of the professionals had in the research.

The outcome of the discussions with industry professionals was very productive, going by the responses received from them and their interest in knowing the research outcome. A railway research group offered to apply the research outcome to the rail industry to produce an app that will be adopted and eventually used in some other sector.

5.3.2 DOCUMENTS

It is expected that for the cost of SuDS retrofit installation, there are documents that are useful to retrieve the required information for the cost of installing SuDS retrofit. These include the bill of quantities (BOQ) and other relevant documents like the preliminary construction documents. These documents confirm details on the implementation process and details about the maintenance of the SuDS retrofit.

5.3.3 OBSERVATIONS

This is a participatory form of study that is useful for physical evidence of data collection. Many of the interview findings need to be confirmed or retrieved through this form of a method to understand the complexities of some of the situations of the impact of the installation of SuDS retrofit. This will help to understand the concept of the installation as it affects any of the locations individually, using the insights of others obtained. It would help to inform many of the questions that may be structured for the interview section of this research.

5.3.4 INTERVIEWS

According to Patton (2013), what people say is a significant qualitative data source, whether they are obtained verbally through an interview or in written form through document analysis or survey responses. Semi-structured interviews with stakeholders such as public building owners, contractors, architects, clients, and property users will be used to gain in-depth and rich data, extending beyond a regular empirical reality into a more realistic and workable outcome. The in-depth interview is a technique that attempts to collect data, emphasising the interviewer asking the questions and listening, where the interviewee responds to the questions.

The interview option's choice is important because some data may be difficult to retrieve by observing a site. Although observations during data collection are beneficial during a case study research, the fact is that we cannot monitor everything. According to Patton (2013), we cannot observe situations that preclude an observer's presence, and we need to ask people questions about those things. To retrieve the required data that would make up the findings both for the costs of installing SuDS retrofit and the intangible benefits, an interview process will be helpful. This in-depth interview will help to get a closer understanding of the impact of the installation of SuDS retrofit and its benefits for the occupier and, most significantly, determine the outcome of the WTP values.

In an interview technique, the researcher can clarify responses and probe further into salient information that could help enhance the findings of the research. Although there are well-documented limitations associated with using interviews as a data collection technique, it requires researcher skill and the interviewees' cooperation, articulation, and perspectives (Dale and Volpe, 2008).

In carrying out the interview sessions, focus groups and individual sessions were embarked upon. The Leisure centre and the Primary school had focus group sessions which made it easier to meet more than one stakeholder and for all of them to share their thought and options. Every other session were individual interview times which made were either done face-to-face or on the phone. Phone interviews were significant because of the period the research was carried out during the Covid 19 pandemic, where most people had to work from home.

5.4 RESEARCH ETHICS

It was intended that no sensitive information would be collected as part of the study, going by the university's regulation. However, specific documents such as the BOQ, plans and planning application documents were used for retrieving the information needed for the research. The required clarity about using the documents will be made and the option to opt-out will be suggested.

Before any fieldwork being undertaken, it is mandatory that approval from the university ethics committee is obtained and amendments are made following the recommendations made. These are also considered for a successful data collection process.

5.4.1 CONSENT

As much as practicably possible, any research involving human participants should be based on the participants' freely given consent (Social Research Association, SRA, 2003). This research will primarily involve voluntary participants with no obligation to participate in the research, including the option of refusing to participate at any stage of the study. This is contained in a consent form which will be distributed to participants at the beginning of the data collection process.

5.4.2 CONFIDENTIALITY

Unless it is specifically requested, the identity of participants, locations and their properties have remained anonymous. This is highlighted by BSA (2002) that the importance of respecting participants' anonymity and privacy and the necessity to store data securely is essential.

5.5 PRESENTATION TO PROFESSIONALS

In the process of identifying the appropriate case study options, presentations were made to flood risk management professionals, environmental agency experts, construction professionals. This process helped produce a more applicable CBA model, which these professionals were able to relate to. These professionals were also able to act as leads towards picking the appropriate type of case study sites.

5.6 SUMMARY

This chapter outlines the methodology and research design, which has been adopted for the study. An interpretivist stance is taken, including a retroductive strategy. A case study approach has been employed for the data collection successfully. Three examples of public buildings with the installation of SuDS retrofit were used to carry out the data collection process, including the installation process, which is to be supported by documentary evidence. Interviews/ focus group sessions were performed with the property owners and various stakeholders. Other vital information about the SuDS retrofit scheme was derived through observatory evidence.

CHAPTER 6: LEISURE CENTRE SCHEME (CASE STUDY 1)

6.1 INTRODUCTION

This chapter presents the first study area, which is a Leisure centre. The other two chapters will also present the two different study areas, while chapter 9 will discuss these cases. This answers the fifth objective: to understand the decision-making process of the installation of the SuDS retrofit scheme, including the value of the benefits of different SuDS retrofit schemes. The chapter further presents the data on the decision-making process of the installation of the scheme, the flood perception of the property, the uniqueness of the funding of the scheme, the cost of installation, including other associated costs and benefits accrued from the scheme.

6.2 THE SUDS RETROFIT SCHEME

The case study is a Leisure centre located in the midlands and built-in 2010 as a community project to offer a range of facilities, including a sports hall, fitness suite, fitness classes, grass pitches and AstroTurf pitches to visitors, especially tourists. A SuDS retrofit scheme was installed on the site in 2016 to help manage flood events while also providing educational, aesthetic, social, and health benefits for the property and the community. Figure 6.1 shows the frontage to the leisure centre, which was previously a vast expanse of concrete block paving, punctuated only by two small circular tree pits.

Figure 6.1: Before and after picture of the outlook of the frontage of the site featuring one of the raingardens.

Figure 6.2 shows the construction stage and the current state of the swale at the leisure centre. This wetland swale has been lined to prevent the risk of subsidence within the sloped banks of the adjacent ditch and create a wetland habitat that compliments the ditch's habitat. The swale receives input via four downpipes to the rear of the building: draining 365m^2 of roof catchment on the building's western side. The swale can hold 10m^3, which is necessary for the 1 in 10-year storm event for the catchment area.

Figure 6.2: During the construction of the Swale and after.

Figure 6.3 shows the current intervention for runoff. Previously, all rainwater collected from roofs and hard surfacing at the leisure centre would discharge directly into the stream behind the Leisure centre but now the stream eventually flows into the River. The runoff from the roof flows through the pipes as shown in figure 6.3. these pipes transports the runoff through drains which are directly linked to the swale.

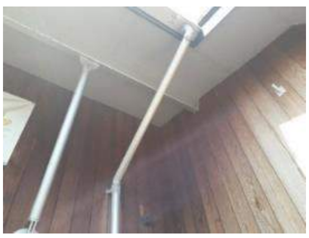


Figure 6.3: Runoff from the front roofs of the Leisure Centre designed to complement the existing metal rainwater goods of the building

6.3 SuDS Design

The SuDS design is a combination of four different components; rain gardens, lined swale basin, basket controlled outlets and stainless steel architectural rain channels. This project used landscape to reduce flood risk and pollution by delivering a controlled flow of clean water into the River. To develop the SuDS rationale, natural flow paths were analysed and landscape zones were broadly divided.

The entrance to the leisure centre is enhanced by the inclusion of two large rain gardens; replacing previously underperforming tree pits and adding year-round aesthetics. Each side is joined (hydraulically) by a bridge which means that should the water level rise, it will happen simultaneously in each feature. The rain gardens receive rainwater from an area of $675m^2$, including adjacent hard standing and half of the parapet roof. They are capable of storing $16.8m^3$ water: accommodating up to the 1 in a 10-year storm event. The planting choice is such that a simple management routine (annual cut of perennials and grasses in February) can be implemented.

In channelling the runoff from the roof, two stainless steel rills were introduced which skirt each flank of the building and is designed to complement the existing metal rainwater goods of the building. The rills are raised only slightly from the ground and can collect water from four downpipes. Each rill outlets rainwater at its centre to the head of a blockwork channel. These surface channels are shallow enough to traverse the pedestrian entrance area, before entering the two large rain gardens. To store and treat the rainwater from the south-facing element of this parapet roof, two downpipes are diverted towards the rain gardens at the entrance. This rearrangement of downpipes extends the catchment area by $190m^2$.

Another component is the swale, which receives input via four downpipes to the rear of the building: positively draining 365m2 of roof catchment on the building's western side. A control orifice, housed in a gabion basket, drains the swale at no more than 5 litres/second/ha. It was determined that amenity benefits could be sought through the addition of Raingardens to the front, while biodiversity improvements could be made to the rear, to link with adjacent existing habitats, by holding water in a lined Wetland Swale.

6.4 RESULTS AND FINDINGS

This section discusses the factors that influenced the decision-making process including the perception of flood risk, the costs of installing the scheme, the process of obtaining the funds and the maintenance procedure of the scheme. Particular emphasis is placed on explaining the perceived benefits and the value of these from the perspective of the key stakeholders.

6.4.1 Decision-making process

The focus group session involved three participants. These stakeholders were fully involved from the beginning of the project and with the daily running of the Leisure centre. Discussions about the involvement of different stakeholders were discussed and other factors that influenced the decision-making process.

6.4.2 Stakeholder Involvement

At the inception of the SuDs retrofit scheme, the main stakeholders involved were the property manager, a council representative (the property owner), a consultant, the contractor, the Landscape Architect and the client. This was confirmed by one of the participants in the focus group section;

"...Yes, we were all involved. We had meetings where we met quite frequently to discuss the project." (Property manager)

This was considered very important because it confirmed the level of support which was necessary to drive the delivery of the project and helped to establish a strong team ethos among the stakeholders. This provided the opportunity to sell the idea for a SuDs retrofit installation to the council and for them to understand the need for the scheme. This also provided a means to secure the necessary funding for the scheme. For example, one of the participants said;

"…well, I could not force it on them. Not that would have been the way even if I could. So unless we got a lot of support, it won't be worth doing." (Consultant)

Statements such as the above, show that the decision to install a SuDs scheme needs to be owned by the stakeholders to the property. Key to this is helping to convey a clear understanding of the benefits of SuDs.

Furthermore, an expert was on the team to provide the required guidance and knowledge of the scheme and to bring clarity and understanding to the process. *"...he knew what criteria was needed and what to do. They are leaders in doing this all work. I mean theory I could have designed it myself, but you know, I didn't have as much experience and the liability factor was important. So we got them to do it in case anything goes wrong"* (Consultant).

6.5 FLOOD PERCEPTION

While this property had no record of previous flooding, the proximity of the nearby River, including the threat of surface water runoff, clearly influenced the decision to install SuDS. *"...because of the rainfall from the roof because it was a concern….there is a watercourse behind that it could slump in."* (Consultant) The presence of the river and the potential risk in the neighbourhood could pose a future risk for the property, making the siting of the scheme a very important one.

6.6 FUNDING AND COSTS OF INSTALLATION

Funding for the scheme was handled by the Manager from the Water group, who prepared the application and submitted this to the Environment Agency Regional Flood Committee. This was confirmed by one of the participants;

"…. But she did the paperwork, put it into the regional flood committee and they funded it (Property manager)." The documentation included the architectural drawings, the scheme's estimated cost, and a written proposal that the client compiled.

Furthermore, it was identified that obtaining the required funds could have some effect on the overall delivery, and so they chose to delay any further action until the required funds were acquired. This is reflected in the statement made by one of the participants; *".....we didn't progress the scheme until we had funding to do it (Property manager)".*

Table 1 shows a breakdown of the costs of installing the scheme obtained from documentary evidence and the focus group discussions.

Table 6.1: Costs of SuDS retrofit installation

Cost item	**SuDS design**	**SuDS cost at the tender**	**Final SuDS cost**	**Overall cost including roof water channelling**
Amount (£)	5000	35000	39000	65000

The additional cost during the construction process was accrued as a result of one of the subcontractors who caused some delay to the project. This led to the need to employ additional workers on the project to speed up the process and this attracted some extra funds.

"…The only problem I said we encountered was with the subcontractor at that time it took them ages. And that was quite frustrating….I mean they were okay but we did have a slight change of staff and I don't think we put enough staff on" (Property manager).

6.7 MAINTENANCE AND OPERATION

Maintenance of the scheme was only considered to some extent at the design stage where it was hoped that the costs could be absorbed within the routine maintenance of the property. This was highlighted by one of the participants;

"Well, we didn't put a cost to it because we said we'd absorb it with our maintenance guys with some extra hours. But we've been really lucky that the medical units have set up a gardening club as part of their social prescribing scheme, and they come and look after it" (Parish secretary) …and this guaranteed the ongoing maintenance as well as which we said that can be an issue with the Parish Council" (Consultant).

Participants also identified the role of the community in terms of their contribution to maintaining the scheme. Two different groups' volunteered to maintain the scheme. The first is the local gardening club *"...and we have the local gardening club come to look after the plants"* while the local school also helps to maintain the SuDS scheme. *"..When they did the planting, the school came down to it".*

6.8 BENEFITS FROM SUDS RETROFIT INSTALLATION

SuDS retrofit's uptake could benefit different stakeholders, including the property owners and users and the wider community. This has been reflected in the scheme and confirmed by the participants in the focus group section.

"... I think the benefits of doing it within a site like this as a community facility, so the community see it, so when they come in, they see the scheme and they appreciate the scheme (Consultant)"

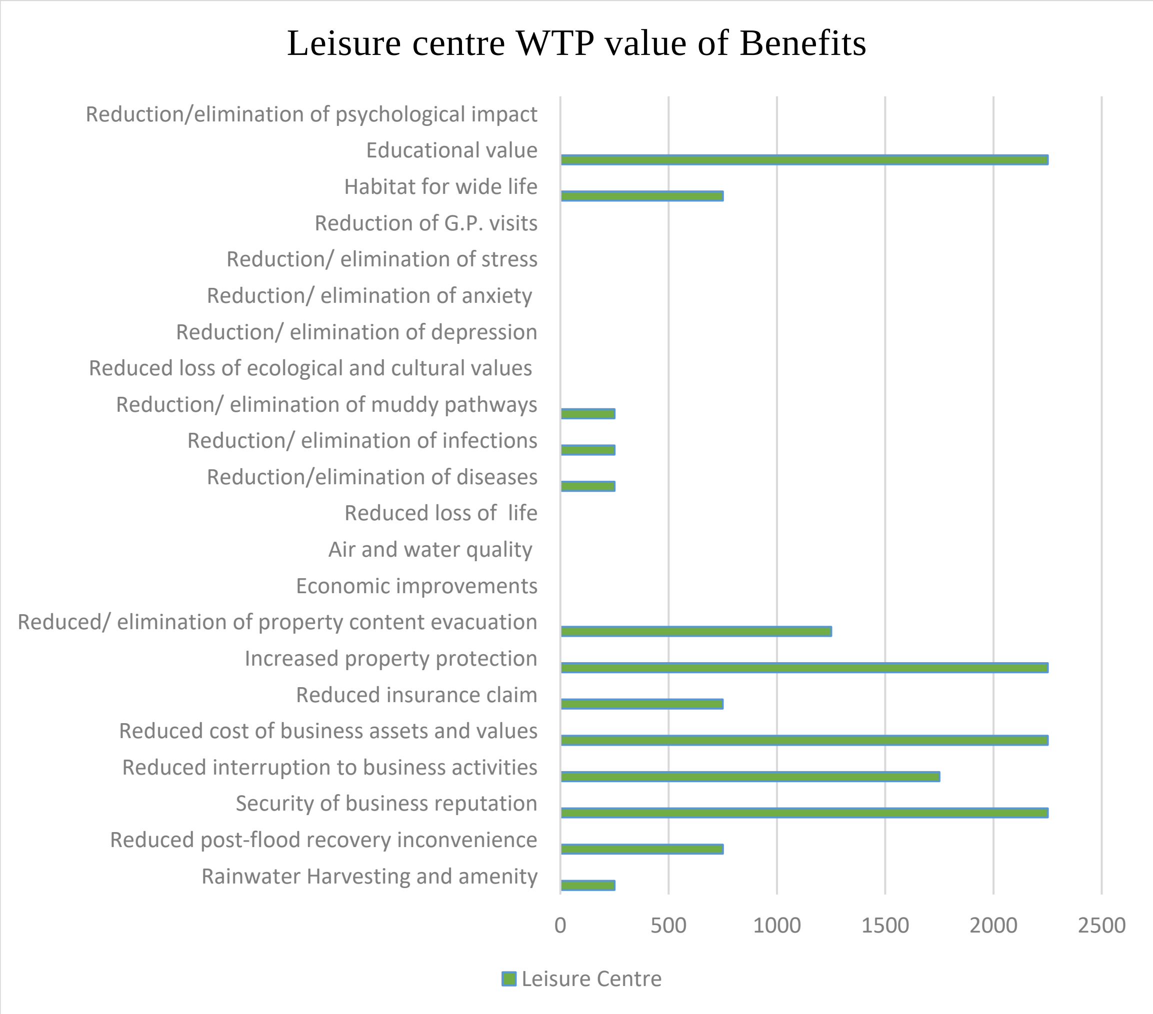
The scheme has had a positive impact on visitors to the leisure centre including tourists and members of the local community. It has also led to other SuDS schemes being installed within the community.

"…I mean, you have loads of people coming to look at the scheme. Yeah, you use it as a model scheme…. And since then we've raised more funds and we've done a SuDS scheme down there (town centre)" (Property manager).

Another significant benefit to the community is the health benefit which has influenced different groups and individuals and has encouraged volunteers to come forward and assist with the maintenance. *"…and we have the local gardening club come to look after the plants that you know, part of their social prescribing, through the doctors, GP referrals and things like that. So as part of their health and social benefits, that's what they do" (Parish Secretary).* Hence, there is little concern about the ongoing maintenance of the scheme and the costs have remained very low.

Focus group participants were asked to quantify the benefits and how much they would be willing to pay (WTP) for these. Figure 6.4 provides a summary of these findings.

Figure 6.4: WTP Value of Benefits



The participants found it difficult to put a value against many of these benefits, especially the intangible benefits as expressed by one of the participants. *"...It is absolutely difficult to quantify because how do you put a price on wellbeing" (Participant B)*. It was evident that some of the benefits had not been considered during the design and had not influenced the decision-making process. Nevertheless, the participants were able to provide approximate values based on their perceptions of these benefits in the context of the Leisure Centre scheme.

A cost-benefit analysis was undertaken by calculating the net value (NV) and the net present value (NPV) of the SuDS retrofit project, assuming investment returns within 10 years, as per (Chambers et al, 2019; Dominguez et al, 2017). Using the average of the upper and lower benefit intervals (see Table 2), the total value of the benefit in the present year and turn the total benefit in 10 years was derived. The cost of installation was then subtracted from the total value of the benefit accrued over 10 years. Importantly, no maintenance costs were included in the analysis, reflecting the use of volunteers on the scheme.

Below is a calculation for the net value (NV) of the entire project in 10 years:

Net cost (NC) = Present Cost (PC) of installation+ maintenance cost (MC)

=£39,000 + 0 =£39,000

Net benefit (NB) in 10 years= total benefit/annum x 10

=£152,565

Hence,

Net value in 10 years= Net Benefit in 10 years – Net Cost

=152,565-39,000

= £113,565

Net benefit is the value of the project within a set period of time. In this case, the net benefit of the SuDS retrofit scheme in 10years of its installation. This has been calculated by dividing the total value of intangible benefits per annum and then multiplying this by 10 which is the number of years being considered. While the discount rate is the rate of return for an investment in the SuDS retrofit scheme.

6.9 DISCUSSIONS

Given the findings presented above, several vital inferences can be made concerning the cost and the benefits of installing SuDS retrofit and the decision-making process. It can be seen that various factors influenced the implementation of the scheme, including the perception of flood risk, the costs of installation, funding, maintenance and some if not all of the benefits.

Stakeholder involvement on this project was encouraging and a good team ethos was evident. This helped make sure that the costs of installation were well understood and well defined. Research has shown that stakeholders often lack interest in new schemes (Castleton et al., 2010; Oladunjoye et al, 2017). However, in this case, the response from the stakeholders was different and could be adjudged as positive; perhaps indicating that the view of SuDS is beginning to change, and its necessity is beginning to be accepted. Proactive response from a team member to lead on fundraising for the project demonstrated that the stakeholders were very much committed to implementing the project. This helped to prevent any unforeseen delays in implementation and helped to drive the scheme at every stage. One of the stakeholders had a lot of experience with SuDs and this made it easier to work through the design and construction stages. This positively influenced the other stakeholders to take up the scheme (Oladunjoye et al, 2017) and helped to overcome previously reported barriers concerning a lack of knowledge (Castleton et al, 2010).

The perception of flood risk among the stakeholders was a major factor that influenced the installation of SuDS. Research has shown that the impact of flood events can be very destructive to properties and the reputation of businesses and activities (Carboni et al, 2016; Castleton et al, 2010; Kuhlicke et al, 2020). Within the leisure centre, the effect of flooding needed to be controlled both on the building and the outdoor sports centre. The data obtained for this property suggests that runoff from the roof to the property and also the flow of surface water at the football pitch was detrimental to the centre and needed to be controlled. In discussing the outcome, reference was made to the fact that all surface water from all parts of the property including the roof has been channelled to the swale and then to the nearby river for easy runoff.

Funding for this retrofit is not part of standard maintenance budgets, so this represented a key challenge. Many organisations are unlikely to consider SuDs retrofit as a priority when considering their financial returns. Therefore, securing sufficient funds represents a barrier (Roelich, 2015; Sustainable development commission, 2010; Cimato and Mullan, 2010). In the Leisure centre case, money was sought from different avenues like flood committees and specialised organisations. This could have delayed the scheme's implementation, but this was made easier because someone was well informed about channels of funding. To ease the difficulty of obtaining funds, it could be useful to have specialised guidance and support for this purpose. This could include advice on managing the cost of installation and ongoing maintenance.

During the focus group discussions, several benefits were identified, however, many of these had not been considered during the decision-making process. There was no attempt to quantify the benefits of the scheme. Earlier research has identified this as one of the major barriers to the uptake of SuDS retrofit (Carboni et al, 2016; Oladunjoye et al, 2017). The willingness-to-pay (WTP) process revealed the difficulties posed in quantifying these benefits, especially the intangible benefits. Research has shown that their subjective nature's intangible benefits are difficult to quantify and are said to be more personal to the victims of flood events (Oladunjoye et al, 2017; Joseph et al, 2014; Yang et al, 2019). Therefore, it was important to carry out this exercise to obtain a full understanding of the benefits of the SuDS scheme to the property owners and propose an appropriate procedure of eliciting the intangible benefits of the scheme.

6.10 LEISURE CENTRE WTP VALUES

Other rated benefits are equally important to the property owners. Ideally, no business or property owner would want to ignore the possibility of property protection or security of business reputation. Every business owner works hard to maintain a good reputation to access the best opportunities in the market. Kamerman and Kahn, (2010) opined that a great reputation will open doors to fantastic opportunities and unhindered access to the ideal client base.

However, it is strange to see how values such as reduction of GP visits, reduction/elimination of stress and reduction/ elimination of anxiety are not of any priority to the stakeholders. It will be expected that due to the activities of the Leisure centre which helps with human health and fitness, these options will be highly rated with great enthusiasm, but this appears not to be the case.

6.11 SUMMARY

The study has investigated the costs and the benefits of the installation of SuDS retrofit at a Leisure centre including some of the key decision-making issues. The importance of teamwork amongst the stakeholders during the decision-making process helped overcome many known challenges. It was clear that maintenance had not been fully considered and fortunately this was being undertaken by volunteers at no cost to the council. The WTP process has shown that the perceived benefits from the scheme were valued at around £15,000. Several intangible benefits were valued highly (i.e. educational, reputation) thus demonstrating the need to capture these in the decision making process. It was found that the installation would provide a net value to the client of well over £100,000 over a 10 year period and that the return on investment would be achieved in just three years.

The first cost-benefit analysis of the retrofit of SuDs, using a conceptual model developed earlier in the research. The findings highlighted many of the apparent barriers that need to be overcome when installing retrofit schemes. The results demonstrate the importance of the intangible benefits derived and it is recommended these are given full consideration at the decision-making stage and in promoting the uptake of the retrofit of SuDs.

CHAPTER 7: CIVIC CENTRE (CASE STUDY 2)

7.1 INTRODUCTION

This chapter presents the second study area which is the Civic centre. This is in line with the fifth objective as mentioned in chapter six. The chapter presents the background of the Civic centre, the data on the decision-making process of the installation of the SuDS retrofit scheme, stakeholder involvement during the installation process, the flood perception of the property, the funding of the scheme, the cost of installation including other associated costs and benefits accrued from the scheme.

7.2 THE CIVIC CENTRE AND THE SUDS RETROFIT SCHEME

The Civic centre is a grade 2 listed old school building located within walking distance of the main pedestrianised High street that connects the town's main shopping area. Figure 1 shows an overview of the Parkside Re-Development which was undertaken on the site of the old Parkside Grammar School located on the Southam Road leading out of Bromsgrove. The old school building which was opened in 1910 is Grade 2 listed and so was subject to some conditions before re-development could be undertaken. This included retaining the facade of the building and the landscape frontage to Southam Road.

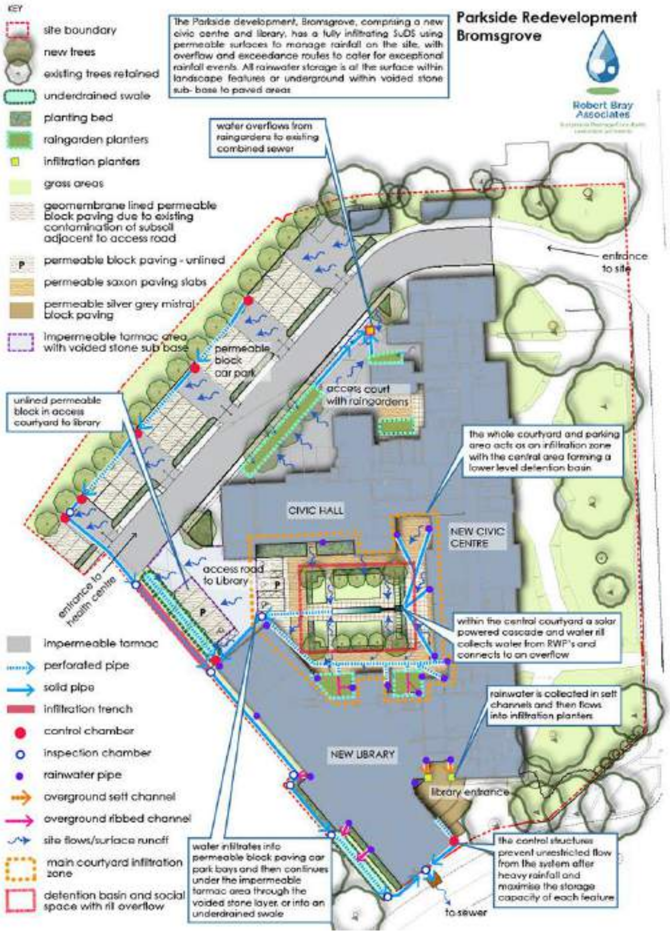


Figure 7.1: Parkside Civic Centre Redevelopment

7.2.1 The SuDS retrofit scheme

The civic centre comprises 5 sub-catchments, each with a different character and therefore with different SuDS components. The first sub-catchment is the frontage of the civic centre, with a soakaway and sewer connection retained in front in a bid to reduce cost during the installation of the SuDS scheme. Raingardens were initially proposed to capture roof water as a protection measure to the existing combined sewer but were not constructed due to a change of plan by the property owner.

The second sub-catchment is the car park to the north of the access road to the Health Centre. The whole site is situated on sandy soil overlying sandstone and is suitable for infiltration. However, there was significant Polycyclic Aromatic Hydrocarbon (PAH) pollution in this location where the car parking is located. A series of lined permeable block double parking bays were constructed with impermeable access surfaces from the road. Each double bay has its control structure linked to a final chamber directing clean water under the access road to an infiltrating swale-basin in the main part of the site. The water that does not infiltrate is conveyed down the western boundary in a solid pipe where it is close to the building or perforated pipe where it passes through an under-drained basin overflowing if necessary into the storm sewer. The third sub-catchment is a small access area behind the main central space with car parking and access pathways. The tarmac surface has been re-used so manipulation of this space has only allowed the partial collection of runoff. This is effected through 2 bio-retention features that collect and clean everyday first flush volumes with occasional larger storms overflowing to the existing combined sewer.

The fourth sub-catchment, comprising the main part of the site, was designed as a civic square in the 20th-century garden tradition. The square integrates with the Georgian school elevation, an existing school hall and the library with Local Authority services. There is a small car park at the entrance to the square. The whole central space was considered as an infiltration surface and therefore the peripheral path is both permeable block and slab paving. The central green space infiltrates water and is slightly lower than the surrounding paving acting as a detention basin during very heavy rain. Permeable block car parking forms another small soakage area. A small area of impermeable tarmac falls to a swale-basin with an underdrain that leads to a controlled flow overflow and the exceedance route. The swale basin is the only dedicated SuDS surface in the central area. Much of the new building has a green roof that mitigates flows and cleans the runoff before it flows to ground level infiltrating through low planters or permeable surfaces.

Finally, the fifth sub-catchment is the very small entrance space that also acts as a collection route for some green roof runoff. This is collected in small planters that link directly to the path sub-base. There is a raised control structure that ensures the day to day rainfall infiltrates but bigger volumes can discharge to the storm sewer if necessary.

7.2.2 Design strategy layout

Figure 7.2 below shows a labelled description of the design strategy layout plan which was adopted during the design stage of the SuDS scheme.

Figure 7.2: Design Strategy Layout Plan

1. Permeable block parking bays.

2. Water overflows from rain gardens to the existing combined sewer.

3. Access court with rain gardens.

4. The whole courtyard and parking area act as an infiltration zone with the central area forming a lower level detention basin.

5. Unlined permeable block in access courtyard to the library.

6. Water infiltrates into permeable block paving car park bays and then continues under the impermeable tarmac area through the voided stone layer, or into an underdrained Swale.

7. Rainwater is collected in sett channels and then flows into infiltration planters.

8. The control structure prevents unrestricted flow from the system after heavy rainfall and maximises the storage capacity of each feature.

7.3 THE SUDS RETROFIT DESIGN

The site naturally divides into four Landscape and SuDS areas. Further details about these sections are discussed below. However, these areas are considered as four landscape character spaces and four SuDS sub-catchments with their drainage characteristics.

7.3.1 The Victorian Frontage

This area retains most of its original character and is retained with modest landscape additions to allow natural infiltration of rainfall into the ground.

The driveway surface will be fully exposed and resurfaced with resin-bound gravel to reflect the likely appearance in the past with a blue brick channel to the edge nearest Stourbridge Road. This channel will carry any surface water to shallow basins designed as ‘rain gardens’ to allow infiltration into the ground. Roof drainage will continue to flow to existing soakaways but if necessary additional channels will carry water to the basins these features will also aid tree growth by directing water towards the trees particularly during intense summer rain. Any surcharge will overflow through a pipe link to the existing storm sewer.

7.3.2 The Car Park adjacent to the northern boundary

The car park of the existing access road falls quite steeply to the northern boundary and is on the ground with locally elevated levels of PAH pollution. The Environment Agency will probably require that there is no infiltration in this area so the design takes this into account.

It is proposed that the car park spaces are constructed in permeable block paving and lined to create a series of tanks that will provide storage for the water cleaned as it passes through the stone sub-base. The remaining access strips will be in conventional tarmac with runoff flowing into the permeable sections. Each 'tank' will have a small control structure releasing the water to a piped conveyance taking water under the access road and along the western boundary of the site to the storm sewer. The pipe link along the swale will be perforated to allow some infiltration of clean water and deep irrigation of the swale trees.

The car park will be set about 1M back from the kerb to provide a hedge and tree screen to the parking with trees along the northern boundary. The block paving to car parking is proposed as red brindle 200x100 permeable block to add contrast to the tarmac but to disguise the inevitable oil drips that the SUDS feature is designed to manage.

7.3.3 The Triangle to the north of the Civic Building

This triangular corner serves largely as access and parking to the rear of the Victorian Buildings on the site. The existing access is retained with a distinct slope down to the court level.

Permeable car spaces deal with pollution from cars and some roof runoff and combine with planters to collect rainfall across re-profiled tarmac areas. The planting also serves to screen the space from the access road and provide enclosure to the triangular court.

Runoff from the permeable car spaces and the 'bio-retention planters' that does not infiltrate naturally is carried along the edge of the access road, in a controlled flow, to the western boundary and outfall to the sewer.

7.3.4 The new Civic Court

The design of the Civic Court has been determined by the need to provide civic space for meeting and managing activities like wedding parties within a day to day working environment. Access to all the buildings has to be accommodated at the same time as providing a social space for visitors. This had been achieved by creating an outdoor room in the centre of the court in a similar way to the garden design style of 20th-century garden styles such as Hidcote or Sissinghurst gardens. The formal garden space is enclosed by yew hedging with openings to provide both visual and physical access. This central green space also allows for levels to be managed informally using steps where necessary but retaining level or gently sloping access round the central garden space.

The whole court is employed to manage rainfall by using permeable surfaces. The paving design includes small unit blocks as an edging to the court, suggested by the cobbled edge on many early college courtyards with larger slab paving as path routes within the court. Roof water from the main Victorian Building is directed to a sett cascade flowing to a simple rill in the garden with an overflow to the sewer. The garden space is slightly lower than the surrounding paved area and provides shallow surface collection and a storage feature in exceptional rainfall with an overflow across the car park.

The final part of the SuDS sequence is a swale along the western boundary with an exceedance grating overflow to the storm sewer. It is expected that this will be needed only very occasionally when the ground is saturated and exceptional rainfall occurs at the same time. The access surface is impermeable but has avoided stone sub-base to continue the infiltration function. Rainfall will flow to the permeable car spaces or the swale.

The infiltration approach to managing rainfall will ensure that all landscape areas are watered naturally and particularly during heavy summer rainfall when conventional drainage removes water from landscape areas. The use of permeable surfaces and an underlying blanket soakaway across most of the site maximizes the opportunity to soak water into the ground and mimic what would happen naturally on the site.

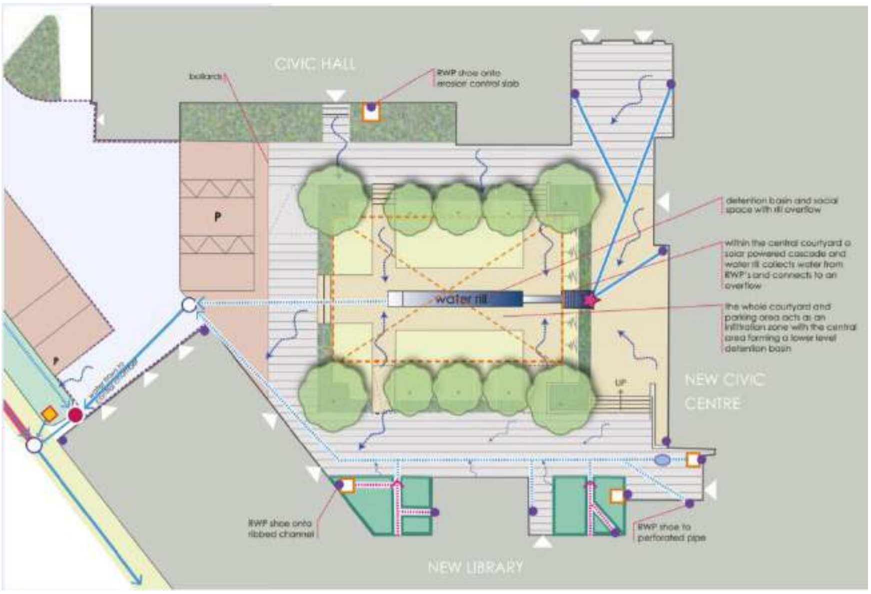


Figure 7.3: The Courtyard

7.4 THE SUDS DESIGN AND EVALUATION GUIDE

This guide was put together by some SuDS professionals on behalf of 18 local councils across the UK, to provide links between the design of SuDS and the evaluation requirements of planning in a sequence that mirrors the SuDS design process. This guide promotes the idea of integrating SuDS into the fabric of development using the available landscape spaces as well as the construction profile of buildings.

…this guide is usually given to clients or organisations within Worcestershire county council before consideration is giving to their SuDS scheme (Landscape architect)" this approach provides more interesting surroundings, cost benefits and simplified future maintenance.

The guide is intended for ensuring that SuDS are designed and implemented to a satisfactory standard according to the Local Planning Authority's (LPA) requirements. This was informed by the proposed flood and water management act in 2010 which encouraged that SuDS should be used on most development and was confirmed in a ministerial statement in March 2015 introducing the non-statutory technical standards for SuDS.

7.5 RESULTS AND FINDINGS

This section discusses the factors that influenced the decision-making process including the perception of flood risk, the costs of installing the scheme, funding, challenges during and after installation and the maintenance procedure of the scheme. Particular emphasis is placed on explaining the perceived benefits and the value of these from the perspective of the key stakeholders.

7.5.1 Decision-making process

Interviews were conducted between three key stakeholders. The current Senior Water Management officer (SWMO) (Participant A) who is directly in charge of the scheme and stands in the place of the property owner, one of the Subcontractors (Participant B) who was invited midway into the project and the Landscape architect (Participant C) who designed the SuDS scheme. The landscape architect was fully involved at the beginning of the project and so he was able to give a well-informed insight into the decision-making process and other information. However, the interview sessions were able to shed light into various themes as it affects the decision-making factors, the challenges faced on the project, the maintenance of the scheme.

7.5.2 Worcestershire County Council Design Group (WCCDG)

The WCCDG was saddled with the responsibility of working on the redevelopment of the Parkside centre. This is a team of professionals within the council constituted for the sole purpose of working on various projects, largely, schools within the county council.

At every available opportunity, the landscape architect was always consulted for his professional advice on various projects within the council. *"…They had responsibility for some projects, large schools, which I worked on and we had got into the habit…so that was a big advantage (*landscape architect*)".* Therefore, bringing him on board for the redevelopment of the centre was more like a norm. This was an advantage that he identified as a means to clarify at the decision-making stage, if it is appropriate to locate a SuDS scheme within the site, especially at Parkside. *"…So in the context of scheming in Bromsgrove, Parkside when they knew that they were going to have to build a new civic centre, they asked me to look at the site right at the beginning saying was SuDS appropriate there, of course, it is appropriate everywhere (*landscape architect*)"*

Aside from the WSCCD team, two other stakeholders were involved at different stages of the project. The main contractor who worked on the redevelopment and the landscape contractor who installed the SuDS scheme. However, reaching out to them for an interview session was quite difficult because the team had been disbanded and contacts were difficult to establish. *"…The project was undertaken by the design group within Worcestershire county council who* *have been disbanded subsequently (*landscape architect*)".* The consequence of this reflected in the difficulty of the SWMO in answering most of the questions asked from her towards the daily maintenance and the knowledge of the scheme. "… I was not involved in decision-making…I don't like to say with my status that I don't have anything to say (SWMO)".

7.5.3 Flood Perception

While the property had no previous flooding record *"… there are no flood issues on this property (SWMO)*", it was important to the council that an infiltration site was constructed to prevent flooding downstream. *"…the reason that SuDS was done there was to prevent flooding further downstream and there is flooding downstream (*landscape architect*)"*

However, the most important factor that influenced the need for the SuDS scheme was the need to have an infiltration site. *"…the most important one was to decide that we were going to have an infiltrating site…in this case, we had to store all the water because much of the site was hard surface (*landscape architect*)".* The presence of the hard surface informed the need to introduce storage under the permeable surface to be stored for a short time and then it can soak into the ground or further into river Severn which is located some miles from the property.

7.5.4 SuDS Costs

An opinion about the cost of the SuDS scheme was expressed by the landscape architect. He opined that identifying the SuDS cost in a typical landscape design will be extremely difficult since they are all interwoven and are doing related jobs. *"…The other thing but from the perspective of the cost of it, and it is very difficult to separate the SuDS cost from any other* *costs because all of the surfaces are doing two jobs… If you would take in the water and put it in somewhere else, then you could say that's a suds cost (*landscape architect*)".*

Some deliberate actions were taken to save costs by the landscape architect. The most important was to keep lots of infiltration stored under the pavement for storage including dropping the centre of the courtyard. *"…at the car park, we didn't ask for any extra land because all the water was stored within the stone. The same with the courtyard. If you look at the courtyard, lots of water stored underneath the pavement, and then the centre of the courtyard was dropped (*landscape architect*)".* This helped to save some extra cost with the installation of SuDS. A further cost-saving process was achieved by reducing the use of additional surfaces *"…So, we hadn't put any additional surfaces and that's why if you do a cost analysis, there are no additional costs (*landscape architect*)".* However, the cost of installing SuDS could either be cheap or expensive, this is mostly influenced by the mode of installation. *"…So it's cheaper to integrate it with design, the landscape designer It's always more expensive to do it separately because you'll have a seBobate construction to it (*landscape architect*)".*

7.5.5 Funding

Funding the scheme was by the council as part of the redevelopment of the site. This, therefore, did not pose any difficulty for the WCCDG team because this had already been integrated into the redevelopment costs. *"…It was funded by the local authority to build a new Civic Centre (*landscape architect*)".*

7.5.6 Maintenance and operation

Maintenance of the scheme was not considered at all at any stage of the scheme. This is mainly because the stakeholders thought that due to the way by which the project was delivered, it would have been odd to separate the SuDS scheme from the overall landscape for the redevelopment. *"…No, because its landscape management cost. There isn't a dedicated SuDS cost (*landscape architect*)".* landscape architect argued that it is not different from the regular daily maintenance of a property. *"...the maintenance for the landscape and the SuDS is very simple and not different from the regular daily requirements of maintaining a property. It is very cheap. You only need to employ sweeping services, cutting the grass (*landscape architect*)".*

Furthermore, Participant A who represents the property owner and is directly involved with the scheme confirmed that the scheme is not maintained. *"…very, very rarely maintained (SWMO)".* This later resulted in the invitation of the Consultant as a subcontractor to repair some aspects of the scheme that were either not properly maintained or installed. *"…I was asked to go to Parkside and finish off some remedial works and some of those remedial works obviously to do with the building fabric but most of it was to do with the SuDS system (SWMO)".*

7.5.7 Challenges

Managing contamination on-site and dealing with inefficiency on the part of the landscape contractor were two major challenges encountered on site.

At the inception of the project, it was identified that there existed some level of contamination within the location of the proposed car park. This was confirmed by the landscape architect and documentary evidence submitted as part of the planning documents *"…when we did a ground investigation, there seemed to be one part of the car park of the site which was contaminated*

(Consultant)" The contamination which is referred to as Polycyclic Aromatic Hydrocarbon (PAH) led to a delay in the planning process because the planning authority did not want any construction to be done where the contamination is located. Therefore, a different approach was applied and adopted. *"..., but the Environment Agency wanted us not to infiltrate around the car park area where the contamination was located. So we had a different solution there (Consultant)."*

The second challenge was with the landscape contractor. In a bid to make some money from the scheme, he decided to reduce the depth of the impermeable surface of the courtyard. This action to the landscape architect is going to affect the future of the scheme. *"...Asking about the challenge, but the challenge would have been the fact that the contractor didn't build what we designed. So they've had to go back and do a lot of work. So for instance, we designed it to have a certain amount of soil underneath but they had something different just to make some money for themselves I guess. Furthermore, Nobody was checking because the contract was very badly managed. So we went six months over. And nobody was paying me to go, I would go there. And they say, yes, we've done all this (*landscape architect*).*

7.5.8 Benefits from SuDS retrofit Installation

The SuDS scheme has been of benefit to different stakeholders including the property owner and the community. This has been confirmed by the interviewees.

"... Yes, it is very beneficial to the community (SWMO)",

"...Yes, there is the benefit of storage, that's quantity. The quality of water, all the court quality is good because it's been through a filter. I mean, people can use all the surfaces we created. They can use them so it's all usable. And it looks good. And biodiversity, biodiversity is a bit

more difficult, but we planted in where we could and the water is clean, it's good for the streams, good for the rivers.

*, "…Yes, it has its benefits (*landscape architect*)"*

Some benefits were identified and given more attention to the decision-making stage. Quality, quantity, amenity and biodiversity. These benefits were not quantified because of the difficulty in quantifying them. *"…So how can you quantify beauty? How can you quantify well-being? You can quantify quality or quantity…. Can you quantify clean water as opposed to dirty water?... maybe you want to ask the water agency how they do it but it won't be money" … I can't put a figure on amenity. All I can tell you is that this is used by the public and they like the space (Consultant)".*

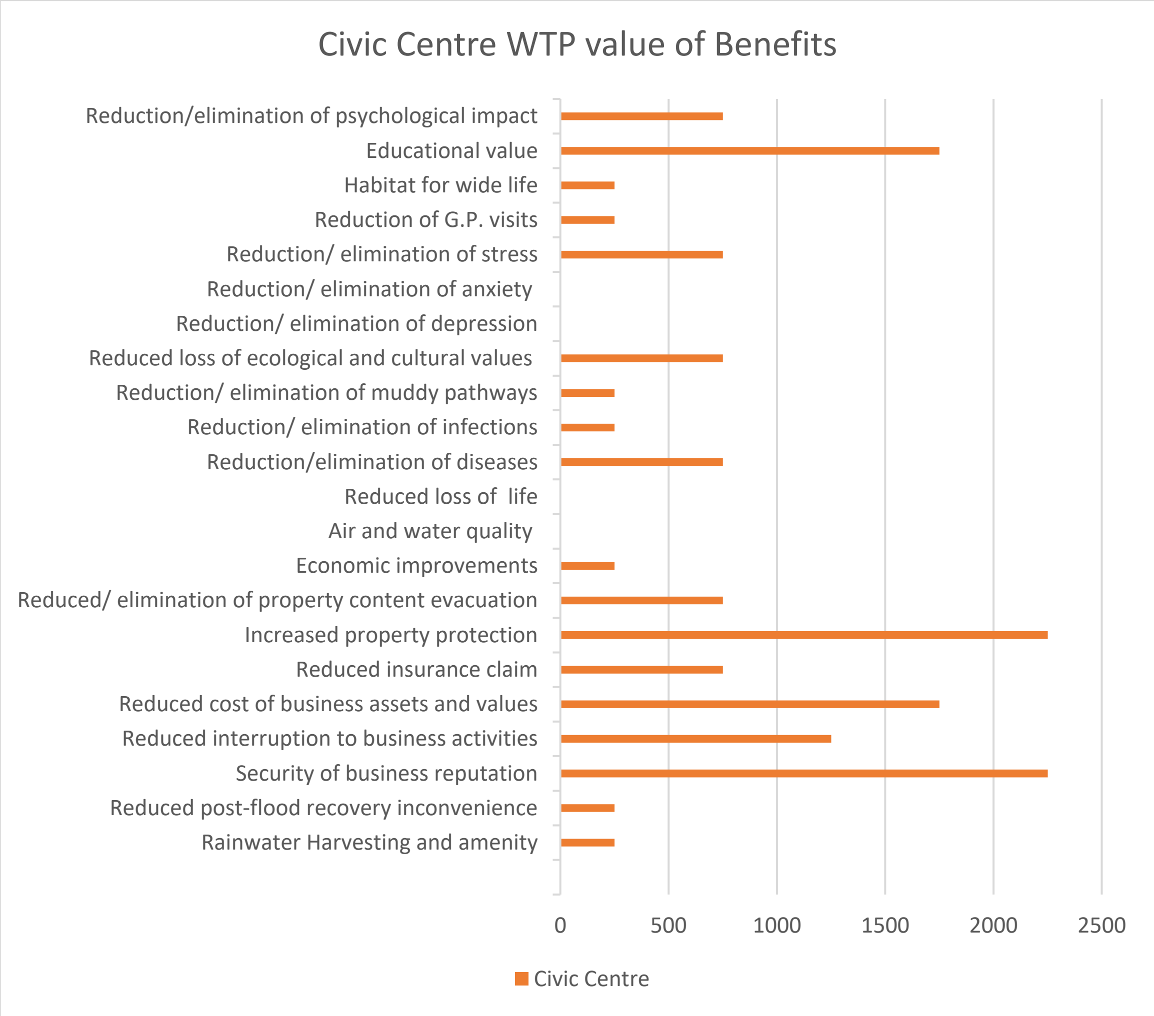
However, all the participants found it difficult to suggest values to the benefits. *"…how do you put values to these benefits? (Senior water officer)", "…honestly, I don't think I can value these benefits (Consultant)".*

"…The SuDS design incorporates techniques that encourage natural soakage into the ground with modifications where local pollution levels are high and an overflow arrangement to deal with exceptional rainfall events (Design statement)"

7.5.9 WTP value of Benefits

Each participant was asked to quantify the benefits of the scheme to the council and the community. Figure 7.4 below provides a summary of these values.

Figure 7.4: WTP value of benefits



7.5.10 CBA of the SuDS retrofit scheme

A cost-benefit analysis was undertaken by calculating the net value (NV) and the net present value (NPV) of the SuDS retrofit project, assuming investment returns with 10 years. Using the average of the upper and lower benefit intervals, the total value of the benefit in the present year and turn the total benefit in 10 years was derived. The cost of installation was then subtracted from the total value of the benefit accrued over 10 years. Importantly, no maintenance costs were included in the analysis, reflecting the use of the workers at the Civic centre. Below is a calculation for the net value (NV) of the entire project in 10 years:

Net cost (NC) = Present Cost (PC) of installation + maintenance cost (MC)

= £106,105 + 0 = £106,105

Net benefits (NB) in 10 years -= total benefits/annum x 10

= £183,000

Hence,

Net value in 10 years = Net Benefit in 10 years – Net Cost

= £183,000 – £106,105

=£76,895

Net benefit is the value of the project within a set period of time. In this case, the net benefit of the SuDS retrofit scheme in 10years of its installation. This has been calculated by dividing the total value of intangible benefits per annum and then multiplying this by 10 which is the number of years being considered. While the discount rate is the rate of return for an investment in the SuDS retrofit scheme.

7.6 DISCUSSIONS

Given the findings presented above, several inferences can be made concerning the decision-making process, costs and benefits of installing the SuDS retrofit scheme. It can be seen that various factors influenced the implementation of the scheme including the flood events downstream, the impact of surface water within the property, funding, maintenance, challenges and some of the benefits.

The steps that were taken at the decision-making stage of the scheme by the WCCDG team in involving professionals is quite interesting. Bringing in an expert to advise on the appropriate location for a SuDS scheme and also towards a well-designed scheme is quite impressive.

Oladunjoye et al, (2017) opined that one significant barrier to the uptake of SuDS is the lack of seasoned professionals within the field to aid a proper SuDS scheme that meets the required standard. Having professionals on board at the early stage of the decision-making process will help to achieve a design that is flexible, integrated, collaborative and innovative (Backhaus et al, 2012, Potter and Vilcan, 2020)

Constructing an infiltration site was the major factor that led to the installation of the SuDS scheme. This was important to manage the flood events on-site and the flood events downstream. The detrimental effect of flood events can lead to various negative effects (Proverbs et al, 2008; Castleton et al, 2010; Oladunjoye et al, 2019) therefore, taking up the resilient measure at the appropriate time will help mitigate the resultant effect of flood events (Pitt, 2008; Joseph et al, 2014; Oladunjoye et al, 2017; Adedeji et al, 2018).

Funding for this sort of retrofit is integrated into the cost for redevelopment. Research as shown that this procedure helps to save the costs of installing SuDS independently by 10% because of the early incorporation of the scheme into the construction process. This also makes it easier to consider the cost of installing the SuDS scheme alongside every other procedure on-site (Horton et al, 2016; Everard, 2020).

Facing challenges on construction sites or at the decision-making stage most times is inevitable however, the response to this challenge goes a long way in informing the outcome. The contamination discovered could result in various factors that will either prolong the execution of the project or increase the cost of construction. Also, if these issues are not well handled, it can lead to some legal actions in the future. PAH was that contamination discovered by the landscape architect which was also confirmed by adopting the Historic Environment Record (HER) data. Beyer et al, (2010) described PAH as a ubiquitous environmental contaminant that constitutes a diverse class of hydrophobic organic molecules. In this case, the planning authority advised that no aspect of the SuDS should be constructed on the contamination site. This led to the landscape architect changing to an alternative means of dealing with the contamination on-site and this was very helpful yet did not attract any extra cost.

Being fraudulent to make more money by altering specifications, results in detrimental results that lead to a SuDS scheme that will fail to show the true reason why it is installed. One of the main barriers to implementing SuDS is concern about performance and maintenance costs (Heal et al, 2009). The participants had differing opinions about the maintenance of the scheme. Participants A and C confirmed the scheme's poor maintenance. Participant B says it is not different from any other daily maintenance process that will require regular property maintenance. However, the challenge of having to invite participant C for repairs and the difficulty to locate someone to discuss the maintenance process of the scheme confirms that having a laid down maintenance procedure may be helpful towards a better output from the scheme. Research as shown that a well designed and maintained SuDS scheme is more cost-effective to construct and costs less to maintain (Duffy et al, 2008).

During the individual interview sessions, some benefits were identified. The landscape architect identified a few standard benefits being used by CIRIA and some other researchers, which was applied by him at the design stage. Water quantify, water quality, amenity and biodiversity are standard benefits that CIRIA offers through the SuDS manual towards an idea SuDS scheme. However, Oladunjoye, et al, 2019 opined that there is more to these standard benefits and how they are quantified (CIRIA, 2007).

Research has shown that a major barrier to the uptake of SuDS is the no existing procedure to quantify the benefits of SuDS. Using a Willingness-to-pay (WTP) process, stakeholders have clear difficulty to either quantify or suggest a value to the benefits, especially the intangible benefits. Research has shown that their subjective nature's intangible benefits are difficult to quantify and are said to be more personal to the victims of flood events (Joseph et al, 2014; Oladunjoye et al, 2017; Oladunjoye et al, 2019; Yang et al, 2019). Therefore, it was important to carry out this exercise to obtain a full understanding of the benefits of the SuDS scheme to the property owners and propose an appropriate procedure of eliciting the intangible benefits of the scheme.

7.7 CIVIC CENTRE WTP VALUE OF BENEFITS

Anxiety is an occurrence that is associated with stress and can come as a result of fear or apprehension about what to come. Exercise, spending time with friends and family, laugh, yoga classes are suggested ways to reduce anxiety (Lyckholm, 2001; In-Albon et al., 2020). Depression, on the other hand, is a mental health condition that can last for a very long time and affect everyday life (Adams et al., 2004). Engaging in activities within the case study sites could also help manage the effect of depression. If the stakeholders had difficulties quantifying these benefits despite the possibility of the properties being able to support the reduction of anxiety, this confirms the Genuity of the difficulty they have faced.

7.8 SUMMARY

This study has investigated the costs and the benefits of the installation of SuDS retrofit at a Civic centre including some of the key decision-making issues. The presence of an expert on the team during the decision-making process helped to overcome many of the known challenges. The long term relationship on various projects within the council made it easy for the council to entrust the installation of the scheme to the hands of the landscape architect. It was clear that the need for an infiltration site within the redevelopment was the main purpose of installing the scheme. However, the maintenance of the scheme has not been carried out for years. This could be as a result of the fact that no department was officially assigned to oversee the scheme. The WTP process has shown that the perceived benefits from the scheme were valued at around £18,300. Again, some of the intangible benefits from the scheme were highly valued, thus demonstrating the need to capture these in the decision-making process. it was found that the installation would provide a net value to the client of well over £76,895 over 10years and that the return on investment would be achieved in less than a year.

CHAPTER 8: THE PRIMARY SCHOOL (CASE STUDY 3)

8.0 INTRODUCTION

In this chapter, the analysis of the third case study is presented. This is in line with objective five of the research, which is to elicit the actual value of the costs and benefits of the retrofit of SuDS including the reduction of flood risk from a sample of case study sites in the UK. Thus this chapter presents the data on the decision-making process of the installation of SuDS retrofit scheme from a primary school scheme, stakeholder involvement during the installation process, the flood perception of the property from the council representative, funding of the scheme, the cost of installation including other associated costs and the benefits accrued from the scheme.

8.1 BACKGROUND

Figure 8.1a: Entrance to the Primary School

Figure 8.1b: The Lawn before SuDS

Figure 8.1a shows the main entrance to the Primary school, and Figure 8.1b shows the lawn before SuDS. Located in the West Midlands region of the UK within a residential community, the primary school, which is the basis for this case study, was first established in September 2001. The purpose of establishing the school was to provide primary education to the community where it is located. Following a directive from the local council for schools to install SuDS within their properties to meet with the 1 in 100 years flood return period policy of the council, it was expedient for the primary school to adhere to this directive. However, the primary reason the SuDS scheme was installed in 2003 was to replace the existing conventional drainage system, which was becoming too expensive to manage and inadequate in attending to the property's water management needs based on the council's requirements.

The scheme's installation lasted for about two years involving various stakeholders including the landscape architect, the headteacher of the school, the property manager, and the council representative. Meetings held at least once stakeholders attended a month to discuss issues that affected the installation of the scheme. It is important to note here that other renovation works were being carried out on-site simultaneously, which meant that the meetings were not solely for the installation of the scheme. Therefore, the landscape architect was not expected at all the meetings. However, he visited the site more often than required, to obtain the necessary information needed to develop the design.

The SuDS retrofit scheme was designed to replace the conventional drainage system mainly installed to manage the flooding events within the property and pump water out of the pumping station to the sewer. However, this process was too expensive with the pumping system's constant breakdown due to its inadequacy. This is because the conventional drainage system was designed to manage a 1 in 30 year's return period of rainfall and this was inadequate for the property and was costing the school more money than required for maintenance. The cost was estimated at around £3000 per annum in terms of being stationed and paying the water company.

The second reason the SuDS system was installed was that those who designed the conventional drainage system had not found a way to drain the playgrounds because the playgrounds were lower than the pumping station. This was difficult for them because they did not consider the topography of the site and the usefulness of the Brook that is close to the property. The Brook which absorbs runoff from the SuDS scheme receives runoff from the swale and is located at the rear of the primary school site. The Brook is linked to a nearby River which is one of the major rivers within the council. The region where the primary school is located is said to experience a regular overland flow of rainfall from neighbouring properties therefore, the Environment Agency identified the location as being at risk as contained in one of the documents provided by the council representative.

8.1 THE SUDS RETROFIT SCHEME

The SuDS retrofit scheme is made up of four different types. A swale, detention basins, a constructed wetland and rainwater harvesters. The SuDS scheme follows the contours of the site and drains downhill to the nearby Brook. This removes the annual charge for the sewer connection.

Figure 8.2 shows an outline of the SuDS scheme as it exists currently on the property. The SuDS scheme begins with two storage/detention basins at the main drive which are referred to as the main drive collection basin and the car park storage basin. These detention basins were designed to hold back storm runoff for a few hours to allow solid components from the runoff to settle before further flow through the swale. They are also expected to reduce peak flows and risks of flooding within the entire property.

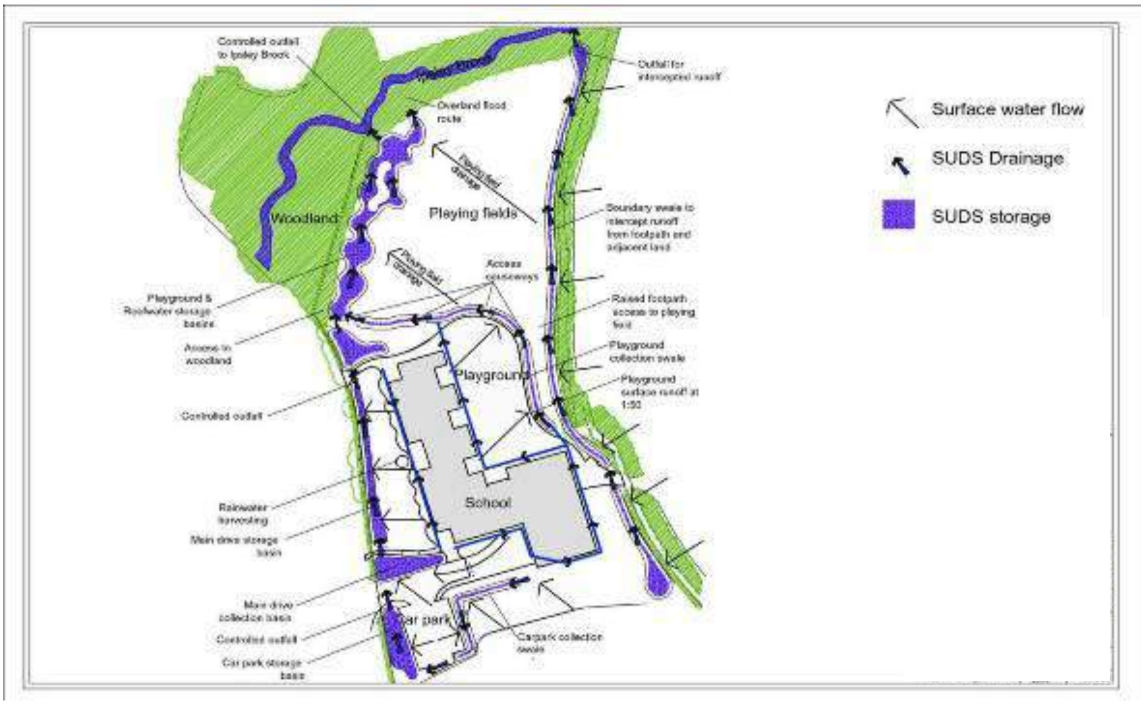


Figure 8.2: Primary School SuDS Outline

Figure 8.3a is a close view of one of the basins at the main entrance to the property, including the basin inlet. A closer view of the inlet can be seen in figure 8.3b. The inlet serves as a channel for purification and channelling of water through the swale to its eventual destination which is the Brook. This component ensures the process of obtaining clean and healthy water which is expected to reduce pollution and contribute to the health benefit which is achieved from a SuDS retrofit installation within a community.

Figure 8.3a: Storage/detention basin

Figure 8.3b: Car park storage basin inlet

The swales collect overland flows from an adjacent site across the main road in front of the property, the runoff from the car park and playground, providing source control. By providing source control, the volume of water and the potential amount of contamination is less and therefore require smaller SuDS components further downstream. The main driveway is then drained to an extended detention basin. These systems connect to a constructed wetland, which also takes runoff directly from the roof and provides amenity as well as useful educational resources. The system was designed to cope with a 1 in 100-year return period storm event which is the policy of the council, and overland flow routes were provided for events exceeding this. The return period is an average time or an estimated average time between events such as floods to occur.

Figure 8.4 is the current outlook of the existing playground which is located next to the main car park. The playground was designed alongside the SuDS scheme as a component to control the flow of runoff within the property. Flower beds were included as components to add some aesthetics within the property, which brightens the playground for the pupils yet serves to manage runoff. The beds infiltrate water and also control water movement just around the playground. Any excess water then flows to the swale which surrounds the playground and then it is thereby transported to the Brook.

Figure 8.4: Flower beds at the Playground

Figure 8.5 shows the channels of water harvesting from the roof and the surrounding of the building which directs runoff from the roof to the storage basin which has been specially designed for the roof and identified in figure 8.2. The runoff flows from the roof into the attached rain gutter through the rainwater roof outlet, through an attached pipe into the rain drain.

Figure 8.5: Roof component showing the drainage channel

Figure 8.6a&b shows the current outlook of the swale. Figure 8.6a presents the swale and the bridge linking the playground to other parts of the school environment where other play areas are located. A view of the slope of the play area can be seen with the swale. Figure 8.6b presents the end of the wetland swale before the Brook. This, as seen, is just at the school wall, which signifies that the maintenance and management of the swale do not go beyond the wall or the property. Therefore, the county council takes up responsibility for the Brook and how it is managed as it affects the swale.

Figure 8.6a: Boundary swale to intercept runoff

Figure 8.6b: The end of the swale before the Brook

8.3 INTERVIEW FINDINGS

This section presents the factors that influenced the decision-making process including stakeholder involvement, the perception of flood risk, the costs of installing the scheme, the process of obtaining the funds and the maintenance procedure of the scheme. Particular emphasis is placed on explaining the perceived benefits and the value of these from the perspective of the key stakeholders. A focus group discussion was carried out with the council representative and the property manager while an interview was conducted with the landscape architect.

8.3.1 Decision-making process

The details below presents the session between the council representative, the property manager and the landscape architect. The property manager and the council representative are involved in the daily running of all that concerns the drainage system of the school, while the landscape architect was fully involved from the decision-making stage. Dialogue about the involvement of the stakeholders was presented including their knowledge of the factors that influenced the decision-making process.

8.3.1.1 Stakeholder Involvement

At the inception of the SuDS retrofit scheme, the main stakeholders involved were the property manager, a representative of the council, the Landscape Architect and the client/headteacher which is the school representative. This was confirmed by the participants in the focus group section and the landscape architect; *"...I know about it because I was on a training course where the landscape architect was expected to give an update of various case studies within the council" (council representative). "...there was an architect from the council, the headteacher,* *myself and the property manager" (landscape architect).* This confirms that there is a network set up that helps the proper coordination of the affairs of the scheme.

It is the usual practice for an expert in the field to carry out a training course for the council staff, using various case studies to describe different scenarios which they may encounter in their various departments. This helps to keep the workers up to date with the various projects within the council.

"...you are shown various case studies so that you can understand the principles guiding the implementation and maintenance of this sort of scheme". (Council representative)

Furthermore, an expert was on the team to provide the required guidance and knowledge of the scheme and to bring clarity and understanding to the process. *"...the landscape architect, he knew what criteria was needed and what to do because he was fully involved from the beginning of the project." (Council representative).*

According to the landscape architect and from some available documents, some important factors influenced the decision to install SuDS within the property. The first is the policy of the county council as contained on their planning website which requires that all new schools that will be built within the council should be designed with SuDS scheme as its drainage system. *"...the county council's policy was to include SuDS schemes on every new school" (landscape architect).* Although there is no formal document that defines this at the moment, the SuDS guidance (Council, 2013) provided by the council gives an insight into this policy. The second reason for this decision is that the conventional drainage system which was meant to pump water from the pumping station to the sewer was becoming too expensive to maintain and inadequate to service the property. *"...the drainage scheme which was proposed was to pump the water in a pumping station to the sewer which was expensive and would have been expensive for the school because there would have been something like 3000 pounds a year in terms of* *being stationed going and paying money to the water company (landscape architect)"*. This is also reflected in Table 8.1 which shows a cost comparison between the SuDS retrofit scheme and the conventional drainage system which was obtained from CIRIA as part of their analysis of the scheme.

The third reason is that there was the overland flow of rainwater from the adjacent properties which resulted in water gathering at various locations within the property and the drainage system at that time was not adequate to manage the storage and channelling to the inflow. *"…The SuDS scheme we designed to protect that land from overland flow from the housing. There's a swale that runs down that boundary, which protects the school site from the housing, the adjacent housing site (landscape architect)".*

As earlier mentioned, the conventional drainage system was inadequate because the original designer of the system failed to drain the playground through the drainage system. *"…The second reason was that whoever designed the conventional drainage scheme hadn't found a way to drain the playgrounds because the playgrounds were lower than the pumping station (landscape architect)".* And the drainage system did not meet up with the return period specified by the Environment Agency which requires that the drainage system within the school property should be 1 n 100. *"…because that was the 1 in 100 year return period storm which was required at that time or at the time we looked at the school as required by the ENVIRONMENT AGENCY for storage (landscape architect)"*. If the flow is to be channelled to the sewer, then the return period will be 1 in 30 years but since it is for a SuDS scheme, it will be 1 in 100 years because this requires an excavation of large basins and there was no storage in the conventional system. *"…there was no storage in the conventional drainage scheme which was a mistake and it shouldn't have been allowed (landscape architect)".*

This is the frequency of rainfall within the property as determined by the environment agency.

This eventually met the expectations of the property owner in terms of cost reduction within the property by draining the whole site to the Brook which saved a lot of what could be regarded as yearly recurrent maintenance costs of a minimum of £3000 per annum. This is reflected in Table 8.1 below and the interview with the landscape architect. *"…we could drain the whole site and we saved ongoing maintenance costs of approximately 3000 pounds a year for the school (landscape architect)".*

8.3.2 Flood Risk Perception

While this property had no record of previous flooding, the proximity of the nearby River linked to the Brook which experienced a huge impact of the flooding event of 2007 partly influenced the decision to install SuDS. *"...in 2007, there was the flood event which led to the council advising that local properties should take up flood defence measures in case of future occurrences."(council representative).* The presence of the river and the potential risk considering the historical impact of flood events in the neighbourhood could pose a future risk for the property and this makes the siting of the scheme a very important one.

One major reason for installing the scheme is to manage the overflow from the surrounding properties. *"…The SuDS scheme we designed to protect that land from overland flow from the housing (landscape architect)".* The swale runs down the boundary which protects the school site from the adjacent housing site and takes the flow to the Brook. This swale solves the problem of pumping the water from the playground and the overall property into the sewer, which was adding some costs to managing the drainage system within the property.

8.3.3 Funding and costs of installation

Funding for the scheme was handled by the school within the allocated resources given by the government. This was confirmed by one of the participants; *"...funding for the school comes from the government which is from a central purse." (council representative).* However, obtaining funds for implementing the scheme was quite difficult because there was a need to justify the installation of the scheme. According to the council representative, presenting a project of this nature could raise a series of questions that will require a broad explanation to justify the need for the scheme within that property. "…*talking about the challenge, you've got to justify, for example, as an organisation like a school and say, Well, why do you spend this money on this? And ultimately, they've got very limited resources that they want to spend on this sort of thing.*

So one thing that eased the funding of the scheme eventually, was the fact that it was embedded into a general renovation work that was carried out on the property at that time. *"...it was part of a general renovation carried out within the property. So I only attended the meetings when we had to discuss the scheme (landscape architect)"*. There were other activities to be carried out which also included the need to meet up with the requirements of the council which specifies that the drainage system should meet up with the 1 in 100 years return period which is the policy of the council.

The fact that the benefits derived from a SuDS scheme are beyond managing the drainage system, made it easier to present a valid argument for this scheme. "*...but obviously, a big part of it is not only doing you get the drainage system, but you get all of the wider nice landscaping features for the children to enjoy and improves, you know, it's the amenity value of the site as well as the other part of it was the other elements (council representative)".* At that time, the headteacher was particular about finding a way to drain the playground and then the SuDS scheme being a good way to educate the students about water management. Unfortunately, this could not be confirmed from any minutes, however, it was confirmed by the landscape architect. *"...the headteacher at that time invited me to see if a SuDS scheme could be installed and for it to be useful to educate the students".*

Table 8.1 shows a breakdown of the costs of installing the scheme in comparison with the cost of installing and maintaining the conventional drainage system. This was obtained from some of the documents provided by the landscape architect to CIRIA.

The table shows a clear disparity between the installation of a SuDS retrofit scheme and the conventional drainage system. The total capital cost is a difference of £23,685. This is a huge difference even though they were installed within the same property to serve the same purpose or more, considering the 1 in 100 return period of the SuDS retrofit scheme which requires a larger storage system.

Table 8.1: Costs comparison between the SuDS retrofit scheme and the conventional drainage

Item	**Cost (£)**	
	SuDS	**Conventional**
Trenches, pipework and associated fittings	16825	53170
Drainage accessories	400	2380
Drainage Channels	9630	4010
Manholes	3300	10400
Pumping station	0	10880
Connection to sewer	0	750
Headwall to stream	750	3000
Land drainage to the playing field	32110	32110
Constructing swales, basins and wetlands	25000	0
Reducing levels of site to accommodate SuDS because it was not incorporated earlier in the development of the project	5000	0
Total capital cost	**93, 015**	**116,700**
Annual sewer connection	0	3180
Annual pumping station maintenance	0	800

SuDS maintenance	Marginal – Landscaping maintenance already undertaken for grounds	0
Total operating costs	**Marginal**	**3980**

According to the landscape architect, despite the SuDS retrofit scheme costing less than the conventional system, it was more expensive considering that it is a retrofit. *"…SuDS is very cost-effective in new sites or redevelopment, but if you've got a retrofit situation where you've got existing hard surfaces, and all the ground is covered with something that you know, it can be quite expensive and difficult to get SuDS in" (landscape architect)*. To him, therefore, it is better to introduce SuDS earlier in the construction process.

8.3.4 Maintenance and operation costs

Table 8.1 shows the cost of maintaining the sewer connection and pumping station on the conventional drainage system. This was supposed to cost a total of £3980. This to the landscape architect was saved by installing SuDS. So they did not have to consider the annual financial commitment of maintaining the scheme but they can use their regular staff including the property manager, to maintain the scheme.

Maintenance of the scheme was not considered at the design stage. It was hoped that the costs could be absorbed within the routine maintenance of the property. This was highlighted by one of the participants; *"Well, we didn't think it was necessary to provide special funding for maintenance because it is expected that the school will use their staff who manages the school environment (landscape architect)."*

A further observation by one of the participants also emphasised that giving special consideration to maintenance outside the use of regular staff is not necessary because maintaining a SuDS scheme is not different from a standard maintenance process. "*…the standard maintenance would be picking, sweeping of the car parks, the road and say some entity (council representative)".*

So far, the maintenance of the scheme has been handled by the property manager who looks after every aspect of the school property. However, a change in personnel has made it difficult for some level of technicality to be applied to handling the scheme within the property. The current manager thinks that his lack of knowledge and training towards managing some aspects of the scheme is making it difficult to produce the desired output required from him. *"…of course, I was not allowed to get there on my own because of the shallow part and the level of experience and training of the other guy. That's just standardisation clearance for the maintenance side of things (property manager)."* However, the landscape architect had a different view about this, he emphasised that there is no specific training required to maintain the scheme. *"…Any landscape contractor could maintain that scheme easily. It's probably because the man that you spoke to hasn't got the information so that he understands the scheme".*

Another issue affecting the maintenance of the scheme is the irregular funds' allocation which affects the school. *"… And I suppose the potential issue is that because as well as local authorities, the schools are suffering budget-wise at the moment because of central government funding so all of that money that should be allocated for maintenance might not be allocated eventually (council representative)".* This was obvious after a visit to the scheme. Figures 7 and 8 above shows some parts of the swale that have not been maintained in a while. During the inspection before the focus group session, the council representative expressed his displeasure in what he saw about the maintenance of the scheme and promised to follow it up with the management of the school for the right steps to be taken.

Table 8.2 is a breakdown of the maintenance procedure which is usually presented to clients as a guide for any rainwater system after installation. *"...well, we did a maintenance plan for the scheme (landscape architect)".* It is expected that many of the monitoring tasks could be incorporated into the routine caretaker staff, which may help reduce the operating costs while ensuring the system operates efficiently. This maintenance procedure is usually provided by the landscape architect on every site after handing over to the client.

Table 8.2: Ongoing maintenance of rainwater systems

Component	**Maintenance frequency range**
Filters – Manual cleaning	Monthly cleaning
Filters – self-cleaning or coarse filters	Every three months of cleaning
Gutters and roofs	Annual or twice-yearly cleaning, aiming to keep
Disinfection – ultraviolent (where applicable)	Half-yearly or annual replacement
Disinfection – chemical (where applicable)	Monthly disinfectant replacement
Pump	Annual check of function and wiring
Tank	Annual visual inspection, with the removal of excessive silt Allow the tank to overflow twice a year to flush out floating debris Drain down and cleaning of tank appropriately every 10years
Mains water top-up	Every six months to a year checking

8.3.5 Benefits from the SuDS Retrofit Installation

The uptake of SuDS retrofit could be of benefit to different stakeholders including the property owners, and the wider community. This has been reflected in the scheme and confirmed by the participants in the focus group session.

"... events are being organised by the school which involves the parents using some parts of the scheme like the play area, so I make sure there is good stuff for the children. (property manager)"

However, there is a limit to what can be done on the site due to the obvious restrictions being a school environment and the existing wall which keeps the community out of a normal visit to the property. "*...I mean, there are community benefits, but obviously, there's a limit to when people come into the school, you know because it's largely like that from a school perspective. They've got a perimeter fence. Obviously from a safety perspective and safeguarding perspective I would imagine that (council representative)".*

Another significant benefit is the educational benefit which has helped the students in terms of having a place to interact with their colleagues. *"...we could give you a bit of advice about what to do and some of the features on the scheme that is educational...so I suppose that's educational (council representative)."* Again, as stated earlier under the decision-making process, the headteacher at the time of installing the scheme requested that it should be installed as a way of educating the students about water management. This will reflect in some of their courses or their outdoor activities. The Willingness To Pay (WTP) in table 8.3 also gives an idea of the financial value attached to the educational benefits by the stakeholders.

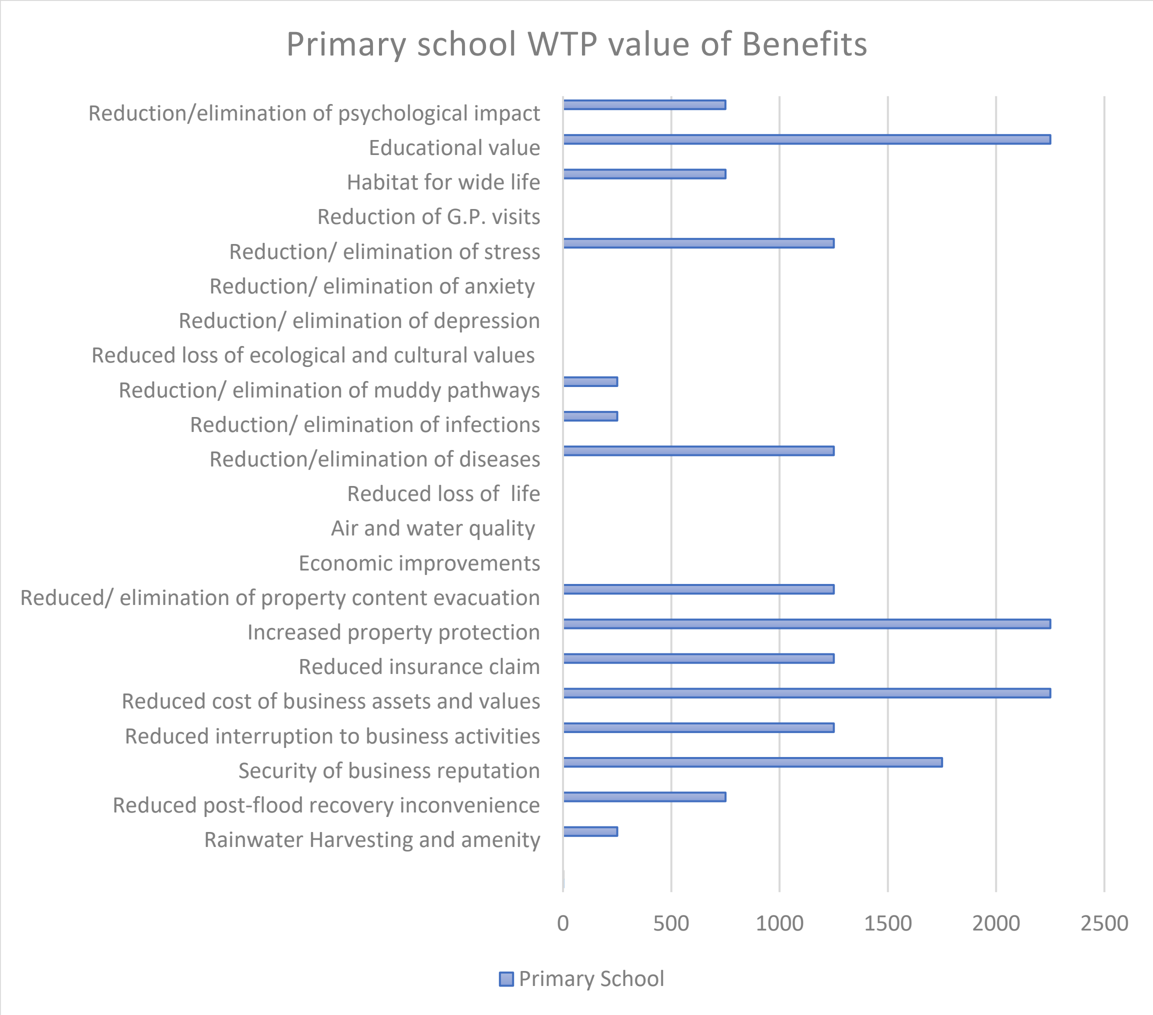
Another benefit that contributed to the decision to install the SuDS retrofit scheme flood risk management, water attenuation and amenity and biodiversity. This was specifically confirmed by the council representative, *"...The main benefits of the scheme are flood risk management, water attenuation, biodiversity in terms of it provides a bit of habitat for various creatures and then water quality instead of what the conventional drainage system will provide."* However, the landscape architect had a different opinion about the benefits. *"...we did not put a financial cost against it because it's very difficult...as a landscape architect, you have been trained to know what benefits the scheme will deliver...intelligence is a better method".*

Although the BeST tool is provided and used by CIRIA, it does not seem very useful for schemes of this nature. The landscape architect emphasised the fact that apart from the scheme being too small for the BeST tool, he would expect that every landscape architect or SuDS specialist won't have to use a specific tool to determine whatever they have been trained to provide. To him, the tool may be better as a means of selling the idea of the benefits associated with SuDS to the clients. *"...But you might need a tool if a lot of people don't believe that there are benefits."*

To further buttress his point, he identified benefits like integrated SuDS schemes or creating a more valuable and beautiful space, the BeST tool does not cover this and so it won't be useful for a project of this nature. *"...for instance in reducing or when you integrate SuDS into the landscape and the layout, you're saving money and you're creating a more interesting space and a more valuable space. I don't think the best tool allows you to do that. Because it's designed for bigger schemes (landscape architect)".*

The stakeholders were asked to quantify the benefits and how much they would be willing to pay (WTP) for these. Figure 8.6 provides a summary of the discussion of the benefits with the stakeholders.

Figure 8.6: WTP Value of Benefits



During the focus group session, the participants found it difficult to put a value against many of these benefits, especially the intangible benefits as expressed by one of the participants. *"…hmmm…we should be able to try but it's quite tough." (property manager)*. It was evident that some of the benefits had not been considered during the design and had not influenced the decision-making process. Nevertheless, the participants were able to provide approximate values based on their perceptions of these benefits in the context of the primary school scheme.

8.3.6 CBA of the SuDS retrofit scheme

A cost-benefit analysis was undertaken by calculating the net value (NV) and the net present value (NPV) of the SuDS retrofit project, assuming investment returns within 10 years. Using the average of the upper and lower benefit intervals, the total value of the benefit in the present year and turn the total benefit in 10 years was derived. The cost of installation was then subtracted from the total value of the benefit accrued over 10 years. Importantly, no maintenance costs were included in the analysis, reflecting the use of the workers at the school.

Below is a calculation for the net value (NV) of the entire project in 10 years:

Net cost (NC) = Present Cost (PC) of installation+ maintenance cost (MC)

=£93015 + 0 =£93015

Net benefit (NB) in 10 years= total benefit/annum x 10

=£177,575

Hence,

Net value in 10 years= Net Benefit in 10 years – Net Cost

=177,575-93015

= £84,560

Net benefit is the value of the project within a set period of time. In this case, the net benefit of the SuDS retrofit scheme in 10years of its installation. This has been calculated by dividing the total value of intangible benefits per annum and then multiplying this by 10 which is the number of years being considered. While the discount rate is the rate of return for an investment in the SuDS retrofit scheme.

8.4 DISCUSSIONS

Given the findings presented above, several key inferences can be made concerning the cost and the benefits of installing SuDS retrofit and the decision-making process. It can be seen that various factors influenced the implementation of the scheme including the costs of maintaining the conventional drainage system, the presence of flood risk which resulted in SuDS being a policy for schools in the local council, the management of overland flow from adjacent properties.

Stakeholder involvement on this project was not so much of an issue due to the involvement of an expert at the early stage of the decision-making process and based on the fact that they were left with no other choice than to take up a more effective and affordable alternative to a conventional drainage system. This helped make sure that the costs of installation were well understood and well defined. Research has shown that stakeholders often lack of interest by stakeholders in new SuDS schemes because of the lack of knowledge of the monetary and non-monetary value of the scheme (Castleton et al, 2010; Oladunjoye et al, 2017). However, in this case, the response from the stakeholders was different and could be adjudged as positive; perhaps indicating that the view of SuDS being a better alternative is beginning to change, and its necessity as a defence measure is beginning to be accepted. One of the stakeholders had a lot of experience with SuDs, which made it easier to work through the design and construction stages. This positively influenced the other stakeholders to take up the scheme (Oladunjoye et al, 2017) and helped to overcome previously reported barriers concerning a lack of knowledge (Castleton et al, 2010).

As earlier stated, it appears that SuDS is gaining recognition as a better alternative to conventional drainage systems. Three factors influenced the installation of the SuDS retrofit scheme; the overland inflow from adjacent properties; draining of the playgrounds and the replacement of the conventional system due to rising annual costs of maintenance. Research has shown that lack of interest in new schemes and innovations is one of the major barriers to the uptake of SuDS in the UK (Kirby, 2005; Stovin, 2013; Oladunjoye et al, 2017; Piacentini and Rossetto, 2020). Therefore, taking the risk of installing SuDS retrofit as an alternative within the property is a welcomed initiative by the stakeholders.

A significant barrier to the uptake of SuDS is the lack of experience and training in SuDS installation and design (Duffy et al, 2008; Ossa-Moreno et al, 2017; Oladunjoye et al, 2017). In recent times, organisations like CIRIA have organised regular training sessions, involving the landscape architect as a facilitator. An example of such activity is what has been identified by the council representative as stated in the interview session above, which confirms that regular pieces of training for the staff of the local council is done to make sure that they are well informed about SuDS scheme within the council. This is important to bridge the gap that may have been created by not passing down the required knowledge needed for the delivery of schemes that are up to standard. This trainings by experts and organisations like CIRIA will address the barriers of not taking up SuDS.

The Environment Agency advises various return periods for water management agencies or organisations to take into consideration when installing a scheme. This depends on the estimate of how long it will be between rainfall events of a given magnitude within a location. Determining the return period of a site is essential in other to install the right specification of flood management scheme. In the primary school case, the conventional drainage system was said to be 1 in 30 years. This was not adequate for the primary school which required a 1 in 100 years return. This means SuDS can take great capacities of surface water as well as delivering other benefits.

A key factor in the decision-making process was the perceived flood risk among the stakeholders which influenced the installation of SuDS. Research has shown that the impact of flood events can be very destructive to properties and the reputation of businesses and activities (Castleton et al, 2010; Carboni et al, 2016; Kuhlicke et al, 2020). Within the school, the effect of overland inflow and future flood events needed to be controlled both on the building and the outdoor playground area. Historical evidence suggests that flooding events experienced in the past have been destructive to some properties in the county council. This lead to the council advising that defensive measures should be adopted and schools should install SuDS within their properties. In discussing the outcome, reference was made to the fact that all surface water from all parts of the property including the roof has been channelled to the swale which then flows to the Brook for easy runoff. This helps to reduce the cost of water storage and water management charges from water agencies. Research by CIRIA suggests that water conservation and water-efficient technology reduces water usage and bills (Waggett and Arotsky, 2006).

A conventional drainage system was installed within the property. However, the annual maintenance costs appeared to be too much. Table 8.3 compares the cost of installing and maintaining the SuDS retrofit scheme and the conventional drainage system. Considering the difference between the cost of installation, it appears that a difference of £23,000 makes it obvious that the SuDS retrofit scheme is cheaper both at installation and maintenance. Research has shown that factors like the knowledge of the costs of installing and maintaining SuDS discourage stakeholders from taking up the scheme (Williams and Dair, 2007; Everett and Lamond, 2014; Oladunjoye et al, 2017). This scheme is evidence that stakeholders are now seeing SuDS as a better alternative in terms of its costs, maintenance and benefits in managing flood events.

Table 8.2 is a guide to maintaining rainwater systems which are usually provided by the landscape architect on any SuDS scheme installed by them. Ellis and Lundy (2016) argued that due to the lack of training and professional knowledge of the requirements of maintaining a SuDS scheme, potential clients avoid taking up SuDS. A reflection on the property manager's response also sheds some light about not having access to necessary pieces of training to support his inability to maintain the SuDS retrofit scheme. Therefore, a guide similar to Table 8.2 could be very useful for every property owner in providing adequate maintenance procedure for a typical SuDS scheme.

Funding for this sort of retrofit is part of standard maintenance budgets and so this represented a key challenge because the availability of funds is determined by whatever is provided by the government. A typical maintenance budget implies a regular financial allocation towards the scheme that may be provided annually, depending on the organisation. Some organisations find themselves executing projects based on whatever funding is available to them. They are therefore forced to manage the limited available resources. Many organisations are unlikely to consider SuDs retrofit as a priority when considering their financial returns and therefore securing sufficient funds represents a barrier (Sustainable Development Commission., 2010; Cimato and Mullan, 2010; Roelich K., 2015). In the case of the school, money was subject to whatever is provided by the government. One of the stakeholders identified the fact that the two factors were evident. The fact that the use of funds would have to be justified before its released and the availability of funds is currently a challenge. This was made easy by embedding the SuDS retrofit scheme within a general renovation within the property and the government's policy, which encouraged the uptake of SuDS within primary school properties in the council. To ease the difficulty of obtaining funds in future, it could be useful to have specialised guidance and support for this purpose. This could include advice on managing the cost of installation and ongoing maintenance including making the costs and benefits of SuDS more evident and clear to stakeholders which is the aim of this research.

During the focus group discussions, some benefits were identified, however, many of these had not been considered during the decision-making process. The session with the landscape architect was able to shed some light on the reason why these benefits were not quantified. Earlier research has identified this as one of the major barriers to the uptake of SuDS retrofit (Carboni, 2016; Oladunjoye et al, 2017).

Quantifying the benefits of a SuDS scheme is advised as a significant process of encouraging the uptake of SuDS in the UK (Oladunjoye et al, 2019). According to Ossa-Moreno et al, (2017), weighing the costs of installing SuDS against its benefits is a useful way of appreciating the wider benefits of the scheme. However, going by the statement made by the architect, he thinks these benefits were not quantified because every professional should have developed the skill of providing the required benefits, by the training acquired from their formative years in academics and their years of professional experience. He further stated that if any of these benefits are to be quantified at all, they can be useful to convince clients. It is useful to note that CIRIA provided the BeST tool for quantifying these benefits but the landscape architect thinks that the tool is not able to attend to smaller projects. This may add up to the reason why SuDS professionals are not keen to use the tool or quantify the benefits.

The willingness-to-pay (WTP) process revealed the difficulties posed in quantifying these benefits, especially the intangible benefits. Research has shown that their subjective nature's intangible benefits are difficult to quantify and are said to be more personal to the victims of flood events (Joseph et al, 2014; Oladunjoye et al, 2017; Oladunjoye et al, 2019; Yang et al, 2019). Therefore, it was important to carry out this exercise to obtain a full understanding of the benefits of the SuDS scheme to the property owners and propose an appropriate procedure of eliciting the intangible benefits of the scheme.

A closer assessment of table 8.3 suggests that specific benefits were rated highly. These benefits are; Educational value, reduced costs of business assets and values, and increased property protection. These benefits appear to be very significant to the school, especially the educational value. From the findings presented above, it can be noted that during the decision-making process, the headteacher at the time of implementation was keen to install SuDS as a means of educating the students about water management. At the design stage, it was also considered that a pond that would educate the students about wildlife should be included, however, parents were not comfortable with this idea due to safeguarding issues. These are a few educational values that may have been considered by these stakeholders in suggesting a high price for educational value.

Furthermore, protecting the property from flooding events is of high importance to the stakeholders. This is obvious with the initiative of taking up SuDS as a resilient measure within the property. The value suggested by the stakeholders expresses the level of importance they have attached to keeping the property from any flood event.

8.5 PRIMARY SCHOOL WTP VALUES

A Primary school is a facility that allows for formal and informal education. It is not surprising that the stakeholders would rate education highly. Among the highly valued benefits is the reduced cost of business activities that do not seem to associate properly with the primary school activities. However, it is not surprising that the reduction/ elimination of anxiety and reduction/ elimination of depression were not valued at all. This can be linked to the fact that these benefits are related to health and well-being, which is not a major benefit derived from a primary school.

It is quite surprising to see that rainwater harvesting was not rated highly by the stakeholders, because the major reason for installing the SuDS retrofit scheme was to manage surface runoff within the property. It would have been expected that this benefit will be of a major priority to the stakeholders given that the SuDS retrofit scheme has been able to rescue the cost of maintenance within the property and the flow of surface runoff through the installation of the SuDS scheme.

8.6 SUMMARY

The study has investigated the costs and the benefits of the installation of SuDS retrofit at a primary school including some of the key decision-making issues. The presence of an expert on the team during the decision-making process helped overcome many known challenges. It is clear that flood risk and maintenance was one of the major decision-making considerations for the delivery of the SuDS retrofit and the culture of providing the required training of professionals is an added advantage for the delivery of the scheme within the council. The WTP process has shown that the perceived benefits from the scheme were valued at around £17,000. Some intangible benefits were valued highly (i.e. educational, Reduced cost of business assets and values) thus demonstrating the need to capture these in the decision making process. It was found that the installation would provide a net worth to the client of well over £80,000 over 10 years and that the return on investment would be achieved in less than a year.

This chapter has undertaken the cost-benefit analysis of the retrofit of SuDS for a school. The findings highlighted many of the apparent barriers that need to be overcome when installing retrofit schemes. The results demonstrate the importance of the intangible benefits derived and it is recommended these are given full consideration at the decision-making stage and in promoting the uptake of the retrofit of SuDs. The analysis has shown that SuDs retrofits on schools can deliver significant benefits.

CHAPTER 9: DISCUSSIONS AND MODEL REFINEMENTS

9.1 INTRODUCTION

Following on from the presentation and discussion of the individual SuDS retrofit schemes, it is important to understand the wider issues and how they relate across the three cases towards informing the refinement of the framework and the development of recommendations for overcoming the barriers to the uptake of SuDS retrofit in public buildings. Hence, this chapter presents a discussion of the case projects presented in Chapters six to eight in the context of the wider body of knowledge, drawing on the earlier literature review and the conceptual framework. The key findings from the qualitative information gathered across the cases and these discussions are used to refine the conceptual framework. The chapter is structured around the original research questions that discuss the significant issues in the decision-making process of the different case projects, stakeholder engagement, the cost of installation of the scheme, including the value of the benefits and the maintenance process SuDS retrofit scheme. This corresponds directly to the sixth objective of this study which is to develop a CBA framework to support the decision-making process of the installation of the SuDS retrofit scheme including the value of the benefits and refine the conceptual CBA framework towards its potential relevance for practical application in future community buildings.

9.2 STAKEHOLDER ENGAGEMENT

Stakeholder engagement is arguable the most important ingredient for successful project delivery and yet is often regarded as a fringe activity or one that can be outsourced to business-as-usual functions (Floater et al, 2017). Drawing inferences from the findings presented in the case study chapters, stakeholders were engaged at every stage of the delivery of the schemes. These engagements are communication through meetings, emails and phone calls which cuts accord all the cases, leadership in terms of each stakeholder understanding the requirements of their roles, community engagement as seen at the leisure centre and expert involvement which is more evident at the Leisure centre. It is quite interesting to see the result positive engagement had on the delivery of the SuDS retrofit scheme. Everett *(*2016) stressed that stakeholder engagement is both profoundly simple and difficult at the same time and the success of a SuDS scheme is also tied to the culture being practised between the stakeholders which were borne out by these case studies in the way obtaining funds at the leisure centre was managed, a possible delay from the subcontractors was handled both at the Civic centre and the Leisure centre and managing planning requirements were handled at the Civic centre.

It is not enough to identify the contributions made through positive engagement, it is important to identify these contributions and how they have influenced the delivery of the scheme. To adequately understand the levels of engagement on these cases and the implications for practice, key parameters will further discussed to develop an understanding of their relationship with the cases; these include effective communication between project team members, well-defined team responsibilities and roles, clear team goals and objectives, and good collaboration among stakeholders (Yap et al, 2020).

9.2.1. Stakeholder engagement through effective communication

Site meetings were organised across the cases to bring every stakeholder together to deliberate on issues pertinent to the schemes' successful implementation. This is about the main mode of communication between the stakeholders outside emails and phone calls. This is an essential attribute of stakeholder engagement that enhances effective communication. Usually, site meetings allow for an opportunity to communicate the purpose, plan and clear instructions guiding the delivery of projects such as the installation of SuDS retrofit schemes (Fewings and Henjewele, 2019). This helps to convey and clarify various issues that may arise in the cause of the delivery of the scheme. Nalewaik and Mills (2016) noted in assessing the performance of the delivery of a SuDS retrofit scheme, that meetings will clarify situations where for example, stakeholders may be working from out-of-date information, or a breakdown in the sharing of relevant data, which can all lead to delays, cost overruns and inefficiencies such as duplication of work - not to mention accidents or poor execution of work on-site. The cases presented extend the research of Nalewaik and Mills by demonstrating how meetings in these cases helped understand the strengths and opportunities of the schemes for the stakeholders on the projects, rather than just providing a way of avoiding problems. They allowed the stakeholders to identify strengths such as the landscape architect's potential contribution in improving the delivery of the scheme by contributing his knowledge of SuDS retrofit delivery design and the knowledge of available funding bodies that the property manager handled at the Leisure centre.

Other ways of achieving effective communication also need to be considered in future projects for a more effective output. The rise in the use of technology to communicate ideas and concepts and to meet virtually is not to be taken for granted. Producing updates through posters either at regular meetings or to stakeholders with some explanations could be useful in communicating details about the ongoing project. Meeting virtually could also help to reduce the pressure of travelling down to the project site or this could save some cost which will have less impact on the overall cost of delivering the scheme. Encouraging regular feedbacks from the stakeholders or workers could be a good means of communicating the progress of the project delivery.

9.2.2. Stakeholder engagement through efficient team leadership

To further understand the levels of stakeholder engagement, efficient team leadership was also found to be significant. In delivering the SuDS retrofit schemes in these cases, stakeholders were drawn from various disciplines and organisations. Efficient leadership is therefore essential for a smooth decision-making process. Chow et al, 2005 opined that SuDS retrofit schemes are traditionally fractured into interdisciplinary project teams which are usually assembled and organised temporarily for a single project. This means that it takes efficient team leadership to manage these groups of stakeholders and to get the best out of them. This research demonstrates the particular challenges of this for public buildings, which involve a far greater number and diversity of stakeholders. However, some positive outputs of team leadership from the case study sites were evident. Some of these outputs are examples such as community engagement at the leisure centre towards the maintenance of the scheme, proposed funding options from the leisure centre, the contribution of the landscape architect in terms of guiding the delivery of the scheme through his expertise, and the intervention from the consultant at the Civic centre to correct the dysfunctional installation as a result of a poor maintenance process. In this context, and given that the installation of SuDS as a retrofit is still a relatively new approach, effective leadership was particularly important. It was important for the stakeholders to deliver skills beyond their professional knowledge for the success of the implementation of the scheme. Among these stakeholders, it is evident that the landscape architect was able to deliver the scheme from the angle of his knowledge as a professional SuDS expert. Given that he is the only one out of all that is close to the possibility of being able to deliver SuDS retrofit projects by his profession, it will be helpful to suggest that putting a landscape architect in charge of the delivery of SuDS retrofit schemes should be encouraged. Policies should be put in place by the government to make it a standard that the delivery of all SuDS retrofit schemes should be lead by a landscape architect. This will change the impression of the stakeholders about the barrier discussed in chapter 2 which identifies that fact that the lack of expertise in what is affecting the uptake of SuDS retrofit.

9.2.3. Stakeholder engagement through well-defined team responsibilities

Well-defined team responsibilities and roles also supported the flow of the delivery of the schemes, with the stakeholders being able to contribute their skills and expertise in the delivery process. Although the Leisure centre appeared to be more evident in this (e.g. with regard to many of the clear involvements and contributions from the stakeholders), the Civic centre and the Primary school still had similar practices. Meredith et al, (2017) opined that well-defined roles and responsibilities of stakeholders in a construction project will help cover all the activities that need to be carried out for a project to be successful and result in recorded outputs from the project. This is supported by the data presented such as the funding options at the Leisure centre as discussed in 9.7 below, the involvement of the community in the maintenance process at the Leisure centre, the maintenance process at the Primary school and the intervention at the Civic centre to control the damage on site.

However, it is important to note that at the Civic centre and the Primary school, many of those who were involved during the delivery of the scheme did not participate in the research for various reasons such as a change of organisation or location. These may have affected some other activities within these establishments in the aspect of continuity. At the Civic centre, there was no department directly assigned to the scheme neither was there anyone responsible for the daily administration of the scheme. This was evident in the way the workers expressed their lack of knowledge about how the scheme was maintained including some of the documents that could support the research were not specific about who may have been assigned to the scheme.

A similar scenario occurred at the Primary school during the observation process, some aspects of the scheme were not well maintained and this led to some confusion about understanding the maintenance process of the scheme. Continuity of the good team working process beyond the design stage of a project is needed to deliver the long term output from these schemes by being specific about the department within any organisation that should be responsible for the SuDS retrofit scheme. Considering the social, economic and health benefits that could be derived from these community buildings, the government must pay more attention to properties of this nature, looking at the positive impact it will have on the community by being deliberate in employing individuals with the appropriate skills and expertise within the local council to manage these retrofit schemes.

At the Civic and Leisure centres, the subcontractors almost grounded the delivery of the schemes by failing to add value to the system through positive engagement. Laxity at the Civic centre in terms of adjusting specifications at the courtyard to save some money and the subcontractor at the Leisure centre who did not provide enough staff during the construction process just to save money. In practice, many organisations in the construction industry have identified various complications and irregularities as a product of the lack of positive stakeholder engagement which is experienced among mostly third party contractors, often referred to as subcontractors. It will be helpful to encourage subcontractors to take responsibility for whatever is being delivered on project sites, which is beyond their profit but as far as putting the responsibility of the success of the scheme not only on the contractor but also on their result.

9.3 EXPERT INVOLVEMENT FOR SPECIALISED ADVICE

Two significant issues from the cases were the involvement of the landscape architect and the council representative who intervened to obtain funds for the delivery of the scheme at the

Leisure centre. Every stakeholder is specialised and important in the delivery of the scheme, however, when considering the barriers to the uptake of SuDS retrofit, the negative impression from failed schemes remains a concern (Wilkinson and Sayce, 2015; Ossa-Moreno et al, 2017; Oladunjoye et al, 2017). In standard project delivery, architects represent the client as well as coordinates the project team, the architect coordinates the aesthetic and practical needs of the client with the practicalities and design criteria of the engineer, the builders and the local authorities. However, in the data presented here, the architect had a longer-term role in the project, allowing him to give his expertise at relevant points to remove/reduce the likelihood that the project would fail (as other authors have noted is a huge reputational problem for SuDS)

A common factor to all the cases here is the way the architect was invited on the project. The landscape architect enjoyed the privilege of a long term working relationship that had spanned through various construction projects in the past. This has helped build a level of trust between the clients and the landscape architect which does not always happen on construction projects (Thyssen et al, 2010). Dutton and Heaphy, (2003) opined that in a business relationship, connections are established with every person, organisation and piece of information we come in contact with. In some of these connections, some establish stronger and long-lasting business relationships which are productive and help to shape future project delivery. The employment of the architect may not be the common way of employing the services of an architect, but given that the clients expressed their satisfaction based on some of the interview outcomes, it will be useful to understand how effective this process can be in achieving the required output from any installation of SuDS retrofit. In practice, architects are required to tender their design to the client, based on different design criteria that may have been suggested to them, they then come up with a well-designed and functional scheme. CIRIA provides a system where specific experts in SuDS installation are awarded (CIRIA, 2020), clients can be encouraged to look out for CIRIA certified professionals or a platform that rates SuDS professionals can be helpful to ease the process of identifying specific landscape architects that can be trusted.

When considering the relationship of the Landscape architect and how he was taken on board on these schemes based on established relationships as discussed in chapters 6,7 and 8, it can be assumed that the decision to install SuDS retrofit within the properties would have been influenced by this relationship. In the absence of these relationships, SuDS may not have been one of the options to be considered during the preliminary stage of the scheme.

A further discovery is the role of the council representative in obtaining funds for the delivery of the scheme. Although more about funding is discussed in 9.6 below, the emphasis here is about identifying specific professionals that will be able to address projected areas of concern that may lead to a delay or failure in delivering the scheme. The intervention of the council representative saved the client from some embarrassing moments at some point during the installation of the scheme which may have led to a delay or total halt of the whole scheme. In practise when constituting the construction team, attention is seldomly given to individuals or professionals that can specifically provide financial solutions to deliver projects (Tsui et al, 2009). Identifying specific needs on a project and looking out for stakeholders that will help in delivering the required solution is quite essential. Being very strategic in identifying useful stakeholders to promote the delivery of SuDS retrofit schemes will encourage the uptake of SuDS retrofit. Therefore, being more strategic in employing stakeholders that can provide financial advice on construction projects including SuDS retrofit installation could aid the adoption of these schemes in the future.

9.4 LOCAL COMMUNITY INVOLVEMENT

At the Leisure centre, the community was closely involved in the design and maintenance of the scheme. Wood-Ballard et al, (2007) argued that to promote the uptake of SuDS retrofit, developers should produce a communications plan that will raise public awareness which will address the general concerns of the community and encourage a sensible and responsible approach to living with SuDS. This communication plan which will outline various roles of the stakeholders involved can be achieved by the involvement of the community in the decision-making process of the installation of a SuDS retrofit scheme. Everett and Lamond, (2016) opined that early discussion should be encouraged between stakeholders and the community in other to boost the standards of any proposals towards any SuDS retrofit installation. This is precisely what happened with the Leisure Centre, which went further than just improving the standard of installation but its long term quality by playing a role in its maintenance.

Involving the community at the decision-making stage will further encourage the uptake of SuDS retrofit by the community showing a sense of commitment which will involve taking up some aspects of the delivery of the scheme, as demonstrated at the leisure centre. The involvement of the community has been useful in terms of reducing the cost of maintenance of the scheme at the property. This, however, was not as evident in the cases at the Civic centre and the Primary school. Involving the community at the leisure centre was not only an advantage to the centre but also to those community members that were involved, in terms of the health benefit, recreational benefits, social benefits. In Chapter 2, factors such as the health benefits and economic values were identified as opportunities towards the uptake of SuDS retrofit, this makes community involvement essential. Noblega et al, (2020) opined that communities are better positioned for negotiation and gain new responsibilities compared to the traditional drainage works because SuDS are decentralized systems located at a neighbourhood scale. Furthermore, the social benefits SuDS retrofit provides may create sustainable behaviours among citizens and may encourage more interest in SuDS.

Given that a water-sensitive stage is driven by integrating ecological equity and preparing the communities to face climate change, involving communities beyond just maintaining the scheme is necessary (Faram et al, 2010). This involvement can be introduced at the inception stage as a means of understanding what they will like to have in their community. The consultant at the leisure centre took this action when visiting the different locations within the community to decide on where to locate the SuDS retrofit scheme. This is very important given that the scheme and the property are of great advantage to the community.

9.5 FUNDING AND COSTS OF INSTALLATION

Shifting the responsibility of the cost of maintaining and implementing of SuDS retrofit by stakeholders is one of the major barriers to its uptake (Agwuele, 2013; Wilkinson et al, 2015; Oladunjoye et al, 2017). This has been attributed to fear of the high cost of maintaining SuDS retrofit schemes and clarity in the value of the monetary and non-monetary values of the scheme. In the case studies considered in this research, there is no record of such a challenge it appears that the stakeholders were more inclined to find ways by which the retrofit schemes can be funded. At the Civic centre, funds were already available from the local council to execute the scheme as part of other construction processes that were to be implemented on-site. This does not rule out the fact that this challenge persists as confirmed from these cases. A lack of understanding about the availability of funds, lack of a clear funding procedure by the government to support SuDS retrofit schemes, the fragmented nature of systems of funding, resulting in the assessment of proposals from varying angles contributes to the difficulty in taking responsibility for funding the schemes by stakeholders.

In practice, there are different sources of funding for SuDS and it is difficult for property owners to navigate the funding process. Most times, these funding opportunities are not known to many as is obvious in the Leisure centre. Funding the SuDs schemes across the properties was a very significant aspect of the research as reflected in the conceptual framework. At the Leisure centre and Primary school cases, funding posed a major challenge in implementing the SuDS retrofit scheme within their properties. Stakeholders had to strategise on how to raise funds to actualise the project at the Leisure centre while funding the scheme at the primary school had to be included in the overall renovation process for it to receive the required attention. Funding is an essential aspect of any project, it could either aid the speedy delivery of a project or stop the execution of any project (Halliday and Atkins, 2019). As stated in the case study chapters, funding this sort of retrofit is usually not part of the standard maintenance budget and so this represented a challenge. Many establishments or organisations may be faced with challenges of this nature which will act as a setback for them towards the uptake of SuDS retrofit.

The cases addressed these issues in some ways. While the council representative at the Leisure centre was able to submit the required documents to Regional flooding coastal committees, Environment agency and specialised organisations to request funding support, the leadership of the Primary school were able to use the opportunity of an existing renovation process to achieve their goal. It would be useful to provide specialised guidance and support at the level of the government or specialised bodies, which will be helpful for other organisations, to ease the process of obtaining funds on future SuDS retrofit schemes. The National Flood and Coastal Erosion Risk Management (FCERM) is a strategy put together by the Environment Agency with the responsibility to bring together a diverse group of expert practitioners and provide opportunities for funding opportunities for future SuDS retrofit schemes.

O'Donnell et al, (2017) opined that it can be challenging to get funding for green SuDS schemes from local organisations that are likely to benefit most from them. This may be because most people and organisations do not know what SuDS are or the benefits they can offer. Because of this, many SuDS schemes remain funded by the local government and their agencies. Raising awareness of SuDS retrofit schemes and active engagement with communities to help breakdown socio-institutional barriers related to a lack of knowledge and understanding is strongly advised. This goes beyond passive engagement as active engagement holds greater potential for a behavioural and cultural change compared with solely relying on public observation (Jonsson et al, 2018). This will also raise more public interest and increase the number of interested organisations willing to invest in the scheme.

9.6 MAINTENANCE AND OPERATION COSTS

Similar to all drainage systems, SuDs retrofit components are meant to be inspected and maintained. This is to ensure that the systems are efficient and unexpected failure is prevented. One of the main barriers to implementing SuDS retrofit is concern about performance and maintenance costs since there are limited examples of well-developed schemes (Heal et al, 2009; Ashley et al, 2010;). Maintenance of the scheme on the different properties was approached differently. At the Leisure centre, the maintenance of the scheme was considered at the design stage of the project, it was decided that the regular maintenance workers involved in the routine gardening would add the maintenance of the SuDS retrofit scheme to their duties. However, things took a different turn when the local gardening club and the local secondary school volunteered to handle the regular maintenance process. It is interesting to see that the community showed their interest in the scheme and supported by volunteers to keep the scheme working properly. This implies that involving the community at the preliminary stage of the implementation of future SuDS retrofit schemes could raise awareness of the scheme and encourage the uptake, including allowing for involvement in the maintenance process which will eventually reduce the running cost of the scheme (Everett et al, 2016).

The Primary school is another good example of a planned maintenance process. The high maintenance rate of the traditional drainage system was what informed the decision to install a SuDS retrofit scheme. Attention was given to the maintenance process of the scheme during the design process and this included assigning the responsibility of maintaining the scheme to the property manager and providing a detailed maintenance procedure. This helped develop a clear understanding of the areas needing the required attention to maintain the performance of the SuDs. These steps towards developing a clear and effective maintenance process are worth adopting for every property. McDonald (2018) suggests that having a specialised staff assigned to a SuDS retrofit scheme makes it easier to hold someone responsible for the daily maintenance process. Training and a follow-up process will be useful to keep the staff up to date with any changes that may occur in the policies available for every SuDS retrofit scheme. Furthermore, having a detailed procedure was very helpful in having a written record of the processes and tasks involved. This could help serve as a guide for those who may not understand what to expect when considering a SuDS scheme.

Drawing inferences from each of the cases, it is useful to conclude that the maintenance process at the primary school has been aided by the provision of a maintenance procedure which is useful to improve the maintenance culture for every organisation that takes up the scheme. In the SuDS manual provided by CIRIA, a standard procedure has been provided to aid the maintenance process of any SuDS scheme. It will be useful to create more awareness of this system and make it more of a statutory procedure so that every organisation will see it as a standard procedure to prepare a maintenance schedule at the preliminary stage of the decision-making process (Woods-Ballard et al, 2007). The manual should also include more detailed guidance on the retrofit of SuDS including its maintenance for a better relevance of the manual to the SuDS retrofit scheme.

9.7 BENEFITS FROM THE SUDS RETROFIT INSTALLATION

Some benefits were considered at the preliminary stage of each of the SuDS retrofit schemes, however, many of these benefits were not quantified. The stakeholders at the Leisure centre explained that they never considered quantifying these benefits because it did not occur to them as a needed procedure. Similarly, this was also the case with the Civic centre and Primary school. It is interesting to discover however that the stakeholders were keen about the available ways to quantify the benefits however, they were very much naïve about any process that will aid the procedure and the advantage of quantifying these benefits. Research has shown that a breakdown of the costs related to the benefits in monetary value has the potential to help inform a business case for the use of SuDS retrofit (Vincent et al, 2017; Ashley et al, 2018). However, the only available procedure is the BeST tool (CIRIA, 2019). The BeST tool was discussed in chapter 2 and it was observed that there were limitations and shortcomings such as the benefits listed in the tool are not comprehensive enough, which was also confirmed by the landscape architect during the interview session, and the BeST tool is also designed for new schemes including NFM schemes rather than retrofits.

At the Leisure centre, some benefits were more useful to the wider community. Stakeholders acknowledged the fact that the community had been very responsive to the scheme as a result of some of these benefits such as aesthetic value, health, tourists attractions, ecosystem and educational value. This had encouraged the presence of volunteers in contributing to the maintenance of the scheme and resulted in little or no concern about maintenance on the part of the stakeholders. While at the Civic centre, the benefits were influential at the design stage, to drive the steps that were taken for implementation. Aesthetic value, educational and FRM benefits were strongly considered because the building was a Victorian building and some ancient features, the aesthetic value SuDS was going to contribute to the property was a key influence. The educational and FRM benefits were also very essential to the implementation of the scheme. In the case of primary school, benefits such as education, FRM, were part of the factors that influenced the decision to install SuDS within the property.

The clarity of the value of the benefits is one of the barriers to the uptake of SuDS which has been reported in research (Carboni et al, 2016; Oladunjoye et al, 2017). This suggests that the main concern of the stakeholders was towards managing the flood risk within the site and these wider benefits were not considered. Another factor that may have influenced this response is the confidence the stakeholders have in the landscape architect who was on board to drive the delivery of the scheme. The parties had established a good working relationship, meaning they trusted the landscape architect on every professional advice given towards the installation of SuDS as an FRM measure. However, the landscape architect saw no need to quantify tangible or intangible benefits because to him, it is expected that the experts in the field would have acquired the knowledge and expertise needed to understand the benefits associated with the scheme.

The Landscape architect opined that to convince the clients or the wider community, it would be useful to be able to quantify these benefits at the design stage so that they could appreciate the opportunities that are derived from the uptake of SuDS retrofit. As the benefits derived from the scheme were not well understood by the clients and the community, a means of establishing these in a robust method based on evidence, facts and figures were very appealing. Many of these benefits and the opportunities brought about by them had not have been considered by these clients and the wider community.

9.8 WILLINGNESS-TO-PAY (WTP) VALUES

When considering the installation of a SuDS retrofit scheme, the consumer is faced with the decision about what and how much to pay for it (Everett et al, 2019). These are basic assumptions that drive the willingness-to-pay concept and are perceived as the costs and benefits of installing a SuDS retrofit scheme which is also related to one's needs or wants concerning the scheme. WTP is quite hypothetical and may not be a full substitute in this context, however, it has been useful in solving similar problems in other research (Zalejska-Jonsson et al, 2020). Since consumers are usually faced with the need to solve a major FRM problem that may have invaded their property, it is usually a huge commitment deciding on the implications of investing in a scheme or other available alternatives to mitigate the effect of flooding events. This process is largely characterised by an extended problem solving and CBA consideration which has been expressed in the details obtained in figure 9.1.

The figure demonstrates the perception of the benefits derived from the installation of the SuDS retrofit scheme within the properties. However, many of the stakeholders had little or no understanding of how to quantify these wider benefits because they have not paid attention to the need to understand the value of the benefits that could be derived from the scheme. Zalejska-Jonsson et al, (2020) argued that users/ purchasers of properties with Green Infrastructure (GI) pay a premium to either buy or use the properties with good GI. However, there is little research about the process in consumers' minds leading to such a premium. This research sought to provide insight into that process. The purpose of the Willingness-to-Pay procedure is to quantify and value the benefits and to establish the importance of these values towards a full appreciation of the advantage the scheme is to the stakeholders. The figure shows the value of the tangible and intangible benefits obtained from stakeholders. Across the cases, this procedure revealed the way the stakeholders perceived these benefits, particularly intangible benefits such as educational value and habitat within their property. Research has shown that intangible benefits by their subjective nature are difficult to quantify (Joseph et al, 2014; Oladunjoye et al, 2019). The dialogue with the stakeholders revealed the difficulty they had in agreeing to put a value to each of the benefits.

9.8.1 WTP Benefits within the range of £1500 to £2500

These are WTP benefits that are most valued by the stakeholders. These benefits are within the range of £1500 to £2500. Educational value increased property protection, reduced cost of business assets and values, reduced interruption to business activities, the security of business reputation. It is essential to identify these benefits for easy consideration by stakeholders on future projects. Although it is expected that every property has its peculiarity which will mean that the benefits will vary.

9.6.2 WTP Benefits valued within the range of £0 to £1499.99

These are WTP benefits that were valued by stakeholders between the range of £0 to £1499.99. Habitat for wide life, Reduction /elimination of muddy pathway, reduction/ elimination of infections, reduction/ elimination of diseases, reduced/ elimination of property content, reduced insurance claim, reduced post-flood recovery inconvenience, rainwater harvesting and amenity.

9.6.3 WTP Benefits that were not valued

These are WTP benefits that were not valued at all by the stakeholders for various reasons. These values must be represented and identified in the framework for further consideration in future decision-making collaborations, depending on the interests and consideration of those stakeholders that are considering the SuDS retrofit scheme. Reduction/ elimination of psychological impact, Reduction of G.P visits, reduction/ elimination of stress, reduction/ elimination of anxiety, reduction/ elimination of depression, reduced loss of ecological and cultural values, reduced loss of life, air and water quality, economic improvements.

9.9 CBA OF THE SUDS RETROFIT SCHEME

Willingness-to-pay (WTP) values were obtained to elicit the benefits of the installation of SuDS retrofit. The CBA approach has been used to undertake an economic appraisal of the monetary and non-monetary benefits of the uptake of SuDS retrofit across the three cases. A key contribution of this study is to develop a clearer understanding of the CBA of the retrofit of SuDs.

The CBA process was undertaken by calculating the net present value (NPV) of the SuDS retrofit scheme across the cases, assuming the investment returns within 10years. By obtaining the NPV, the investor who in this case is the property owner is concerned about the interval of time between when the investment is made and the cash flow. Drawing inferences from the case study sites, it can be concluded that the SuDS retrofit schemes were cost-effective and that the benefits outweighed the costs. This is because the return on investment (ROI) on each of the SuDS retrofit schemes will be achieved in just three years. ROI is important when making a more decisive step when considering the uptake between different FRM schemes in terms of their cost-effectiveness and asset utilisation (Cochran, et al, 2015).

When performing a cost-benefit analysis for a SuDS retrofit scheme, it is generally helpful to weigh the total benefits and total costs of a future project at their present value (NPV). The interpretation of the NPV can be viewed from three major angles of consideration: Engage in the project if its benefits outweigh its costs, do not engage in the project if its costs outweigh its benefits and if the benefits of the scheme are equal to its costs, then a decision of whether uptake is necessary or not is, therefore, the final option.

Table 9.1 compares the three cases, including the ratio of the cost to the benefits. A closer look at this table shows that there is a level of difference in net benefits (NB) compared with each of the cases. This is due to the value of the benefits as seen by the stakeholders and as a function of the nature of the property. Zalejska-Jonsson, et al., (2020) found out that dense areas give high value to green urban spaces, whereas less dense areas (suburban) value is lower. This is a factor that may have affected the perceived value the stakeholders have given the benefits in the WTP process. When considering the location of the case study sites, it can be observed that the Leisure centre and the Primary school sites are located in suburban areas, while the Civic centre is located within an urban area. A stakeholder who decides to allocate a certain value for SuDS retrofit scheme, it is likely that an overestimation of value will appear in urban spaces due to relative low accessibility and the existing level of SuDS retrofit coverage in comparison to suburban or rural areas. On the other hand, in lower density area, WTP is most likely to be underestimated, since the general saturation level is higher than in a close CBD area.

Table 9.1: CBA values of the SuDS retrofit scheme

Property Type	**Cost of Installation**	**Net Cost (10yrs)**	**Net benefits (10yrs)**	**Net Benefit (10yrs) minus Net cost**	**Return on investment ratio**
Leisure Centre	39,000	39,000	152,565	113,565	7:10
Civic Centre	106,105	106,105	183,000	76,895	4:10
Primary School	93,015	93,015	177,575	84,560	5:10

Furthermore, the size of, and distance from, SuDS retrofit schemes have significant effects on individual appraisal, utility and weighting in CBA. Some studies found that people were willing to pay a premium to increase the coverage of green areas and to decrease the distance between household and green urban spaces (Deely and Hynes, 2020; Zalejska-Jonsson, 2020; Kim et al, 2020). Most of these green spaces provide facilities that are useful for their well being and mental health. Some of these are reflected in the way the stakeholders valued the perceived benefits to the property. The leisure centre is one of those areas that will attract individuals or organisations because of the facilities they offer which provides an opportunity for social interaction and biodiversity.

9.9.1 Return on investment (ROI)

ROI confirms if the choice to install SuDS as a retrofit by the property owners is a good one. ROI is a performance measure used to evaluate the efficiency of an investment or compare the efficiency of some different investments. It tries to directly measure the number of return on a particular investment, relative to the investment cost. To confirm the accuracy of the investments by these property owners, it is important to consider the ROI to obtain a more efficient understanding of the implication of investing in the SuDS retrofit scheme.

To calculate ROI, the initial cost of installation of the scheme is subtracted from the benefit (or return) on investment and then divided by the initial cost of installation, with the result presented as a percentage or a ratio. In this case of the SuDS retrofit schemes of these properties, the formula for calculating the ROI is as shown below;

(Current value of SuDS scheme – Cost of Installation)/Cost of installation

Therefore, ROI for each property is as stated in table 9.1 above and by all indications, the investments are positive and are worthwhile. If this procedure will be applied to other potential options, this will help investors eliminate or select the best options and avoid a loss.

Further consideration of the ROI without the WTP values which sums up to the overall net value in 10yrs should give a clearer understanding of the implication of investments in the schemes. In the initial calculations with the results indicated in Table 9.1 above, the benefits added value to the scheme to obtain a positive ROI. Without these values, the investment will indicate no value and the result is zero.

9.7.2 ROI Ratio

Calculating the ROI ratio helps the property owners to evaluate the performance or even the potential return from the investment in SuDS retrofit. This ratio allows stakeholders on how to efficiently evaluate their investment in SuDS retrofit to understand how it has impacted their organisations positively. The higher the return on investment ratio, the more efficiently the schemes are being used to meet their purpose. In table 9.1 above, it is obvious that the ROI ratio is high and at different levels. These also confirm the efficiency of these schemes in terms of investment by the stakeholders.

9.10 REFINEMENT OF CBA MODEL

The CBA model has now been tested and presented. This was achieved by a research method that involved an interview/ focus groups session, observation and documentation. Some points have been identified for further discussion; the properties used for the case studies can be said to be successful and functional examples of SuDs retrofit projects. However, the benefits of the schemes were not extensively considered or quantified by the stakeholders. This is a result of a lack of understanding of the importance of this process and a lack of any guidance on how to do this. Dialogue before the actual interview/focus group session revealed that the stakeholders were quite comfortable with the framework for the study and are looking forward to the outcome. This shows that stakeholders are interested in some useful information that will further encourage the uptake of SuDS retrofit.

In light of these findings, it is important to emphasise that stakeholder engagement is an essential element of the success envisaged from the installation of SuDS retrofit. A proper stakeholder engagement process that includes a representation of the community will allow for good planning and delivery of SuDS retrofit which will produce a broader set of benefits for which stakeholders will be willing to pay and install within their property. This framework will further enable the smooth running of the decision-making process of the implementation of the scheme. This has been included in the current version of the framework as a way of emphasising the relevance of this tool in the decision-making process of SuDS retrofit installation.

It is also important to conclude that different properties are peculiar based on the nature of the properties and the services they offer. In this study, commercial properties which can be regarded as public interest buildings were considered. Following the findings from the WTP process, it is important to point out that stakeholders are willing to pay for a wider set of benefits in community buildings than they would be in commercial buildings. This emphasises the importance of the WTP in this research and its reflection in the overall framework of the study.

In practice when deciding to install SuDS retrofit, it will be useful to consider the nature of the property in understanding the benefits, the historical benefits of the property among many other important considerations. This will help to determine a clear value of the scheme beyond the FRM function and the way funding can be managed or determined in other to avoid any delay in the delivery of the scheme.

To further achieve a functional and relevant framework, the previous model which has been discussed in chapter 4 has been reorganised based on the outcome of the qualitative research. The findings have been very helpful especially the outcome of the WTP process. To achieve the required relevance, few inclusions were made such as adding stakeholder engagement and allocating different stages to the level of costs required for the scheme and as well as the benefits into Tiers. Stakeholder engagement has been discussed extensively in section 9.2 above. However, it is important to identify a few points that make these points very important to be included in the framework. These are the involvement of experts which influenced a stronger outcome from the professional installation of the schemes and the way funds were obtained towards the scheme at the leisure centre. The consultation with the community also helped to develop the interest of different organisations in terms of maintenance of the scheme as well as understanding the interest of those who will use the scheme as required by the landscape architect. These points are important for the smooth running of the decision-making process.

Introducing the Tier system is very important to understand the level of importance of these benefits to the stakeholders based on this research. This also emphasises the need to categorise the benefits that could be derived from any installation, based on the interest of the stakeholders, for a clearer understanding of the benefits that may be of a higher priority and to be able to apply them to the CBA process accordingly. This is based on the understanding that the benefits which have been listed will vary in terms of priority to the stakeholders and this will need to be considered.

The current framework will be useful for future installation processes on different sites, to inform a clearer decision-making process by stakeholders. stakeholders will be able to follow the stages of attending to the costs of installation and then consider the level of the benefits where needed, based on the three stages that have been identified in the framework.

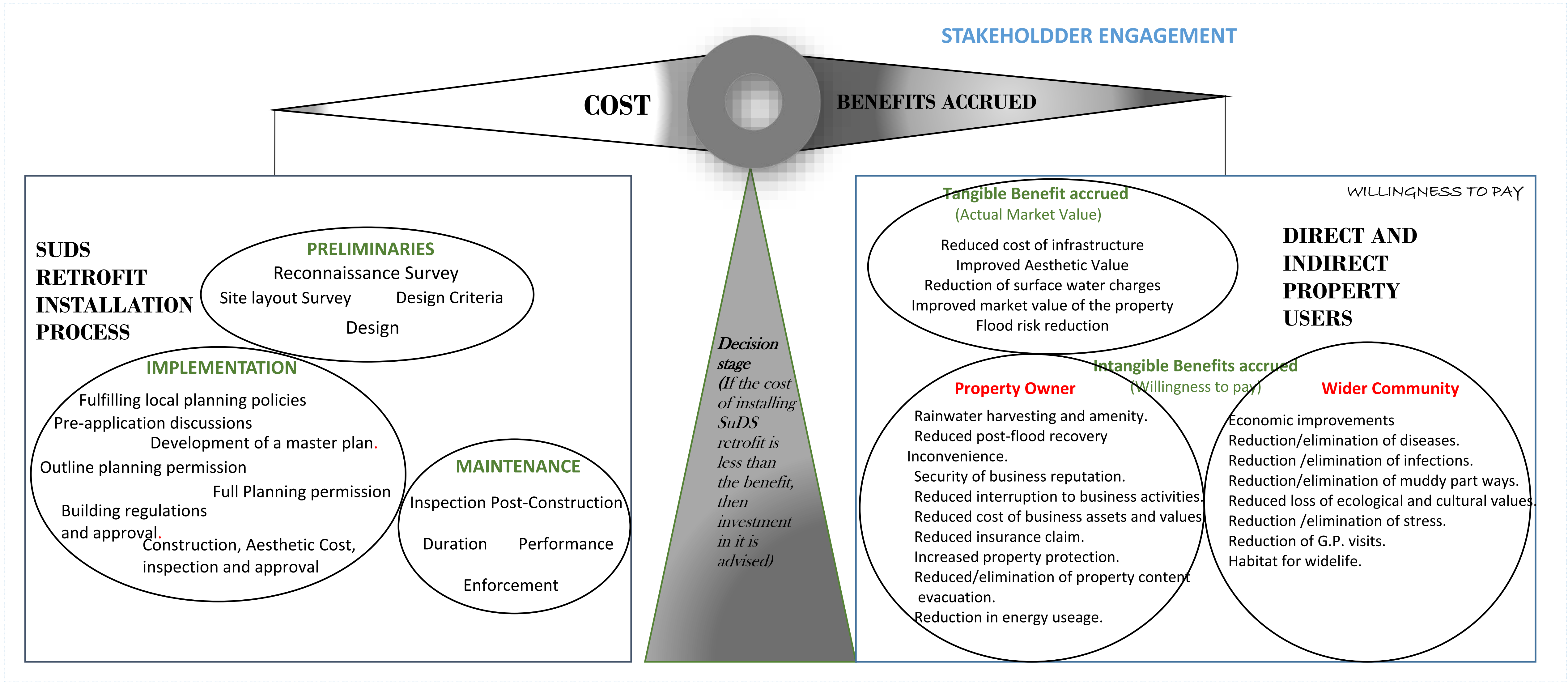


Figure 9.1: Conceptual framework for comparing the costs and benefits of SuDS retrofit in public buildings

9.11 SUMMARY

This chapter has sought to discuss the findings across the cases and to refine the framework. A WTP was applied to the valuation process of these benefits, to elicit the values and understand the perception of these benefits to the stakeholders. Some interesting findings were made which further contributed to a better outcome from the framework. The uptake of SuDS is largely influenced by the perception of the value of its benefits to the property. Based on the data, the framework has now been refined with some of the outcomes of the discussions around the values obtained from the WTP process. This was necessary because some of the benefits included in the WTP process were not valued which suggests the level of importance to the stakeholders which can be concluded to be of no importance. This should therefore reflect in future policies by the government or the stakeholders of the SuDS retrofit scheme.

CHAPTER TEN: CONCLUSIONS AND RECOMMENDATIONS

10.1 INTRODUCTION

The analysis of the costs and benefits of the retrofit of SuDS has been explored in this research, emphasising the WTP value of monetising the intangible benefits. This has led to a clearer understanding of the monetary and non-monetary value of the retrofit of SuDS and the management process and cost of maintaining a SuDS retrofit scheme. The CBA framework has provided improved and robust decision-making information on the installation of the retrofit of SuDS as an FRM tool. Therefore, this chapter summarizes the entire research and then answers the seventh objective: to draw conclusions from the study's findings to provide a basis for proposing implications for flood risk management as it affects the installation and uptake of SuDS as a retrofit make recommendations for further studies.

10.2 EVALUATION AGAINST ORIGINAL AIM AND OBJECTIVES

In chapter one of this thesis, the background of the research was presented. The main issue that came to light was that currently, in the UK, there exists a low uptake of SuDS retrofit. This is due to the lack of understanding by stakeholders about the monetary and non-monetary values of the retrofit of SuDS and that stakeholders were concerned about the maintenance of the scheme. Currently, there is no means of understanding this procedure, hence the research aims to investigate the monetary and non-monetary values of the costs and benefits of SuDS retrofit installation through a case study research, with particular emphasis on the WTP procedure of obtaining the value of its benefits in the CBA framework. To achieve this aim, seven research objectives were developed.

10.2.1 Review of Research Objectives

A review of the research objectives below outlines how these objectives were achieved in this research.

Objective 1: To critically review SuDS retrofit's effectiveness in managing flooding events in the UK towards identifying the benefits and opportunities alongside the barriers and obstacles to its adoption.

This objective is addressed in chapter 2. Well-reviewed literature was undertaken to understand the effectiveness of SuDS retrofit in managing flood events globally and in the UK. Findings revealed that SuDS have been applied successfully in cities worldwide and have proven to be a cost-effective solution to manage flood risk whilst also delivering a range of other benefits. However, despite these benefits, there has been a relatively low uptake of SuDS retrofit in the UK. Further research revealed some barriers and opportunities to the uptake of SuDS which identified existing numbers of potential barriers such as the lack of experience and trust in such schemes. SuDS tend to be undervalued by stakeholders due to the lack of understanding of the monetary and non-monetary values of its benefits. This formed the basis of this study which was aimed at developing a fuller appreciation of the true costs and the wider monetary and non-monetary values of its benefits including a clearer understanding of the cost of maintenance of the scheme.

Objective 2: To critically review the literature on CBA in order to identify its potential application to the study of SuDS retrofit in the UK.

This objective was addressed in chapter 3. An in-depth review of CBA literature was undertaken towards developing a suitable approach for its application in SuDS retrofit installation. The review revealed two main methods of quantifying intangible benefits of SuDS retrofit schemes. These methods are the revealed preference methods (RPM) and the stated preference methods (SPM). Given the context of the research, the SPM was adopted. The review revealed that the choice modelling method (CMM) of SPM is more appropriate to elicit the value of the benefits of willingness to pay (WTP) through the stakeholders' perception. The value of the benefits derived from the stakeholders' perception is then used to estimate WTP, which represents the benefits derived from each property. Identifying a suitable method of quantifying intangible benefits of SuDS retrofit schemes to incorporate it in the CBA framework represented a significant achievement. This CMM method was successfully applied to the three case study options and this produced a very useful outcome which formed most of the discussions in chapter 9.

Objective 3: To develop a CBA conceptual model, aligned explicitly to public buildings in the UK, of the costs and benefits of installing SuDS as a retrofit, based on integrating the existent literature.

This objective is addressed in chapter 4. CBA framework is often used to explain the link between different costs and benefits of FRM schemes. A review of some existing CBA models of flood adaptation measures was undertaken to obtain insight into how these costs and benefits are incorporated in the decision-making framework. Since this is a new concept in the study of SuDS retrofit. It was revealed from the literature review that the existing CBA models of flood adaptation measures acknowledged the importance of intangible benefits, but due to difficulties in monetising these intangible impacts, they were largely ignored. This suggests that there are still difficulties in accurately reflecting the full benefits in these studies. A further revelation showed that there is currently no CBA framework that is used in the study of SuDS retrofit. By identifying this gap in the existing research of flood risk management and SuDS retrofit, a conceptual framework of CBA model of SuDS retrofit was developed. The framework also included other factors that influence the costs and benefits of the installation of SuDs retrofit.

This framework has been refined and presented in Chapter 9 after its application to three different case study options.

Objective 4: To elicit the actual value of the costs and benefits of the retrofit of SuDS, including reducing flood risk from a sample of case study sites in the UK.

This is addressed in Chapter 5, building on the achievement of the third objective, the need to verify the conceptual framework through a case study research that involves retrieving information from documents, observatory process and interviews/ focus group sessions. Three study areas were identified, a Leisure centre, a Civic centre and a Primary school. These study sites have.

Drawing on the findings from the literature, a set of interview questions was designed to elicit the views of the stakeholders on the flood perception within the property, possible impacts of flooding and the benefits from the installation of the scheme and the perception of the value of the benefits accrued from the scheme.

The analysis conducted on the data provided broader insights into stakeholder engagement, the costs of installation, the scheme's maintenance, how the schemes were funded, the benefits accrued, the WTP values of the benefits and the CBA analysis of each of the schemes.

Objective 5: To analyse the costs and benefits of SuDs retrofit schemes and explore the decision-making process towards refining the conceptual CBA framework and its relevance for practical application in future public buildings.

This is addressed in chapter 6, 7, 8 and 9. The three study areas' discussion was elaborately considered under headings such as stakeholder engagement, funding and costs of installation, maintenance and operation costs, WTP values, and CBA. It was established that the landscape architect's presence was beneficial in facilitating a smooth decision-making process at the different study areas. This will imply that the landscape architect's position in the scheme's overall delivery is of great importance. Therefore, it is advised that the landscape architect should be made the head of the project team so future projects can be handled the proper way. Another point in the decision-making process is the property manager's contribution at the leisure centre in facilitating the sourcing of funds for the scheme. It is important to include a professional who can provide the required information needed to meet this important aspect of the delivery of the scheme. In terms of the scheme's maintenance, providing a clear procedure that is available in the SuDS manual and enforcing it by the government for every SuDS retrofit scheme will help stakeholders with the required knowledge needed to maintain different schemes. Even when there are volunteers, it will be helpful to guide everyone involved in the maintenance process for the smooth delivery of the scheme.

Objective 6: To draw conclusions from the findings to provide a basis for proposing implications for FRM as it affects the installation and uptake of SuDS as a retrofit and make recommendations for further studies.

.Through a detailed review of the literature, this research, analysis of existing SuDS retrofit schemes through qualitative research, has established evidence to support some essential conclusions and recommendations presented in this chapter.

10.3 CONCLUSIONS

This section presents the conclusions from the research, which are stated below;

- Taking to account the intangible benefits, SuDS retrofit is found to be very beneficial based on the results of the ratios of the ROI which was calculated based on account of the cost of the scheme and the calculated benefits. This knowledge was lacking among the stakeholders because there has not been a procedure available to determine the outcome achieved from this research. SuDS retrofit is certainly cost-beneficial when you take into account the intangible benefits derived from the scheme.

- A flip side of the argument in this research is the implication of not taking into account the intangible benefits. As reported in chapter 9, it was determined that this would imply a zero outcome, which means that the scheme is of no value to the stakeholders. This further strengthens the argument that considering intangible benefits in determining the CBA of SuDS retrofit is quite beneficial and should be adopted as part of the procedure for future projects.
- Stakeholder engagement has been identified as one of the strong outcomes of this research. It is essential to acknowledge the role the landscape architect played in facilitating these schemes' installation within the properties. The landscape architect's expertise can be said to have supported the eventual positive outcome of these schemes at their properties. This, therefore, will imply that for the success of future SuDS retrofit installations, it is essential to include professionals that are well knowledgeable about the process. The landscape architect stands out as the best bet for this role. Therefore, it is good to suggest that the landscape architect should be given the right to head the construction team in future projects.
- Another outcome of the research is the importance of working out a detailed funding procedure for future schemes. Funding is one of the barriers to the installation of SuDS retrofit schemes. Having a stakeholder who is specifically involved in the decision-making process to work out modalities for obtaining funds is a strong point that needs to be implemented in future SuDS retrofit projects, to guide against unexpected delays. Having specialised guidance and support at the level of the government or specialised bodies which will be helpful to ease the process of obtaining funds for future projects. The FCERM is one of these bodies which have been assigned to this responsibility. Therefore raising the awareness of what these organisations can offer as well as these

organisations establishing active engagement with the community and stakeholders will further create opportunities for the uptake of SuDS retrofit.

- Another essential point in understanding stakeholder engagement in this research is the community's involvement. Consulting with the community is key to the success of implementing SuDS retrofit schemes in public buildings because of the potential of sensitisation and developing their interest. This will encourage the involvement of the community in the maintenance process by way of volunteering. These volunteers will not only reduce the cost of maintaining the scheme but will also help in promoting its benefits.
- The maintenance process of managing the schemes in this research was approached differently. This clarified the gap in the scheme's maintenance process, which increased the lack of understanding by the stakeholders over the years. The SuDS manual provided by CIRIA has helped provide a procedure for maintaining any SuDS retrofit scheme. Adopting this procedure and raising its awareness among stakeholders will help to bring clarity to the maintenance cost and procedure.
- Although stakeholders are interested in the benefits that can be derived from the installation of a SuDS retrofit scheme, they were not well informed about the importance of quantifying these benefits. The benefits from the installation of a SuDS retrofit scheme have been elaborately outlined and discussed. A WTP process of eliciting these benefits helped understand a SuDS retrofit scheme's cost-effectiveness and how best to quantify its benefits and apply it to understand the CBA outcome.
- Several economic methods of quantifying intangible benefits of SuDS retrofit installation in public buildings exists; however, the CMM method was employed. This was used to elicit WTP values from stakeholders to understand their perception of the value these benefits are to their property. The advantage of using CMM is that stakeholders are presented with various alternative descriptions of the benefits with

different financial commitments that are then ranked from most preferred to the less preferred by including price as one of the rankings.

These conclusions provide answers to the research questions posed to develop the CBA framework of the retrofit of SuDS. In summary, quantifying the benefits of SuDS retrofit is crucial for a smooth sailing decision-making process and carrying stakeholders along accordingly.

10.4 CONTRIBUTION TO KNOWLEDGE

This research has provided new insight into the study of CBA framework of the installation of SuDS retrofit for public buildings. The contribution of this research to knowledge are discussed under these subheadings; CBA model for the retrofit of SuDS, which the government could use, stakeholders in the industry, in future studies in the UK and with further modification, it could be used in various locations, providing more understanding to the value of the benefits of the installation of SuDS retrofit and also in the dissemination of research findings.

10.4.1 Contribution of the CBA framework of the installation of SuDS retrofit

The CBA framework is a whole new concept in the study of SuDS retrofit installation. The CBA framework represents the activities that sum up to present a cost-effective and well presented SuDS retrofit scheme. The CBA framework answers various questions that have added to the failure of stakeholders taking up SuDS retrofit as an FRM measure to mitigate flooding events. In this study, the installation process of a SuDS retrofit scheme was considered. The costs of installation and accrued benefits were obtained. Using an innovative means of obtaining the value of the benefits of a SuDS retrofit scheme from the perception of the stakeholders. The framework developed in this research provides the much needed conceptual clarity about the monetary and non-monetary value of the installation of a typical SuDS retrofit scheme. The framework has a wide range of potential beneficiaries such as property owners, government departments and agencies responsible for flood risk management. The framework can be used to access the cost-effectiveness of the installation of SuDS retrofit, thereby addressing the barriers to its uptake.

10.4.2 The value of the benefits of SuDS retrofit installation

The value of the benefits of installing SuDS retrofit was determined through the WTP process which was derived from the perception of the values by the stakeholders. This is the first attempt to quantify the intangible benefits of the installation of SuDS retrofit and to understand the extent of these benefits, and their significance in the CBA of the retrofit of SuDS. Without the intangible benefits, the SuDS retrofit scheme will not be considered to be cost-beneficial. A sound decision is therefore made when the intangible benefits are fully considered.

10.5 IMPLICATIONS OF THE RESEARCH FINDINGS

The findings of this research have several important implications for FRM stakeholders, property owners, government departments responsible for flood risk management such as the Environment Agency (EA), Construction Industry Research and Information Association (CIRIA), water research groups such as the Water, Environment and Research committee at BCU. The practical implication of the findings are discussed below;

FRM practitioners can use the developed CBA framework for the installation of SuDS retrofit to advise property owners and government agencies on the costs and possible benefits associated with their investment in any SuDS retrofit scheme.

Property owners can use the developed CBA framework for the installation of SuDS retrofit to make an informed decision on the adoption of SuDS or it can be used by FRM professionals employed by property owners to carry out an informed installation process of the retrofit of SuDS. This will bring clarity to the understanding of the cost-effectiveness of adopting SuDS retrofit as a mitigative measure.

Another important implication is the need to involve a professional with the right expertise whenever a client or a project manager is considering the installation of a SuDS retrofit scheme within their property. It is important to have someone with the right expertise who will deliver the scheme with the needed experience to attend to the technicalities of the design and installation process.

Furthermore, this CBA framework is a good explanatory model for environmental good. This framework can be useful for other environmental good as a decision-making tool such as the travel system by considering the perception of the stakeholders in understanding their willingness to pay for the benefits derived from the system which will result in an improvement.

In the study of Natural flood management (NFM), one of the barriers to its adoption is understanding the costs of installation and maintenance, including the accrued benefits. The application of the CBA framework will further bring clarity to the monetary and non-monetary value of the scheme.

Green financing is rising research that could encourage investment into rural communities which recognises the benefits this type of schemes can deliver. One of this scheme's primary outcomes is to ensure current, and future financial risks and opportunities from climate and environmental factors are integrated into mainstream financial decision making. The developed CBA model will facilitate a robust delivery of the requirements of the scheme.

The flooding coastal erosion risk management (FCERM) strategy was launched in 2020 by the EA. Adopting the CBA framework as a property flood resilience measure will facilitate a clear knowledge of the costs and benefits of the implementation of the strategy.

Regional flood groups will be able to relate the developed model to their daily discussions around property resilient measures.

10.6 RECOMMENDED FURTHER RESEARCH

This research has focussed on developing a CBA framework for the installation of SuDS retrofit cannot claim to have addressed in full all issues related to the costs and benefits of SuDS retrofit installation. Therefore, further research is recommended in the following areas:

- Findings from this study require similar research in other property types for comparison and validation of these findings' universality. There is a need to consider more varieties of SuDS retrofit schemes and SuDS schemes within new builds in researching other properties.
- The research was limited by the current statistics of SuDS retrofit schemes in the UK. If these conditions change, the mean WTP values of the benefits of SuDS retrofit may change. It is therefore recommended that further research should be carried out to establish whether the perception of the benefits of the SuDS retrofit schemes has changed.
- The CBA model developed in this research aimed to simplify decision-making on the installation of SuDS retrofit. The use of appropriate software to simplify the simulation process and make it easier for the users would enhance the accessibility of the findings.

A interactive, user-friendly template is advised, given the current requirement of various establishments due to the rise in virtual communication.

- Further research could be undertaken towards the CBA of the retrofit of natural flood management (NFM). The rising research in NFM as a flood risk management tool identified the need to understand the cost implication of implementation. It is recommended that the CBA model developed from this research should be applied to the NFM tool to appreciate its applicability to this FRM measure.
- The UK government is currently working on the environmental land management scheme which will be delivered by 2024 as a new agricultural policy. This is expected to adopt various FRM measures for flood management. The application of the CBA model will help set out a clear understanding of the cost implication of the delivery of the scheme and how to quantify the benefits which will be derived from its implementation.

10.7 LIMITATIONS OF THE STUDY

This section focuses on the research project's scope, which was anchored on the literature review and the exploratory phase of the research. This study was set out to develop a CBA model for the retrofit of SuDS for public buildings. The study's limitations were identified; however, the methodology sought to minimise these limitations wherever possible.

The current number of retrofitted public buildings is relatively low. This affected the possibility of being able to use more study areas for this research. It is advised that this research can be updated some years later to understand the relevance of this current research on other retrofitted public buildings.

In carrying out this research, the world was faced with the Covid-19 pandemic, which resulted in various restrictions ranging from lockdowns and working from home. This made it difficult for some of the stakeholders to have access to some useful documents that could support some of the research findings and revisit the study areas when needed. However, the data collected at the end of the research was able to meet the expectation of the outcome of the research.

The current economic situation in the UK has seen some loss of jobs and recession as a result of the current Covid-19 pandemic. This as affected various people in different ways and it is said that the approach of many people to live may change as those things which were said to be normal do not seem the happen as expected anymore. So also, the perception of the stakeholders may have changed over these months. Some comparison of the different scenarios may be useful for more research.

10.8 SUMMARY

The research was carried out by applying the concept of CBA to the installation of SuDS retrofit with the incorporation of the WTP process to quantify the accrued benefits of the measures in the CBA model. Thus, this chapter has provided a review of the research objectives and the extent to which they were achieved. The main conclusions addressing the research aim and, hence, the research objectives have been presented, including the main contributions to knowledge which have also been meaningfully summarised. The practical implications of the research findings and recommendations for further studies have also been presented.

In summary, the research has developed the CBA model of the installation of SuDS retrofit, which represents a robust mechanism for decision making on by property owners. Flood risk management professionals could use the model to advise property owners of the potential benefits of investing in SuDS retrofit. It is, therefore, concluded that the developed CBA models have the potential for improving the uptake of SuDS retrofit. This research, thus, provides the much-needed comprehensive cost and benefit information in the domain of flood risk management as it affects the installation of SuDS retrofit.

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APPENDIX A-1: TYPICAL COVERING LETTER FOR INTERVIEW SESSION

Dear L…

LETTER OF INVITATION TO PARTICIPATE IN INTERVIEW

My name is Oluwayemi Oladunjoye, a PhD student at Birmingham City University within the Faculty of Computing, Engineering and the Built Environment. I am supervised by Prof David Proverbs, Dr Beck Collins and Dr Hong Xiao.

As part of my doctoral programme, I am carrying out a study into SuDS retrofit and my research title is ‘A Cost-Benefit Appraisal of Retrofit of Sustainable Urban Drainage Systems towards Improved Flood Risk Mitigation’.

At this stage, I am looking for assistance in identifying some useful case studies of SuDs retrofit projects that might then be used as part of my data collection. I would also welcome the opportunity to meet with you and discuss my research including my CBA framework which is appended for your information.

Please advise if you need any more information and if you would prefer me to give you a call.

I look forward to hearing from you.

Kind Regards,

Oluwayemi

Email:

Mobile:

Home:

APPENDIX A-2: INTERVIEW/ FOCUS GROUP QUESTIONS

<table>
<tr><td colspan="3">Interview schedule with …………………..: A Cost-Benefit Appraisal of Retrofit of Sustainable Urban Drainage Systems Towards Improved Flood Risk Mitigation</td></tr>
<tr><td>Main Question: to be shared in advance with participant</td><td>Prompts/ clarifications use any or all: for interviewers use only as appropriate</td><td>Requests for information use any or all if the response to a question indicates appropriate: for interviewers use</td></tr>
<tr><td colspan="3">Preamble: Thank you for agreeing to take part in this interview, I hope you have had the chance to read the information that I sent and are happy to proceed.

Research summary: This is an independent doctoral research carried out by Birmingham City University (BCU), Birmingham and it is for academic and research purposes only.
SuDS have been applied successfully in different parts of the world, however, the uptake of SuDS, in particular the retrofit of SuDS, has been restricted by a number of issues including a lack of experience and trust in their performance and a lack of understanding in their true benefits. In particular, there is limited experience of retrofitting SuDS and there are no well established procedures for evaluating the feasibility, value or cost-effectiveness of doing this.

This research aims to understand the decision-making processes involved in considering the installation of SuDS retrofit. To help make this assessment the research is aiming to develop a Cost-Benefit-Analysis (CBA) tool. Of particular interest is how willing people would be to pay for the deployment of SuDS in their properties to prevent any future flood damage.

The information you give will be held confidentially by BCU and will not be passed on to any third parties. Respondents will remain anonymous in the storage and reporting of the data provided. We hope that you will find the interview interesting.

SECTION A: INTRODUCTION</td></tr>
</table>

1. As the Property owner/ Local authority/Environment agency/ Landscape designer on this project, in what way did you influence the decision to install SuDS on-site?	**You might like to consider:** What was your role on the project? Have you any prior experience of using SuDs and/or SuDs retrofit? Was this a challenge in any way? Are you willing to discuss some of these challenges if any?	
2. What factors did you consider in the decision to install SuDS?	Flooding perception Flooding experience Flood risk awareness So how did you come about these factors? Did you have to do some consultations?	
3. Were any of these factors more important than others?	If yes, Why? What informed their level of importance?	
4. What impact did these factors have on the decision to install SuDS?	Do you think any of the factors formed a major part of the decision to install SuDS?	
SECTION B: PERCEPTION OF FLOOD RISK		
1. What is your perception of the flood risk within this property?	Is this property is at risk of flooding? Have you experienced any flooding event within the property?	

	Flood experience? If any? What impact was made on the property? Any damage?	
2. How did your perception affect the decision-making process?	What were the issues raised that needed attention? Were these issues more important than others?	
3. What are your thoughts about the flood risk of the property in the near future?		
SECTION C: ACCESS TO SUITABLE EXPERTISE		
1. To what extent were you able to obtain suitable professional advice on the retrofit of SuDS?	What were your discoveries?	
2. Was the expertise on this type of project problematic?		
3. Where did you go for guidance?	Was this information useful/helpful How did this information help the decision-making process	
4. Was there any added cost from this process	How did this affect the decision-making process? Was this a setback?	
SECTION D: COSTS OF INSTALLING SUDS RETROFIT		
1. How was the project funded?	Government funding Company funding Individual funding	

2. What concerns around funding did you have on the project?		
3. What is the overall cost of construction of this project?		
4. Considering the costs of installing the SuDS retrofit project, can you put the actual monetary value (AMV) or estimated monetary value (EMV) to these stages in the construction process?	**A.** Design **B.** Construction **C.** Maintenance	
SuDS Maintenance		
1. How do you maintain the SuDS project?	External funding Company funding Voluntary service	
2. What is the overall cost of maintenance of the project?	Voluntary cost Financial cost	
3. What are the challenges you have faced in ensuring a good maintenance process for this project?	How best will you describe these challenges? External delivery Internal delivery No functional delivery Who is responsible for maintaining the SuDs?	
SECTION E: ACCRUED BENEFITS FROM INSTALLING SUDS RETROFIT		
1. Did you quantify the benefits?	If yes, how?	

2. What do you consider to be the main non-financial benefits of this project?						
3. How would you value the perceived benefits to your organisation from the following, using these range of financial values?						
	£0	£1-£500	£501-£1000	£1001-£1500	£1501-£2000	£2001 - above
Rainwater Harvesting and amenity						
Reduced post-flood recovery inconvenience						
Security of business reputation						
Reduced interruption to business activities						
Reduced cost of business assets and values						
Reduced insurance claim						
Increased property protection						
Reduced/ elimination of property content evacuation						
1. How would you value the benefits of this project to the community?						
2. Within these range of financial values, how much will you be willing to pay to achieve these level of benefit(s) towards the community?						
	£0	£1-£500	£501-£1000	£1001-£1500	£1501-£2000	£2001-above
Economic improvements						
Air and water quality						
Reduced loss of life						
Reduction/elimination of diseases						
Reduction/ elimination of infections						

Reduction/ elimination of muddy part ways						
Reduced loss of ecological and cultural values						
Reduction/ elimination of depression						
Reduction/ elimination of anxiety						
Reduction/ elimination of stress						
Reduction of G.P. visits						
Habitat for wide life						
Educational value						
Reduction/elimination of psychological impact						

3. Are there other comments you may like to add to the interview which you think may have been left out?		
4. Is there anyone you suggest it may be worth to have an interview with on this project?		

Thank you so much for completing this interview session with me. Your answers will assist us in developing a good understanding of the decision making the process of installing SuDS retrofit by adopting a cost-benefit analysis tool. If you require additional information or any clarification, please feel free to call me (Yemi Oladunjoye) on 07958530375, alternatively, you can send me an email: Oluwayemi.oladunjoye@mail.bcu.ac.uk

APPENDIX B: LIST OF ABSTRACTS OF JOURNAL AND CONFERENCE PAPERS PUBLISHED DURING THE RESEARCH PROGRAMME

The Barriers and Opportunities to the Retrofit of Sustainable Urban Drainage Systems (SUDS) Towards Improving Flood Risk Mitigation in Urban Areas in the UK

SEEDS CONFERENCE 2017

ABSTRACT

In the UK, about 5.2 million properties, accounting for about one-sixth of all properties, are in areas at risk of flooding. A chronic shortage of housing, a growing population, and increased rainfall are likely to exacerbate this situation. Sustainable Urban Drainage Systems (SuDS) have been successfully applied in cities worldwide and have proven to be a cost-effective solution to manage flood risk whilst also delivering a range of other benefits. Despite these benefits, there has been a relatively low uptake of SuDS in new developments and even less so in the opportunities for retrofitting SuDS in existing buildings. The aim of this study is to examine the barriers and opportunities in the retrofit of SuDS in a bid to appraise their effectiveness in the mitigation of flood risk. A systematic search of the available literature is employed to identify key sources of evidence. An examination of the search results reveals a range of multiple benefits from retrofitting of SuDS including enhancement of air quality, health improvements, and towards conducting a whole life costing methodology, among others. Furthermore, there exists a number of potential barriers to their uptake including, for example, the lack of experience and trust in such schemes, and that SuDS tend to be undervalued by stakeholders owing to the complexity of the monetisation and quantification of their wider benefits. Further research is therefore recommended to help develop a fuller appreciation of the true costs and the wider monetary and non-monetary benefits towards addressing some of the apparent barriers to the retrofit of SUDS. This will help to increase the uptake of SuDS retrofit as a valid approach within an integrated flood risk management strategy.

Keywords: Flooding, systematic review, retrofit SuDS, Benefits, barriers.

A cost-benefit analysis model for the retrofit of sustainable urban drainage systems towards improved flood risk mitigation

International journal of building pathology and adaptation (2019)

Abstract

Purpose–The Environment Agency estimates that one in six homes in England (approximately 5.2mproperties) are at risk from flooding and 185,000 commercial properties are located in flood-prone areas. Further, an estimate of 10,000 new homes are built on flood plains yearly. The UK has witnessed a significant increase in flood events over the past 10 years. During this period, there has been growing research attention into measures to mitigate the effects of flooding, including the benefits of deploying sustainable urban drainage systems (SuDs) in new developments or as a retrofit. The purpose of this paper is to present the development of a cost-benefit analysis model for the retrofit of SuDs focusing on the potential for improved flood risk mitigation in the context of commercial properties.

Design/methodology/approach–A synthesis of flood risk management and SuDs literature is used to inform the development of a conceptual cost-benefit analysis model for the retrofit of SuDs and focusing on the potential for improved flood risk mitigation in the context of commercial properties.

Findings–SuDs have been applied successfully in different parts of the world; however, the uptake of SuDs, in particular, the retrofit of SuDs, has been restricted by a number of issues including a lack of experience and trust in their performance and a lack of understanding in their true benefits. In particular, there is the limited experience of retrofitting SuDs and there are no well-established procedures for evaluating the feasibility, value or cost-effectiveness of doing this.

Social implications–This offers the potential to support the UK government's flood risk management policy by helping to increase the resilience of properties, whilst offering other benefits to communities such as improvements in air quality and biodiversity and also presenting a clearer understanding of the monetary and non-monetary implication to owners of commercial properties for a more informed and acceptable uptake of SuDs retrofit.

Originality/value–The proposed model will allow a more comprehensive understanding of the costs and associated benefits associated with SuDs retrofit, highlighting the flood risk mitigation benefits that might accrue over a period of time for commercial property.

Keywords: Flood risk, Commercial properties, Conceptual framework, Costs, Benefits

COST-BENEFIT ANALYSIS (CBA) OF SUSTAINABLE URBAN DRAINAGE SYSTEMS (SUDS) RETROFIT: A CASE STUDY

International Journal for environmental impacts (2021)

ABSTRACT

The retrofit of Sustainable Urban Drainage Systems (SuDS) has been applied successfully to properties to help mitigate future flooding and to deliver other benefits to properties, such as improvements in air and water quality, economic benefits and improved business reputation. However, the uptake of SuDS retrofit has been low due to a lack of understanding of the true costs and benefits and concerns about long-term maintenance. This study presents a cost-benefit analysis (CBA) of the monetary and non-monetary values of SuDS retrofit in the context of an individual property, in this case, a leisure centre. A qualitative study was carried out comprising a series of interviews with stakeholders to the property, an analysis of documentary evidence and observations on the site. The findings demonstrate the importance of teamwork amongst the stakeholders during the decision-making process in helping to overcome many of the known challenges. The Willingness To Pay process is used to value the tangible and intangible benefits arising from the scheme. The installation would provide a net value to the client of well over £100,000 over a 10 year period versus the installation costs of £39,000 and the return on investment would be achieved in just three years. The findings highlight many of the apparent barriers that need to be overcome when installing retrofit schemes and clearly demonstrate the importance of the intangible benefits derived. It is recommended that these are given full consideration at the decision-making stage and in supporting the uptake of the retrofit of SuDs.

Keywords*: SuDS retrofit, flood, leisure centre, costs, benefits and maintenance*