MASTER OF SCIENCE IN PROJECT MANAGEMENT

The Critical Success Factors for landscape management of operations on Sustainable Urban Drainage System (SuDS) projects

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ACKNOWLEDGEMENTS

The author acknowledges the following individuals and organisations for their valuable time and assistance for the purposes of this research, namely:

Associate Professor Kathy Michell, for her guidance in supervising this thesis.

The Intaka Blouvlei Environmental Committee and the CCPOA, for their willingness to provide in-depth insight and give freely of their time whenever required.

Kirsty Carden for assisting with information regarding the SuDS project register in the Western Cape.

Dr Angela Stott-Vogt for her listening ear, insight, and many discussions regarding various aspects of research.

Jacqueline Barnard for always showing an interest.

DEDICATION

This thesis is dedicated to my devoted and generous parents.

ABSTRACT

Population explosion and urbanization are the most significant reasons for increasing pressure on the earth’s natural resources, particularly water. Historically, water services have been supplied and discharged through a network of piped infrastructure and hardened surfaces with the main objectives of efficiency and risk management. Separation in service provision of water resources has proven operationally unsustainable, with increasing negative impacts on the environment.

New approaches have been sought to mitigate these impacts through a new paradigm in urban stormwater management, referred to as Sustainable Urban Drainage Systems (SuDS), which describes a strategic sustainable approach to the management of stormwater quality and quantity. Various typologies are used individually or in configurations to form a treatment train with engineered and landscape infrastructure components that are mutually supportive. Much research has been done on the design and implementation phases of this infrastructure, but the literature reveals a less detailed understanding of the intricate management and operational aspects of SuDS.

This case study considers the Critical Success Factors in the operational phase of SuDS on landscape projects during the operational phase, that contribute to optimal functioning of these complex ecological systems for the benefits of ecosystem goods and services and quality of life for all. This research design has been couched in the pragmatic paradigm which considers the problem at the heart of the research, approaching research from a pragmatic perspective. To fulfill the research objectives, a critical literature review was conducted, and a single case study research methodology used to investigate this phenomenon, located at Intaka Island, Century City, Cape Town that has been operationally successful for over two decades. Pragmatic thematic analysis was carried out through empirical inquiry on the current operational approaches. The research design included data collection of from a variety of sources. These were then expressed through rich descriptive text which was, analysed, and interpreted through a process of triangulation, leading to the establishment of emergent themes and the assertions of four prominent Critical Success Factors, namely: strategic vision, culture of learning, clearly defined management objectives and adaptive management. From this, conclusions are drawn, and recommendations made.

Contents

ACKNOWLEDGEMENTS iii
DEDICATION iii
ABSTRACT iv
ADDENDA IN GOOGLE DRIVE x
LIST OF FIGURES xi
LIST OF IMAGES xv
LIST OF WEB PAGES AND SOCIAL MEDIA POSTS xviii
GLOSSARY OF TERMS xx
CHAPTER 1: INTRODUCTION 23
1.1 Context 23
1.2 Background to this research 24
1.3 Research problem area and statement 26
1.4 Research question 27
1.5 Research aim 27
1.6 Research Objectives 27
1.7 Research methodology 28
1.8 Structure of thesis 29
CHAPTER 2: LITERATURE REVIEW 30
2.1 Background 30
2.2 Systems 30
2.3 Sustainable Development 31
2.3.1 What is sustainable development? 31
2.3.2 Sustainable Development goals 32
2.3.3 Resilience 33
2.4 Water as environmental capital 34
2.5 The context of Southern Africa 36
2.5.1 Challenges facing developing countries 36
2.5.2 Challenges unique to South Africa 38
2.5.3 Cape Town climate 41
2.6 National legislation, strategies, and policies 41
2.6.1 Historical development of legislation 41
2.6.2 Current national laws, strategies and policies include: 43
2.7 Regional legislation, strategies, and policies 45

2.7.1 Current regional laws, strategies and policies include: 45
2.8 Local legislation, strategies, and policies 45
2.8.1 Current local level strategies and policies include: 45
2.8.2 Governance 49
2.8.3 Examples of successful government organisations 51
2.9 Stormwater 52
2.9.1 Conventional stormwater systems 52
2.9.2 Terminology 53
2.9.3 Sustainable Stormwater Management Systems 55
2.9.4 Urban Water Management 62
2.9.4 SuDS related to this case study 65
2.9.5 WSuD Planning and Management 69
2.9.6 Operational maintenance 70
2.9.8 Technology 74
2.9.9 Training 74
2.9.10 Standards 75
2.9.11 Monitoring 77
2.9.12 Costs 78
2.9.13 Public awareness 79
2.9.14 Outcomes 80
2.10 Open space amenity 80
2.10.1 Natural and man-made systems 80
2.10.2 The role of Landscape Architecture 80
2.10.3 SuDS landscape operations 84
2.11 Success Factors 88
2.11.1 Projects 88
2.11.2 Project success 89
2.11.3 Organisational success 102
2.11.4 Corporate strategy and goals 103
2.11.5 Benefits management 103
2.11.6 Adaptive management 104
2.11.7 Governance 107
2.11.8 Summary 108
2.11.9 Conclusion 109

CHAPTER 3: RESEARCH METHODOLOGY AND DESIGN ... 110
3.1 Introduction ... 110
3.2 Paradigm ... 111
3.3 Case study research design ... 111
3.3.1 Development of the research question ... 111
3.3.2 Research design ... 112
3.3.3 Single case study ... 113
3.3.4 This case study ... 113
3.4 Methodology ... 114
3.5 Research methods ... 115
3.5.1 Mixed method research ... 115
3.5.2 Pragmatic research ... 116
3.5.3 Pragmatic methods ... 116
3.5.4 Tools, techniques, and instruments ... 118
3.5.5 Time period for data collection: ... 118
3.5.6 Geographical area for physical data collection: ... 118
3.5.7 Transcribing ... 118
3.6 Analysis ... 118
3.6.1 Thematic analysis ... 119
3.6.2 Unit of analysis ... 119
3.6.3 Interpretation of data ... 120
3.7 Quality control ... 120
3.8 Ethics in research ... 122
3.8.1 Informed consent of Respondents ... 122
3.8.2 Protection of Respondents ... 123
3.8.3 Storing sensitive information ... 123
3.8.4 Recognition of other scholars ... 124
3.9 Limitations of case study research ... 124
3.9.1 General limitations of case study research: ... 124
3.9.2 Limitations of this case study research: ... 124
3.9.3 Research rigour ... 125
3.10 Conclusion ... 126
CHAPTER 4: DESCRIPTIVE DATA, INTERPRETATION AND RECOMMENDATIONS ... 127
4.1 Introduction ... 127

4.2 An overview of the case 127
4.2.1 Context, biodiversity, climate, and catchment area 127
4.2.2 The original site 129
4.2.3 Zoning information 132
4.2.4 Planning, design, and approvals 136
4.2.5 The Environmental Impact Assessment (EIA) process 139
4.2.6 A complex site 140
4.2.7 Research focus 140
4.2.8 Critical Success Factor themes 141
4.3 Emergent theme 1: Strategic management - A strategic vision with associated objectives 143
4.3.1 Description and findings 143
4.3.2 Discussion and interpretation 147
4.3.3 Recommendations 148
4.3.4 Summary 148
4.4 Emergent theme 2: Adaptive management - SuDS supports a culture of learning 149
4.4.1 Description and findings 149
4.4.2 Discussion and interpretation 167
4.4.3 Recommendations 168
4.4.4 Summary 168
4.5 Emergent theme 3: Strategic management - Clearly defined management objectives underpin success 169
4.5.1 Description and findings 169
4.5.2 Discussion and interpretation 203
4.5.3 Recommendations 206
4.5.4 Summary 206
4.6 Emergent theme 4: Adaptive management - Organisational capacity and technical expertise facilitates adaptive, responsive, and experimental operations 207
4.6.1 Discussion and findings 207
4.6.2 Discussion and interpretation 233
4.6.3 Recommendations 238
4.6.4 Summary 239
CHAPTER 5: CONCLUSION 241

5.1 **Introduction** 241
5.2 **Revisiting the research objectives** 241
5.3 **Revisiting the research question** 242
5.4 **Brief discussion of the key findings** 242
5.5 **Recommendations** 246
5.6 **Final Conclusion** 247

ADDENDA IN GOOGLE DRIVE

Addendum 1: The South African Guidelines for SuDS.
Addendum 2: Ethics Application Form.
Addendum 3: Semi-structured interview questions
Addendum 4: Consent to participate in research
Addendum 5: Water quality of Rivers and Open Water Bodies in the City of Cape Town.
Addendum 6: Century City Precinct Plan, 2009.
Addendum 7: The constructed heronry at Blouvlei, Intaka Island.
Addendum 8: Plants Adapted for Life in the Western Cape.
Addendum 9: Environmental Management Plan (EMP), 2019.
Addendum 10: Operational EMP (OEMP), 2003.
Addendum 11: Operational EMP (OEMP), 2009.
Addendum 12: Memorandum of Incorporation of Century City Property Owners Association (CCPOA) NPC.
Addendum 13: Century City app.
Addendum 14: Species List, 2009.
Addendum 15: Intaka Island Plant Species list.
Addendum 16: Breeding at constructed heronries at Blouvlei, Western Cape.
Addendum 17: Weyers Islands: A Successful design for Constructed Heronries.
Addendum 18: CCPOA budget for 2021.
Addendum 19: Sample transcript
Addendum 20 Nvivo code / node list
Addendum 21 Nvivo exported codebook

See link

LIST OF FIGURES

Figure 1:	Sustainability depicted as three intersecting circles (Calkins, 2012, p. 3) or as nested spheres (Ayres, 2017, p. 8).	P.32
Figure 2:	Sustainable Development Goals (United Nations, 2015).	P.32
Figure 3:	Relationships between the built environment, urban water and WSUD (Armitage, et al., 2014, p. 8).	P.35
Figure 4:	Relational model for green infrastructure (Abbott, 2012).	P.37
Figure 5:	Forces of influence directing urban development in sub-Saharan Africa (Abbott, 2012, p. 20).	P.38
Figure 6:	Adapted framework for Water Sensitive Settlements in South Africa (Armitage, et al., 2014, p. 25).	P.39
Figure 7:	Primary categories of interacting urban natural resources (Abbott, 2012, p. 290).	P.40
Figure 8:	Urban ecosystem and urban green infrastructure models (Abbott, 2012, p. 293 & 296).	P.40
Figure 9:	National Urban Development Framework nine policy levers (IUDF Working Group, 2016, p. 40 & 41).	P.44
Figure 10:	Core elements of the IUDF (IUDF Working Group, 2016, p. 40 & 41).	P.45
Figure 11:	Urban water management transitions framework (Brown, et al., 2009) (Wong & Brown, 2009).	P.47
Figure 12:	A Material Flow Diagram (MFD) quantifying the flow of water resources from the natural environment to the anthroposphere in the City of Cape Town (Cameron & Katzschner, 2017).	P.48
Figure 13:	Key organisations in water management (Beck, et al., 2016).	P.49
Figure 14:	Adaptation actions and links (City of Cape Town, 2020).	P.50
Figure 15:	High performing government organisations (Brown, 2008, p. 228).	P.52
Figure 16:	Diagram indicating the conventional approach to managing stormwater runoff (Armitage, 2011, p. 2).	P.53

Figure 17: The Sponge City approach (Nguyen, et al., 2019, p. 152). P.54
Figure 18: The Sustainable Urban Water Cycle (Grant, 2016). P.55
Figure 19: Water Sensitive Urban Design (WSUD) (Armitage, et al., 2014, p. 46). P.56
Figure 20: Water Sensitive Urban Design (WSUD) (Armitage, et al., 2014, p. 46). P.57
Figure 21: Key components for the integration of WSUD into development projects (Lloyd, et al., 2002, p. 25). P.58
Figure 22: Adapted version of the concept of a SuDS treatment train (Woods-Ballard, et al., 2007, pp. 1-12). P.59
Figure 23: Processes of planning, design, assessment, and implementation of WSUD to urban stormwater management (Lloyd, et al., 2002, p. 3). P.63
Figure 24: Typical detention basin profile (Woods-Ballard, et al., 2007). P.65
Figure 25: Typical longitudinal section through a wetland (Woods-Ballard, et al., 2007). P.68
Figure 26: System development cycle (Nicholas & Steyn, 2017). P.72
Figure 27: SuDS maintenance standards (Charlesworth & Booth, 2017, p. 51). P.76
Figure 28: Inspection and maintenance activities (Charlesworth & Booth, 2017, p. 47). P.78
Figure 29: A depiction of capital versus operational project phases by Charlesworh and Booth, 2017 (Spolander, 2022). P.79
Figure 30; Complex interconnections between ecosystem services and human wellbeing (Armitage, et al., 2014, p. 60). P.82
Figure 31: Landscape classification of ecosystem services (Calkins, 2012, p. 6). P.83
Figure 32: The Logical Framework Method of project success (Baccarini, 1999). P.91
Figure 33: Co-operation between project management and operations management (Cooke-Davies, 2002). P.94
Figure 34: The Iron Triangle (Atkinson, 1999). P.96

Figure 35:	Classification of critical success factors (Belassi & Tukel, 1996).	P.98
Figure 36:	Project Implementation Profile (PIP) (Pinto & Slevin, 1987).	P.102
Figure 37:	Differences between conventional and sustainable approaches to urban drainage (Charlesworth, 2010; Nguyen, et al., 2019).	P.105
Figure 38:	Iterative PSIR framework (Wong & Brown, 2009).	P.107
Figure 39:	The research process (Punch, 2014, p. 12).	P.110
Figure 40:	The benefits of triangulation through multiple sources of evidence (Yin, 2009, p. 93).	P.121
Figure 41:	Cape Floristic Region and succulent karoo biodiversity hotspots (Brownlie, et al., 2005, p. 203).	P.128
Figure 42:	Cape Town climatic data (Wikipedia, 2021).	P.129
Figure 43:	Main rivers and sub-catchments within the City of Cape Town (Liz Day Consulting, 2020, p. 7).	P.131
Figure 44:	Century City Precinct Plan (CCPOA, 2017, p. 1). Refer to Addendum 6.	P.138
Figure 45:	Scenic trail map (CCPOA, 2021).	P.159
Figure 46:	Educational brochures (CCPOA, Intaka Island About & History, 2021).	P.163
Figure 47:	Nvivo word cloud (QDA, 2021).	P.170
Figure 48:	Hierarchy Chart (QSR International, 2022).	P.173
Figure 49:	EMP timeline (Spolander, 2021).	P.174
Figure 50:	Intaka Island signage (Spolander, 2021).	P.178
Figure 51:	CCPOA structure (CCPOA, 2017, p. 6).	P.187
Figure 52	BIIEC Terms of Reference (BIIEC, 2009).	P.189
Figure 53:	Green infrastructure (Armitage, et al., 2014, p. 21).	P.191
Figure 54:	Model of progression into the operational phase	P.212

LIST OF TABLES AND LISTS

Table 1:	Examples of structural BMP's (Lloyd, et al., 2002, p. 7).	P.59
Table 2:	Detention Pond operational requirements (Woods-Ballard, et al., 2007).	P.65
Table 3:	Wetland operational requirements (Woods-Ballard, et al., 2007)	P.68
Table 4:	SuDS wetland functionality and maintenance (Catchment, 2011).	P.72
Table 5:	City of Cape Town SuDS species list (Catchment, 2011).	P.73
Table 6:	Property value factors (USEPA, 1995 as cited in (Armitage, et al., 2014).	P.82
Table 7:	Operational activities (Woods-Ballard, et al., 2007).	P.87
Table 8:	Project success criteria (McLeod, et al., 2012).	P.90
Table 9:	Theoretical critical success factor lists (Belassi & Tukel, 1996).	P.91
Table 10:	Project success assumptions (Ika, 2009).	P.92
Table 11:	Comparison between traditional and integrated water management approaches (Wong & Brown, 2009).	P.105
Table 12:	Sources of data (Yin, 2009).	P.114
Table 13:	Annual plan of operations for Intaka Island (Blouvlei Intaka Environmental Management Committee, 2019, p. 5).	P.180
Table 14:	Goal 6 (Blouvlei Intaka Environmental Management Committee, 2019, p. 23).	P.181
Table 15:	Rating ranges for water quality variables in city vlei's and dams (Liz Day Consulting, 2020, p. 9).	P.196
Table 16:	Annual operational plan (BIIEC, 2019).	P.209

LIST OF IMAGES

Image 1:	Aerial view of the Century City site, taken from the south prior to development (CCPOA, 2021).	P.128
Image 2:	Pre-development aerial view of Century City, taken from the east (CCPOA, Unknown).	P.130
Image 3:	Districts, suburbs, sub-councils, wards and zones (Maps, 2021).	P.132
Image 4:	Zoning map (Maps, 2021).	P.133
Image 5:	Biodiversity Network (Maps, 2021).	P.133
Image 6:	Biodiversity Network (Maps, 2021).	P.134
Image 7:	Indigenous vegetation map (Maps, 2021).	P.135
Image 8:	Soil map (Maps, 2021).	P.135
Image 9:	Wetland map (Maps, 2021).	P.136
Image 10:	Century City Precinct (Google Earth, 2021).Aerial view of the Century City site, taken from the south prior to development (CCPOA, 2021).	P.137
Image 11:	Pre-development aerial view of Century City, taken from the east (CCPOA, 2021).	P.151
Image 12 & Image 13:	Information on the vegetation (CCPOA, 2021).	P.151
Image 14 & Image 15:	Information on the various habitats and information on aquatic plants (CCPOA, 2021).	P.153
Image 16 & Image 17:	Classroom type educational learning opportunities (Spolander, 2021).	P.153
Image 18 & Image 19:	Classroom type educational learning opportunities (Spolander, 2021).	P.154
Image 20 & Image 21:	Lapa and educational signage (Spolander, 2021).	P.160
Image 22 & Image 23:	Educational learning on the wetland pathways and observation deck with seating and educational signage at floating islands (Spolander, 2021).	P.161
Images 24,25,26,27:	Educational boat trips (CCPOA, 2021).	P.161

Image 28:	Recycling, composting and waste management initiatives (Spolander, 2021).	P.176
Image 29:	Aerial view of the Intaka Island in 2009 from the west with wetland cells in the foreground and the ephemeral pans in the background (Armitage, 2011, p. 4).	P.177
Image 30:	Aerial view of the Intaka Island from the west with the wetland cells in the foreground (Williams,).	P.185
Image 31:	Map of Intaka Island with superimposed layout (Google Earth, 2021).	P.194
Image 32 & Image 33:	Constructed heronries in the wetland – cell 3 (CCPOA, 2021).	P.211
Image 34:	Intaka Island depot (Google Earth, 2021).	P.215
Images 35 & Image 36:	Intaka Island depot (Google Earth, 2021).	P.164
Image 37:	*Schinus terebinthifolia* sprouting along the soft edges of the grand canal, Century City (Spolander, 2021).	P.217
Images 38 & Image 39:	Floating jetty with nets and poles (Spolander, 2021) and web page 7: sickle bar reed cutter on the harvester (CCPOA, 2021).	P.218
Image 40 & Image 41:	Catch nets and buoys (Spolander, 2021).	P.218
Image 42 & Image 43:	Bolt jetty maintenance access with 3 aluminium skiffs for scooping aquatic weeds (Spolander, 2021).	P.220
Images 44 & Image 45:	Interconnected educational pathway network with parallel maintenance jeep track. Left – informal access point. Right – formal access point (Spolander, 2021).	P.222
Image 46-49:	Gabions along the Grand Canal (Spolander, 2021).	P.228
Image 50:	Floating islands and other habitat (Spolander, 2021).	P.230

Images 51 & Image 52:	Century City canals and canal levels (Spolander, 2021; CCPOA, 2017).	P.229
Images 53 & Image 54:	Metal perforated aeration pipe under footbridge (Spolander, 2021).	P.232
	Conventional irrigation standpipes (Spolander, 2021) and wetland semi-submerged reed growth (Spolander, 2021).	P.232

LIST OF WEB PAGES AND SOCIAL MEDIA POSTS

Web page 1:	History (CCPOA, 2021).	P.132
Web page 2:	Intaka webcams (CCPOA, 2021).	P.162
Web page 3:	Intaka webcam at the wetland (CCPOA, 2021).	P.162
Web page 4 and 5:	Harvester (CCPOA, 2021).	P.220
Web page 6	Aquatic weed harvester (CCPOA, 2021).	P.217
Web page 7:	Aquatic weed harvester (CCPOA, 2021).	P.219
Web page 8:		
Social media post 1:	Eco centre entrance (CCPOA, 2021).	P.152
Social media post 2:	Educational learning (CCPOA, 2021).	P.154
Social media post 3:	Viewing platform (CCPOA, 2021).	P.155
Social media post 4:	Bird hides (CCPOA, 2021).	P.155
Social media post 5:	Birding photographers in the bird hides (CCPOA, 2021).	P.156
Social media post 6:	Bird hide views (CCPOA, 2021).	P.156
Social media post 7:	School learners at the dipping pond (CCPOA, 2021).	P.157
Social media post 8:	Guided tours (CCPOA, 2021).	P.158
Social media post 9:	Evening hikes (CCPOA, 2021).	P.159
Social media post 10:	Educational boat rides along the perimeter canal (CCPOA, 2021).	P.160
Social media post 11:	Constructed heronries at wetland cell 3 (CCPOA, 2021).	P.194
Social media post 12	Bird counts by rangers (CCPOA, 2021).	P.196

Social media post 13:	General maintenance (CCPOA, 2021).	P.202
Social media post 14:	Caracal sighting (CCPOA, 2021).	P.202
Social media post 15:	Bird photography (CCPOA, 2021).	P.203
Social media post 16:	Aquatic weed harvester (CCPOA, 2021).	P.218
Social media post 17:	Constructed heronry (CCPOA, 2021).	P.226
Social media post 18:	Floating island habitat (CCPOA, 2021).	P.227

GLOSSARY OF TERMS

Best Management Practises (BMP's): May be interpreted in a multitude of ways but mainly describes a structured approach in the prevention, mitigation and management of stormwater pollution through structural and non-structural interventions by considering the total water cycle (Fletcher, et al., 2014; Lai , et al., 2007; Wong & Brown, 2009).

Blouvlei Intaka Island Environmental Committee (BIIEC). This committee was established to guide the implementation of the Environmental Management Plan (BIIEC, 2019).

Century City Property Owners Association (CCPOA): Means the section 21 Company constituted in terms of the Articles of Association (CCPOA, 2017).

Environmental Impact Assessment (EIA): This type of environmental assessment became regulated in South Africa in 1997 and refers to "a systematic process of identifying, assessing and reporting environmental impacts associated with an activity" (Department of Environmental Affairs, 2017, p. 218).

Environmental Management Plan (EMP): Environmental Impact Assessments have been accepted practise for scoping and assessment of environmental issues on projects. It required a supportive approach for operational aspects relating to an EIA. The EMP is the vehicle through which the recommendations in the EIA are realised by providing an outline of methods and procedures to be followed that will ensure mitigation measures in the EIA are fulfilled (DEAT, 2004).

Integrated Urban Water Management (IUWM): Integrated management of all the elements of the water cycle within a specified catchment area including water, groundwater, wastewater, and stormwater (Biswas, 1981; Fletcher, et al., 2014).

Low Impact Development (LID): Aims to retain the pre-development hydrological state of a site by retaining and treating stormwater at source (Lai , et al., 2007).

Source control (SC): Refers to the practise of attenuating stormwater on site where runoff starts (Fletcher, et al., 2014).

Sustainable Stormwater Management (SSWM): Design interventions that introduce spatial planning to water management.

Sustainable Urban Drainage Systems (SuDS): May be described as an approach to treat stormwater in a more sustainable way such that the natural cycles of the original site are replicated as closely as possible through a series of stormwater facilities that form a treatment train (Fletcher, et al., 2014).

Water Sensitive City (WSC): A Water Sensitive City considers the total water cycle in the sustainable design and development of urban areas catchment and allows users to access water resources in different ways that ensures a healthy environment with social, environmental, and economic benefits (Water Sensitive Cities Australia, 2022).

Water Sensitive Settlements (WSS): This is where management of the urban water cycle is handled sensitively and sustainably by considering the total water cycle and its interaction with urban design for the benefit of all ((WRC), 2015).

Wetland: Refers to the 8-hectare area designated as wetland and forming part of the greater 16-hectare nature reserve that is recognised as Intaka Island.

Water Sensitive Urban Design (WSuD): The principal application is in the management of water and this approach has objectives to protect and enhance the natural water system, integrate stormwater management with the landscape, protect water quality by reducing sediment and contaminants from runoff, reduce runoff through the preservation of natural hydrological cycles of a catchment, minimise infrastructure costs, creating value through the provision of amenity for passive and active recreation (Fletcher, et al., 2014; Lähde, et al., 2019).

Integrated Urban Water Management (IUWM): Integrated Urban Water Management (IUWM) has been described by UNEP (2003) as the practise of managing various services within an urban area that is considered a “unit of management” and connects urban water resources that rely on water supply (Carden, et al., 2009).

ACRONYMS

BIIEC	Blouvlei Intaka Island Environmental Management Committee
CCPOA	Century City Property Owners Association
CBA	Conservation and Biodiversity Area
CSF	Critical Success Factors
CSIR	Council for Scientific and Industrial Research
LID	Low Intensity Development
SDG	Sustainable Development Goals
SuDS	Sustainable Urban Drainage Systems
WSC	Water Sensitive Cities
WSUD	Water Sensitive Urban Design

CHAPTER 1: INTRODUCTION

1.1 Context

> Sustainable practise is the medium through which current needs are addressed without compromising the needs of future generations (Brundtland, 1987). It is the pursuit of a humane and equitable global society, aspiring to achieve human dignity for all (United Nations, 2002, p. 6).

The earth acts as a support system for abundant human, animal, and plant life but some of its resources are limited and have been impacted by increased urbanisation and development stemming from population growth and change in recent years (Ayres, 2017; Casal-Campos, et al., 2018; Qiao, et al., 2018; Wong & Brown, 2009). Growing human populations place spatial and resource strain on the biophysical environment especially in cities and rapid urbanisation has resulted in increasing interactions at the interface between man-made and natural systems, impacting negatively on biodiversity, resulting in the collapse of natural systems with a detrimental impact on ecosystem goods and services and consequently a compromised existence for all (Ayres, 2017; Grant, 2016). To counter the consequences from these negative impacts, more sustainable approaches are being pursued to protect and enhance resources (Wong & Eadie, 2000). The principles of sustainability focus on the long-term conservation of the earth's features, preservation of ecosystem services and mitigation of the effects of environmental degradation (Geissdoerfer, et al., 2017). This is supported by the interconnected spheres of the triple bottom line: economic, environmental, and social performance which underpin life on earth (United Nations, 2002; Purvis, et al., 2019).

The earth has been described as a closed system with finite capacity supporting human activities through its co-existing sub-systems (Boulding, 1966; Geissdoerfer, et al., 2017). These interconnected sub-systems evolve and change in relation to each other to maintain an equilibrium and sustain life (Calkins, 2012). The existence of a stable state is the ideal for life, but various predictable and emergent factors have the potential to reduce resilience, increase vulnerability and exacerbate risk (Ayres, 2017). Risk is considered a function of frequency and severity where the former is influenced by natural factors and the latter is influenced by both natural and man-made factors.

Rapid advancement in research is required to further understand humans and their relationship to the environment, to advance innovative technologies and practical solutions that address the numerous complex challenges and risks facing mankind (Geissdoerfer, et al., 2017; Kates, et al., 2005). Increasing unique environmental challenges have stimulated a movement away from purely mitigating risk, toward proactive long-term equitable management of natural resources and systems for the benefit of human life and public health (Butler, et al., 2008).

The most essential resource for mankind is water as it is required for many life-sustaining activities (Ayres, 2017; Postel, 1999). As urban populations increase, pressure is placed on supply chains, bringing the topic of water security to the fore, especially in water scarce and developing countries such as South Africa. Water scarcity limits a country's capacity to safeguard access of acceptable quality water (Ayres, 2017). Provision of basic services such as water of a suitable standard for personal, business and industry usage, is one of the most significant challenges currently facing South Africa. Scarce water supply has led to increasing demand for sustainable water management, to improve resilience and adaptability in urban communities (Wong & Brown, 2009). Ayres (2017) argues that sustainable development alternatives potentially expand resilience as access to natural resources such as water is optimised, and risk reduced. However, sustainable development is a process rather than a static state and requires long-term holistic planning and management (Armitage, et al., 2013).

1.2 Background to this research

Open space networks in cities are planned with consideration of the available local natural resources and often respond with designs that include elements of hard and soft landscape infrastructure suitable for multi-use active and passive recreational amenity (Grant, 2016). Blue green infrastructure forms part of that network of inter-connected open spaces and ecosystems which contain an abundance of natural resources (Armitage, et al., 2014). This network relies on natural resources such as vegetation, soil, water, and other natural elements to harmonise and restore natural processes. Conversely, impermeable surfaces form barriers to natural processes such as the hydrological cycle, resulting in reduced ground water absorption (Nguyen, et al., 2019). This creates a disconnect within the water cycle by artificially increasing peak flows and surface runoff (Radcliffe, 2019; Harvey, 2017; Wong & Brown, 2009). Hardened surfaces and barriers also result in restricted movement corridors for local flora and fauna, thereby compromising wildlife habitat and diminishing water quality which is vital for natural function (Armitage, 2011; Sullivan & O'Keeffe, 2011). Historically, impervious surfaces have formed part of developments to manage and mitigate inconvenience and risk posed to human life, but the negative impacts thereof have become increasingly obvious (Butler, et al., 2008; Radcliffe, 2019).

Traditionally, inconvenience and risk has been managed purely from an infrastructural and institutional perspective by designing conventional systems that separate potable, waste, and storm water systems through a constructed network of drainage pipes (Wong, et al., 2011; Butler, et al., 2008). This approach is unsustainable (Brown, 2008; Wong & Brown, 2009). The knock-on effect of poorly integrated, inadequate, and inappropriate infrastructure, urban management, and law enforcement is evidenced in poor quality public amenities, services, safety, security, health, and social wellbeing which negatively impact on quality of life (Armitage, et al., 2014). Holistic solutions that consider and incorporate the total water cycle are more likely to bring about increased resilience (Wong & Brown, 2009). However, these solutions should not be considered an end-state but rather part of a system that is forever changing and evolving. A clear vision is needed to encourage growth, stability, and inclusivity through refined service delivery models, capital infrastructure and adaptive urban water management to meet growing demands (COGTA Working Group, 2016). These demands can be met by utilising human and economic capital to carefully and sustainably plan, design, and manage drainage systems (Armitage, et al., 2014). Coherent management strategies that compliment sustainable design initiatives, are essential to address water consumption, distribute water efficiently and steward resources sustainably (Rural Development and Land Reform, 2018).

Strategies for designing and managing Water Sensitive Cities are aimed at protecting, regenerating, and repairing environments, addressing public health needs, providing social and economic benefits that ultimately build resilience (Brown, et al., 2007). Similar integrated and interdisciplinary approaches are described and documented worldwide such as Water Sensitive Urban Design (WSuD) in Australia, Sustainable

Urban Drainage Systems (SuDS) in South Africa and Best Management Practises (BMP's) elsewhere are approaches that are more likely to optimise benefits to society as they promote ecological functioning of urban open space (Butler, et al., 2008; Department of Housing, 2000). There are four main objectives in the pursuit of ecological functioning of open space, namely: 1. improving water quality; 2. managing water quantity; 3. maintaining biodiversity and 4. enhancing amenities by addressing design, maintenance, cost, and risks (Armitage, et al., 2013).

Much focus has been placed on the planning, design, and implementation phase of SuDS projects, however the operational phase of projects may be considered more critical to value creation and long-term success. Most of the current literature discusses operational aspects of SuDS in broad terms but further research is required to understand in more detail how natural systems may be better managed and maintained considering that these biodiverse systems that produce ecosystem goods and services and are essential for life (Grant, 2016; Sullivan & O'Keeffe, 2011). For this reason, the author will conduct research to investigate the various factors that contribute to successful operational outcomes to achieve a balance between biodiversity, ecosystem integrity and amenity to yield ecosystem goods and services. This may ultimately lead to the establishment of a framework or guideline for sustainable landscape operational practises in the post-completion phase of projects to support current SuDS literature.

1.3 Research problem area and statement

An extensive number of project Critical Success Factors have been outlined in the literature (Mavi & Standing, 2018). Quantitative metrics such as the iron triangle link to the hard paradigm as described in the PMBOK (Ebbesen & Hope, 2013; Pollack, 2007; Mavi & Standing, 2018). These are supplemented with metrics that are more pragmatic and subjective, such as the ethics (Mishra et al, 2011; Mavi & Standing, 2018), competence and experience of the project manager, quality of communication and management of stakeholders (Alam et al, 2008; Mavi & Standing, 2018). Human factors are reported to contribute more significantly to project success than technical factors and therefore need to be explored further (Mavi & Standing, 2018). Investment into researching new technology and infrastructure endeavours to meet urban water sustainability goals (Wong & Brown, 2009). Research in the field of SuDS has been boosted through increased implementation (Torres, et al., 2019). But the question remains as to whether these factors apply during the operational phase of a project (Ebbesen & Hope, 2013). Organisations still appear to have values that are not sufficiently sensitised to managing urban water sustainably and there is reportedly a degree of apathy in administrative systems associated with alternative sustainable approaches (Brown, 2008). Without an understanding of the Critical Success Factors (CSF's) of SuDS that specifically relate to hard and soft landscape operations, undesirable outcomes are more likely. The question remains as to whether the Critical Success Factors on projects, as established in the literature, apply to SuDS projects within the context of landscape operations. SuDS landscape operations have formed part of this research, to test and build on theory and practise.

Hence, the problem statement is:

Little is known about the key Critical Success Factors and best management practices in the post-completion and operational phase of Sustainable Urban Drainage Systems (SuDS) landscape projects.

1.4 Research question

What are the key Critical Success Factors in the management of landscapes during the operational phase of Sustainable Urban Drainage Systems (SuDS) projects?

1.5 Research aim

To understand the Critical Success Factors of Sustainable Urban Drainage Systems (SuDS) post completion, during the operational phase to meet sustainability objectives and ensure optimal long-term outcomes specifically relating to the landscape components.

1.6 Research Objectives

In answering the research question stated above, the main research objectives are stated as:

- To determine whether Critical Success Factors exist for SuDS during the operational phase of a project.
- To identify these Critical Success Factors and organisational approaches that are likely to best influence successful outcomes in SuDS landscape operations.

1.7 Research methodology

Research is a systematic process of inquiry where data is collected, analysed, and interpreted in increasingly complex and diverse ways. This is influenced by the researcher's theoretical framework which forms the basis of establishing connections between the various constructs of a phenomenon (Mackenzie & Knipe, 2006). The author applied the pragmatic paradigm in underpinning the research which influences the way knowledge is studied and interpreted (Mackenzie & Knipe, 2006). This choice sets out the philosophical intent, motivation and expectations for the research and provides the foundation for choices in the methodology and research design. The nature of research design is motivated by the objectives of the research (Benatar & Cameron , 2015). A traditional theoretical grounding in both the positivist or hard paradigm and interpretivist or soft paradigm epistemology is entertained in developing theory (Pollack, 2007). The research paradigm and methodology connect to form the cyclical research study (Mackenzie & Knipe, 2006). For the purposes of this research, the following research methodology will be employed:

1. A literature review of Critical Success Factors with a specific focus on operational aspects that relate to Sustainable Urban Drainage Systems (SuDS).
2. A single local case study of successful SuDS in the operational phase will be undertaken applying a pragmatic approach to data collection of the landscape component and will comprise the following:
    - Review: supporting documentation, websites, social media posts and other documentation available to the public.
    - Semi-structured interviews: these were held with key stakeholders involved in operational decision-making.
    - Field work: observations and photographic material of SuDS landscape operations.

3 The collected data will be analysed using pragmatic thematic analysis.

4 Lastly, conclusions will be drawn, and recommendations made in terms of the Critical Success Factors of SuDS in the post-completion operational phase.

1.8 Structure of thesis

Chapter 1 Introduces the research that describes the background to the problem. This is followed by the research problem, research aim, research question, research objectives and an overview of the methodology to be employed.

Chapter 2 Provides a critical literature review of Project Management Critical Success Factors with a specific focus on operational aspects that relate to SuDS.

Chapter 3 Documents the methodology and research design to be employed in this study.

Chapter 4 Contains the description of findings, discussion and interpretation and recommendations.

Chapter 5 Draws conclusions in terms of Critical Success Factors on SuDS projects post-completion highlighting the significance of landscape operations.

CHAPTER 2: LITERATURE REVIEW

2.1 Background

Global population growth preserves human society and is often associated with the development of stable economies, but it results in increased pressure on resources, loss of biodiversity, degradation of natural ecosystems and climate change (Ayres, 2017). Due to unsustainable practices and re-engineering of the planet, the earths resource base has been significantly compromised and global biophysical limits have been exceeded thereby undermining human development (Ayres, 2017; Steffen, et al., 2015; Walker & Salt, 2006). This is considered the greatest challenge to sustainability as it threatens resource availability, impacts global weather patterns, and causes significant changes to the steady state of water resources (Abbott, 2012). Changes to weather patterns are evidenced in extreme events such as flooding, drought, sea level change and have extensive economic consequences (Walker & Salt, 2006).

2.2 Systems

A system is a set of interconnected individual elements or component parts that are structured in a manner that together display a set of unique characteristics and functions, making them resilient, adaptable, responsive, self-healing and able to bring about change (Meadows, 2008; Ayres, 2017). Ayres (2017) describes ecosystems as dynamic open systems with constant flows of matter and energy within closed systems such as the earth allowing free flow of energy. Meadows (2008) defines systems as a set of interconnected parts with operating stocks and flows, modelled and having feedback loops. Systems respond to change through stock flows that result in time delays (Ayres, 2017). The operating unit of a dynamic system is the feedback loop which amplifies or diminishes system disturbances (Ayres, 2017). Feedback loops indicate responsiveness to system changes, while connections indicate flows of resources or capital and their adherence to certain rules and laws (Ayres, 2017). Managers who deal with dynamic systems and complex problems face the dilemma of managing systems responses (Meadows, 2008). Walker (2006) emphasises the importance of recognising complexity, uncertainty and change from a systems perspective in contrast to purely recognising quantitative measurements of performance. Due to the challenges posed by complex environmental systems, a strong grounding in systems theory is helpful when considering appropriate approaches that respond to socio-environmental conditions. Once the workings of a system and the factors that induce results in these systems is understood, one may better understand the problem and identify possible solutions, thereby steering systems toward patterns of behaviour that are more beneficial (Meadows, 2008). A systems thinking perspective is best accompanied by independent economic, environmental, social, political, technical, and organisational considerations (Vice, 2011). Linear thinking with a single-minded focus on end states wis likely to limit effective functioning of systems, outcomes and fail to address and manage environmental complexity appropriately (Vice, 2011). This necessitates a change in approach toward non-linear, organic thinking to ensure more appropriate outcomes (Vice, 2011). Integrated environmental, economic, and social aspects underpin sustainable practise.

2.3 Sustainable Development

2.3.1 What is sustainable development?

The term sustainability has become commonplace in society today and there are varied perceptions associated with this term. It most commonly describes the three interconnected spheres or the “triple bottom line” of economic, social, and environmental sustainability (Calkins, 2012; Purvis, et al., 2018). Ayres (2017) depicts the concept of three nested spheres, depicted in Figure 1. The Brundtland Commission formally defined sustainability as the ability to meet current human needs in order to preserve human wellbeing without compromising the future of subsequent generations (Ayres, 2017; UNEP, 2007; Walker & Salt, 2006; Keeble, 1987). Sustainability from an environmental science perspective implies that human needs are met without increasing throughput of matter and energy beyond the regenerative capacity of a system, specifically applied to the field of planning, design, and development of the built environment, integrated with the natural environment so that the systems of economic, social, and environmental capital are preserved and upheld without exceeding biocapacity (Abbott, 2012). These definitions imply:

- good stewardship or management with care (Harvey, 2017).
- efficient use of resources (Walker & Salt, 2006).

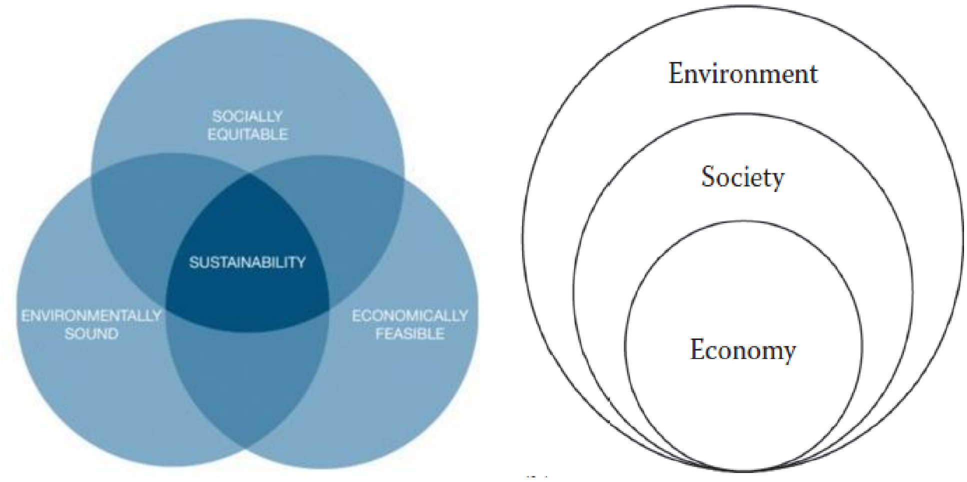

Figure 1: Sustainability depicted as three intersecting circles or as nested spheres (Ayres, 2017, p. 8; Calkins, 2012).

2.3.2 Sustainable Development goals

The United Nations adopted Sustainable Development Goals (SDG's) in 2015 which are geared toward worldwide peace and prosperity by 2030. The seventeen integrated goals are intended to balance economic, environmental, and social sustainability (United Nations, 2015). This research is mainly concerned with SDG 11 – Sustainable Cities and Communities as depicted in Figure 2.

Figure 2: Sustainable Development Goals (United Nations, 2015).

2.3.3 Resilience

Ayres (2017) puts forward the notion that urbanisation potentially leads to a more concentrated footprint on the earth with a lower demand for infrastructure beyond the urban edge, potentially making cities more efficient through economies of scale and increasing the earths carrying capacity**.** However, urbanisation also results in the removal of vegetation and an increase of hardened impervious surfaces, changing the characteristics and quality of surface runoff as it transports waterborne contaminants such as heavy metals into receiving waters (Barbosa, et al., 2012; German, et al., 2005; Goonetilleke, et al., 2005). This leads to stormwater quality and quantity issues that arise from development, negatively impacting the relationship between humans and nature in urban areas, ultimately leading to human and environmental health issues (Barbosa, et al., 2012; Harvey, 2017).

Vulnerable communities are more profoundly affected by extreme events (Abbott, 2012). Conversely, more "*resilient systems can sustain their structure and function over long periods*", showing a connection between resilience and sustainability (Ott, 2003, p. 49). Resilience refers to the amount of disturbance that can be absorbed by a system while remaining stable in a set state, indicating an ability to self-organise. It also refers to the degree to which a system can build capacity to adapt (Ayres, 2017; Mazur, 2013; Wong & Brown, 2009). Resilient systems encompass a diversity of elements, functions, uses and response mechanisms while redundancy describes a variety of ways to perform those functions to ensure their longevity (Ayres, 2017). Relationships between the natural and built environment offer opportunities to foster resilience through adaptive strategies that support conservation, preservation, restoration and efficient resource use with a positive effect on biodiversity and quality of life (Ayres, 2017; Armitage, et al., 2014; Abbott, 2012). Green cities are made up of urban environments that apply sustainable, efficient, resilient, and adaptive strategies with robust solutions for the benefit of both society and the environment (Rodrigues & Antunes, 2021; Brears, 2018).

Resilience science teaches us that ecosystems and natural resource supply systems cannot be maintained in an optimal state because complex, adaptive systems are dynamic, having uncertain rates of regeneration (Ayres, 2017). Socio-ecological systems may rather be described as having numerous stable states with thresholds that impact on system behavioural changes (Walker & Salt, 2006), losing resilience if overstressed and making it difficult to return to a previous state (Ott, 2003). Constant change requires careful and efficient management with an understanding of system archetypes and adaptive cycles (Walker & Salt, 2006). Current management approaches protect human activities from variability in environmental conditions and decrease risk by applying technical innovation which may result in positive feedback loops (Wong & Brown, 2009). Positive feedback loops have the potential to destabilise a system due to exponential growth whereas negative feedback loops, stocks are more constant and stable (Ayres, 2017). Significant changes in a system may be tempered by applying the precautionary principle which promotes accountability in decision-making so as not to cause harm (Ayres, 2017). This approach accommodates the cycles of growth, conservation, release, reorganisation, and awareness in ecological systems which form the basis of adaptive management (Ott, 2003).

2.4 Water as environmental capital

Water is regarded as the most essential resource that sustains life (Ayres, 2017; Postel, 1999). Because it is a finite resource, strong sustainability strategies have been developed to defend the efficient use and protection of this asset as part of the broader economic, social, and environmental capital (Ayres, 2017; Ott, 2003; Walker & Salt, 2006). The hydrological cycle sits within the earths closed system and forms part of its greater environmental capital, containing existing stocks of water mass such as oceans and groundwater to smaller and more transitional water bodies, connected via flows. Water stocks are continually transferred, with inflow and outflow rates affecting stock sizes and the equilibrium (Ayres, 2017). Environmental flows refer to the total water available in a system as well as the spatio-temporal distribution of water that is necessary for healthy function to maintain system integrity and ensure the continuation of environmental services by that system (Dyson , et al., 2003; Pahl-Wostl, 2007).

Access to water has been declared a human right by the United Nations however the hydrological cycle is being impacted by humans globally as the demand for water intensifies and water security diminishes, compromising the sustainable use thereof (Ayres, 2017). Due to problems such as overharvesting and pollution, the quantity and quality of water available for human use has reduced and exposure to contaminated water has become the greatest environmental reason for sickness, posing a risk to public health and safety (Ayres, 2017). To counteract this, sustainable development utilises resources via the conduit of infrastructure, which acts as a mediator in the pursuit of economic prosperity and sustainability goals while promoting intergenerational and social equity (Abbott, 2012; Ott, 2003). The economic, environmental, and social context reflect the value of water (Rodrigues & Antunes, 2021). This is depicted in Figure 3 which highlights the interactions between the built environment, the urban water system, and Water Sensitive Urban Design (WSUD) (Armitage, et al., 2014).

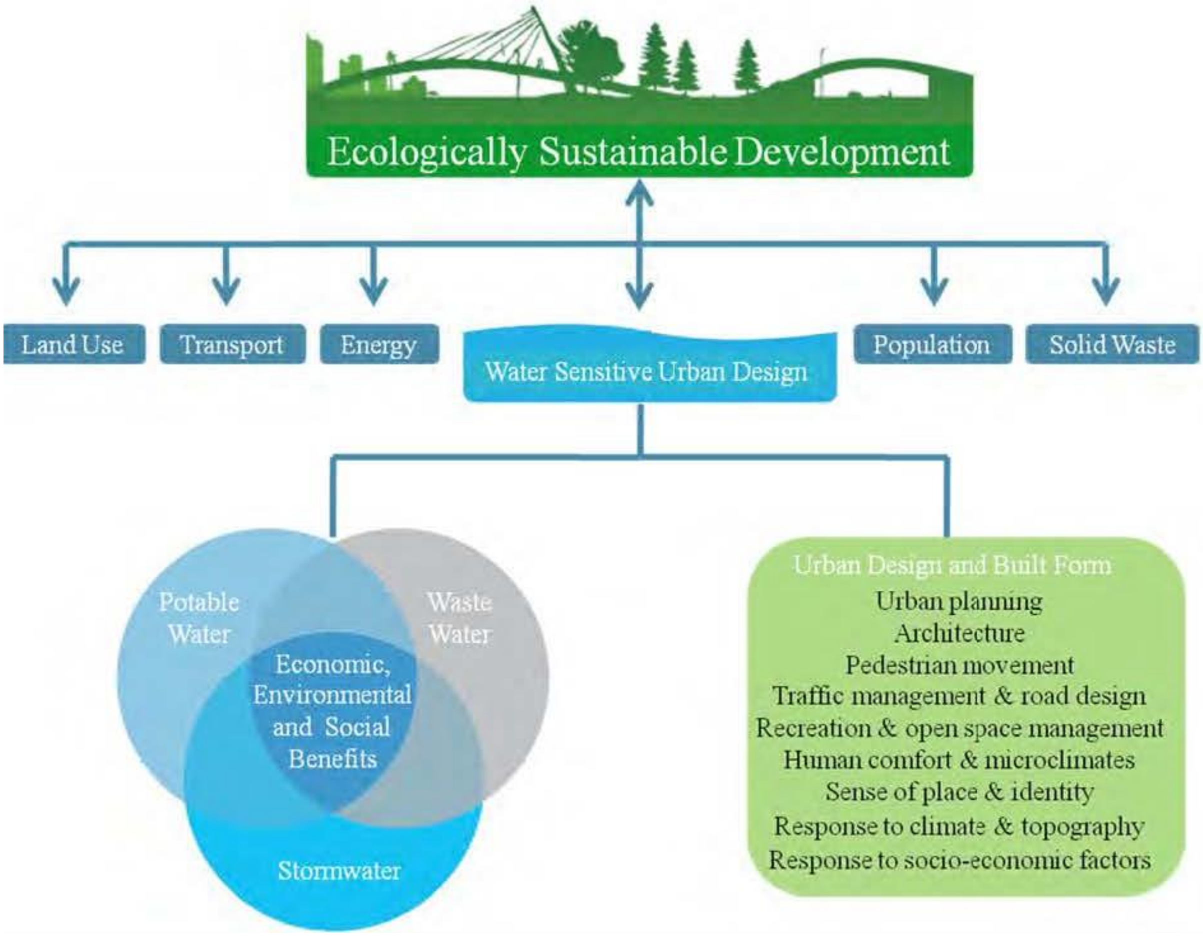

Figure 3: Relationships between the built environment, urban water and WSuD (Armitage, et al., 2014, p. 8).

2.5 The context of Southern Africa

2.5.1 Challenges facing developing countries

Globalisation, urbanisation, and poverty are factors that influence sustainability in developing countries (Ayres, 2017). Rapid urbanisation has impacted weather systems (Enqvist & Ziervogel, 2019; Grasham, et al., 2019). To cope with climate change variability, cities are adopting a combination of proactive and reactive measures (Buurman, et al., 2017; Enqvist & Ziervogel, 2019). In Sub-Saharan African countries, the dominant planning and development paradigm was aligned with international funding which was grounded in an approach founded on an external model from a different culture, society, economy, politics, and timelines and may be considered a model that failed in the South African context (Abbott, 2012). A shift away from infrastructure as the basis for urban development and urban growth was spurred on by spatial and economic development, with a reliance on urban spatial planning while infrastructure was delegated as a subsidiary support service (Abbott, 2012) and considered less important in an urban context, and therefore often eliminated from the planning process even though it is an integral part of the social and cultural fabric of society (Abbott, 2012).

Urbanisation also resulted in a tendency towards centralised governance (Abbott, 2012). Centralised systems are vast and operate in a linear fashion, with huge capacity built over time. Any meaningful decentralisation to bring about better resilience, predictability and adaptation to change initially requires parallel operation of both systems which can prove challenging (Chocat, et al., 2007). The benefit of decentralisation is an abdication of centralised responsibility and transference to local communities and individual homeowners, but if not managed correctly, this may lead to quality issues and ultimately failure of a system (Chocat, et al., 2007). To ensure successful outcomes, urban planning models need to be at the forefront of development, they need to be interactive, relevant, appropriate, and contextual to provide adequate frameworks for sustainable development (Abbott, 2012).

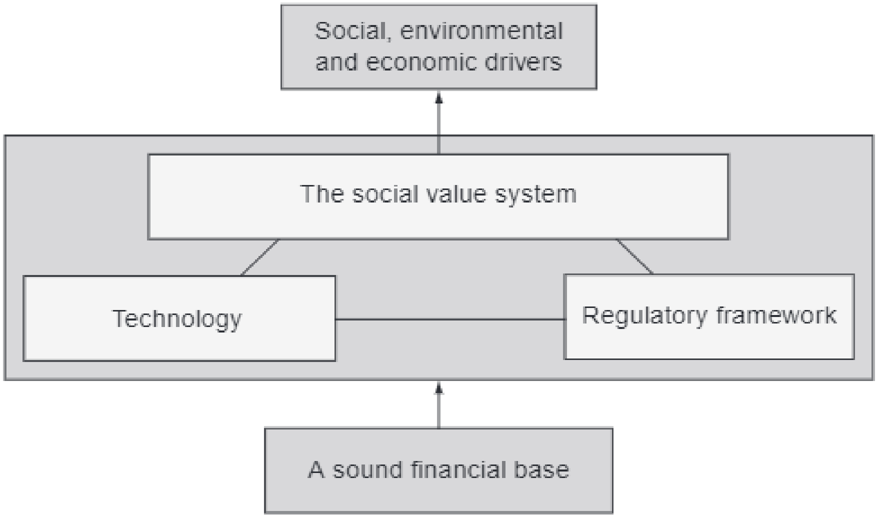

Figure 4: Relational model for green infrastructure (Abbott, 2012, p. 265).

Since worldview or weltanschauung is considered to significantly influence the development approach of a culture and society, the weltanschauung located in African urban society should allow for the fostering of unique models and drawing lessons from the precedents set by developing countries where development patterns, interactive models and associated solutions have grown out of unique needs to tackle the conflict between development and sustainability (Abbott, 2012). Abbott (2012) describes four thematic forces in infrastructure delivery and management, as depicted in Figure 5 and recommends an understanding of these forces of influence as a starting point (Abbott, 2012). More flexible models accommodate increasing complexity such as models developed for green infrastructure that incorporate social, environmental, and economic drivers (Abbott, 2012). Sustainable urban system models require a grounding in the current environmental context and need to be founded on a new urban green economy which takes a holistic view of urban development to effectively address urban water management needs (Abbott, 2012).

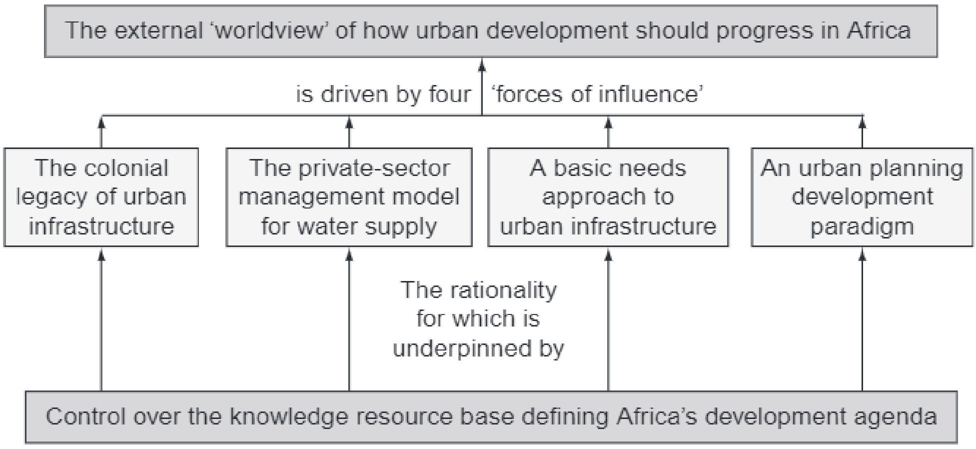

Figure 5: Forces of influence directing urban development in sub-Saharan Africa (Abbott, 2012, p. 20).

2.5.2 Challenges unique to South Africa

South Africa still faces the challenge of overcoming the legacy of historical state-led racial and economic inequality which resulted in unequal access to public amenities and service delivery (Enqvist & Ziervogel, 2019). The lack of infrastructure and delayed or low-quality service delivery to the general population, many of whom likely fit within a mid to lower income bracket, coupled with constraints in management and operational capacity have been critical concerns and are evidenced in poor urban development outcomes (Abbott, 2012). Poor management is described as the "single greatest and most urgent development constraint facing South Africa" (Cameron & Katzschner, 2017; Scholes, 2001). This has led to a contentious debate regarding the inclusion of the private sector in the supply of services that are currently fragmented and aging (Abbott, 2012; Chocat, et al., 2007). Water scarcity increases the pressure to privatise but as a resource that flows and changes form, this proves difficult, further complicated by differing opinions (Ayres, 2017). The World Bank and International Monetary Fund are promoting Integrated Water Resource Management (IWRM) and privatisation with the motivation that this will encourage conservation initiatives and facilitate equitable service delivery (Ayres, 2017; Cameron & Katzschner, 2017). According to the Bill of Rights in South Africa's Constitution, access to safe water and sanitation are deemed a basic human right, reinforced by environmental sustainability, social and economic equity and therefore should not merely be thought of as a tradeable commodity to be privatised (Cameron & Katzschner, 2017; Chocat, et al., 2007; Government of South Africa, 1996), as the private sector often focuses on cost efficiency, control of labour costs and profit through increased service fees (Chocat, et al., 2007). An understanding of the critical relationships between public and private sectors and their dominant value systems or world views within any development framework may assist in the development of an entirely new system (Abbott, 2012). Armitage (2014) provides an adapted framework that envisions an equitable future through Water Sensitive Settlements in South Africa as depicted in Figure 6 where two existing separated systems of formal and informal areas are integrated into one equitable system with the end goal of intergenerational equity (Armitage, et al., 2014).

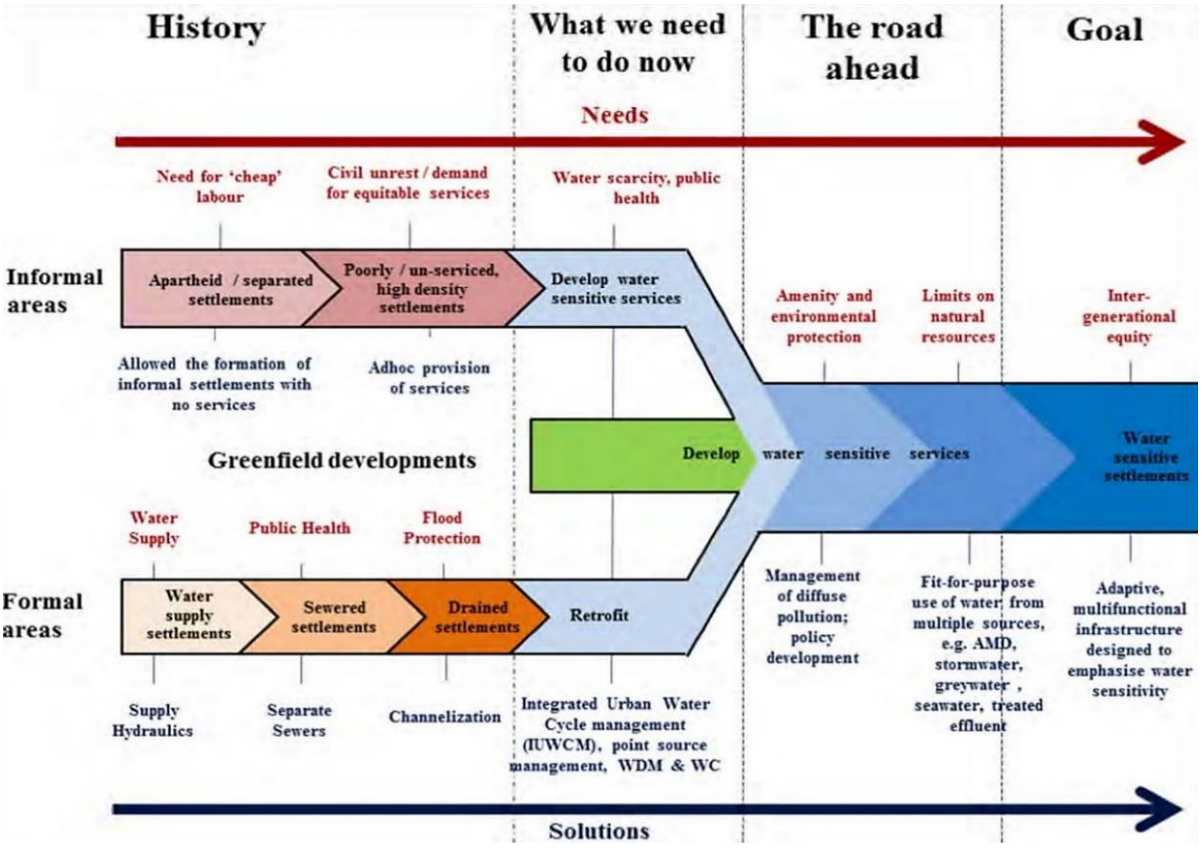

Figure 6: Adapted framework for Water Sensitive Settlements in South Africa (Armitage, et al., 2014, p. 25).

Compliance with Agenda 21 principles (Abbott, 2012) is important. In doing so, developing countries such as South Africa have the potential to leapfrog outdated technologies and environmentally harmful stages of development and steer investment toward environmental imperatives (Ayres, 2017). An urban ecology paradigm may be more appropriate as the basis for infrastructure planning where resources are transferred equitably (Abbott, 2012). Abbott (2012) draws from the model of the city as part of a wider ecosystem (Schwirian, 2007) by proposing a new conceptual model in Figure 7, with carefully planned and managed urban infrastructure that mediates the movement and use of resources (Abbott, 2012).

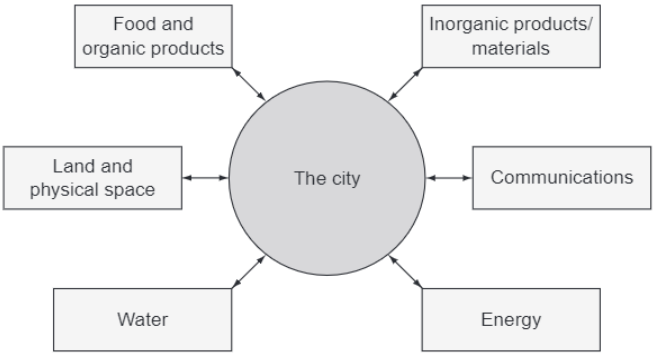

Figure 7: Primary categories of interacting urban natural resources (Abbott, 2012, p. 290).

Abbott (2012) suggests that the key to sustainable development in sub-Saharan Africa is the integration of metabolic and eco-city models that regard cities as the convergence of systems where urban development contains infrastructure that facilitates resource flows sustainably and independently yet tolerating a level of interacting cross-boundary sub-systems for convenience to meet functional needs and objectives collectively and individually (Abbott, 2012). He creates categories of urban activities in the green infrastructure models depicted in Figures 8 and recommends that they be recognised as interacting resource systems, underpinning the city as a geopolitical, socio-spatial, and economic system which impacts on the natural system.

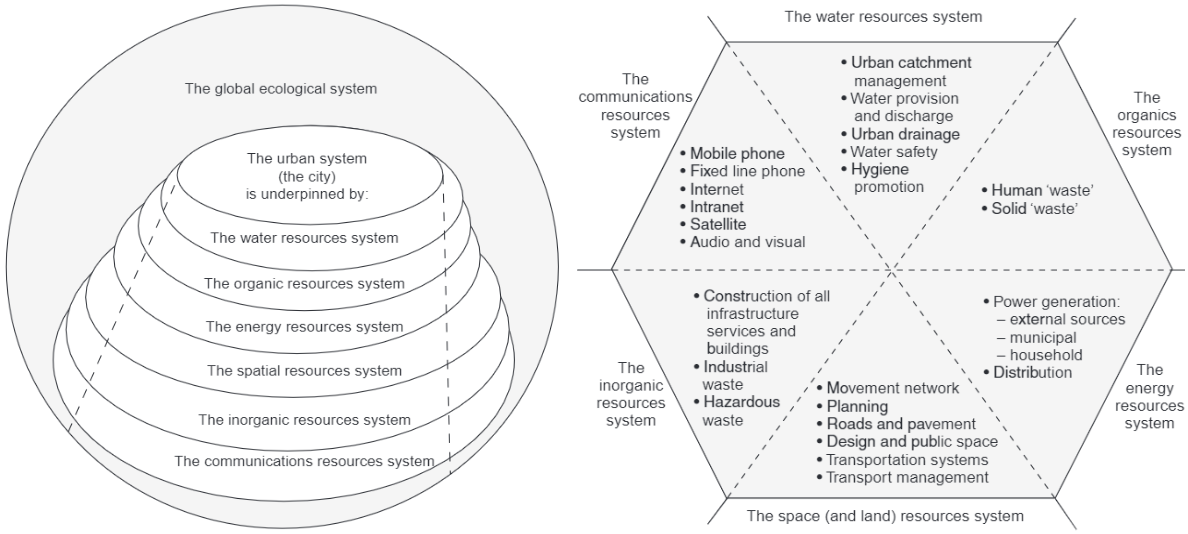

Figure 8: Urban green infrastructure models (Abbott, 2012, p. 293 & 296).

Abbott is mainly addressing development in secondary towns in South Africa, which form the basis and context of his research, however in his account of the historical development of systems, the models appear somewhat incomplete in their lack of inclusion of the crucial component – the open space network – within which hydrological systems are nested. The open space network provides a framework of interconnected corridors of natural, semi-natural and artificial ecological systems which serve urban development (Harvey, 2017; Sandstrom, 2002). Such open space systems facilitate natural and infrastructure flows and serve as a connecting thread around which human activities are focussed.

2.5.3 Cape Town climate

The consequences of water scarcity are enormous, considering that many primary activities and ecological systems rely on availability of water for health functioning (Cameron & Katzschner, 2017; Enqvist & Ziervogel, 2019). Climatically, South Africa has low rainfall with high variability and poor-quality water due to pollution. Cape Town receives most of its water in Winter, with heavy rains often resulting in saturation of the ground water table and flooding in low lying areas due to inadequate infrastructure and management (Enqvist & Ziervogel, 2019; Jozipovic, 2015). Like many other cities, Cape Town has been experiencing increasing demand in anthropogenic consumption resulting in strain on water resources, exacerbated by predictions of uncertain rainfall, considerable dryness and decreasing supply (Enqvist & Ziervogel, 2019; Cameron & Katzschner, 2017). This decreased supply potentially poses a threat to human life in the face of extreme events such as the drought of 2017 which was unprecedented (Enqvist & Ziervogel, 2019; Mariño, 2017). It cemented the fact that water security is not guaranteed (Harvey, 2017).

2.6 National legislation, strategies, and policies

2.6.1 Historical development of legislation

Generally, water policies, land use planning and practise are still considered unstainable worldwide (Ayres, 2017; Oelkers & Valsami-Jones, 2008). These approaches attempt to balance supply and demand rather than being holistic (Walker & Salt, 2006). Policy making and management need to provide a platform for change

(Goulden, et al., 2018). The urban system is planned through policy, strategy, and decision-making processes which are starting to reflect integrated, adaptive, co-ordinated, and participatory approaches that respond to environmental mandates and consider the unquantifiable values of ecosystem services, thereby representing a broader set of societal values and interests (Brown & Farrely, 2009). However, challenges in institutional knowledge, competency, funding, and financial management of natural resources still exist, which perpetuates unhealthy ecosystems and compromises human health (Anon., 2012). A sustainable and resilient society is only possible when macro-economic and planning processes are fully integrated with ecosystem values (Sullivan & O'Keeffe, 2011). Autonomous, self-reliant, and resilient communities are most likely to achieve this (Ayres, 2017). Legal incentivisation has the potential to bring about the type of structural change, co-ordination, and multi-disciplinary action that builds, trains, and empowers communities to develop with environmental policy that supports broader economic, ecological, and social goals. Academic research and discourse will improve the integration of these nature-based approaches in the built environment (Goulden, et al., 2018).

Stormwater management requires cohesion at national, regional, and local levels with a clear strategy to integrate management streams and bring about an enabling institutional context in support of the transition to Sustainable Stormwater Management (SSWM) (Ferguson, et al., 2013; Goulden, et al., 2018). An understanding of public attitudes toward stormwater management and implementation is an important part in the process of raising awareness of the multi-dimensional nature of stormwater as a resource both in private and public spheres (Goulden, et al., 2018). Raising awareness may result in a shift in attitudes and norms regarding sustainable development from one of mere stormwater management to one that embraces ecological and landscape values (Goulden, et al., 2018). Stakeholder values are significant when compiling scenario-based approaches that model desired future states (Ayres, 2017). Social choices bring about change in organisations through:

- Cultural cognitive factors – accepted ways of doing things
- Normative factors – professional conduct
- Regulative factors – coercive mechanisms

2.6.2 Current national laws, strategies and policies include:

- *The National Development Plan 2030* is an overarching planning framework in South Africa (Harvey, 2017). It affirms that natural assets such as biodiverse environments require protection, conservation, and rehabilitation with consideration of future generations.
- *The National Spatial Development Framework,* 2019 calls for just, optimised, efficient and sustainable use of all resources to develop compact, resilient, resource-efficient, multi-functional, safe urban areas that are socially integrated, economically fair and encourage active participation (COGTA Working Group, 2016).
- The *Integrated Urban Development Framework*, 2016 is a government policy that addresses changing spatial distribution and resources impacted by urbanisation, referring to the pivotal role cities play in redefining development of human settlements and urban management to become increasingly inclusive, safe, resilient, and sustainable (IUDF Working Group, 2016). It contains nine policy levers as depicted in Figure 10, the first of which states that: "*Integrated urban planning is essential for coherent development. It stimulates a more rational organisation and use of urban spaces, guides investments and encourages prudent use of land and natural resources to build sustainable communities*" (IUDF Working Group, 2016, p. 8).
- *The National Water Resource Strategy of 2013* contains a clear vision for a healthy, ecologically sustainable, protected water environment that is equitable, efficient, and founded on the principles of integrated resource management (Anon., 2012). Its sub-strategies are supported by the National Biodiversity Management Strategy, which outline the protection of environmental assets, natural resources, and aquatic ecosystems (Anon., 2012).
- *Water Conservation Management and Water Demand Strategy, 2004* is a strategy that refers to the crucial role of management approaches to water to ensure environmental sustainability, socio-economic equity, and efficiency (Department of Water Affairs and Forestry, 2004).
- *The National Environmental Management Act* (No 107. of 1998, amended by Act No 25. of 2014) and the *Spatial Planning and Land Use Management Act* (No

16. of 2013) are in place to ensure that the strategic objectives of effective, efficient, and sustainable development are met (COGTA Working Group, 2016).

- *The National Water Act No 36 of 1998* outlines the responsibility of National Government to manage the quality and quantity of water resources of South Africa in an integrated manner (South African Government, 1998).
- *South Africa's National Urban Development Policy* comprises nine policy levers to ensure coherent, integrated, and sustainable development that is well governed, with an emphasis on empowerment of communities as depicted in Figure 9. It upholds a vision for climate resilient, resource efficient and carbon neutral cities that promote social and economic equity as well as sustainability. This is unpacked in long term desired outcomes with strategic focus areas of which flood risk is a key area. From this, one of the goals outlined is: the proactive reduction of risk through the implementation of Water Sensitive Cities (WSC).

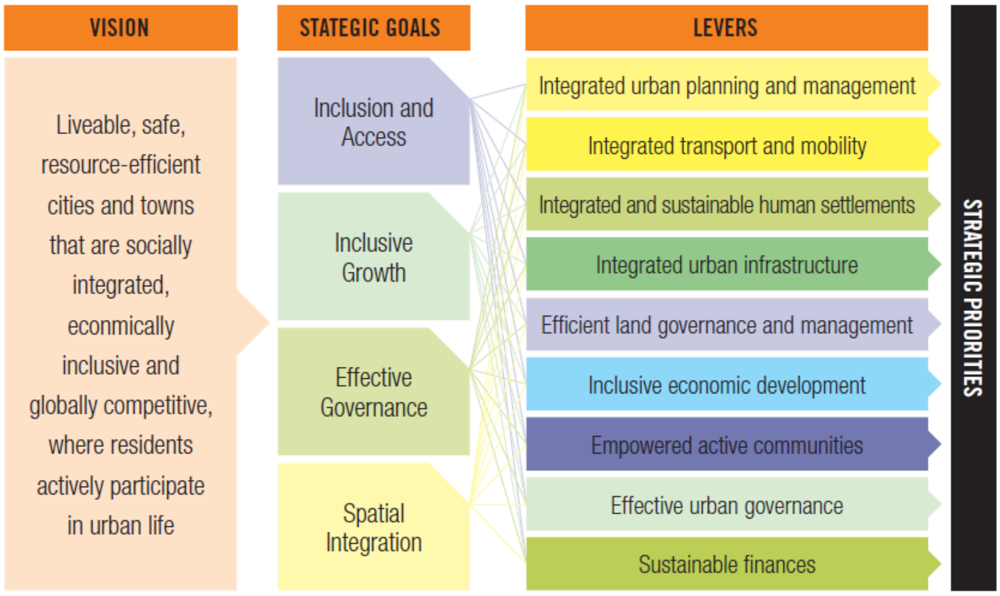

Figure 9: National Urban Development Framework nine policy levers (IUDF Working Group, 2016, p. 40 & 41).

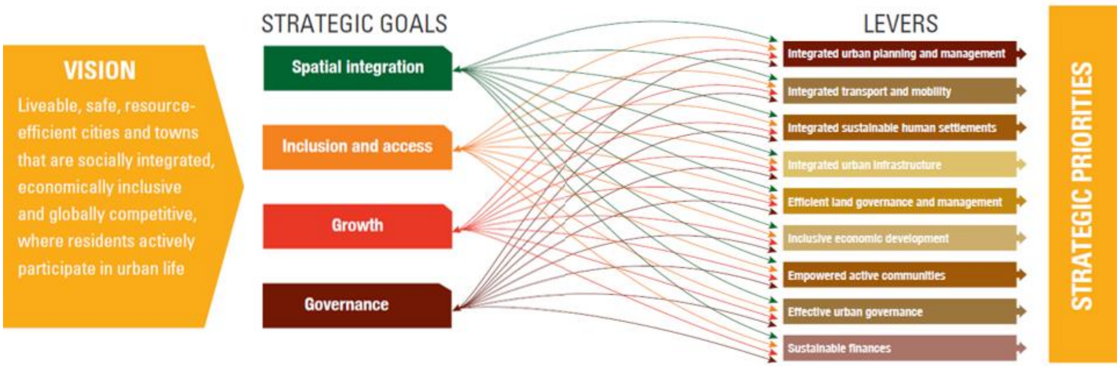

Figure 10: Core elements of the IUDF (IUDF Working Group, 2016, p. 40 & 41).

2.7 Regional legislation, strategies, and policies

2.7.1 Current regional laws, strategies and policies include:

- *Western Cape Sustainable Water Management Plan*, 2017-2022 outlines the constitutional legislative mandate held by the Provincial Government of the Western Cape concurrent with National Government to control, plan, develop, monitor, and support Local Government with regards to the incremental approach towards protection and conservation of natural and environmental resources. (Environmental Affairs and Development Planning, 2018).

2.8 Local legislation, strategies, and policies

Approaches to transform systems are often contained through urban water values that define hydro-social contracts (Lundqvist, et al., 2001; Wong & Brown, 2009). These institutional agreements and regulatory frameworks outline the way government, communities and businesses manage infrastructure and water (Wong, et al., 2011). Local governments are responsible for implementation of projects through effective, efficient, appropriate, and practical decision-making, coupled with solution-finding through community participation, skills transfer, and management of systems by the beneficiaries using local resources (Department of Housing, 2000).

2.8.1 Current local level strategies and policies include:

- The *Integrated Development Plan* contains a Spatial Development Framework which is used as a long-term guide for smaller District Plans (Harvey, 2017).
- *The City of Cape Town Draft Cape Town Water Strategy*, 2019 refers to five commitments, one of which is the provision of sufficient reliable water from

diverse sources to increase resilience and another being the intent to transform Cape Town into a Water Sensitive City (City of Cape Town, 2019).

- *Management of Stormwater Impacts Policy*, 2009 includes policy around implementation of WSUD and operational guidelines with structural interventions and requirements for the monitoring of SuDS. This progressive policy states that: "*In order to reduce impacts of urban stormwater systems on receiving waters, all stormwater management systems shall be planned and designed in accordance with best practice criteria and guidelines laid down by Council"*, to support Water Sensitive Urban Design (WSUD).
- *The Municipal Systems Act*, 2000 of Cape Town mandates the Integrated Development Plan (IDP) as the main visionary document and planning framework for Cape Town (Harvey, 2017).

Urban centres transition through various states en-route to advancing toward becoming Water Sensitive Cities as they pursue more sustainable futures in a nested continuum as depicted in Figure 11 evolving from conventional, maladaptive approaches to those that embrace institutional flexibility and adaptiveness through innovative approaches that engage stakeholders when managing infrastructure (Nguyen, et al., 2019; Wong & Brown, 2009). Urban design, urban water management, social and institutional systems have the potential to be mutually supportive in establishing and maintaining Water Sensitive Cities (WSS) as: 1. The city as a supply catchment; 2. The city as providing ecosystem services; and 3. The city consisting of water sensitive communities (Wong & Brown, 2009). Stakeholder engagement often includes government departments, non-government organisations, NGO's, professional bodies, and the private sector (Enqvist & Ziervogel, 2019; Taylor, 2019; Wong & Brown, 2009). Generally, the greater the variety of stakeholder representatives, the greater the challenge due to differing approaches, resources, attitudes, expectations, and available technologies (Enqvist & Ziervogel, 2019; Ziervogel, et al., 2016). The City of Cape Town Draft Cape Town Water Strategy shows an intent to develop as a Water Sensitive City with a commitment to guide development to ensure integrated potable, waste, and stormwater through institutional, community and individual initiatives (Rodrigues & Antunes, 2021). Figure 12 is a graphic representation of the primary characteristics of Cape Town's current water systems encompassing water, wastewater, and stormwater services. It was compiled to detect strategic synergistic opportunities within the system and shows strong evidence of a reliance on external water supply despite there being an equal proportion of rainwater in the catchment (Cameron & Katzschner, 2017).

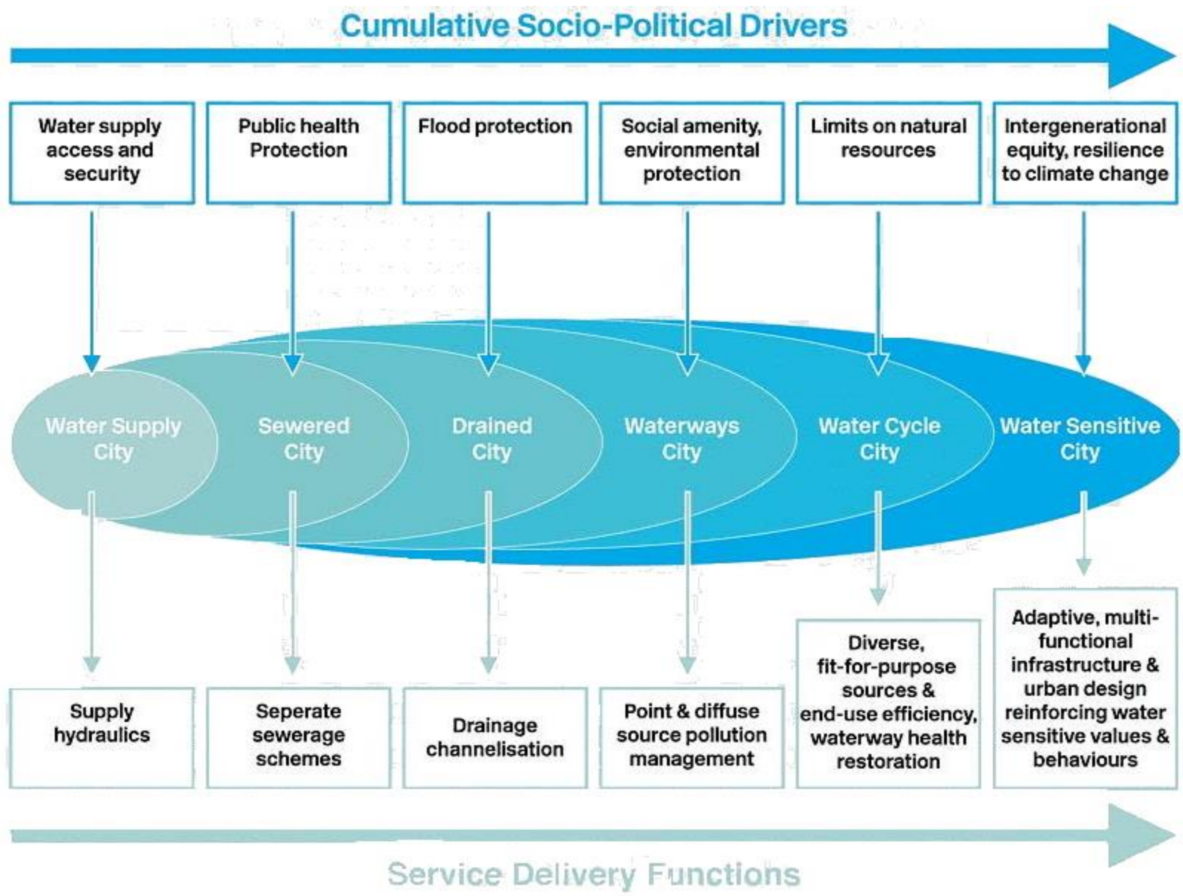

Figure 11: Urban water management transitions framework (CRC for Water Sensitive Cities, 2021).

The City of Cape Town, in its "*Management of Stormwater Impacts Policy*", 2009 refers to SuDS structural and non-structural interventions with operational and management procedures intended to discourage activities that increase runoff and polluted water from entering receiving waters (Barbosa, et al., 2012; Martin, et al., 2007). However, despite the recognition of SuDS, the development of Integrated Urban Water Management (IUWM), and reorganisation of government departments as seen in Figure 13, institutional lethargy exists due to low levels of water literacy in urban planning, resulting in poor integration of spatial planning and water management. This often results in a slow transition to IUWM despite innovative concepts around infrastructural, economic and governance systems (Armitage, et al., 2013; Cameron & Katzschner, 2017). At the City of Cape Town, the Environmental Resources Management Department have developed climate change adaption strategies by including nature-based approaches to stormwater management and a theoretical spatial water framework has been compiled, proposing "*multiple strategy pathways, otherwise known as transition scenarios*", serving as options to guide innovative development in Cape Town in its transition to a water secure future through proactive mitigation of inequality, unemployment, resource depletion and service provision, embracing the ideals of current environmental approaches (Cameron & Katzschner, 2017, p. 209).

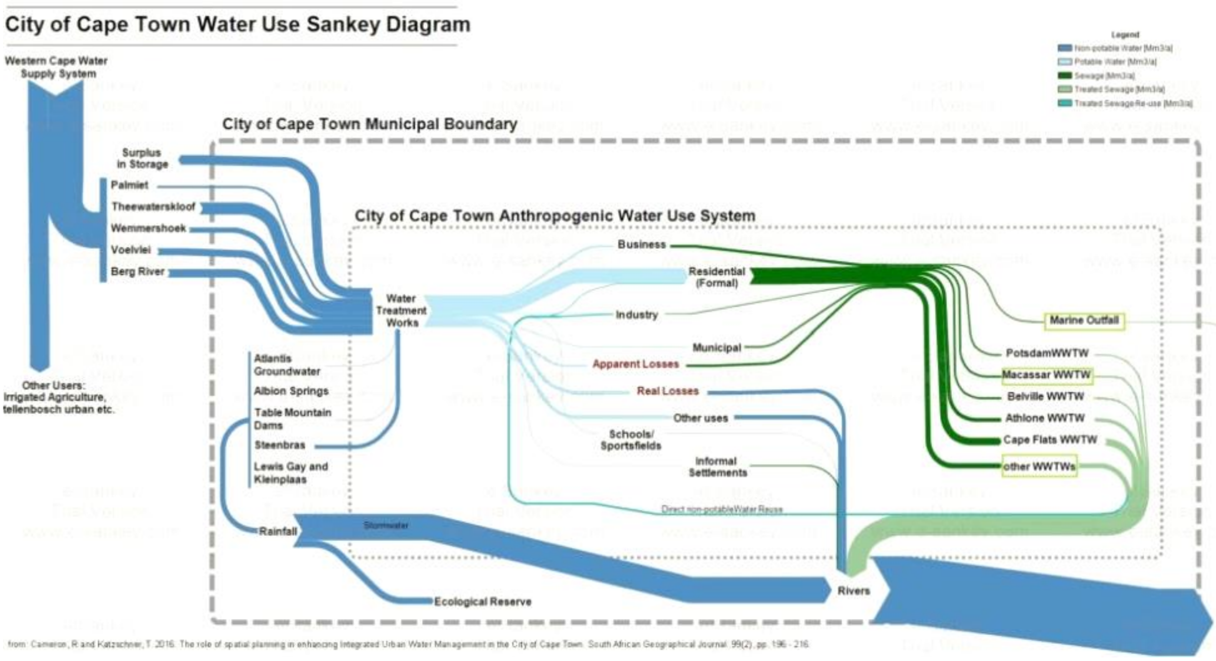

Figure 12: A Material Flow Diagram indicating flow of water from the natural environment to the anthroposphere in Cape Town (Cameron & Katzschner, 2017, p. 205).

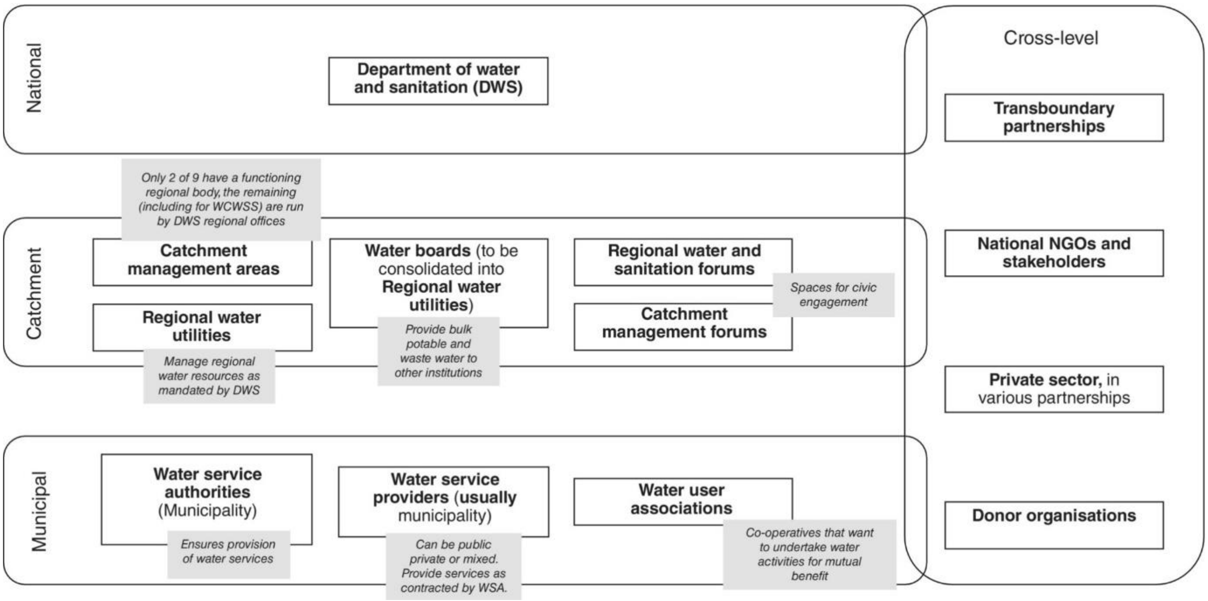

Figure 13: Key organisations in water management (Enqvist & Ziervogel, 2019, p. 6).

2.8.2 Governance

A water crisis such as the one experienced in 2017 indicated the lowest period of rainfall in a 20-year period (Liz Day Consulting, 2020). This is indicative of a deeper issue, namely local governance, showing that despite efforts, institutions are still failing to adequately address resilience and adaptability (Enqvist & Ziervogel, 2019; Ziervogel, et al., 2017). The City of Cape Town adopted a *Climate Change Strategy* in 2019, integrating it within departments at the highest level to bring about increased resilience through good governance, climate adapted planning, integrated and balanced grey and green infrastructure, changed behaviour and ultimately a resilient city as depicted in Figure 14 and are committed to a new strategy to becoming a Water Sensitive City by 2040 (Liz Day Consulting, 2020). The document has since been revised in May 2021 with ambitious goals and clear pathways for action. Still, certain issues continue to lead to a spatial disjoint in the Cape Town Metro, such as: availability of resources, weaknesses associated with a spatially differentiated city, lack of infrastructure capacity and a disconnect between people and the environment (Cameron & Katzschner, 2017; Harvey, 2017). In addition, lack of engineering expertise and operational capacity place additional pressures and challenges on the rolling-out of newer technologies in a developing world context that may lead to a degree of failure (Chocat, et al., 2007).

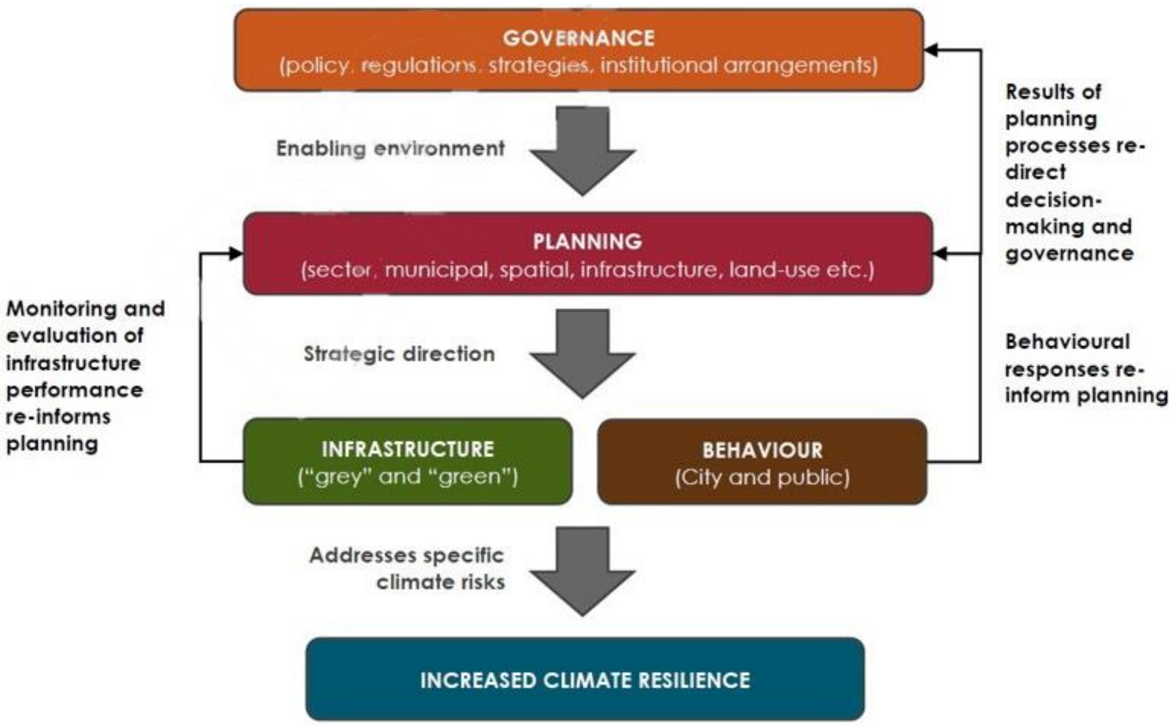

Figure 14: Adaptation actions and links (City of Cape Town, 2020, p. 12).

Total organisation and staff commitment to sustainability principles with dedicated capacity building interventions such as inter-departmental committees with shared resources are more likely to result in strong stakeholder networks that improve and enhance Sustainable Urban Stormwater Management (SUWM) practise and programs (Bellamy, et al., 1999; Brown, et al., 2009). As commitment to SUWM principles increase, so policy formulation develops and matures, management systems become more established in facilitating the allocation of resources which improves performance and success (Brown, 2008). This level of Institutional capacity is required to advance SUWM and move away from a reliance on traditional water sources toward more diverse sources that safeguard the provision of water (Wong & Brown, 2009). Academic and practitioner literature supports institutional capacity building to mobilise change toward human resource development which enhances performance and strengthens organisational processes, procedures, communication, legal and policy development (Brown, 2008). This commitment needs to be supported by officials who can carry out operations autonomously (Brown, 2008).

2.8.3 Examples of successful government organisations

Studies of successful local government organisations in Sydney, Australia where SuDS applications are advanced depicts an entirely different context to South Africa, nevertheless they reveal the benchmarks for effective performance as (Brown, 2008):

- An internal political prioritisation of the environment.
- The integration of sustainability principles and practises.
- Good governance.
- Community leadership and participation.
- Corporate policies.
- Dedicated resources for environmental management.
- Active inter-departmental committees dedicated to SUWM administration.
- Planning.
- Local research and practise.
- External development through educational initiatives.
- Internal development through staff training and learning (Brown, 2008).

A model of a typical structure of a high performing local government organisation is depicted in Figure 15. Such organisations may have inherent constraints due to variable capacity within local government departments but are still able to adapt to differences in comprehension of SUWM (Brown, 2008). Technical competence in SUWM technology has been found to be less essential compared with soft skills such as: competence, experience**,** environmental planning, facilitation, negotiation, networking, and organisational relationship building (Brown, 2008). For optimal implementation and governance of SUWM, a common vision and goals, improved policy, regulatory mechanisms, well-structured administrative systems, a well-developed knowledge base (Chocat, et al., 2007), defined responsibilities and community participation in the operations and management of infrastructure is vital (Brown, 2008).

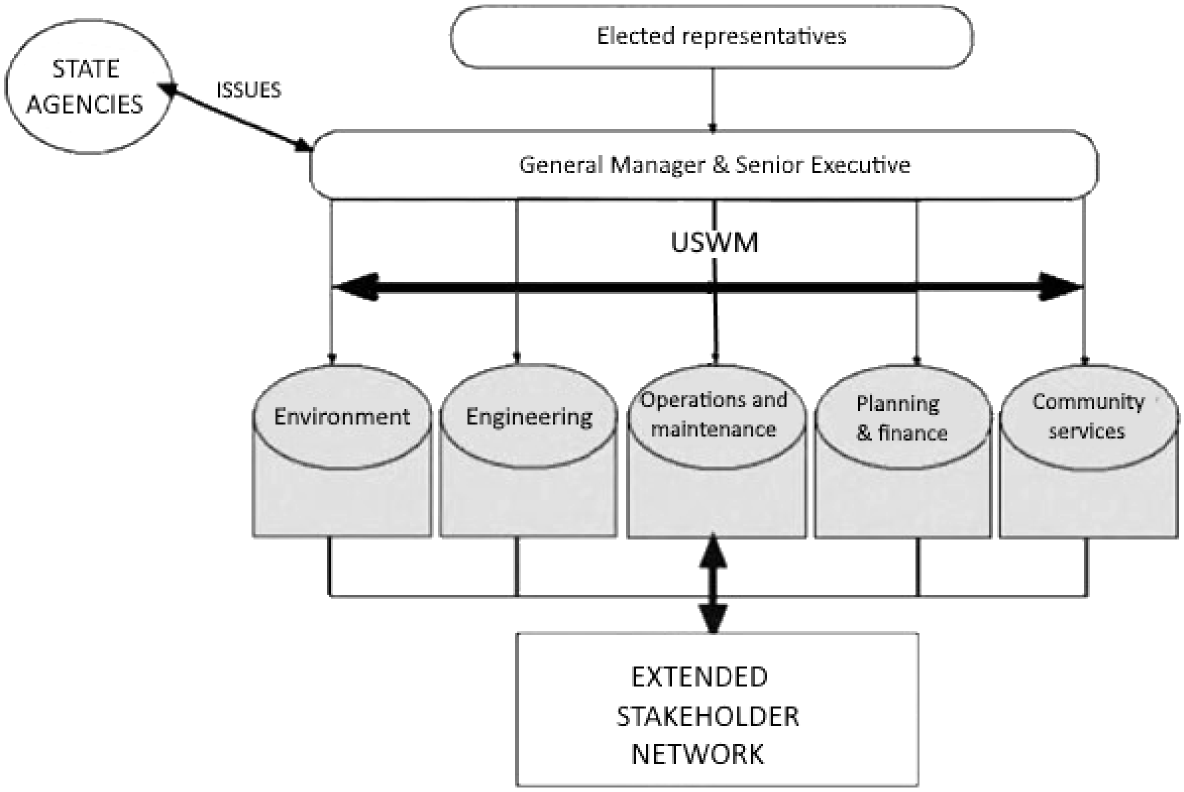

Figure 15: High performing government organisations (Brown, 2008, p. 228).

2.9 Stormwater

2.9.1 Conventional stormwater systems

Urban water infrastructure includes stormwater, sanitation, groundwater, and water which, when carefully designed, provide ecosystem goods and services to sustain life. Urban stormwater forms part of the greater urban water infrastructure network and is a multifunctional resource (Lähde, et al., 2019). Conventional approaches have focussed on the symptoms of the problem, treating water as a risk to be removed from urban areas efficiently without a view to long term sustainability (Goulden, et al., 2018). This is depicted in Figure 16. These approaches often result in reduced water quality as polluted surface runoff is directed into natural water bodies in an uncontrolled manner (Brears, 2018). These traditional water-related systems have negatively impacted the hydrological cycle as they are separated from natural systems and fed through a piped network of infrastructure, lowering their resilience in the face of extreme events, and reducing the availability of water for humans, fauna, and flora (Brears, 2018). A paradigm shift is required from conventional management approaches of risk and control which has conflicting and competing goals, to embracing an adaptive learning approach (Pahl-Wostl, 2007).

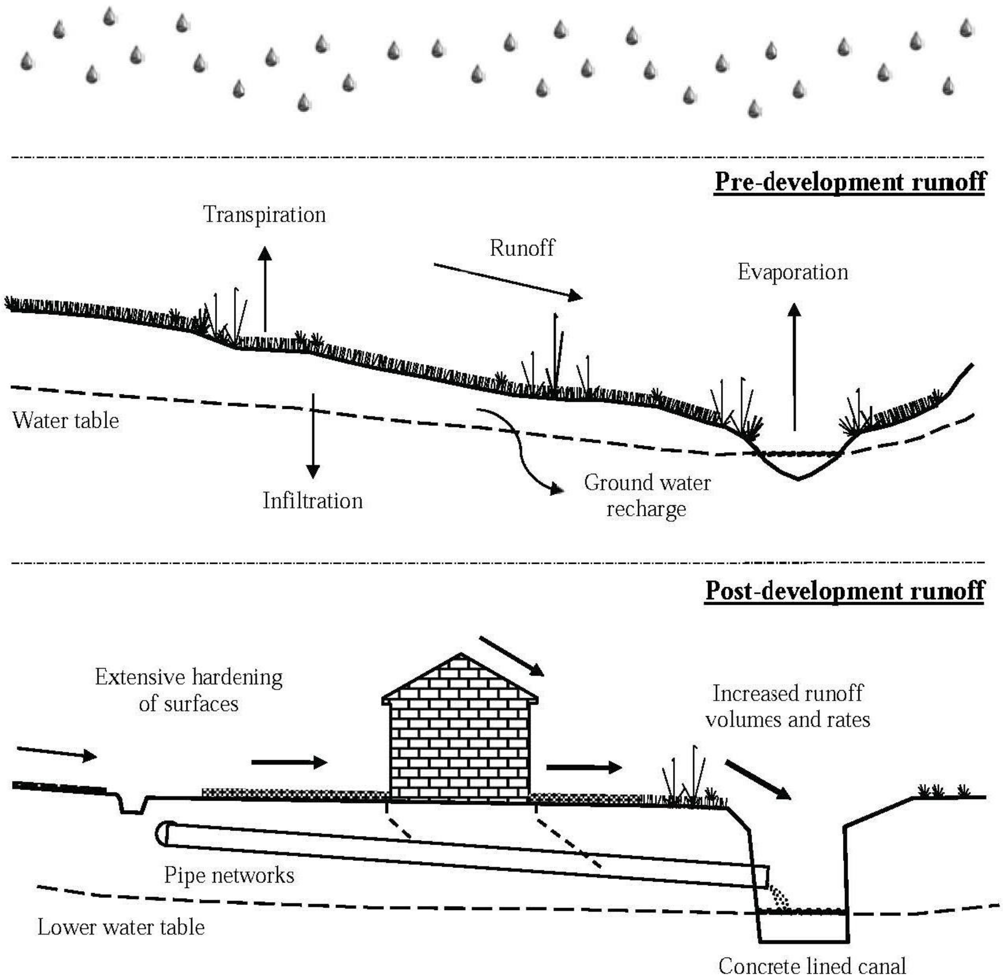

Figure 16: Diagram indicating the conventional approach to managing stormwater runoff (Armitage, 2011, p. 2).

2.9.2 Terminology

Different terms are used to describe similar approaches in countries across the world (Barbosa, et al., 2012). “Best Management Practises” were developed by policy makers in the United States The term Best Management Practises (BMP’s) may be interpreted in a multitude of ways but mainly describe a structured approach to the prevention, mitigation and management of stormwater pollution through structural and non-structural interventions (Fletcher, et al., 2014; Lai , et al., 2007). This considers the total water cycle (Wong & Brown, 2009) and offers value that extends beyond risk management, providing integrated solutions that are founded on ecological system principles that mimic nature (Qiao, et al., 2018; Semadeni-Davies, et al., 2008). This results in the restoration of natural cycles and functioning, more efficient systems and reduced environmental impact during the operational phase (Rodrigues & Antunes, 2021).

“SuDS” was introduced in the United Kingdom in the 1970’s (Ellis & Lundy, 2016; Qiao, et al., 2018). “Low Impact Development” (LID) was later introduced in New Zealand (Nguyen, et al., 2019). In Australia the term “Water Sensitive City” (WSC) and “Water Sensitive Urban Design” (WSUD) became commonplace while China has a program called Sponge Cities (Jiang, et al., 2017; Qiao, et al., 2018). This is based on Low Impact Development principles for managing urban water as depicted in Figure 17 (Ahiablame, et al., 2013; Qiao, et al., 2018). Its main goal is the mitigation of the negative impacts of urban development on natural systems (Li, et al., 2017; Li, et al., 2018). Mitigation is achieved through targeting designers and developers in the built environment field to 1. Install surfaces that are pervious 2. Manage water ecology 3. Purify, restore, and reuse stormwater via green infrastructure 4. Instal permeable pavements.

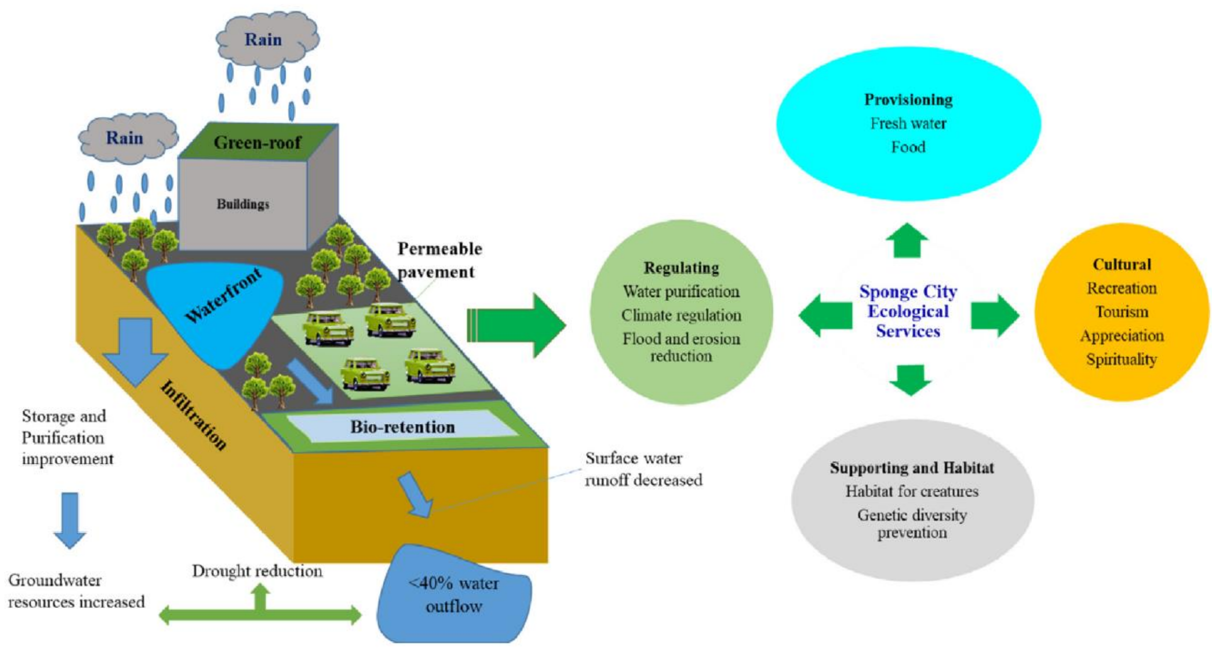

Figure 17: The Sponge City approach (Nguyen, et al., 2019, p. 152).

In South Africa, “SuDS” is well understood, and the design of Water Sensitive Settlements (WSS) refers to the equitable and holistic treatment and management of water (Armitage, 2011; Radcliffe, 2019). Figure 18 shows how Water Sensitive Settlements (WSS) are influenced by urban planning, urban design and urban management. Urban management is most relevant in the context of this study.

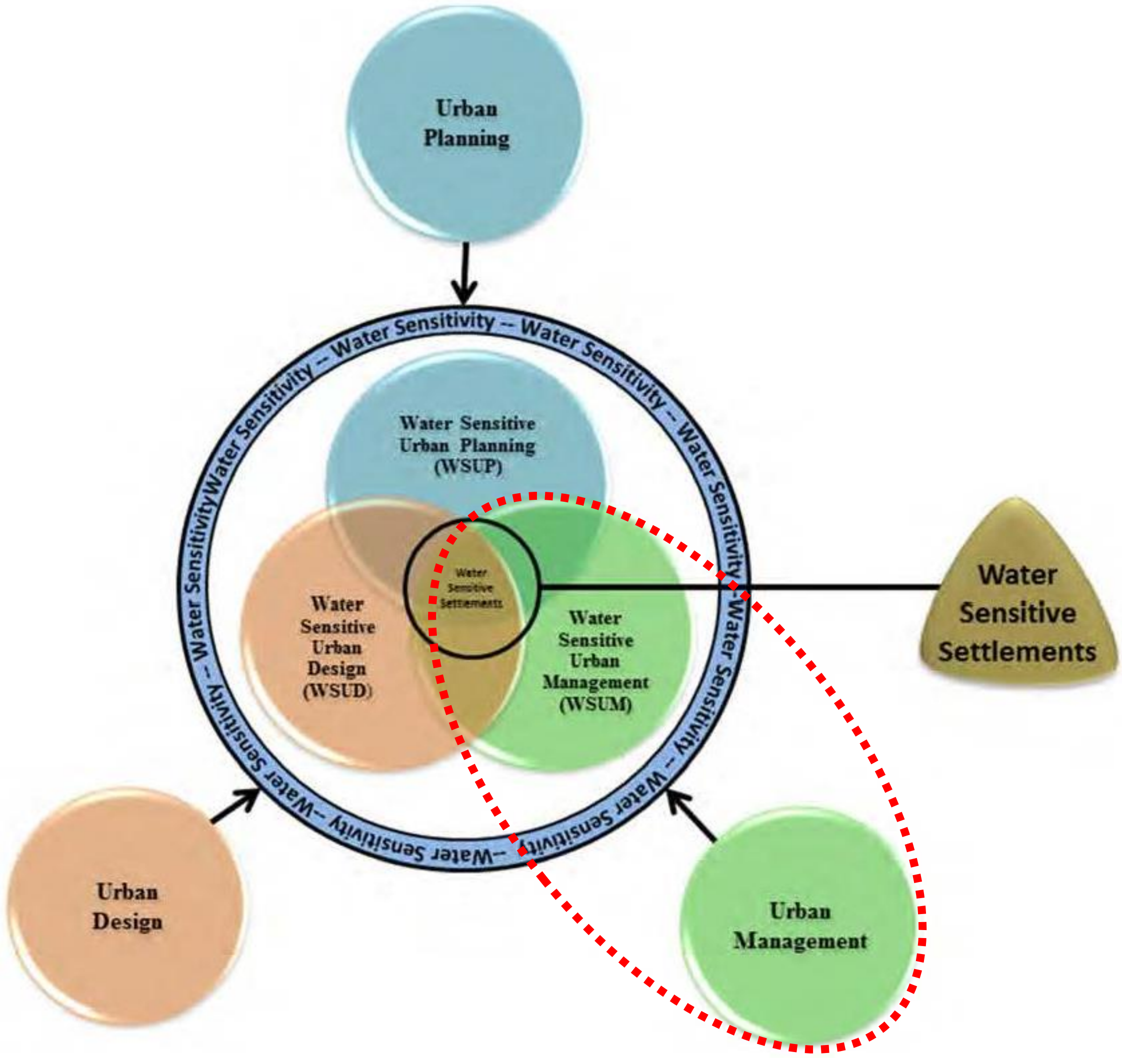

Figure 18: Integrated WSS (Armitage, et al., 2014, p. 19).

2.9.3 Sustainable Stormwater Management Systems

Emerging paradigms in sustainable stormwater management systems include that of Water Sensitive Urban Design and Sustainable Urban Drainage Systems approaches (Goulden, et al., 2018). WSUD aids the development of resilient, socially integrated, equitable and adaptive cities (Armitage, et al., 2014; Goulden, et al., 2018; Wong, et al., 2011). The Sustainable Urban Water Cycle Model in Figure 19 shows how the conventional urban water cycle may be adapted and changed to accommodate sustainable alternatives. When these sustainable stormwater strategies are applied in an urban context, they are likely to bring about numerous environmental benefits, such as stabilisation of topsoil, cleansing of polluted water and protection of receiving water bodies (Barbosa, et al., 2012; Goulden, et al., 2018; Rodrigues & Antunes, 2021).

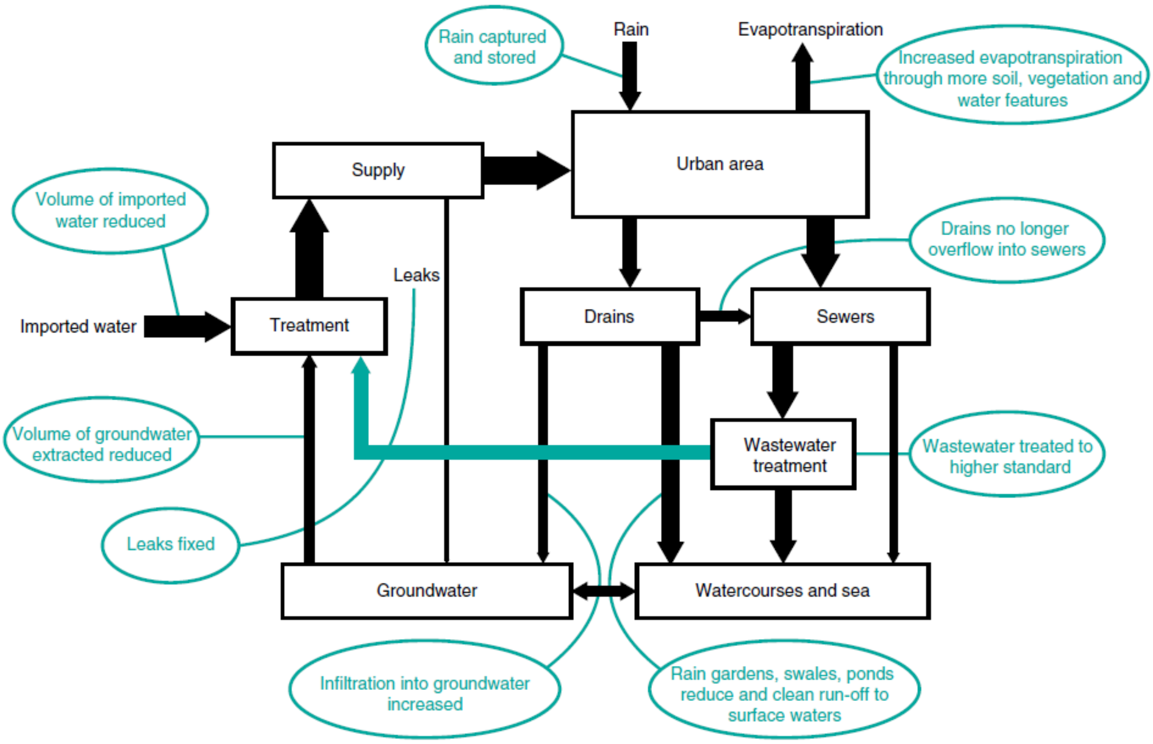

Figure 19: The Sustainable Urban Water Cycle (Grant, 2016).

WSUD connects planning and design with urban water infrastructure as per Figure 20. When integrated into design, WSUD provides numerous ecosystem services which have been classified according to the Common International Classification as provisioning, regulating and cultural services (Lähde, et al., 2019; Madureira & Andresen, 2014). WSUD principles merge urban water cycle planning with urban design, environmental, the social sciences and management (Wong & Ashley, 2006; Wong, et al., 2011). This is done through the following actions:

1. Consideration of water in land use planning.
2. Addressing water resource issues at various catchment levels.
3. Applying the precautionary principle to water management.
4. Recognising water as a valuable finite resource.
5. Recognising intergenerational equity.
6. Considering unique site constraints in designing scientifically based solutions.

7. Protecting systems integrity.
8. Including community participation.
9. Considering short- and long-term economic value (Rodrigues & Antunes, 2021).

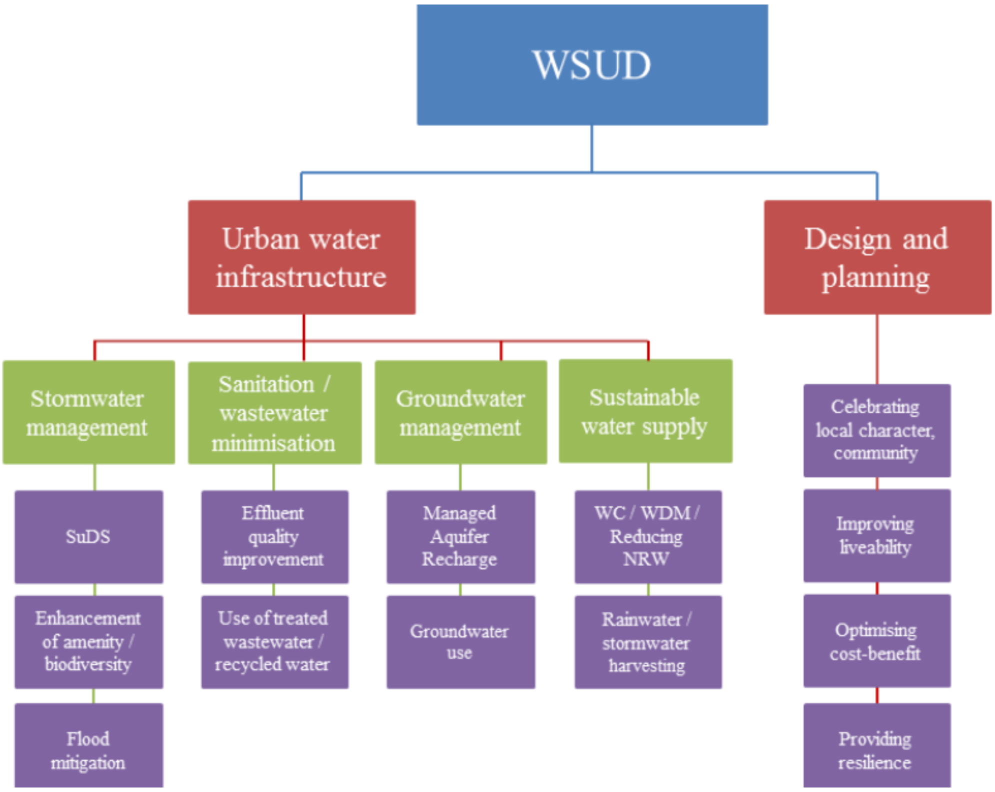

Figure 20: Water Sensitive Urban Design (WSUD) (Armitage, et al., 2014, p. 46).

Four major components required for furthering WSUD adoption are contained in the inner circle of the Figure 21, namely: 1. Regulatory framework; 2. Technology and design; 3. Marketing and acceptance and 4. Assessment and costing (Lloyd, et al., 2002). As can be seen in this model, WSUD technology and design as well as the regulatory framework strongly influence operations.

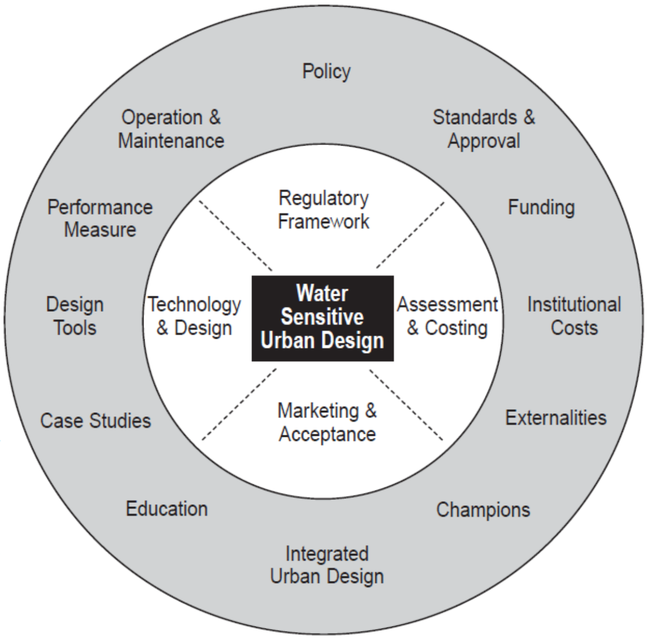

Figure 21: Key components for the integration of WSUD into development projects (Lloyd, et al., 2002, p. 25).

SuDS mimics natural drainage patterns through a treatment train that allows interception, attenuation and absorption of stormwater to advance environmental protection and conservation (Armitage, 2011; Armitage, et al., 2014; Grant, 2016; City of Cape Town, 2011). Figure 22 illustrates how sustainable stormwater management typologies may be incorporated during the design and operational phases, in isolation or in various configurations as a treatment train (Armitage, 2011; Lloyd, et al., 2002). These configurations complement each other at the different scales of source, local or regional controls (Armitage, 2011; Barbosa, et al., 2012). SuDS treatment train configurations have varying stormwater regulating capacities (Lähde, et al., 2019; Muerdter, et al., 2018). They should be flexible, spatially appropriate and consider legal constraints among other considerations (Barbosa, et al., 2012). The unique site characteristics, opportunities, and constraints may be used to determine the selection of the most appropriate typology (Armitage, et al., 2013). To further this cause, a set of international best practise guidelines has been developed in South Africa to outline principles, set parameters, and provide standards for the design and long-term management of SuDS infrastructure (Armitage, 2011). Theoretically, the ideal sequencing of SuDS should be based on flow and quality of water controls relative to lifecycle costs as: 1. Non-structural SuDS to mitigate any further interventions; 2. Structural SuDS at the source; 3. Managing stormwater impacts on receiving waters

(Lloyd, et al., 2002). SuDS infrastructure is best located as close to the source as possible to retain, detain, transfer, and maintain stormwater flow and recharge the groundwater (Rodrigues & Antunes, 2021). Efficient and effective source control is desirable and may be supplemented with local control interventions where stormwater is managed on public property (Armitage, et al., 2013).

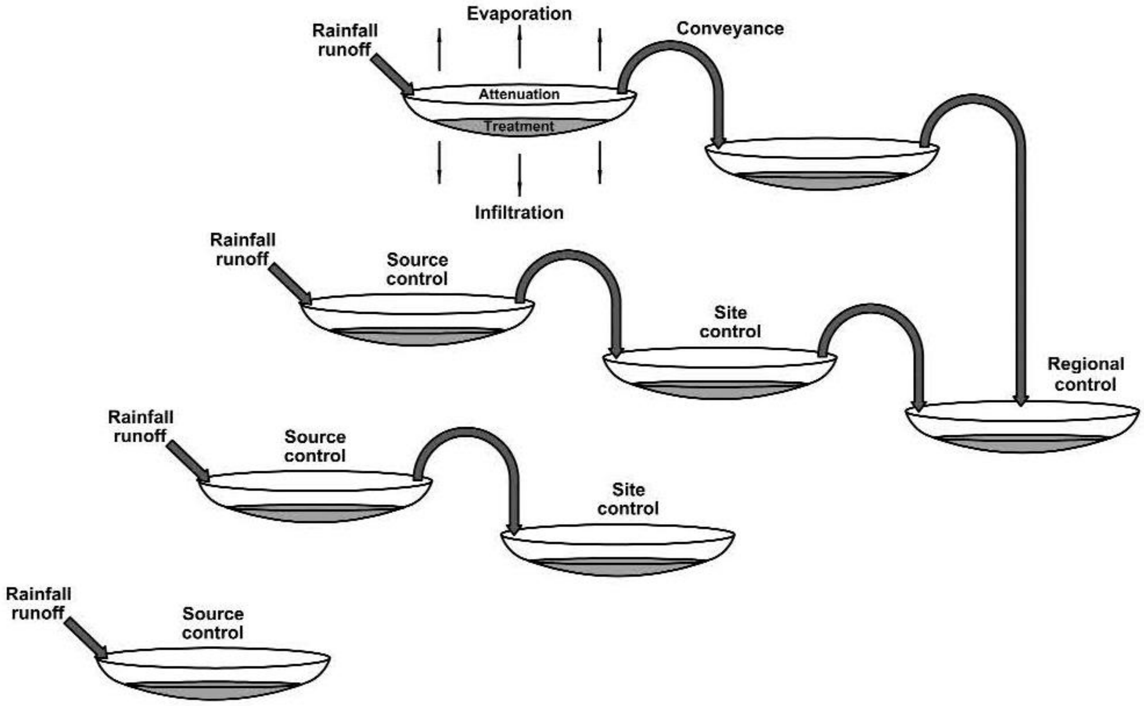

Figure 22: Adapted version of the concept of a SuDS treatment train (Woods-Ballard, et al., 2007, pp. 1-12).

SuDS consists of structural and non-structural controls which are integrated into an existing landscape in a manner that brings social benefits by enhancing the aesthetics (Armitage, et al., 2014; City of Cape Town, 2011). SuDS have been classified and are most effective when applied in combination as:

2.9.3.1 Structural controls

Practises for managing stormwater quantity including collection, conveyance and detainment of stormwater and the control of water quality focussing on retaining water or infiltration of water in a combined treatment train to distribute SuDS across a catchment (Lloyd, et al., 2002). Structural SuDS include decentralised or retrofitted systems that complement or replace inappropriate centralised urban stormwater systems (Brown, et al., 2009; Nguyen, et al., 2019; Rodrigues & Antunes, 2021). Decentralised responsibility enables adaptive management and allows decisions and actions to be taken relatively easily without bureaucratic hinderances (Chocat, et al., 2007). These systems are mainly comprised of detention and retention facilities, infiltration and soakaway beds and permeable paving and others listed in Table 1 and address water volumes by preventing flooding during extreme weather events (Rodrigues & Antunes, 2021). They are also designed to address water quality by filtering and polishing water. This in turn improves environmental conditions, human lifestyles, overall health and reduces capital and operational costs (Martin, et al., 2007).

Structural BMP	Allotment	Streetscape or precinct	Open Space networks or regional scale
Diversion of runoff to garden beds	✔		
Rainwater tank/reuse scheme (ie. garden watering, toilet flushing)	✔		
Sediment trap	✔		
Infiltration and collection system (bio-filtration system)	✔	✔	✔
Infiltration system	✔	✔	✔
Native vegetation, mulching, drip irrigation systems	✔	✔	✔
Porous pavement	✔	✔	✔
Buffer strip		✔	✔
Constructed wetland		✔	✔
Dry detention basin		✔	✔
Litter trap (side entry pit trap)		✔	
Pond and sediment trap		✔	✔
Swale		✔	✔
Lake			✔
Litter trap (gross pollutant trap)			✔
Rehabilitated waterway			✔
Reuse scheme (ie open space irrigation and toilet flushing)			✔
Urban forest			✔

Table 1: Examples of structural BMP's (Lloyd, et al., 2002, p. 7).

2.9.3.2 Non-structural controls

Non-structural controls are used in combination and focus on behavioural aspects such as good governance, education, environmental and urban development policy, and management to increase the effectiveness of implementing sustainable strategies (Lloyd, et al., 2002; Rodrigues & Antunes, 2021). Non-structural controls are most relevant during the operational project phase (City of Cape Town, 2011). A level of detail is required from the early planning and design phases of these projects and throughout the project life cycle to ensure the work is practical, appropriate, achievable and enhances infrastructure functioning (Armitage, et al., 2013).

Non-structural controls provide an opportunity to improve social, educational, and environmental circumstances in urban areas through stakeholder engagement (Barbosa, et al., 2012). Community engagement is considered a vital component of Urban Water Management as it allows for the fostering of community spirit and collective identity in relation to water (Rodrigues & Antunes, 2021). It also provides employment opportunities for local individuals (Chocat, et al., 2007). Development and management of SuDS depends on key champions, political support, community acceptance and participation in decision-making and increased implementation of Water Sensitive City principles (Wong & Brown, 2009). In contrast, lack of information accounts for a significant proportion not implementing SuDS results in the devaluation thereof (Martin, et al., 2007). Community acceptance and values govern design decisions and impact water management practises and operations (Wong, et al., 2011). Value is realised through the process of creating a continuously evolving multi-operational system, effectively connecting a project from its inception to the operational phase (Morris, 1983). Stakeholders play a critical role due to their insight into the local context (Lloyd, et al., 2002) but awareness of the potential role and value of SuDS currently appears low among stakeholders even though SSWM goals are expanding and the cultural cognitive shift toward SSWM is evident (Goulden, et al., 2018). Increasing stakeholder numbers will lead to a greater level of public discourse (Goulden, et al., 2018; Morison & Brown, 2011; van de Meene, et al., n.d.) and the opportunity to raise concerns about SuDS maintenance (Lloyd, et al., 2002). Such discourse forms part of the process of information dissemination and gaining community support, which is vital for the successful operations of SuDS (Rodrigues & Antunes, 2021).

2.9.4 Urban Water Management

Natural water bodies are fluid, extending into massive catchment areas that extend well beyond the confines of man-made systems and boundaries (Harvey, 2017). These water bodies are the subject of management models that are generally constructed to identify problems and recommend solutions, many of which aim for approaches that optimise systems for maximum benefit (Walker & Salt, 2006). Due to the scale and nature of the infrastructure and associated systems, urban water management best practise is complex and challenging. These challenges start in the early stages in the planning process. Approaches that seek to protect and improve the total water cycle are often pursued to realise the benefits to society (Wong & Brown, 2009). The realisation of benefits is a desired outcome from following Best Management Practises. Best Management Practises are derived by identifying the project objective as depicted in Figure 23.

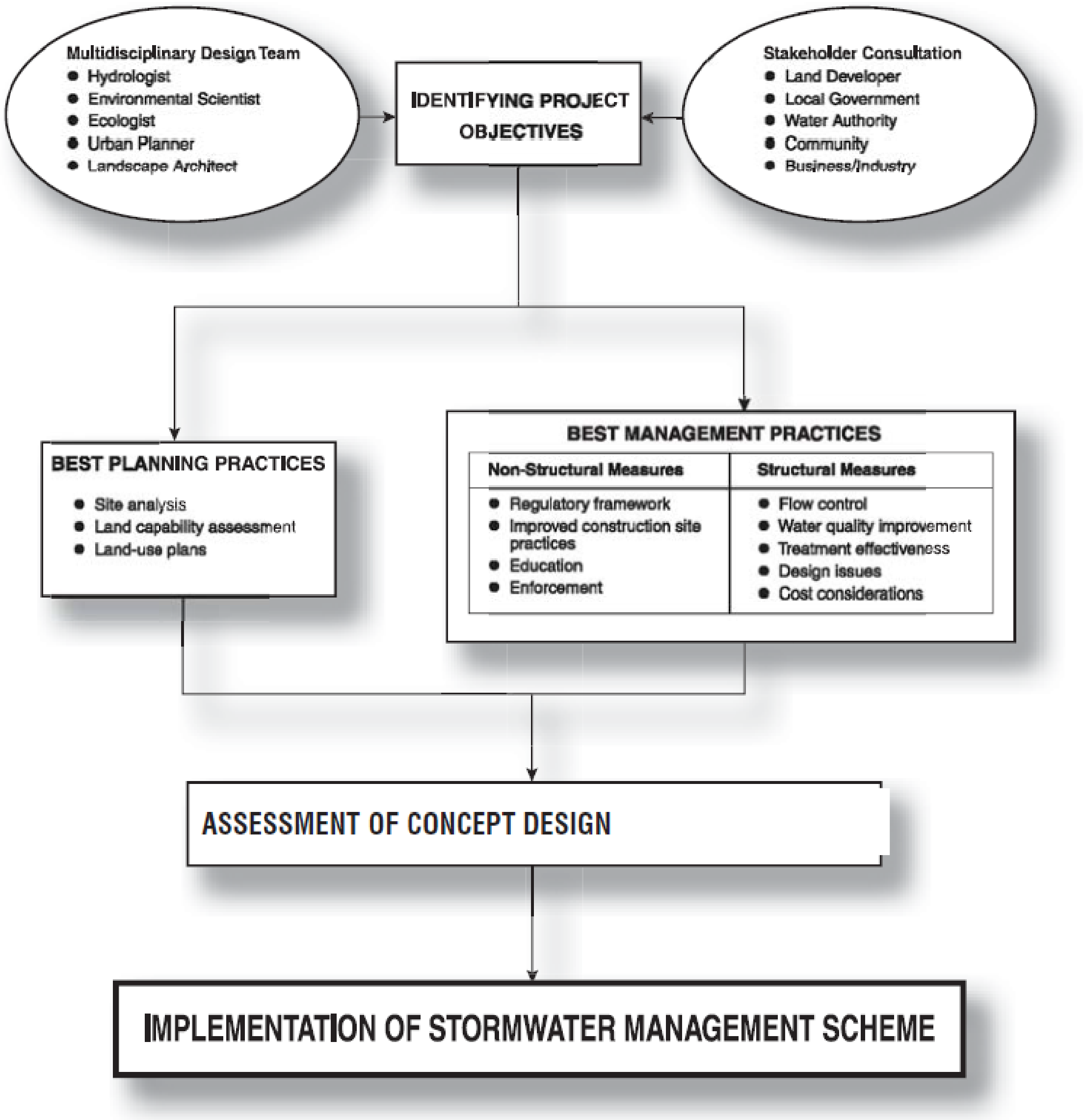

Figure 23: Processes of planning, design, assessment, and implementation of WSUD to urban stormwater management (Lloyd, et al., 2002, p. 3).

Urban water management can be complex and fragmented. Limited and incomplete implementation of sustainable strategies often result in stifled outcomes. Historically professionals have been trained to manage extreme events and natural variations through risk management. Risk management calculates buffers for protection of human activities and can have far-reaching implications on both the environment and nearby communities (Ayres, 2017; Pahl-Wostl, 2007). This does not support a sustainable systems approach but conversely requires extensive infrastructure with associated costs (Abbott, 2012). A systematic approach is needed for the long-term monitoring, evaluation, and management of sustainable infrastructure such as SuDS

(Hakimdavar, et al., 2016; Nguyen, et al., 2019). The diversion away from technical management to a more integrated and adaptive management approach of Integrated Urban Water Management (IUWM) may prove vital to remaining relevant and operational under changing and complex conditions of water systems (Pahl-Wostl, et al., 2004; Pahl-Wostl, 2007). This case study intends to produce findings that suggest whether success hinges around adaptive and highly responsive environmental management rather or pure risk management.

Water demand management forms the basis of urban water management, focusing on reducing demand as the starting point for water management (Ayres, 2017; Postel, 1999). Effective management of existing systems requires mobilisation of resources to address water availability and the utilisation of all waste as far as possible, ultimately to mitigate future water crises (Armitage, et al., 2014; Sullivan & O'Keeffe, 2011; Muller, et al., 2009; Nkondo, et al., 2012). Reducing demand is an essential component of sustainable urban development (Nguyen, et al., 2019; Schaffer & Vollmer, 2010). Barriers to change include socio-institutional such as a lack of vision and understanding, limited resources, unclear lines of responsibility, poor co-ordination, and low levels of community acceptance (Brown & Farrely, 2009). Socio-institutional barriers can be overcome through the establishment of alternative decision-making bodies or authorities which may be set up to preside over operational aspects of environmental or sustainable infrastructure and services, while still being accountable for and reporting to the local authority. A key to operational success is dependent on the manner in which delays associated with red tape are addressed and ways in which sustainable operations are integrated with conventional management processes. Another key contributing factor in the success of SuDS operations is the ability to make and effect timeous decisions. Other barriers to change in water demand management can be overcome through securing alternative water sources and including all stakeholders throughout the operational lifespan. More helpful approaches are certainly ones where the concepts of resilience, complexity, unpredictability, and change is embraced (Walker & Salt, 2006).

2.9.4 SuDS related to this case study

2.9.4.1 Detention basin

Regional stormwater controls such as detentions basins, seen in the typical cross section in Figure 24, have the potential to provide multiple services since they are formed through contouring of the surface of the land in order to create an amenity that functions as a temporary stormwater attenuation facility, improving water quality through the settling of sediments and pollutants, and releasing stormwater in a controlled manner (Woods-Ballard, et al., 2007). They are often vegetated with grass but may have other types of vegetation to stabilise embankments, improve the visual appearance and increase biodiversity. They can potentially serve a multi-functional role of providing active or passive recreational space while not inundated with water and therefore accessibility and safety are important considerations (Woods-Ballard, et al., 2007).

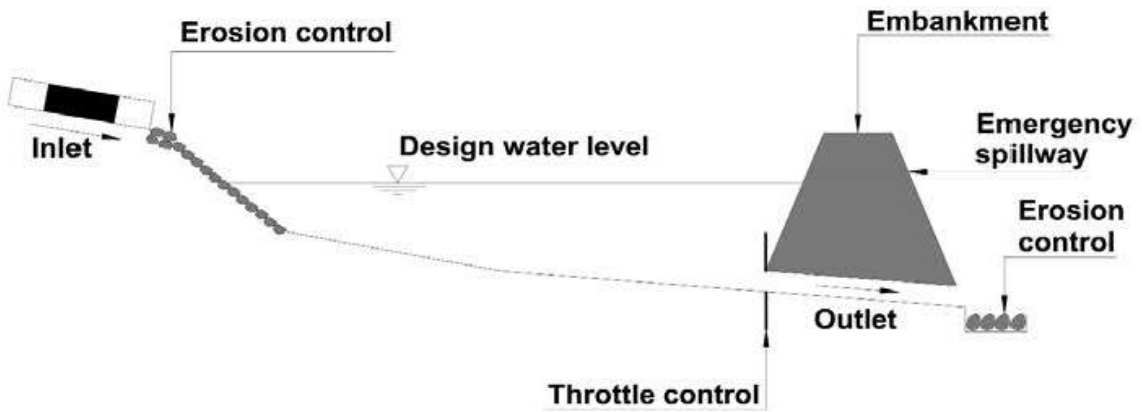

Figure 24: Typical detention basin profile (Woods-Ballard, et al., 2007, pp. 16-2).

The main operational requirements associated with this type of facility have been detailed in Table 2.

The design criteria for detention ponds have been described as:

- Managing peak flow by limiting outflows.
- Slopes to conform to safety requirements.
- Forming a part of a treatment train to manage removal of pollutants.

Operational activities for detention basins include regular maintenance, routine maintenance and occasional maintenance which are dependent on environmental conditions and human factors, as well as remedial actions which focus on repair and remedial work. The author asserts that the inclusion of remedial actions in the maintenance schedules, such as the one in Table 2, make provision for emergent factors that require urgent, immediate, or planned interventions.

Maintenance schedule	**Required action**	**Frequency**
Regular maintenance	Litter and debris removal	Monthly
	Grass cutting for spillways and access routes	Monthly (during growing season) or as required
	Grass cutting meadow grass in and around basins	Half yearly (Spring - before nesting season and Autumn)
	Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)
	Tidy all dead growth before the start of the growing season	Annually
	Remove sediment from inlet, outlet and forebay	Annually (or as required)
	Manage wetland plants in outlet pool	Annually
Occasional maintenance	Reseed areas of poor vegetation growth	Annually (or as required)
	Prune and trim trees and remove cuttings	2 years, or as required
	Remove sediment from forebay when 50% full and from micro-pools if volume reduced by >25%	3-10 years (or as required)
Remedial actions	Repair of erosion or other damage by re-seeding or re-turfing	As required
	Realignment of rip-rap	As required
	Repair / rehabilitation of inlets, outlets and overflows	As required
	Re-level uneven surfaces and reinstate design levels	As required
Monitoring	Inspect inlets, outlets and overflows for blockages and clear if required	Monthly / after large storms
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly / after large storms
	Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies	Half yearly
	Check penstocks and other mechanical devices	Half yearly

Table 2: Detention basin operational requirements (Woods-Ballard, et al., 2007, pp. 16-8)

2.9.4.2 Wetlands that treat stormwater

Wetlands serve to attenuate stormwater, allow for sedimentation and act as a treatment facility to remove pollutants from plant material such as macrophytes and floating aquatics (Woods-Ballard, et al., 2007).

The design criteria for wetlands that treat stormwater have been described as:

- Upstream water quality treatment.
- Temporary attenuation of stormwater.
- A tapering profile and slopes to allow continuous base flow or permeation of ground water where permanent inundation of water occurs, which supports plant growth.

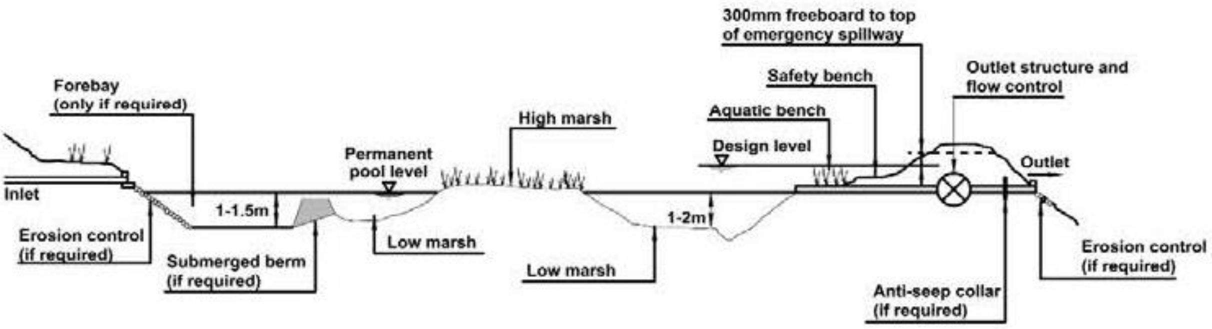

Figure 25: Typical longitudinal section through a wetland (Woods-Ballard, et al., 2007, pp. 18-3).

Wetlands are generally considered beneficial for treating or removal of pollutants, especially in shallow sections as they reduce suspended solids and heavy metals to a large extent and provide a moderate reduction in nutrients while also improving ecological, aesthetic and amenity value (Woods-Ballard, et al., 2007). The design of wetlands may vary to meet the intended design criteria. Wetlands are best located proximal to biodiverse sources of native species. A longitudinal section through a typical shallow wetland is depicted in Figure 25, showing limited water depths and shallow gradients, which are required in the longitudinal section to maximise water retention capacity and pollutant uptake of plants, while also considering safe maintenance protocols. Wetlands are intended to have large surface areas which increase opportunities for habitat and biodiversity (Woods-Ballard, et al., 2007). Contrary to the literature this case study provides evidence that wetlands may not always adequately deal with the quality of water, as required by SuDS. This is particularly apparent when large populations of birds are attracted to wetland habitats, this has the potential to yields high guano loads. In such instances, narrow and deep canals with limited habitat provision may better serve the function of water polishing and purification. It is prudent practise to include the detailed design and installation objectives and requirements for each SuDS intervention in operational manuals, as these may be used to guide the responsible operational teams regarding:

- The design intent.
- The functional intent or objectives.
- Landscape maintenance approach and compilation of method statements.

The main operational requirements associated with wetlands are tabulated below.

Maintenance schedule	Required action	Frequency
Regular maintenance	Litter, trash, debris and surface scum removal	Monthly
	Grass cutting – public areas	Monthly (during growing season)
	Grass cutting - meadow grass	Half yearly (Spring - before nesting season and Autumn)
	Inspect vegetation to wetland edge and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1m above wetland base). Include max 25% of wetland surface. This activity may require a boat.	Annually, or as required.
	Remove 25% of bank vegetation from water's edge to a minimum of 1m above water level.	Annually, or as required.
	Tidy all dead growth before start of the growing season.	Annually
	Remove sediment from one quadrant of sediment forebay.	Annually, or as required.
	Remove sediment from one quadrant of the main body of wetlands without sediment forebays.	2-5 years

Occasional maintenance	Remove sediment from the main body of wetland when its volume is removed by 20%	> 25 years, (usually).
Remedial actions	Repair of erosion or other damage.	As required
	Repair / rehabilitation of inlets, outlets and overflows.	As required
	Supplement plants (to maintain at least 50% surface area coverage) of vegetation is not established after the second growing season,	One off event.
Monitoring	Inspect structures for evidence of poor operation.	Monthly / after large storms
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly / after large storms
	Inspect silt accumulation rates and establish appropriate removal frequencies. Establish appropriate silt removal frequencies	Six monthly.
	Check penstocks and other mechanical devices	Six monthly.

Table 3: Wetland operational requirements (Woods-Ballard, et al., 2007, pp. 18-9).

2.9.5 WSuD Planning and Management

Managing the transition towards WSuD, SuDS and Water Sensitive Settlements (WSS) in South Africa requires a concerted effort in policy development, facilitation of institutional structures, community participation, construction, and operations (Armitage, et al., 2014). Stormwater systems that are designed by applying appropriate SuDS planning, design and maintenance principles are more sustainable and resilient in the face of adverse environmental effects (Woods-Ballard, et al., 2007). Water Sensitive Urban Management (WSUM), Sustainable Stormwater Management (SSWM) and Integrated Urban Water Management (IUWM) refer to management of stormwater infrastructure to support the urban water cycle in a holistic, comprehensive, and sensitive manner that achieves the desired economic, environmental, and social benefits. Operational aspects usually require careful planning, the creation of community awareness, empowerment, and knowledge-building through education to achieve optimally managed resources (Armitage, et al., 2014). SuDS management requires a comprehensive approach that marks out and accounts for the entire SuDS lifecycle (Charlesworth & Booth, 2017).

2.9.6 Operational maintenance

Operational maintenance describes activities that reduce risk to human life through attention to quality, quantity and safety issues that ensure the continued functioning and operation of a system while progressively moving toward an optimal state or condition (Charlesworth & Booth, 2017). The benefits SuDS may be negated through undervaluing the environmental, social, and recreational amenity which ultimately results in poor maintenance (Charlesworth & Booth, 2017). The outcomes from poor maintenance are often reduced aesthetic quality, functionality, and decreased property value (Charlesworth & Booth, 2017). Although perceptions of SuDS have improved in recent years operational aspects are still currently considered challenging (Charlesworth & Booth, 2017; Martin, Ruperd, & Legret, 2007). An adequate and consistent level of planning, design, installation, and establishment should be a prerequisite, with a regular maintenance programme once the operational phase resumes (Charlesworth & Booth, 2017). Some authorities have established mechanisms for long-term ongoing maintenance of SuDS by means of a guarantee or maintenance arrangement which will ensure a minimum standard of upkeep and care (Woods-Ballard, et al., 2007). Operations should be easy and safe to understand and execute as well as tailored to site conditions (Charlesworth & Booth, 2017; Woods-Ballard, et al., 2007). Operational challenges highlighted in List 1 indicate the change in perceptions around SuDS operations being key to success.

Operational issues	There is no consensus on who benefits from SuDS. There is a belief that SuDS may present maintenance challenges. There may be concerns that the colonisation of SuDS may be too successful. SuDS may present a target for vandals.
Design and standards	SuDS are not promoted by the Building Regulations. There are no standards for the construction of SuDS. SuDS require input from too many specialists. SuDS may be seen as untried technology. The guidance on how to build SuDS is limited or unclear. It is difficult to predict the runoff from a site. SuDS can be difficult to retrofit to an existing development.
Management/operational framework	SuDS require new approaches to enable full participation. Planning, design and construction of SuDs will require better coordination. SuDS can require multi-party agreements that may be difficult to set up. SuDS present challenges in setting up long-term management and ownership agreements. SuDS can be difficult to implement because of the variability of roles and responsibilities within local authorities and other bodies. Sewerage undertakers may be reluctant to adopt foul sewers when they are only sewers serving developments using SuDS.

List 1: Challenges with SuDS operations (Charlesworth & Booth, 2017, p. 7).

The unique combination of SuDS infrastructure installed in a treatment train configuration will affect the type, detail, complexity, frequency, and cost of maintenance. These factors also affect the operational lifespan of the facility and the ongoing necessity for corrective interventions (Charlesworth & Booth, 2017; Jeffaries, et al., 2009; Woods-Ballard, et al., 2007). Corrective interventions are often determined by risks associated with pollution, flooding, injury and community interest (Charlesworth & Booth, 2017).

Success is more likely when project inception is linked to project outcomes and the operational phase, as this is when the benefits become tangible realisations, creating value long after project completion (Artto, et al., 2016). In the Systems Development Cycle, the system transitions into Phase D, the operational phase after execution, with predictable and consistent requirements that lead to repetitive activities and resources (Nicholas & Steyn, 2017). Every system has a finite lifespan, and may either be terminated, upgraded, or modified to serve current or evolving requirements of its users and for this reason, Phase D may transition back to Phase A in Figure 26. The process is advanced through intricate social connections, starting at project conception to a mature operational entity for value creation during the operational phase (Morris, 1983).

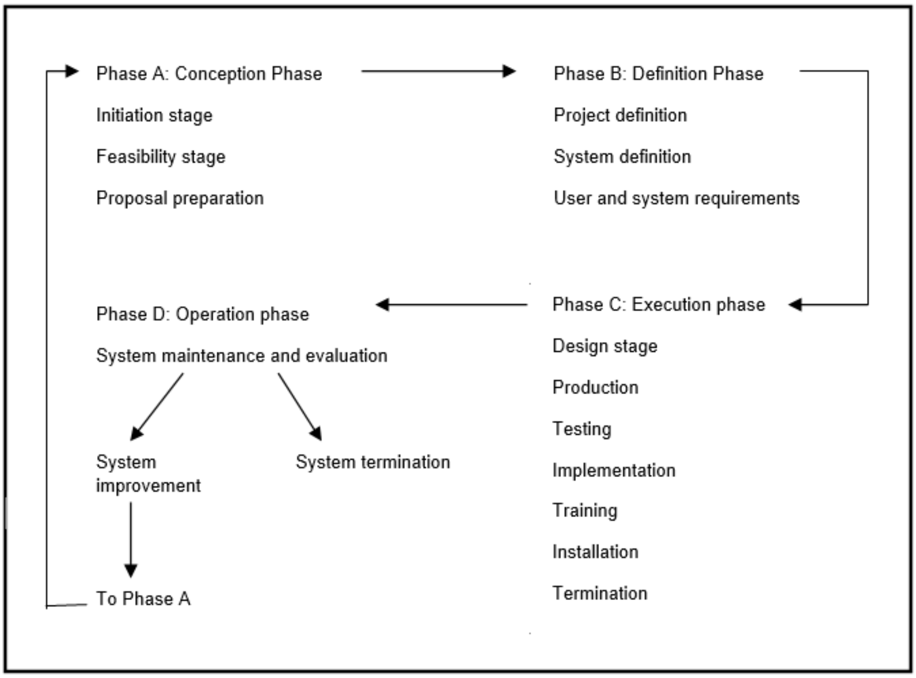

Figure 26: System development cycle (Nicholas & Steyn, 2017, p.69).

2.9.7 Operations of SuDS relating to this case study

The greatest uncertainty regarding SuDS infrastructure has been identified as the complexity of vegetative cover of which continued and regular maintenance is required to ensure optimal growth and function (Armitage, et al., 2013; City of Cape Town, 2011; Woods-Ballard, et al., 2007). Woods-Ballard et al. (2007) categorise landscape maintenance, scheduled for both regular and occasional maintenance, with adaptations to suit specific site requirements and conditions. SuDS systems may have ongoing sedimentation due to treatment process which will require regular maintenance for optimal operations and may require specialised equipment and vehicles (Woods-Ballard, et al., 2007).

Woods-Ballard (2007) include a chapter on landscape best practises, which further outlines the landscape objectives and principles. Considerations of site characteristics such as soil, orientation, and exposure as well as plant selection is important (Woods-Ballard, et al., 2007). Planting guidelines are provided with a list of recommended plants for specific applications. Addendum 1 contains "The South African Guidelines for SuDS" containing basic operational best practise guidelines. Landscape aspects have been included as a paragraph at the end of each chapter. Information such as:

- Recommended maintenance cycles.
- Recommended maintenance activities.

The document is intended to be used in association with the "SuDS Landscape and Indigenous Plant Species Guideline", prepared by the City of Cape Town: Catchment, Stormwater and River Management Department in 2011 which contains a table of SuDS typologies and a list of suitable indigenous plant species and their required wetting regimes (Catchment, 2011) as well as the Development Management Information Guideline Series 8: Landscape Plans (Development Management, 2020), however these are non-specific for SuDS. Following this, landscape protocols are intended to ensure that the requirements of the authorities are met, not only in a static end-state form but as a landscape that functions optimally and in perpetuity.

SuDS type and function	**Typical conditions**	**Exposure to wet conditions / stormwater pulses**	**Comments**	**Maintenance requirements (not all have been listed)**
Constructed wetlands T ; D	Pool, DM, SH, WM/EM	Year round (?) with extended detention of storm "peak" in pool for 48-72 hours)	Wetlands attract birds which can result in significant water quality deterioration (eutrophication) – any roosting structures should therefore not accommodate large numbers of birds. Species lists for WM / EM can possibly be used around the outer margin of the constructed wetland.	Maintenance of forebay area (litter trap, sedimentation area, inflow structure), vegetation maintenance in various zones as appropriate, maintenance of outlet structure, maintenance of high flow bypass channel.

Table 4: SuDS wetland functionality and maintenance (Catchment, 2011, p. 5).

DETAILS OF WETTING REGIMES

POOL (>0.4m deep) hydroperiod: 12 months

DM: DEEP MARSH (0.2 – 0.4m deep) hydroperiod: 12 months

SM SHALLOW MARSH (0 – 0.2m deep) hydroperiod: < 9 months

WM WETLAND MARSH (0 – 0.1m deep) hydroperiod < 4 months

Mostly dry = can withstand 72 hours immersion

Scientific name	**Common name**	**Preferred wetting regime**	**Growth form**	**Max height (m)**	**Soil type**	**Comments (known propogation)**	**Impedes flow?**	**Commercial availability?**
Aponogeton distachys	Waterblommetjie	Pool	Floating herb	n/a	n/a	Winter growing and flowering		Y
Nymphae nouchali	Blue water lily	Pool	Floating herb	n/a	n/a	Summer growing ad flowering		Y

Table 5: City of Cape Town SuDS species list (Catchment, 2011, p. 6).

2.9.8 Technology

SuDS management has evolved with the use of technology to proactive, dynamic, smart systems that allow for real-time management of urban stormwater infrastructure (Butler, et al., 2008). Flexible and adaptive new technologies allow for experimentation in complex, developed urban areas (Armitage, 2011; Chocat, et al., 2007). Sensors, regulators, controllers, and data transmitters may be used to create control loops that are programmed to fit within a control strategy that allows for adjustments for optimal performance (Butler, et al., 2008). Therefore, technology provides the tools for data acquisition and analysis to actively model, predict, and optimise controls and provide warning systems that assist with flexible and remote risk management responses (Butler, et al., 2008).

2.9.9 Training

Training improves project implementation and often leads to the assimilation of a broader informal professional network where discourse is encouraged away from drainage towards stormwater management and sustainable practises (Goulden, et al., 2018). For Sustainable Stormwater Management (SSWM), it is important to incorporate technical knowledge into professional norms and forms of governance through informal information sharing bodies such as communities of practise (Ferguson, et al., 2013; Goulden, et al., 2018). Knowledgeable and experienced staff and teams are prerequisites to success (Charlesworth & Booth, 2017). Maintenance teams should have pre-determined skill levels with associated responsibilities together with a basic knowledge of SuDS infrastructure and how they function. This should be supported by specialists who carry out less frequent technical assessments that provide an overview of the general and specific condition of the site and functioning (Charlesworth & Booth, 2017). Training during the operational phase will empower individuals and teams to make educated and timeous decisions regarding amendments and improvements to SuDS systems (Charlesworth & Booth, 2017). In addition, communities may be educated about the facility and therefore also feel empowered to assist with a basic level of reporting (Charlesworth & Booth, 2017). Community participation can supplement these experienced teams for observation, data collection and information transmission (Butler, et al., 2008). Formal reporting should consist of formal, standardised, and simple with written, graphic, and photographic evidence as proof of due diligence around technical quality and quantity of maintenance and inspections as well as tracking specific issues and patterns in maintenance and the evaluation of risks, recommendations, and adjustments in activities (Charlesworth & Booth, 2017).

2.9.10 Standards

Operational requirements should be considered during the design phase, and it is important that the consultant team who worked on the planning and design prepare the maintenance details and schedules well in advance of the work (Woods-Ballard, et al., 2007). All aspects relating to engineering and landscape infrastructure management must be included such as access, material specifications, maintenance regimes, operational suitability, expected standards and allocation of responsibility (Charlesworth & Booth, 2017). Maintenance regimes of soft landscaping such as plant zones, plant densities, quality of plant cover, seasonal care, plant seeding, and control of invasive species require careful consideration as these aspects impact on SuDS functioning (Woods-Ballard, et al., 2007).

Very specific maintenance is required for optimal functioning to "retain, protect and enhance natural drainage patterns" (Armitage, et al., 2013, p. 44). The standard of maintenance required depends on various influences and are categorised as follows and seen in Figure 27 showing that basic operational regimes include inspection, litter and debris clearance and vegetation maintenance. This regime may be expanded to serve more wide-ranging objectives related to aesthetics, biodiversity, and amenity.

Low visibility sites

Low: Basic maintenance to ensure function
Low frequency visits
Mainly litter removal and maintenance of vegetation
Additional activities may be identified to improve operations

High visibility sites

Medium: For function and aesthetic appeal
More frequent visits

Urban area, public amenity spaces and densely populated areas

High: Enhanced maintenance
Additional focus on the planting specification and aesthetic appeal

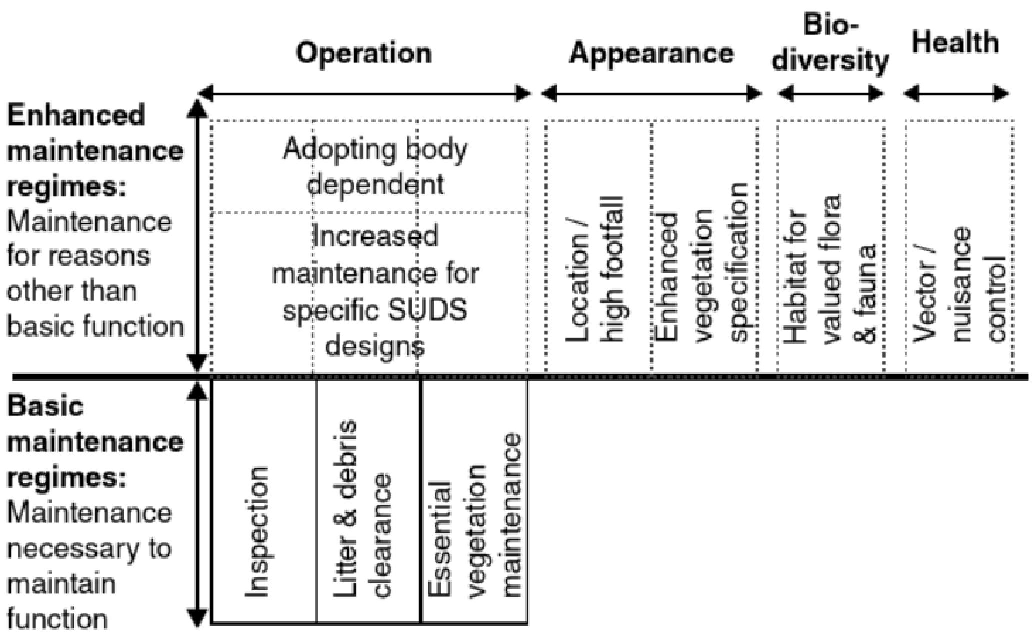

Figure 27: SuDS maintenance standards (Charlesworth & Booth, 2017, p. 51).

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The SuDS Manual recognises that fixed states cannot be achieved during operations and therefore aims for optimal site-specific outcomes in changing environments (Woods-Ballard, et al., 2007). For this reason, the landscape design, objectives and installation requirements for each SuDS intervention is to be outlined in detail with basic operational requirements. This can be done in the same format for each SuDS intervention. The level of detail relating to management, maintenance, inspections, and reporting will depend on the complexity of the site, the land use, exposure to theft and vandalism, level of detail and end-user or owner requirements (Woods-Ballard, et al., 2007). Maintenance may be measured through visits and performance standards or a combination thereof. Often engineering elements are maintained and assessed on a frequency basis whereas landscape elements are maintained and measured according to performance standards (Charlesworth & Booth, 2017). "Minimum visits" is used as a basis for measuring frequency while performance standards are used where a high standard is required and to establish a predetermined standard of care (Charlesworth & Booth, 2017; Woods-Ballard, et al., 2007).

2.9.11 Monitoring

Management practises are intended to enhance functioning and may either require a change in the types of activities away from conventional practises or discourage activities that may be considered harmful practise (Butler, et al., 2008). Manuals, legal documents and agreements for the basis of monitoring and usually provide a datum. Inspections allow for monitoring and recording according to this datum and may require irregular and corrective supplementary maintenance activities as seen in Figure 28. Ongoing record keeping often includes monitoring of groundwater quality as vital information that is used to motivate for additional interventions when changes occur (Butler, et al., 2008).

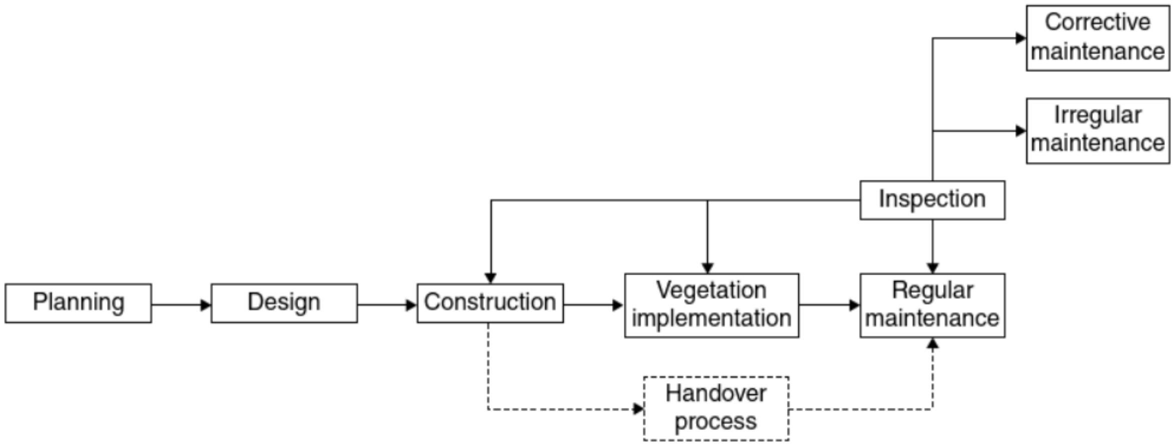


Figure 28: Inspection and maintenance activities (Charlesworth & Booth, 2017, p. 47).

2.9.12 Costs

The influence of the design and installation on the day-to-day functioning and ease of maintenance of the infrastructure needs to be understood, with the ultimate intention of realising ecosystem services and benefits (Charlesworth & Booth, 2017). A clear link has been found between SuDS infrastructure which is geared toward operations to improve its lifespan (Charlesworth & Booth, 2017). A greater level of detail and setting of standards during the design stages reduces risk during the operational phase of the project and needs to be weighed up against the cost during the implementation phase (Charlesworth & Booth, 2017). Full lifecycle costs and cost effectiveness of conventional versus SuDS stormwater management should also be considered early on in the design process and may include land acquisition, operational costs and unforeseen costs such as training (Armitage, et al., 2014; Barbosa, et al., 2012; Davis & Birch, 2009). These costs are easier to ascertain when the end-user or owner is involved in the development of detail design and standards, which also reduces corrective work and operational risk (Charlesworth & Booth, 2017).

Despite perceptions around costs, SuDS stormwater treatment options are considered to provide more cost-effective solutions and need to be compared with comprehensive long-term operational data comparisons and monetised amenity value (Butler, et al., 2008). However, the SuDS operational phase requires involvement of numerous line departments which brings about greater complexity (Butler, et al., 2008; Grant, et al., 2017). Whole Life Cost (WLC) consist of the full life cycle cost of a SuDS facility, from planning and design, through implementation phases (referred to as CAPEX) and after handover into operations (referred to as OPEX), the details and specifications of which may be separated into CAPEX and OPEX as depicted in Figure 29, depending on contractual agreements and end-user or owner requirements (Charlesworth & Booth, 2017). Where SuDS is integrated as passive space within a larger open space network, a reduction of cost may be found due to economies of scale (Charlesworth & Booth, 2017).

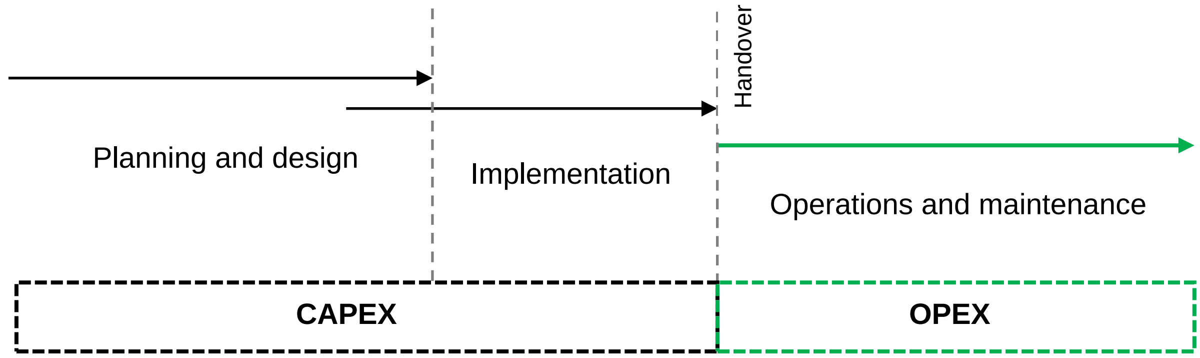


Figure 29: A depiction of capital versus operational project phases by Charlesworth and Booth, 2017 (Spolander, 2022)..

2.9.13 Public awareness

Over time, SuDS has developed and advanced into systems that are more commonly understood, accepted and form part of stormwater legislation. More recently in South Africa there has been much focus on sustainable development in detail design, however a lack of information, lack of adequate maintenance regarding SuDS operations still exists and results in reluctance by some communities (Charlesw(Butler, et al., 2008; Charlesworth & Booth, 2017). Ongoing public awareness and education of internal and external stakeholders is required before and after the installation of SuDS infrastructure to ensure that the concept of sustainable approaches is accepted by communities, the risks associated with inappropriate activities understood and the value that these amenities bring to society is appreciated (Butler, et al., 2008). For optimal outcomes, involvement of communities from project inception, through design, installation and maintenance can bring a sense of community ownership and tailoring of a project to meet their specific needs (Butler, et al., 2008).

2.9.14 Outcomes

Varying data on the long-term performance of SuDS show that most systems operate effectively if they receive appropriate maintenance (Butler, Digman, Macropolous, & Davies, 2008; Jefferies, 2004). A balanced approach in maintenance operations is important as this may impact environmental stability and cost (Charlesworth & Booth, 2017; Graham, et al., 2012). Allowance needs to be made for alternative interventions to minimise risk (Chocat, et al., 2007). Poor outcomes are reported when water, sewerage and stormwater is compartmentalised, during the construction and operational phases (Brown, 2008; Wong & Brown, 2009). Poor performance strengthens the perception that SuDS do not fulfil the criteria for a sustainable system, however both conventional and sustainable systems, require a certain level of maintenance to function and function optimally.

2.10 Open space amenity

2.10.1 Natural and man-made systems

Population growth, climate change and urban water scarcity demand solutions that bring increased resilience and provide ecosystem services that ameliorate impacts in the face of uncertainty (Chan, et al., 2018; Nguyen, et al., 2019). Sustainable living options need to be made accessible through careful planning (Cilliers, et al., 2015; Harvey, 2017). Governments, authorities, planners, and designers need to further promote the restoration of green spaces through design interventions that mitigate the negative impact of urban development on the hydrological cycle and restore the connection between people and nature (Harvey, 2017; Ayres, 2017). Urban landscapes need to connect spatial planning to water management, be multi-functional and multi-dimensional, challenge outdated approaches in design and reverse the trend of depleting water reserves and ecosystems (Wong & Brown, 2009). These systems need to preserve natural ecosystems and continuous systems of green space at the interface with man-made systems to provide opportunities complex ecological function (Department of Housing, 2000; Wong & Eadie, 2000; Ayres, 2017).

2.10.2 The role of Landscape Architecture

Direct and indirect environmental impacts are more pronounced in urban areas, affecting property and human life negatively (Dhakal & Chevalier, 2016; Qiao, et al., 2018). Research shows that individuals who value the environment, have direct experience and are connected to natural processes, value the environment. This proximity to nature in an urban context can have long term cultural and environmental benefits as this provides opportunities for learning and solution-finding through the observation of natural templates (Calkins, 2012). For this reason, multi-disciplinary holistic approaches are required to plan, design, and maintain liveable, environmentally responsible spaces that engage with communities in the development of sustainable cities (Wong & Brown, 2009; Woods-Ballard, et al., 2007). Sustainable site design focuses on assessment of the entire system at a broader scale, respecting human and natural ecosystem health and responding appropriately by integrating water, vegetation, and soil systems that manage, protect, and restore function to the hydrological cycle through monitoring and management initiatives (Calkins, 2012). Sustainable Stormwater Management is closely linked to urban planning and landscape design, drawing from principles in nature and applying them through mimicking of natural processes in planning and design and therefore contributing to the ecological functioning of landscapes and advancing the cause of green infrastructure (Goulden, Portman, Carmon, & Alon-Mozes, 2018; Wong & Brown, 2009).

Amenity refers to the aesthetics and use of a site for recreational purposes (Jose, et al., 2015; Lähde, et al., 2019). Goals relating to this amenity may include recreational, educational, safety and aesthetics. Biodiversity and amenity value may be improved through biotic and abiotic interventions (Lähde, et al., 2019; Backhaus & Fryd, 2013; Monberg, et al., 2018). Increased amenity value is attached to green open spaces that contain water bodies as they result in increased biodiversity in urban areas (Lähde, et al., 2019; Backhaus & Fryd, 2013; Wood, et al., 2018). SuDS conserves and restores land parcels close to their original condition thereby protecting and maintaining biodiversity and enhancing amenity (Armitage, 2011; Grant, 2016).

Ecosystem services are the direct or indirect benefits that are derived from ecosystems through the interaction and processes of living and non-living elements utilised by humans (Armitage, et al., 2014). The relationship between ecosystem services and human wellbeing has been well documented as depicted in Figure 30. This model reflects the four spheres of ecosystem services, namely supporting, provisioning, regulating and cultural spheres and how they influence various aspects of human wellbeing. Ecosystem services have a positive impact on human wellbeing and can be carefully managed to achieve synergistic functioning in urban areas, resulting in numerous socio-ecological benefits (Fletcher, et al., 2015; Goulden, et al., 2018; Lähde, et al., 2019; Mitchell, 2006). Ecosystem services also improve property value substantially, but this is not always accounted for since economic systems do not always sufficiently reflect the value of these services nor account for their degradation or depletion (Armitage, et al., 2014; Calkins, 2012). It is for this reason that effective and efficient long-term operations of ecosystems is important.

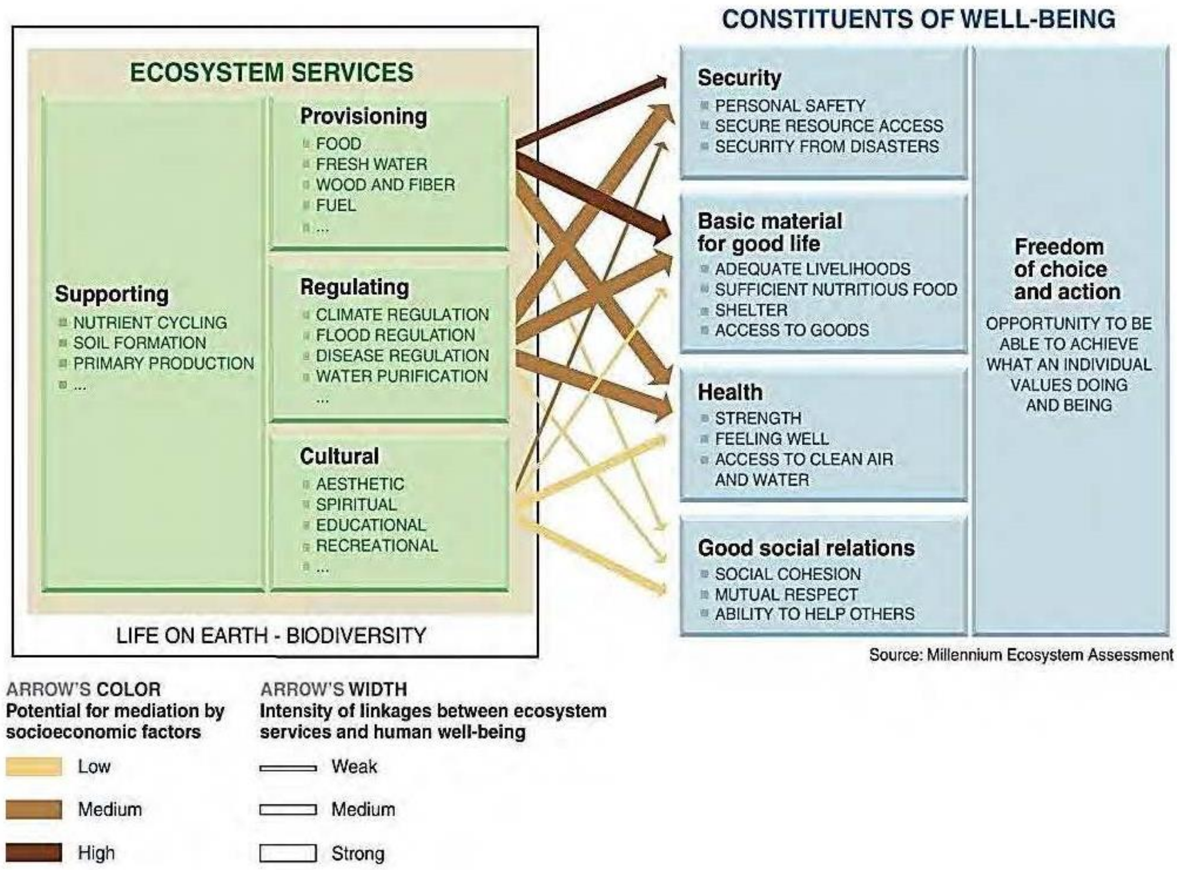


Figure 30: Complex interconnections between ecosystem services and human wellbeing (Armitage, et al., 2014, p. 60).

The SuDS approach serves to protect and restore optimal stormwater management, enhance ecosystem benefits and life function (Armitage, et al., 2014). SuDS indicators can be monitored as performance criteria in the measurement of ecosystem performance and is evidenced by reduced flooding, improved water quality, increased groundwater recharge, enhanced biodiversity, amenity, aesthetics, and consequently increased property value as seen in Table 6. Account needs to be taken of ecosystem services and the value of essential urban ecological landscapes, as these have the potential to reverse degradation caused by outdated conventional approaches (Wong & Brown, 2009). Such ecosystem services have been classified according to landscape type as illustrated in in Figure 31.

Factors affecting property values near open water bodies	
Increase	**Decrease**
Naturally designed water bodies (Wet ponds)	Open, unprotected water is a concern to residential owners with young children – drowning hazard
Ponds & lakes create ideal scenery for business parks	Poor design / aesthetic appeal (particularly dry ponds)
Positioning water features near entrances increase sale and value of properties	Safety concerns are the main negative effect of stormwater controls
Property with water views or other amenities can be charged premiums	Poor maintenance leads to unsightly wet / dry ponds due to excessive algal growth or garbage build-up
New recreational facilities (paddling, open areas, etc.)	Health concerns (mosquito breeding grounds)

Table 6: Property value factors (Armitage, et al., 2014, p. 62).

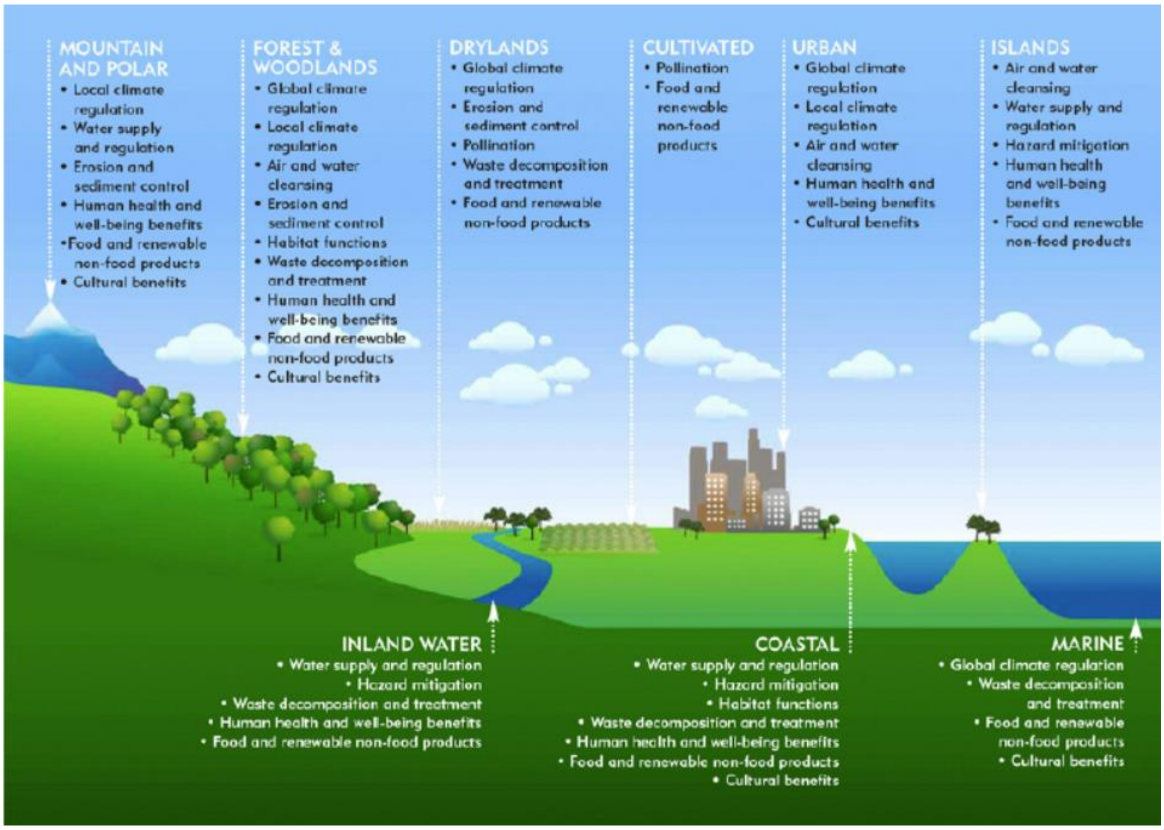


Figure 31: Landscape classification of ecosystem services (Calkins, 2012, p. 6).

Landscapes form part of urban areas, providing so much more than places for social, cultural, economic, and environmental interaction. They also have aesthetic appeal which benefits human health (Calkins, 2012). Therefore, Landscape Architects have the responsibility to plan and design ecosystems that function as well as enhance the aesthetic experiences of the user and provoke awareness of environmental impacts (Calkins, 2012). There is a general lack of knowledge regarding the ability of landscape architectural design approaches to enhance biodiversity and ecological function as part of stormwater management in urban open space (Lähde, et al., 2019). Applying evidence-based research tends to engage researchers and practitioners into a stimulating dialogue on the application of SSWM to enhance quality of life (Goulden, et al., 2018). In contexts where Landscape Architects drive stormwater management projects, the involvement of other professionals remains keyin integration of professional expertise and capacity building (Goulden, et al., 2018).

2.10.3 SuDS landscape operations

The role of landscape is often that of mitigation of impacts on the site through vegetative cover that is selected according to site characteristics such as climate, orientation, drainage, soil types and exposure to improve function and aesthetics of SuDS (Woods-Ballard, et al., 2007). Appropriate local and native vegetation has the potential to enhance SuDS by stabilising soil, trapping soil particles, improving infiltration of water, filter pollutants, provide a safety function, delineate edges, improve aesthetics and enhance ecological function. In so doing, amenity and economic value is optimised (Woods-Ballard, et al., 2007).

2.10.3.1 SuDS operational documentation

a) Management Plan

The Management Plan describes the operational objectives within a stipulated period and the associated strategies to achieve these objectives. This may be expanded to accommodate wildlife and habitat objectives. A Management Plan assists with clarifying the purpose of the system and priorities related thereto (Woods-Ballard, et al., 2007). A maintenance plan supports the Management Plan as it clarifies the purpose and function of the SuDS intervention and identifies maintenance protocols to address the management objectives.

b) Operational manual

Long-term maintenance of SuDS is to be considered early in the planning phase of the project to ensure that all costing related to SuDS is adequately accounted for. The transition between construction and operations a key gateway that ensures that the design is fully validated and operational as intended. A validation report may be provided for this purpose, which allows close-off of the construction phase and is used in conjunction with an operating manual as a vital resource for SuDS infrastructure with the following information:

- The location of SuDS.
- Function of SuDS.
- Risks and mitigation of risks.
- Access and prohibited areas.
- Preliminary maintenance plan.
- Remedial and repair work considerations.
- Health and safety aspects.

(Woods-Ballard, et al., 2007).

c) Conditions of contract

The conditions of contract may be linked to the construction contract or completely independent. This depends on the post-construction maintenance appointment.

d) Specifications

This document details the standards, performance, materials, methods, and time allocation for the work.

Macrophytes and vegetative cover:

When selecting plant material or vegetative cover and infill, it is best to select native plants that will thrive in the climatic and soil conditions and are suited to the hydrological conditions (Woods-Ballard, et al., 2007). Vegetative cover has the potential to effectively suppress unwanted weed and alien invasive growth and limit the requirement for manual removal in sensitive environments (Woods-Ballard, et al., 2007). Plants that are locally sourced are more likely to have been hardened off and adapt to the climatic conditions than plants supplied from distant locations. Additionally, maintenance regimes require consideration of their impact on the functionality of SuDS interventions in the short or long-term (Woods-Ballard, et al., 2007).

Aquatic maintenance:

Aquatics become prolific due to the presence of nutrients in water and require harvesting after nutrient uptake, but this means that green waste needs to be carefully managed to maximise recycling of organic matter. Disposal areas and collection points need to be determined upfront for ease of maintenance (Woods-Ballard, et al., 2007). Maintenance is carried out to:

- To minimise weed and alien invasive plant growth.
- To limit the accumulation of dead plant material that store nutrients from stormwater uptake.
- To promote healthy vegetative growth and optimal water quality.
- To limit siltation.

The literature recommends that emergent aquatics be harvested about 100mm above the ground level every 5-10 years to reduce the impact of vegetation on water levels, flow and water quality. This harvested material may be stacked alongside the water's edge for 48 hours to allow for drying out of the vegetation and for small faunal creatures to return to the SuDS and then removed for composting.

Growing mediums:

Limited additives and amendments to the soil are preferred to avoid these leaching down into the wetland system or groundwater table and increasing nutrient loads (Woods-Ballard, et al., 2007).

e) Work schedule

This details the individual tasks, performance, frequency, and allocation of time. Some tasks are based on performance while others are based on frequency (Woods-Ballard, et al., 2007).

The SuDS Manual describes three types of maintenance:

- Occasional maintenance: Sediment removal and vegetation interplanting.

- Routine maintenance: Inspections and reporting, litter removal, weed and alien plant control, shrub maintenance, aquatic maintenance, management of green waste.

- Remedial maintenance: This is site specific and carried out to remedy faults such as repair, reinstatement and rehabilitation work every 10-25 years to alleviate clogging of the system but is dependent on the level of routine maintenance. Such maintenance is likely to require machine access (Woods-Ballard, et al., 2007). For this reason, SuDS infrastructure is best left exposed and visible and therefore easily accessible for assessment and maintenance purposes.

f) Monitoring and reporting

	SuDS component												
Operational and maintenance activity	Pond	Wetland	Detention basin	Infiltration basin	Soakaway	Infiltration trench	Filter tranch	Modular storage	Pervious pavement	Swale / bioretention / green roofs	Filter strip	Sand filter	Pretreatment systems
Regular maintenance	■	■	■	■	■	■	■	■	■	■	■	■	■
Inspection	■	■	■	■	□	■	■	□	■	■	■	■	■
Litter / debris removal									■	■	■	■	■
Grass cutting	■	■	■	■	□	■	■	□	□	■	■	□	□
Weed / invasive plant control	□	□	□	□		□	□		□	□	□	□	□
Shrub management	□	□	□	□					□	□	□		□
Shoreline vegetation management	■	■	□										□
Aquatic vegetation management	■	■	□										□

Occasional maintenance													
Sediment management *	■	■	■	■	■	■	■	■	■	■	■	■	■
Vegetation / plant replacement	□	□	□	□						□	□		□
Vacuum sweeping and brushing									■				
Remedial maintenance													
Structure rehabilitation repair	□	□	□	□	□	□	□	□	□	□	□	□	□
Infiltration surface reconditioning	□	□	□					□		□	□	□	□

■ Will be required

Y May be required

*Sediment should be collected and managed in pre-treatment systems, upstream of the main device

Table 7: Operational activities (Woods-Ballard, et al., 2007, pp. 22-3).

Current literature recommends that monitoring and reporting activities form part of regular maintenance with additional inspections after each storm event however, there are also recommendations to monitor according to site specific requirements and complete an annual maintenance report and operating manual for reference (Woods-Ballard, et al., 2007). Table 7 identifies maintenance activities associated with various SuDS applications including wetlands, ponds, and detention ponds which form part of this case study. The table outlines regular maintenance, occasional maintenance and remedial maintenance activities but does not allow sufficient flexibility to support the emergent findings in this case study of tailoring the approach and maintenance schedule to suit site-specific conditions and facilitate adaptive, responsive and experimental operations.

2.11 Success Factors

2.11.1 Projects

Projects may be described as unique, ambiguous, uncertain, and complex in nature (Gauthier & Ika, 2012; Sheard & Mostashari, 2009). They often have quantitative and qualitative goals and objectives (Rodney Turner, 2009). These objectives are fulfilled in engaging, interactive and interpretive spaces (Gauthier & Ika, 2012). Projects also have time and resource constraints, and undergo constant redefinition, yet they pragmatically progress towards outcomes that meet the needs of stakeholders, address challenges in organisations and benefitting society (Mavi & Standing, 2018;

Gauthier & Ika, 2012). Projects are initiated for the purpose of effecting change in organisations, to advance business strategies and ensure global competitiveness (Shenhar, et al., 2001). They have been described as "powerful strategic weapons" that enlarge the competitive advantage of a business to create economic benefit and long-term value (Shenhar, et al., 2001). Long term projects have the potential to drive organisational strategy rather than acting as a tool to exercise strategic intent (Shenhar, et al., 2001).

2.11.2 Project success

A standard definition of project success has yet to be realised (Baccarini, 1999; Belassi & Tukel, 1996; Joslin & Müller, 2015; Shenhar, et al., 2001). In 1996, the PMI's Guide to the Project Management Body of Knowledge identified knowledge areas in the PMBOK as the basis for achieving the required outcomes and referred to project success as achieving the outcomes that meet or exceed stakeholder needs and expectations while balancing competing demands across various dimensions (Müller & Jugdev, 2012). The Association of Project Management defines success factors as the measurable factors present in a project environment that leads success on a project (Müller & Jugdev, 2012). The Project Management Institute (PMI) in 1986 states that:

> *"Project success is a topic that is frequently discussed but rarely agreed upon. The concept of project success has remained ambiguously defined. It is a concept that can mean so much to so many different people because of varying perceptions…"* (Liu & Walker, 1998).

Traditionally, product success was associated with organisational efficiency and effectiveness the final product or output measured in quantitative financial terms at project completion (Pinto & Slevin, 1987; Serrador & Turner, 2015; Shenhar, et al., 2001; Shenhar & Dvir, 2007). Achieving project targets and delivery of successful outcomes has also been considered an indication of project success (Zwikael & Smyrk, 2012). Evidence shows that aiming for project success tends to yield short-term efficiency and long-term effectiveness (Joslin & Müller, 2015; Jugdev & Müller, 2005). Dvir and Lechler (2004) uphold the view that prioritising project planning is the cornerstone of project success and customer satisfaction. Even so, planning alone does not guarantee success (Dvir & Lechler, 2004). Due to the uncertain and changing nature of projects, it is virtually impossible to conceive and plan all activities, resources, and accurately allocate time in advance. A degree of change must be accommodated but too many variables and planned changes may negatively impact project success (Dvir & Lechler, 2004). Ultimately, project success relates to strategic management and aligning project initiatives with an organisations' short- and long-term goals found within the business case and long-term investment objectives (McLeod, et al., 2012; Shenhar, et al., 2001). This is contrary to traditional quantitative measurements, which alone do not provide sufficient indication of organisational success (Shenhar, et al., 2001; Serrador & Turner, 2015). Concerns have been expressed in the literature regarding the predominance of objective, quantitative and hard research approaches (Ika, 2009) while devaluing the soft dimensions which are subjective, interpretive and qualitative and are equally significant measures of success (Baccarini, 1999).

Due to the unique nature of projects, multi-dimensional success factors are considered more indicative of success than factors that have been reduced to the iron triangle (Atkinson, 1999). Project success is dependent on individual perceptions and world views, and the differences between individual perceptions implies that no project can attain complete success (Ika, 2009). Therefore, there is a need to apply alternative theories and methodological approaches to project success that explore differing thought, values, research, and ultimately new possibilities (Cicmil & Hodgson, 2006). Success in a contemporary project management context is based on independent variables (Müller & Jugdev, 2012). These variables may be described as vague, ambiguous, multi-dimensional and subjective (Belassi & Tukel, 1996; Ika, 2009; Jozipovic, 2015; McLeod, et al., 2012; Müller & Turner, 2007). More recently, project success has been defined as the ability of a project to achieve its intended goals and objectives and the realisation of project benefits by its beneficiaries through outcomes (Atkinson, 1999; Badewi, 2016), to produce short term efficiency and long term effectiveness (Judgev, et al., 2001). Project success is recognised as the application of predetermined objectives by a project manager to achieve positive results (Badewi, 2016; Ika, 2009).

Assessing project success may be dependent on the overall project timeline and a switch in focus between short-term measurables and financial outcomes versus a long-term focus on project benefits and value creation, resulting in stakeholder satisfaction (Serrador & Turner, 2015; Shenhar, et al., 2001; Shenhar & Dvir, 2007). When assessing project success and stakeholder satisfaction, a broad range of stakeholders is usually considered (Badewi, 2016; Ika, 2009). Successes of the project, product or project manager may be considered confusing and ambiguous, potentially leading to misunderstanding these terms (Baccarini, 1999; Jugdev & Müller, 2005; Pinto & Slevin, 1987). Muller and Turner (2007) identify the two components of project success as: project success criteria and project success factors (Müller & Turner, 2007). The table below compiled by Mc Leod et al. (2012) outlines these concepts:

Expanding dimensions →		
Project success	**Project success**	**Organisational success**
Focus on project management	Focus on project objectives	Focus on organisational objectives
• On time	• Product use	• Business benefits
• Within budget	• Client satisfaction	• Strategic benefits
• In scope specifications	• Client benefits	

Table 8: Project success criteria (McLeod, et al., 2012, p. 70).

The Logical Framework Method developed by Baccarini (1999) articulates product success relating to goals and purpose versus project management success relating to inputs and outputs, both of which are interconnected. Overall project success however is considered the combination of these as seen in Figure 32.

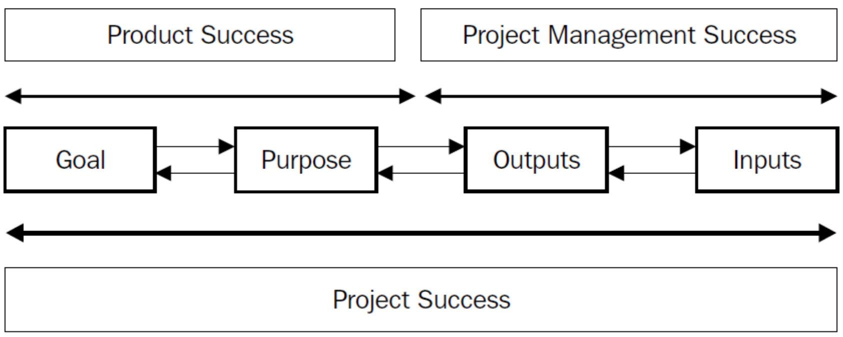


Figure 32: The Logical Framework Method of project success (Baccarini, 1999, p. 28).

Project success factors are the independent variables that contribute to project success (Müller & Jugdev, 2012) or factors that consist of management of system inputs that lead to project success (Cooke-Davies, 2002). These are inherently more “organisational and behavioural” than technical (Pinto & Slevin, 1987). During the process of identifying critical success factors, differentiation was made between 1. project management success; 2. project success and 3. the development of consistent success on projects (Cooke-Davies, 2002). Most projects are initiated for the purpose of advancing business and organisational performance**,** but it is impossible to generalise success factors as they are emerging, dynamic, and subjective. Due to the diverse nature of projects, usually a complex combination of factors over the project lifecycle phases contribute to project success**.** Many lists have been developed in the project management literature containing critical success factors that relate to the project manager and the project organisation, as seen in Table 9 (Belassi & Tukel, 1996, p. 143). These previously compiled lists were usually incomplete, theoretical, and considered subjective (Belassi & Tukel, 1996)**.**

Martin[16] (1976)	**Locke[14] (1984)**	**Cleland and King[25] (1983)**	**Sayles and Chandler[26] (1971)**	**Baker, Murphy and Fisher[9] (1983)**	**Pinto and Slevin[7] (1989)**	**Morris and Hough[11] (1987)**
Define goals	Make project commitments known	Project summary	Project manager's competence	Clear goals	Top management support	Project objectives
Select project organizational philosophy	Project authority from the top	Operational concept	Scheduling	Goal commitment of project team	Client consultation	Technical uncertainty innovation
General management support	Appoint competent project manager	Top management support	Control systems and responsibilities	On-site project manager	Personnel recruitment	Politics
Organize and delegate authority	Set up communications and procedures	Financial support	Monitoring and feedback	Adequate funding to completion	Technical tasks	Community involvement
Select project team	Set up control mechanisms (schedules, etc.)	Logistic requirements	Continuing involvement in the project	Adequate project team capability	Client acceptance	Schedule duration urgency
Allocate sufficient resources	Progress meetings	Facility support		Accurate initial cost estimates	Monitoring and feedback	Financial contract legal problems
Provide for control and information mechanisms		Market intelligence (who is the client)		Minimum start-up difficulties	Communication	Implement problems
Require planning and review		Project schedule		Planning and control techniques	Trouble-shooting	
		Executive development and training		Task (vs. social orientation)	Characteristics of the project team leader	
		Manpower and organization		Absence of bureaucracy	Power and politics	
		Acquisition			Environment events	
		Information and communication channels			Urgency	
		Project review				

Table 9: Theoretical critical success factor lists (Belassi & Tukel, 1996, p. 143).

Muller and Turner assert that critical success factors should be identified as relational or task oriented, since relational critical success factors impact project outcomes more significantly than task-oriented factors (Müller & Turner, 2007). They also assert that behavioural changes, stakeholder management and the ability of mature organisations to manage change are considered significant critical success factors (Yu & Kwon, 2011). The absence of empirical research into critical success factors is considered problematic as no likely universal success criteria have been established (Hyväri, 2006). A provisional approach was explored to establish generic success factors (Dvir, et al., 1998). The first alternative follows the traditional approach that project success may be rationalised, universal and objective while the second alternative applies the notion that projects are unique, emerging, unpredictable, and subjective. This alternative implies that there is no simple approach nor formula for measuring project success, but that success criteria and factors are project specific where success and failure emerge due to complex circumstances that are often not measurable as per Table 10 (Ika, 2009, p.15). The need for structure and groupings of project success factors has led to the development of success factor frameworks (Jugdev & Müller, 2005).

	Common Assumptions	Alternative 1: Contingent Approach	Alternative 2: "Subjectivist" Approach
Project success	A universal set of criteria and CSF exists in practice.	There is no "one best way" account for project success; only idiosyncratic criteria and CSFs exist for specific projects and contexts.	Success and failure are not only subjectively perceived and constructed by people, but they are entwined in meaning and action.
Aim of the research on project success	"Objectivist" view of project success grounded in ideal sets of criteria and CSF. Research undertaken as survey of large samples of projects.	"Situational" view of project success grounded in specific sets of criteria and CSFs. Research undertaken as unique or multiple case studies.	"Subjectivist" view of project success grounded in empirical narratives of success and failure. Research undertaken as comparative case studies.
Research metaphor for project success	Project success framework as a universal tool for achieving goals and objectives.	Project success framework as a context-specific tool for achieving goals and objectives.	Project success as a social construct.

Table 10: Project success assumptions (Ika, 2009, p. 15).

Project success criteria are the dependent variables that may be measured to determine the success (Müller & Jugdev, 2012). To ascertain project success, the success criteria need to be clearly defined (Müller & Turner, 2007) which has proven challenging (Baccarini, 1999). Success factors are determined by the accomplishment of success criteria during the project lifecycle. Success criteria are valued differently by stakeholders and managers (Müller & Jugdev, 2012) which may vary between projects (Müller & Turner, 2007). Success deemed by one stakeholder may be considered as failure by another due to the presence of subjective assessment (Belassi & Tukel, 1996). One thing is clear: success criteria need to be established early during the project initiation or inception phase (Pinto & Slevin, 1987) as this creates a mutually agreed understanding of success criteria (PMI Project Management Institute, 2017; Wateridge, 1998). Contracts may be used to define responsibilities, expectations and provide details to realise outcomes and benefits from investments (Badewi, 2016). Success criteria need to be prioritised against each other by stakeholders, each with their own time scale as they may conflict with each other during the project lifecycle, resulting in a requirement for trade-offs (Wateridge, 1998). The author argues that such success criteria need to be reviewed regularly during the course of the project and into the operational phase, since projects evolve and change. The project sponsor will have a vested interest in project success may measure project success quantitatively or qualitatively against success criteria such as efficiency, teamwork, stakeholder satisfaction (Davis, 2014) , business or strategic organisational goals (Mir & Pinnington, 2014) among other criteria which are delivered during the operational phase. Co-operation is required between the project organisation and operational team or user group (Cooke-Davies, 2002) as seen in Figure 33.

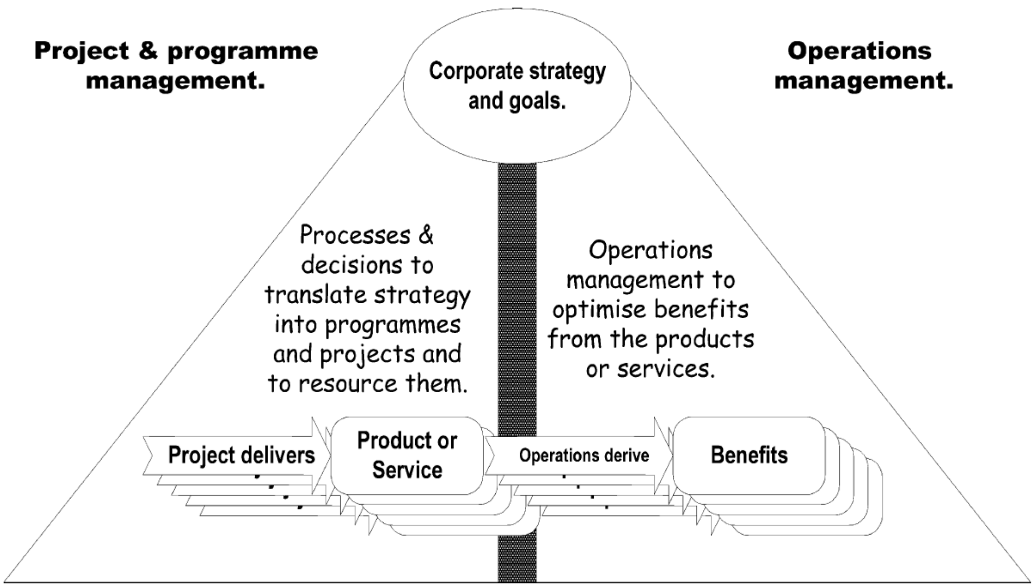


Figure 33: Co-operation between project management and operations management (Cooke-Davies, 2002, p. 187).

Characteristics of complexity, uniqueness, scale, and urgency are considered core dimensions of projects (Belassi & Tukel, 1996). Ika (2009) puts forward the notion that the field of project management offers a competitive edge by maximising outcomes with limited resources for efficient and effective project delivery (Ika, 2009). A variety of management skills such as the ability to negotiate enhances the implementation of project strategies for successful project outcomes (Belassi & Tukel, 1996). The competency, technical background and administrative skills of the project manager and project team to plan, implement and terminate project phases are vital and may be enhanced by qualities such as project commitment, which in turn increase stakeholder satisfaction and project acceptance (Belassi & Tukel, 1996). Qualitative organisational factors, most notably top management support and skills, led by a project champion increases the likelihood of access to resources to meet project objectives however project-manager and team-related factors such as technical competence and commitment were also considered critical (Belassi & Tukel, 1996).

Turner and Muller (2006) affirm that project management success is dependent on several variables such as intellect, emotional intelligence, leadership style and competence (Müller & Turner, 2007). Literature shows that professional certification improves success and is required for high performance but is insufficient to guarantee performance (Müller & Turner, 2007). Professional bodies are increasingly recognising the requirement for different management approaches and tailoring of project processes and procedures (Müller & Turner, 2007). Traditionally, project management performance has been measured through the iron triangle dimensions of time, cost and quality (Atkinson, 1999; Cooke-Davies, 2002; Ika, 2009; McLeod, et al., 2012) as depicted in Figure 34 where time-related performance relates to risk management processes within an organisation and cost related performance is related to control processes (Cooke-Davies, 2002). Quality has proven difficult to define other than the quantitative meeting of scope, technical and functional specifications (Baccarini, 1999). However, the literature shows a change in the traditional definition of project success and moving away from the iron triangle, as this does not guarantee delivery of benefits or stakeholder satisfaction (Ram, et al., 2013; McLeod, et al., 2012). The PMBOK refers to success as: “the application of knowledge, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations" (PMI Project Management Institute, 1996).

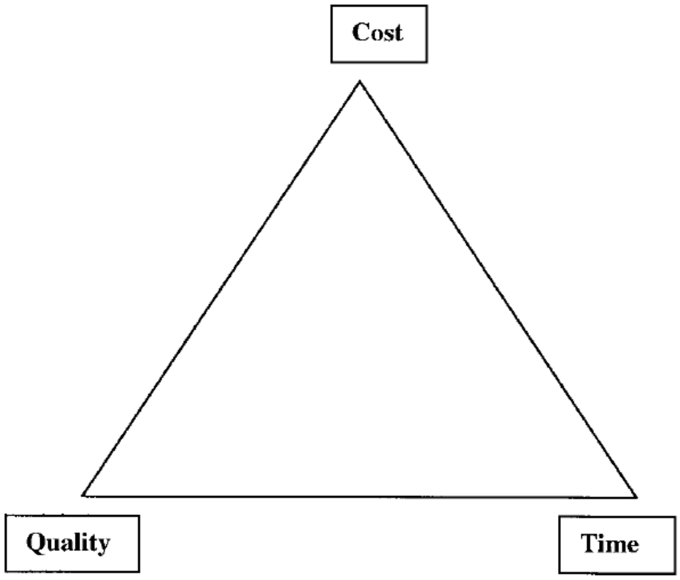


Figure 34: The Iron Triangle (Atkinson, 1999).

Project management success may influence project success, but the converse does not apply (Jugdev & Müller, 2005). Yet, an under-utilisation of project manager capabilities may lead to negative outcomes (Müller & Turner, 2007). Project management success generally relates to project processes and internal efficiency of the project team and is measured against success criteria and the achievement of quantitative time, cost and quality objectives (Pinto & Slevin, 1987; Shenhar, et al., 1997). External environmental factors are most evident in construction projects affecting availability of resources and impacting a project managers' performance. These include political, economic, social, market, technological and environmental factors, described as having the most impact during the planning phase of projects and extending through the full project lifecycle (Belassi & Tukel, 1996). Other factors may also include external sponsors, client consultation and stakeholder acceptance (Belassi & Tukel, 1996).

Project stakeholders are defined as actively involved parties or those whose interests are affected by project outcomes, and they therefore have an interest in project outcomes (Pinto & Slevin, 1987). Badewi's findings show that delivering time, cost and quality may increase stakeholder benefits due to the link between efficiency and effectiveness (Dvir & Lechler, 2004) (Ika, 2009). There has been a notable shift away from organisational factors and toward factors related to teamwork, specifically on large scale projects where team commitment was found to be the most significant success factor (Belassi & Tukel, 1996). This change in success factors over time may also be due to technological and other advances (Belassi & Tukel, 1996).

A need existed to identify a comprehensive set of critical success factors (Belassi & Tukel, 1996) or specific and refined models of success factors, showing the interrelationship between them (Pinto & Slevin, 1987). For this reason, multi-dimensional models reflecting different interests and perspectives were developed, linking organisational strategy with sustainable success showing project success dimensions as dependant on project types (Shenhar, et al., 2001). Project Management Methodologies (PMM) were originally compiled to control budget, plans and quality (Joslin & Müller, 2015) but are more recently described as a diverse set of practises particular to an organisation (Harrington, et al., 2012) such as PRINCE 2. (OGC, 2002) These methodologies were created to support project managers, improve effectiveness, enhance performance and increase success (Besner & Hobbs, 2006; Vaskimo, 2011). Project Management Methodologies vary in completeness and appropriateness for an organisation and there are differing views as to whether they should be standardised or customised. Since projects are often considered a means to achieve corporate goals, they are often standardised. Due to increasing variations in projects Project Management Methodologies (PMM) may be tailored to improve results (Payne & Turner, 1999). Furthermore, standardisation may be achieved at a strategic level while tailoring procedures to fit different contexts (Joslin & Müller, 2015). It may also be argued that the PMM does not improve success, but it is rather the experience and expertise of the project manager applying and tailoring it to the context that enhances success (Joslin & Müller, 2015). The successes from the application of Project Management Methodologies makes it clear that all project managers should have access to PMM's that may be adapted to different project contexts (Joslin & Müller, 2015). Some of the frameworks and Project Management Methodologies have been described below:

a. Morris and Hough (1987) developed one of the first frameworks on success criteria for project success, containing the quantitative and qualitative elements of: "attitudes, project definition, external factors finance, organisation, contract strategy, schedule, communications and control, human qualities and resource management" (Müller & Jugdev, 2012, p. 762) which fluctuate over the project life cycle and may be interpreted subjectively by different stakeholders (Müller & Jugdev, 2012).

b. A holistic framework was developed by Balussi and Tukel in 1996 as seen in Figure 35 consisting of internal and industry success factors, identified according to stakeholder categories as follows: 1. Project; 2. Project manager; 3. Team; 4. Organisation together with success criteria on which performance may be based and then measured to indicate project shortcomings that needed correction (Belassi & Tukel, 1996).

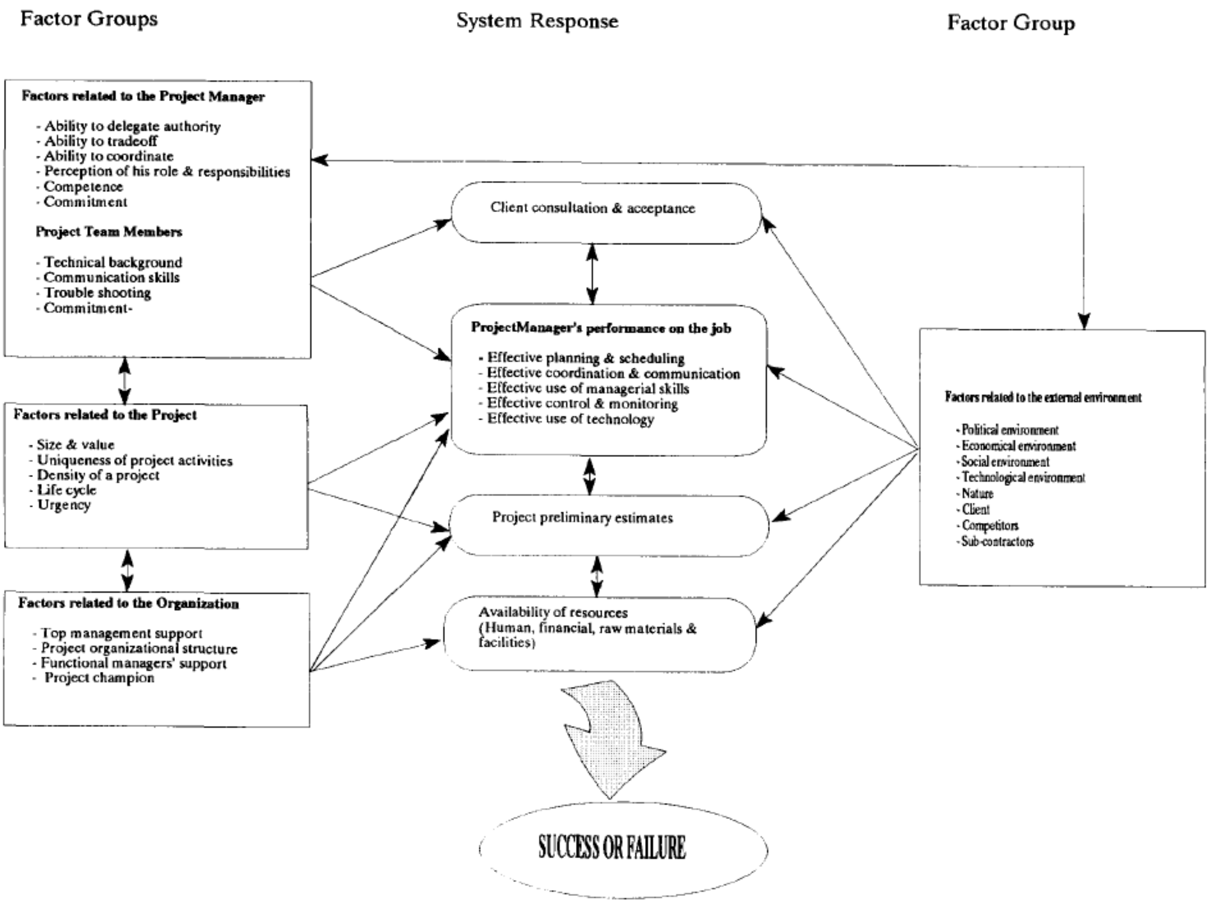


Figure 35: Classification of critical success factors (Belassi & Tukel, 1996).

c. Framework by Shenhar et al.

A comprehensive **four-dimensional framework** was developed by Shenhar et al (2001) to assess project success through three main dimensions: meeting project goals, customer satisfaction and organisational benefits over time (Shenhar, et al., 2001). Projects were distinguished by technological uncertainty and show a dependence on time to deliver on strategy to achieve project success and business value (Shenhar, et al., 2001).

- Success dimension 1:
  This is a short-term dimension during project implementation, measuring efficiency based on constraints such as time and cost, but may include additional measures.
- Success dimension 2:
  This dimension is measured after project delivery and focusses on meeting customer needs such as performance measures, functional and technical requirements.
- Success dimension 3:
  This dimension is measured during the operational phase and refers to the impact of the project on the parent organisation in terms of meeting short and long term strategic organisational goals and objectives.
- Success dimension 4:
  This dimension looks beyond immediate profit to creating new opportunities for an organisation. It is measured over the long-term and refers to diversification, increasing capabilities and developing technology through innovation, appropriate for markets in the long term.

This framework is considered dynamic, changeable, adaptable, and evolving, differentiating between operationally managed and strategically managed projects, supporting successful performance during the execution of projects to achieve short- and long-term objectives (Shenhar, et al., 2001). The strategic focus of an organisation requires early planning and setting of goals for project success by top management and reinforced through appropriate management strategies (Shenhar, et al., 2001). It emphasises the important role of project managers to act with a strategic view of business needs and creating a competitive advantage for teams to perform in all dimensions to achieve long term business value (Shenhar, et al., 2001). Due to the limitations of this framework, its application may not be appropriate for all projects.

d. Pinto and Slevin's success factors

Further research into project success factors was carried out in two streams as: 1. Research into optimisation or quantitative success factors and 2. research into generic success factors. In the latter, Pinto, Slevin and Prescott considered the triple bottom line of time, cost and scope in successful outcomes through a holistic approach, starting with the definition of a project and developing a broad, methodical and systemic approach, providing a foundation and toolkit for managers to assess projects and manage success (Müller & Jugdev, 2012). They were at the forefront of establishing commonality in project success across a broad range of projects as well as the multi-dimensional nature of success by reconciling project management's time, cost and performance dimensions with organisational change literature which referred to the dimensions of technical and organisational validity as well as organisational effectiveness. Thereafter, they developed a framework containing the characteristics of project success (Müller & Jugdev, 2012). Pinto and Slevin identified success characteristics which were applied for the purpose of developing a project assessment, enabling organisations to benchmark projects against average performance results and expanded this across the project life cycle, arriving at the following listed factors that affect success significantly:

INTERNAL PROJECT FACTORS	**EXTERNAL PROJECT FACTORS**
Project mission (all project stages)	Team leader characteristics
Top management support	Power and politics
Project schedule	Environmental events
Sponsor consultation	Urgency
Personnel	
Technology	
Sponsor acceptance	
Monitoring and feedback	
Communication and troubleshooting	

(Müller & Jugdev, 2012).

e. Internal project success factors

Variations in success factors over the project and product lifecycles were also developed, providing a more focussed assessment of factors and evidence that seven of the original ten success factors were linked to project success across all four stages of the project lifecycle in various combinations which allowed project managers to identify specific appropriate success factors (Müller & Jugdev, 2012; Shenhar, et al., 2001).

INTERNAL PROJECT SUCCESS FACTORS

Top management support
Project schedule
Sponsor consultation
Personnel (not correlating with project success in any lifecycle stage)
Technology
Sponsor acceptance
Troubleshooting
(Müller & Jugdev, 2012)**.**

Pinto and Prescott later grouped success factors into planning and tactical categories as follows:

PLANNING	**TACTICAL**
Project mission	Personnel
Top management support	Technology
Project schedule	Sponsor acceptance
Sponsor consultation	Troubleshooting

(Müller & Jugdev, 2012)**.**

Pinto and Slevin (1987) developed a Project Implementation Profile (PIP) for determining success factors for implementation of projects based on empirical research with and an instrument for project managers to measure PIP status through scoring of success factors (Pinto & Slevin, 1987) as seen in Figure 36. This tool is useful for the project manager in ascertaining where attention is required. It is obvious in this model that communication, monitoring and feedback are connected to all other success factors.

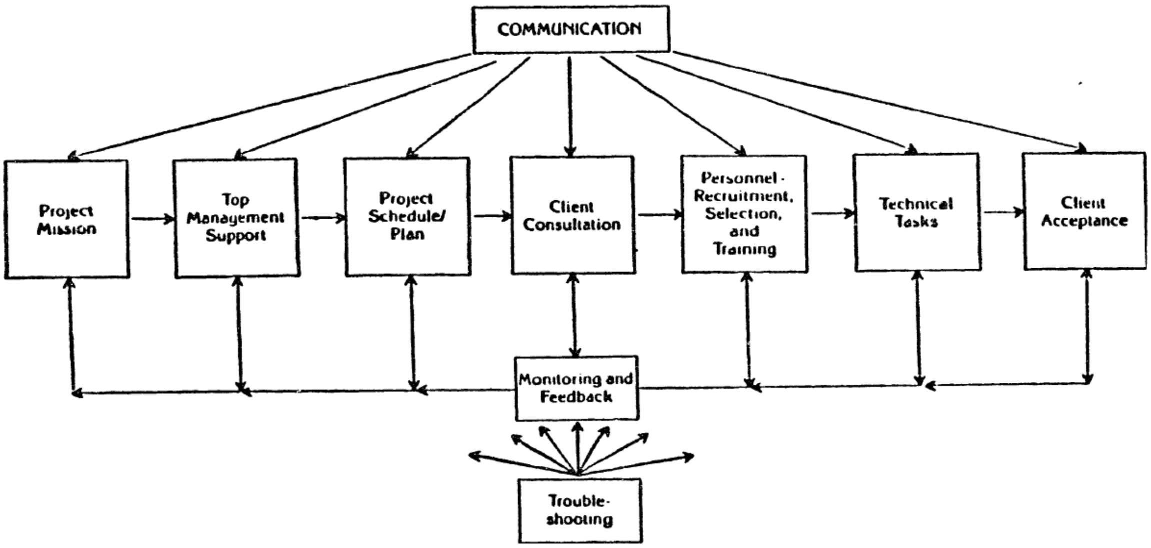


Figure 36: Project Implementation Profile (PIP) (Pinto & Slevin, 1987).

2.11.3 Organisational success

The broader concept of organisational success has developed from the notion that different stakeholders ascribe different meanings to project success and have subjective perceptions of success that change from one concerned with implementation to one encompassing the entire project lifecycle (Müller & Jugdev, 2012; Pinto & Slevin, 1987). Project success and organisational success are connected through their interpretation of the benefits that projects bring, often measured qualitatively through performance and stakeholder satisfaction which are evident in efficiency and effectiveness of products and services (Müller & Jugdev, 2012). This however still needs to translate into business value and extend to the close-out and operational project phases for total lifecycle and business success. In project-based businesses, successful project implementation may reduce operational costs and bring about project investment success (Badewi, 2016; Cooke-Davies, 2002).

2.11.4 Corporate strategy and goals

Co-operation is required between the project organisation and operational team or user group who realise the benefits as seen in Figure 33. This is intended to help decision-makers calculate the value of their investment and returns (Badewi, 2016; Zwikael & Smyrk, 2012). The project sponsor may measure project success quantitatively or qualitatively against success criteria such as efficiency, teamwork, stakeholder satisfaction and the meeting of business or strategic organisational goals among other criteria which are delivered during the operational phase (Badewi, 2016; Davis, 2014; Mir & Pinnington, 2014).

2.11.5 Benefits management

Project management is related to benefits management. Numerous organisations apply both practises concurrently (Badewi, 2016). Project management principles have a greater influence on project investment success (Badewi, 2016). Applying both project management practises and benefits management adds significant advantage and increases success but requires system thinking in order to manage the organisational environment (Badewi, 2016; Fortune & White, 2006). Additionally, “project benefits management” is closely associated with programme management and describes factors that ensure the continuous realisation of long-term financial and non-financial benefits (Badewi, 2016; Bennington & Baccarini, 2004). Sustainable project management aims for efficient project delivery incorporating ecosystem and biodiversity values into economic, ethical, social processes (Sullivan & O’Keeffe, 2011). Incorporating ecosystem and biodiversity values harnesses environmental benefits throughout a project life cycle so that the quality of life of beneficiaries is enhanced and resilience is strengthened (Mavi & Standing, 2018).

The management of water and natural resources is influenced by a combination of complex social, environmental, political, and economic factors that consider community values and aspirations thereby requiring collaboration of various stakeholders to facilitate a change from wasteful to saving approaches and a shift toward softer, more comprehensive approaches of working with nature through the provision of ecosystem services (Armitage, et al., 2014; Ayres, 2017; Postel, 1999). The motivation for integrated resource management is compelling, since it provides an opportunity for co-ordinated development and management of water, land, and other resources to maximise economic and social welfare without compromising ecosystems (Ayres, 2017). There are many long-term socio-economic and environmental benefits associated with sustainable stormwater management including improved air quality, decreased heat island effect, job opportunities and a more coherent green open space network that promotes resilience, mental health and wellbeing and increased social cohesion (Eggermont, et al., 2015; Qiao, et al., 2018). However, sustainable approaches are complex and specific resources, expertise and infrastructure are required. These are limited in many developing countries therefore may be perceived as being aimed at more elite communities (Chocat, et al., 2007). Since Integrated Urban Water Management (IUWM) focuses on the provision of water and protection of aquatic environments from a multi-disciplinary and multi-stakeholder participatory perspective, it requires social acceptance by communities in the current context of extreme inequalities, particularly in South Africa (Armitage, et al., 2014).

2.11.6 Adaptive management

Adaptive management utilises current experience to increase and adjust the adaptive capacity of systems such as SuDS. A learning approach accommodates flux and change and is therefore key to adaptive management as it respects the multi-dimensional and dynamic nature of water systems as they relate to the interdependent cultural, environmental, social, economic, technological, and institutional factors. Systemic approaches make provision for improved and experimental management policies and practises by learning from the outcomes of implemented strategies or by following an inductive approach where changing theories guide dynamic approaches (Pahl-Wostl, 2007). The basis for adaptive management starts with an approach to urban drainage which is based on an all-encompassing systems approach to water rather than separated management systems as seen in Figure 37.

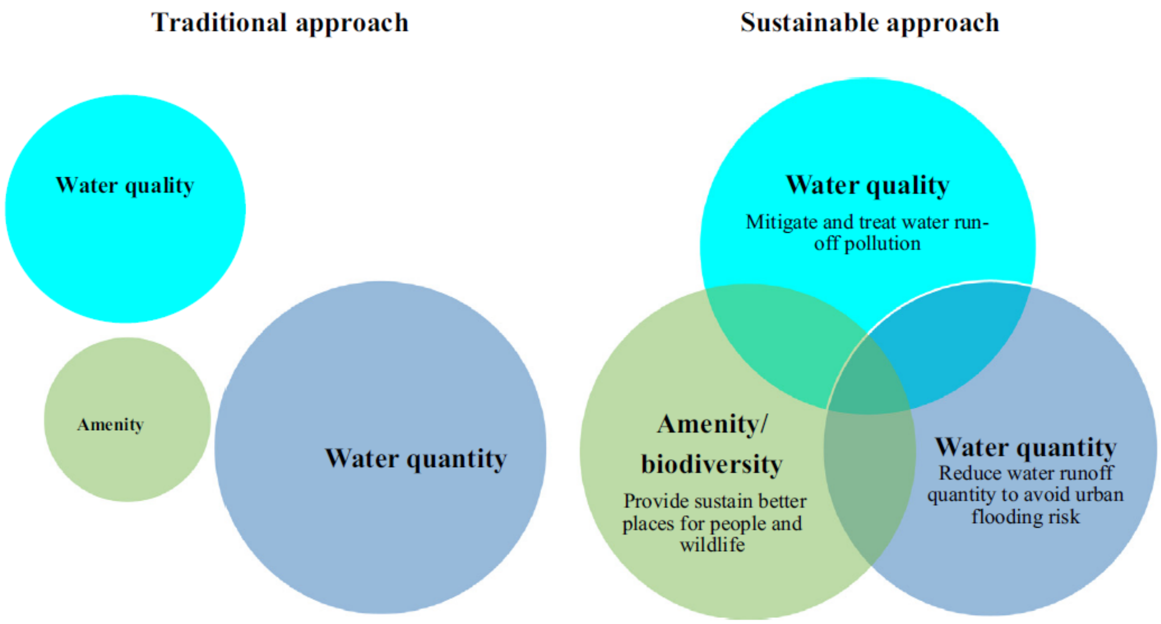


Figure 37: Differences between conventional and sustainable approaches to urban drainage (Charlesworth, 2010; Nguyen, et al., 2019).

Proactive management increases the capacity of an entire system to adapt to change and is therefore favoured (Wong & Brown, 2009). A comparison between traditional and Integrated Urban Water Management approaches is seen in Table 11. It highlights prediction and control in conventional systems versus adaptive characteristics that are evident in integrated water management approaches (Wong & Brown, 2009). To overcome shortcomings in traditional approaches, softer options that explore alternatives to centralised infrastructure, social learning, community-scale systems, and transparent, open decision-making processes are key (Gleick , 2003; Wong & Brown, 2009). The adaptive approach uses socio-technical means to increase the range of variation under which a water system can operate (Wong & Brown, 2009). This decreases sole reliance on technological interventions (Wong & Brown, 2009). In Figure 38, adaptive management is depicted in the form of a Pressure-State-Impact-Response framework representing an iterative and learning cycle with freedom to adapt and manage variability (Wong & Brown, 2009). Such systems have distributed control and the capacity to self-organise and change based on the processing of new information, to form management systems that fulfil social, environmental, institutional, and technological functions (Wong & Brown, 2009).

	Prediction and control regime	Integrated adaptive regime
Management paradigm	Prediction and control based on a mechanistic system's approach	Learning and self -organisation based on a complex systems approach
Governance	Centralised, hierarchical, narrow stakeholder participation	Polycentric, horizontal, broad stakeholder participation
Sectoral integration	Sectors separately analysed resulting in policy conflicts and emerging common problems	Cross sectoral analysis identifies emergent problems and integrates policy implementation
Scale of analysis and operation	Transboundary problems emerge when river sub-basins are the exclusive scale of analysis and management	Transboundary issues addressed by multiple scales of analysis and management
Information management	Understanding fragmented by gaps and lack of integration of information sources that are proprietary	Comprehensive understanding achieved by open, shared information sources that fill gaps and facilitate integration
Infrastructure	Massive, centralised infrastructure, single sources of design, power delivery	Appropriate scales, decentralised, diverse sources of design, power delivery
Finances and risk	Financial resources concentrated in structural protection (sunk costs)	Financial resources diversified using a broad set of private and public financial instruments
Environmental factors	Quantifiable variables such as BOD or nitrate concentrations that can be measured easily	Quantitative and qualitative indicators of whole ecosystem states and ecosystem services.

Table 11: Comparison between traditional and integrated water management approaches (Wong & Brown, 2009).

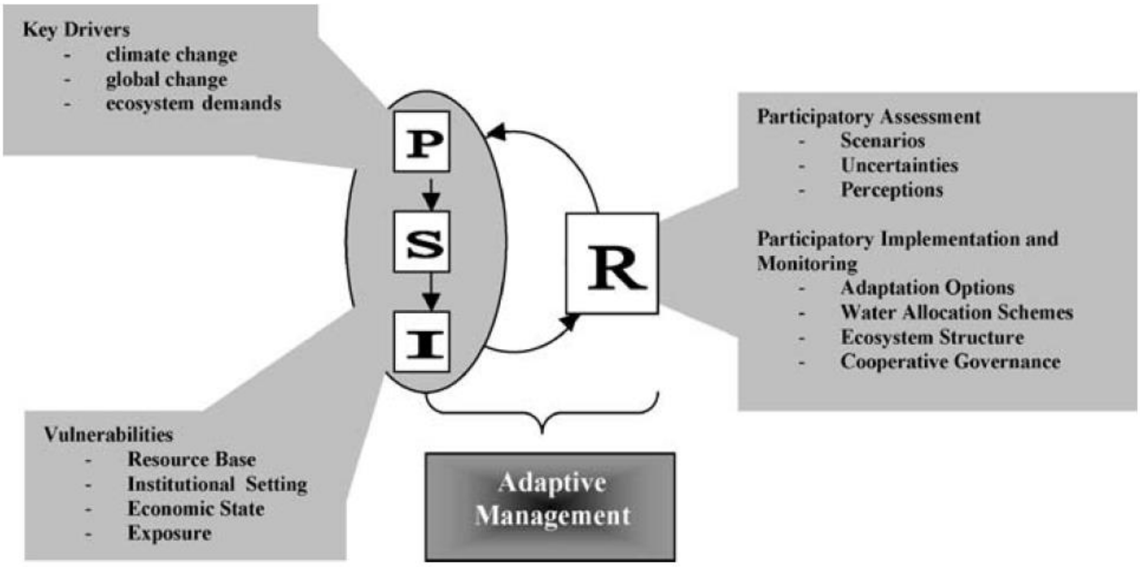


Figure 38: Iterative PSIR framework (Wong & Brown, 2009).

2.11.7 Governance

Water governance refers to all the processes that guide decisions in the provision of water resources in society (Nowlan & Bakker, 2007). Governance is one of the main reasons for the slow implementation rates of SUWM (Qiao, et al., 2018). Governance refers to the informal and formal political, economic, social, and administrative systems of various stakeholders that control decision making around water resources infrastructure and management (Enqvist & Ziervogel, 2019). Sustainable governance of water considers interrelated threats of droughts and flooding and the range of impacts that require adequate responses (Enqvist & Ziervogel, 2019). Governance from the perspective of WSUD points to a multi-disciplinary and participatory approach involving communities, planners, and policy makers at all levels (Ayres, 2017). It is critical to manage water with the appropriate scale of governance. Small resource stocks may be governed by communities through a commons approach to make decisions and act with agency and a level of distributed power for the effective enforcement of rules to promote equitable and sustainable use (Ayres, 2017; Walljasper, 2010). Historically, this has often led to exploitation and environmental degradation, but some communities have worked together by applying social contracts and mechanisms to manage resources for the common good such as trusts which are set up to manage resources and assets in the interests of beneficiaries (Ayres, 2017). Larger resource stocks are generally managed by government for the good of all people (Ayres, 2017). Effective governance relies on government action and interaction with society with predictability, transparency, reliability, ethics, and accountability (Anon., 2012). Qiao and Kristoffersen (2018), have divided challenges into four categories, namely: actors, resources, regulations, and discourse with situational challenges such as leadership, responsibility, funding, lack of data, lack of knowledge, spatial constraints, guideline standards and stakeholder participation. Good governance is manifest by navigating through conflicting expectations and meeting service delivery demands (Enqvist & Ziervogel, 2019) to guarantee strong, accountable leadership, a robust regulatory framework and effective water management institutions (Anon., 2012).

2.11.8 Summary

Water is a vital resource for life but there is increasing pressure on this and other natural resources worldwide due to population growth and urbanisation which impacts negatively on the environment. As urban areas enlarge and development footprints increase, there is increasing evidence of the effects of climate change, which is seen in changes in global weather patterns, with negative impacts on human life. This results in finite natural resources becoming increasingly scarce. For this reason, there is a need for urban developments and environments to be more resilient and adaptive through careful management. Traditional approaches to managing complex biodiverse systems have proven rigid, inappropriate, insufficient, and unsustainable. These approaches have primarily focussed on separation of water resources and risk management which is reactive in nature.

Blue green infrastructure forms the backbone of open space networks in urban areas and requires coherent strategies during planning, design, implementation, and operational and management phases. In recent years, there has been an increasing trend toward managing natural and open space systems within urban areas in more sustainable ways with consideration of long-term system lifecycles. This requires changes in operational approaches that embrace adaptive management. Sustainable development initiatives such as SuDS acknowledge that projects do not exist static states but are susceptible to constant variability and change during their lifespans.

2.11.9 Conclusion

Blue green solutions are becoming ever popular due to increasing evidence through data of the impact of unsustainable living on the planet, Outdated approaches to infrastructure provision such as stormwater is being replaced by more sustainable approaches such as Sustainable Urban Drainage Systems which not only addresses stormwater issues, but also provides enhanced benefits to communities through amenity provision which addresses multiple social issues. However, there is still a lack of understanding and acceptance in some spheres about this more contemporary paradigm and there exists a need for education of all stakeholders regarding ever newer infrastructure and technologies such as SuDS. Urban infrastructure processes can potentially provide cleaner, efficient, and more resilient solutions in the pursuit of economic prosperity, political and social equity and stability, ultimately improving the environmental condition and enhancing the quality of life for all.

There has been exhaustive research on the Critical Success Factors on projects during the implementation stage with varied opinions of what constitutes a successful project as this is often affected by perceptions and is therefore considered subjective. Through this research, the author seeks to establish what the Critical Success Factors are on projects during the operational phase and whether they are similar or different to those established in the implementation phase. This case study seeks to establish what those factors are.

When a SuDS project moves into the operational phase, ongoing environmental functioning will depend on the management approach followed when dealing with such complex and dynamic change that is borne out of biodiversity and flux in ecosystems. Without a clear understanding of the Critical Success Factors during the operational phase of a SuDS project, undesirable or less desirable outcomes are likely. This research aims to test and build upon the existing theory as outlined in this Chapter, together with emphirical evidence of procedures and practises during the operational phase of SuDS landscape projects and start to identify the similarities and differences between success factors during the implementation and operational phases.

CHAPTER 3: RESEARCH METHODOLOGY AND DESIGN

3.1 Introduction

The purpose of research is to study a topic of interest that requires further research and is of interest to the author. The intention is to broaden the knowledge base and offer useful information to researchers and practitioners. In this Chapter, the author outlines the research approach followed. The process outlined in Figure 39 starts with the identification of the research area and the problem statement below. The author conducted an extensive literature review to establish existing knowledge in the field and compile questions that assist in answering the main research topic. The empirical stage started with the research design or methodology. Questions were answered by assembling and organising qualitative data, which led to analysis and interpretation of the data. From this, the author was able to discuss the findings.

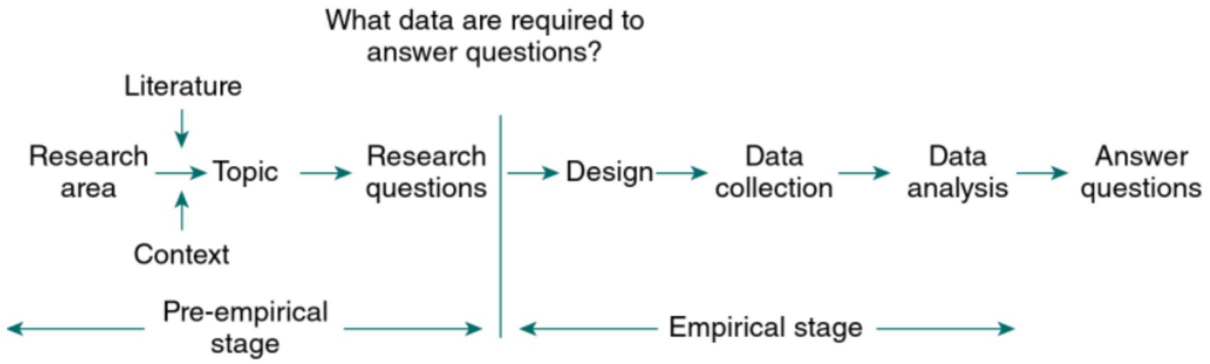


Figure 39: The research process (Punch, 2014, p. 12).

Current literature is limited as to what constitutes successful management of SuDS in the operational phase and how to achieve it. Hence, the problem statement is:

Limited research has been done on the key Critical Success Factors in the operational phase of Sustainable Urban Drainage Systems (SuDS) on landscape projects.

This research seeks to close the gaps in current literature around how SuDS projects may be successfully managed during the operational phase to assist those in the field who compile technical documentation and guidelines in management and maintenance aspects and those who manage and implement the work and are involved in the transition to the operational phase.

3.2 Paradigm

Philosophy refers to abstract concepts and principles that inform a researchers' thinking and approach (Creswell & Poth, 2018). Research is a process of systematic investigation of data collection, analysis, and interpretation (Mackenzie & Knipe, 2006). The author approached this research within the pragmatic paradigm, since this paradigm does not commit to any defined system of reality (Mackenzie & Knipe, 2006). Rather, the pragmatic paradigm allows for any single method or multiple mixed methods to be pursued, allowing the introduction of different world views and assumptions which provide insight into the research question or problem (Mackenzie & Knipe, 2006). Selection of the pragmatic paradigm in this research provides a foundation for the choices of research design, methodology, methods, data collection and analysis which is practise-oriented and is centred around the research problem (Mackenzie & Knipe, 2006). Although case study research is often simply regarded as a method, it may also be acknowledged as a distinct research paradigm to understand the social world (Hammersley & Gomm, 2011). The selection and nature of research design was motivated by the objectives of the research (Mackenzie & Knipe, 2006) and is outlined below.

3.3 Case study research design

3.3.1 Development of the research question

The research question was guided by a critical literature review to gain insight into research subject and was used in the process of identification of limitations and gaps in the literature (Yin, 1994). The conventional approach allows for the undertaking of fieldwork and data collection prior to establishing research questions (Yin, 2003). However, in this instance, the author developed research questions prior to conducting research activities and refined them over time. This research was directed by the main research question which endeavours to understand what the Critical Success Factors are during the operational phase of SuDS landscape projects.

Case study theory and research starts with the selection of a case, described as a broad study of a complex phenomenon (Yin, 2003; Yin, 2009). Case study research is commonly used to document and evaluate the implementation processes and outcomes of programmes on multiple or single sites (Yin, 2003). The case study strategy is particularly relevant where the boundaries between the case study and its context are unclear and where unstructured data is collected and analysed qualitatively (Yin, 1994; Hammersley & Gomm, 2011). While the philosophy guides the overall approach to research, the theoretical application of the case study research methodology is used to investigate this current phenomenon within its context through empirical inquiry (Yin, 2003). This methodology is intended to afford a greater understanding of decisions that were implemented during the evolution of the identified phenomenon. Case study research can follow an exploratory, descriptive, or explanatory strategy (Yin, 1994). The strategy followed depends on:

1. The research question.
2. The level of control from the researcher.
3. Status of the study – contemporary or historical (Yin, 1994).

3.3.2 Research design

The research design is the logic that connects the research questions to the data collection as the research questions need to be researchable with adequately available respondents (Yin, 1994). This specific research design outlines the data collection activities below and aims to meet the criteria of "trustworthiness, credibility, confirmability and data dependability" (US General Accounting Office, 1990; Yin, 2009; Yin, 1994). A simple research design guides the author through a logical sequence by connecting the research questions with data collection, descriptive text, analysis and drawing of conclusions (Yin, 1994). The sequence is as follows:

1. Research questions.
2. Select specific methods.
3. The unit of analysis.
4. The logic linking the question and the data.
5. Criteria for interpreting the findings.

3.3.3 Single case study

A single case study has been selected in this instance as a current phenomenon with exceptional, unique, and complex characteristics in the context of South Africa where conventional methods of managing and operating stormwater systems are still considered the norm. The research followed single case design to address the research question and sub-questions, acquire knowledge and preserve the meaningful qualities of the phenomenon (Yin, 1994). The author applied the single case study research strategy for conducting exploratory research to identify and clarify the subject of exploration (Yin, 2003). Theory has been used to guide the results and indicate whether it is applicabley and generalisable with other cases (Yin, 2003). Due to the nature of the research, the main criteria for selection of the case study were:

1. A successful example of SuDS.
2. That it was in the operational phase at the time of the study.
3. That there is a significant landscape and environmental component.
4. That information pertaining to the case is readily and publicly available.

3.3.4 This case study

The selection of Intaka Island, Century City was drawn from a provisional unpublished SuDS register compiled for the City of Cape Town in 2015. This case has been described and documented as a contemporary phenomenon at a single self-contained location identified at Century City, Cape Town. It is technically distinctive, well-bounded from a human and geographical perspective, but the natural and social environment within which the case is located allows for a level of exchange with the surrounding environment. The main objective of this study was to:

- Determine whether Critical Success Factors exist for SuDS during the operational phase of a landscape project.
- Identify these Critical Success Factors and organisational approaches that are likely to best influence successful outcomes in SuDS landscape operations.

Case study research is applicable in this instance due to the varying sources of evidence for data collection. A pragmatic approach to data collection was followed using these multiple sources of evidence These sources range from publicly available documents, respondent availability for interviews, accessibility for field observations among others. The strengths and weaknesses of these sources of data has been outlined in Table 12.

3.4 Methodology

The following research methodology was employed:

1 A critical literature review of project management Critical Success Factors with a specific focus on operational aspects that relate to SuDS landscape projects.
2 Data collection using different methods from various sources as described in 3.5.3.
3 Analysis of the collected data through sense-making using thematic analysis.
4 Interpreting the data.
5 Quality control through the process of validity and reliability.
6 Lastly, conclusions were drawn, and recommendations made in terms of the Critical Success Factors of SuDS in the post-completion, operational phase.

Source of evidence	Strengths	Weaknesses
Documentaries	• Stable – can be reviewed repeatedly • Unobtrusive – not created as a result of the case study • Exact – contains exact names, references and details of an event • Broad coverage - long span of time, many events and many settings	• Retrievability – can be low • Biased selectivity – if collection is incomplete • Reporting bias – reflects (unknown) bias of author • Access – may be deliberately blocked
Archival records	• (Same as above for documentation) • Precise and quantitative	• (Same as above for documentation) • Accessibility due to privacy reasons
Interviews	• Targeted – focus directly on case study topic	• Bias due to poorly constructed questions • Response bias

	• Insightful – provides perceived casual inferences	• Inaccuracies due to poor recall • Reflexivity – interviewee gives what interviewer wants to hear
Direct observations	• Reality – covers events in real time • Contextual – covers context of event	• Time consuming • Selectivity – unless broad coverage • Reflexivity – event may proceed differently because it is being observed • Cost – hours needed by human observers
Participant-observation	• (Same as above for observations) • Insightful into interpersonal behaviour and motives	• (Same as above for observations) • Bias due to investigators manipulation of events
Physical artifacts	• Insightful into cultural features • Insightful into technical operations	• Selectivity • Availability

Table 12: Sources of data (Yin, 2009).

3.5 Research methods

3.5.1 Mixed method research

There is no best research method, but the method selected should be most appropriate to the research subject (Bodgan & Bicklen, 1998). Data collection methods have been outlined as.

Pragmatic methods:	Data sources:
Field work	Descriptive text
Semi-structured interviews	Photographic
Desktop work	Field notes
Observations	Social media
	Documents
	News and reviews

3.5.2 Pragmatic research

Qualitative research embraces multiple realities and is changeable by nature. It positions the researcher or observer within a particular context and pursues the study of individuals closely with an intention to express multiple views (Creswell & Poth, 2018). It emphasises the importance of research in the field, providing depth and context to the subjective experiences of respondents (Creswell & Poth, 2018). Qualitative research follows an interpretive approach with the purpose of materialising intangible perceptions, meanings, and interpretations of a phenomenon in its natural setting (Creswell & Poth, 2018; Denzin & Lincoln, 29011). Researchers conducting research from a pragmatic standpoint tend to develop a focus while data is being collected and therefore do not initially approach the research with specific questions. They are concerned with understanding behaviour from the subject's frame of reference, which is done through sustained contact and exposure to subjects in settings where subjects spend their time (Bodgan & Bicklen, 1998). During this process, it is important that the original intent of the research focus and questions is maintained. The procedures of research are influenced by the researchers experience in data collection and analysis and are therefore always evolving (Creswell & Poth, 2018). Logic is constructed from experiences and observations in practise rather than being reliant on theory (Creswell & Poth, 2018), therefore the researcher needs to change and adapt the approach during the study in order to collect data that provides the best understanding of a case and answers the research problem (Creswell & Poth, 2018). Qualitative data consists of words with rich descriptions that may be organised to enhance meaning and provide a holistic overview of an observed phenomenon with its unique organisational structures, processes, and rules (Miles & Huberman, 1994). To overcome the pitfalls of holistic case study research, the author ensures that operational detail has been captured in detailed descriptive form during the data collection phase, using multiple sources of evidence (Yin, 2003).

3.5.3 Pragmatic methods

Methods are influenced by the methodology and are used to analyse the data (Behar-Horenstein, 2018). This process involves the action of carrying out the research. Good quality research needs to meet the criteria of:

- a substantive contribution,

- aesthetic merit,
- reflexivity,
- impact (Behar-Horenstein, 2018).

Data collection activities were conducted as follows:

a) Publicly available documents were downloaded with information relating to:
   - Planning phase.
   - Implementation phase.
   - Operational phase.

b) A description of publicly available documentation was produced.

c) Organisational documents were obtained and scrutinised.

d) Contact details and willingness of key stakeholders was established.

e) A formal ethics clearance process was followed. Refer to Addendum 2.

f) Semi-structured interviews were conducted with prepared questions serving as a guide and recorded. Semi-structured interviews with respondents focussed on the successes of operational approaches. The author collected data from respondents about their perceptions and perspectives on the day-to-day operations. The author focussed on specific themes with the intention of maintaining the integrity of the complete body of work (Miles & Huberman, 1994). For case study semi-structured interviews, pre-defined questions about organisational facts, opinions and insights were discussed in a conversational manner. Refer to Addendum 3. The author also used an intuitive approach of adapting the interview questions according to the interviewee's specialised field (Yin, 2003). This enabled the author to corroborate facts through fresh commentary.

g) The author reviewed theory between interviews.

h) Scheduled and unscheduled unguided observations in the field were conducted for 5 days with a camera and notepad to provide a rich and detailed perspective of the physical outcomes. Physical artifacts were recorded as sources of evidence. Observations during visits raised questions about how approaches are linked to outcomes.

i) Social media and website platforms were reviewed.

j) Further questions were posed to respondents via email.

3.5.4 Tools, techniques, and instruments

The pragmatic paradigm affords tools, techniques and instruments from positivist and interpretivist paradigms, depending on suitability for data collection with the intention of answering the research question (Mackenzie & Knipe, 2006).

Techniques:

Open ended interviews

Reviewing of documents

Instruments:

Recorder

Computer and software for qualitative analysis

Researcher / interviewer notes

3.5.5 Time period for data collection:

Data was collected on site between 22nd October 2021 to 21st November 2021.

3.5.6 Geographical area for physical data collection:

Intaka Island wetland, Century City canals and detention pond.

3.5.7 Transcribing

Semi-structured interviews were recorded and transcribed immediately after interviews into a legible text format. A full transcription of the raw data was conducted via You tube with time stamps. A comprehensive check of the full transcription was carried out. Summaries were then compiled, grouping individual interview themes. Salient parts that serve as evidence in support or refuting of the authors claims and theory were extracted from the transcription for the thesis.

3.6 Analysis

The intent has been to document the connection between successes and evidence through descriptive text by assimilating a descriptive theory early in the process of analysis, which carries through to detail descriptions, generalisations, assertions, and recommendations, based on the case study results, to achieve the research objectives (Yin, 2009).

3.6.1 Thematic analysis

In qualitative research, multiple realities are expressed and presented through multiple forms of evidence and arranged in themes using descriptive language and text (Creswell & Poth, 2018).

Coding and categorising

Following data collection from formal and informal documents, web pages, social media pages, You tube videos, photographic material, interview transcripts, website and social media page extracts as well as publicly available documents were assimilated and imported into the data management system, Nvivo 12 to organise unstructured data into nodes or codes. These nodes or codes are used to identify themes, trends, and patterns which ascribed meaning to the data (Merriam & Tisdell, 2016). Data sources were interrogated sentence by sentence, highlighted and allocated to a label or code with word trees that allowed for the identification of prominent words and phrases. This enabled thorough and rigorous analysis across data sources. Theoretical saturation was achieved when no new nodes were formed. A review of the nodes was carried out and clustering of nodes and sub-nodes resulted in the development of emergent themes. These themes have been expressed through descriptive information and inform the structure of Chapter 4. A chain of evidence has been used to create links between questions asked, the data and the conclusions to increase the reliability of the study (Yin, 2009).

3.6.2 Unit of analysis

The unit of analysis is taken at the level of the research question which is concerned with the Critical Success Factors during the operational phase of the organisation that manages Intaka Island. This is the subject of the case as identified in the proposition (Yin, 2009). Therefore, the unit of analysis is defined as the decision-making committee/s for Century City Intaka Island wetland, namely the Blouvlei Intaka Island Environmental Committee and the CCPOA which define the extent of data collection and analysis.

3.6.3 Interpretation of data

Accurate interpretation of the data and identification of contradictions intend to assure readers that preconceptions and bias would not taint the data (Yin, 2009). Care has been taken to ensure the analysis is convincing enough to eliminate other explanations and researcher bias in interpretation (Yin, 2009).

3.7 Quality control

All research must be sufficiently rigorous (Behar-Horenstein, 2018). Various indicators are used to test the quality of the research findings (Behar-Horenstein, 2018). Quality control of this study of the design through the process of:

- Validity.
- Reliability.

The axiological assumption is that research is affected by values and that biases exist (Creswell & Poth, 2018). Due to strengths and weaknesses of individual data sources, a variety of data sources were used in this case study research to improve validity and reliability. Data was collected, analysed, and validated through the process of triangulation and corroboration (Yin, 1994). Semi-structured interviews were relayed from the interviewee’s perspective to avoid bias and inadequate accounts (Yin, 2009). Contradictory data or data that may contain inferences were used as sources of further inquiry by the author (Yin, 2009). Leading questions were avoided as these may have influenced responses (Yin, 2009). In addition, publicly available documents on the case have been attached as addenda to this document. The data contained therein has been made available for inspection, thereby increasing reliability. In this way interpersonal influences have been overcome (Yin, 2009).

Standards of rigor

Validity and reliability or trustworthiness authenticates a study in the research community (Behar-Horenstein, 2018). The author has followed a process of establishing trustworthiness which contains the characteristics of credibility, transferability, dependability, and confirmability as follows:

a. Credibility:

This describes the degree of accuracy of representations of a case. This is established through the strategy of time expended on the data collection process and through triangulation (Behar-Horenstein, 2018).

b. Reflexivity:

This refers to the researcher's self-examination process influence the interpretation of data and how this is circumvented (Behar-Horenstein, 2018).

c. Triangulation:

The selection and application of research methodologies requires epistemological rigour which may be tempered through triangulation or cross-verification and critical realism to prove completeness and suitability of the research approach (Oyegoke, 2011; Smyth & Morris, 2007). Cross verification refers to multiple research methods, sources of data, that are used to support and validate the accuracy of data, evidence, interpretation, and findings (Behar-Horenstein, 2018). For this case study, multiple sources of evidence have been used for the purpose of triangulation of data about this phenomenon, which converge on the same findings (Yin, 2009) as seen in Figure 40. This increases the strength of the case study (Yin, 2009).

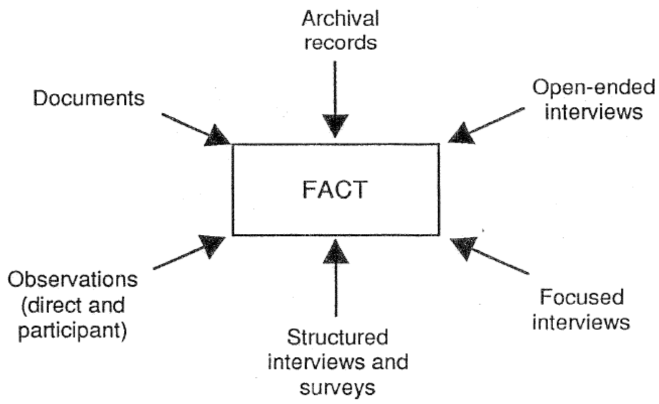


Figure 40: The benefits of triangulation through multiple sources of evidence (Yin, 2009, p. 93).

d. Respondent validation:

This refers to the process of establishing credibility through the scrutiny of the research by members (Behar-Horenstein, 2018). This has been done by disseminating extracts and interpretations of transcribed interviews with Respondents to validate their accuracy.

3.8 Ethics in research

This is concerned with moral, correct, and incorrect practise at a specific time, place, and people (Bodgan & Bicklen, 1998). Ethics clearance was received from the EBE Ethics in Research Committee for this research and a copy of the signed ethics clearance form may be found as Addendum 2. The author commited to setting aside self-interest and adopting the principles that promote societal wellbeing with a view to the common good and to not cause harm. This case study addresses ethics in research, mainly related to human subjects. Respondents were selected based on their role on the project, specifically those who played an integral part in the design, implementation, and operations of the project. Respondents included identified stakeholders who have key insights into the workings of the project, managerial, social, and human dynamics, technical aspects, opportunities and challenges as well as outcomes. It also included stakeholders who derive benefits from the project as their perceptions were likely to be influenced by project outcomes. The potential impacts on respondents were carefully considered and the following were addressed:

- Obtaining permission from authorities.
- Obtaining informed consent of data sources and ensuring confidentiality. Refer to Addendum 4.
- Obtaining consent for using secondary data sets.
- Ensuring anonymity of respondents.
- Storing sensitive information.

3.8.1 Informed consent of Respondents

Respondents were informed of the nature of the study, terms of withdrawal, the risks or potential harm and responsibilities of being involved in the study, the nature of voluntary participation and unintended consequences of the research process in the “Informed Consent Document”. The proposed research was unlikely to expose respondents to any more than minimal risk, but respondents were advised of the terms of withdrawal or non-participation in questions to counteract any potential harm.

3.8.2 Protection of Respondents

Disclosure is the ideal where there is a low risk to the case and to respondents. The risks for respondents in this case study research have been defined as low and likely to cause no more than the risk of harm experienced day to day and routinely. However, even though the case has been disclosed, confidentiality of respondents has been protected and the information provided by them has been carefully managed as this formed part of the ethics application.

Confidentiality has been maintained by means of a numerical or textual coding procedure. Identifiers have been converted to privacy codes. The semi-structured interviews were uploaded into the Nvivo 12 coding programme. Nvivo 12 facilitates pragmatic analysis of imported data by organising it into a centralised system of nodes, codes, or themes. By doing so, the researcher is better able to understand the data as well as make the audit trail explicit. The coding system is described below:

Typical example:
(Respondent 1).

( )	The open and closed brackets indicate that this is a standard citation.
Respondent 1	Refers to the Respondent number.

3.8.3 Storing sensitive information

In this case study research, it will not be possible to ensure anonymity of respondents as the author was directly involved in the case work. Respondent’s confidentiality has been protected through a careful process of storing the data remotely, with limited access and removal of identifiers from transcripts. This data will be destroyed and deleted after a defined period.

3.8.4 Recognition of other scholars

Research, documents, and other publications by professionals have been referenced in this case study to ensure that the work of other scholars and practitioners is recognised.

3.9 Limitations of case study research

In all research there are explicit and implicit limitations. In this research, the explicit limitations are outlined in the literature, mainly relating to the subjectivity of case study research. However there have been several implicit limitations that apply specifically to this study. These have been outlined below. The audience for which the documents were compiled have been considered (Yin, 2009) but the author draws caution to the reader that the research document needs to be reviewed with caution and discretion (Yin, 2009).

3.9.1 General limitations of case study research:

- It is difficult to carry out a good case study.
- Case study skills are not well-defined.
- The findings can reflect a bias.
- In unique case studies, scientific generalisations are not possible, but such may be used for theoretical generalisation or providing a sample.
- They can be lengthy.
- They may be confused with ethnographies or Respondent-observation data collection.
- They require data collection beyond mere field observations (Yin, 1994).

3.9.2 Limitations of this case study research:

The main limitation of this study of Intaka Island is that it is a single case study the findings are not transferable to other cases/wetlands. Other limitations include:

a. Limited available resources due to self-funding.
b. Limited time for data collection.
c. Limited access to Respondents during the data collection process.

d. The author intended to pursue complimentary mixed methods research to strengthen the validity of the case study, but Respondent exposure was limited, and quantitative methods of data collection were discontinued from the study.

e. The authors' understanding of case study research is limited.

f. Problems associated with summarising rich and descriptive case data (Eisenhardt & Graebner, 2007).

g. Qualitative research is nonstandard, unreliable and time consuming in nature.

h. The generalizability of case study research has limitations (Byrne, 2012).

i. The nature of subjective research - This case study is constructed to achieve defined objectives of understanding and may have proven empirical substance or may be framed through limited narrative description and therefore shaped by the observer and the context (Byrne, 2012). Philosophical assumptions are often based on subjective interpretive frameworks such as theories or beliefs (Creswell & Poth, 2018). Assumptions inform the researchers' choice of theories which may be made explicit during the research process (Creswell & Poth, 2018). A researcher is often positioned in relation to the context of the study through social position and experience.

j. Since the author was involved in the data collection and interpretation processes, this may result in some bias in the interpretation of the data (Eisenhardt & Graebner, 2007).The reader is entitled to the freedom of self-interpretation (Dooley, 2002).

k. Context of research - On landscape projects, it is not possible to come across multiple cases that are identical, since each landscape project is unique in terms of physical characteristics such as location, climate and topography and therefore a single case study is appropriate in the context of this research. This research is representative of Winter rainfall in the urban areas of the Western Seaboard, Cape Town, South Africa and therefore not representative of all climatic zones.

3.9.3 Research rigour

The author has been aware that the case is not a sample and therefore generalisations have been avoided. The author endeavoured to exclude preconceived notions that may inadvertently form part of this research and intended to take cognisance of the different contexts, frames of reference and world views.

3.10 Conclusion

The purpose of Chapter 3 is to provide an outline of the research methodology for this single, unique case at Intaka Island, Century City which has been selected due to its location, accessibility, and ongoing successful operations and due to the subjective opinion that other similar SuDS initiatives can gain tremendous insight and improve their operational strategies and approaches by learning from this example. Operating in a pragmatic paradigm allowed for the gathering of data through direct human observation and gathering of information, following which, a rich description in Chapter 4 and analysis thereof has been followed by interpretation of the data and recommendations.

CHAPTER 4: DESCRIPTIVE DATA, INTERPRETATION AND RECOMMENDATIONS

4.1 Introduction

In this instance, a classic case study approach has followed a single narrative that describes and analyses the case including text, tables, graphics, and images. In answering the main question, a case study of the operational phase of a successful SuDS stormwater system has been conducted, to identify and assess the Critical Success Factors. This chapter deals with an overview of the case and follows on to the four emergent themes of success that are borne out of the data collection process. Each theme has the following sections:

- Description and findings: In this section, data collected is put forward in descriptive text.
- Discussion and interpretation: In this section, the author makes sense of the findings, links the data to literature and the research questions are answered through a series of assertions.
- Recommendations: In this section, the author makes recommendations under each theme.
- Summary: A summary of each theme is provided.

4.2 An overview of the case

4.2.1 Context, biodiversity, climate, and catchment area

Cape Town is located within the Cape Floristic Region as indicated in Figure 41 and in 2004, this region was declared to be of universal significance and therefore recognised as a Natural World Heritage Site because it is the smallest and richest of the six floral kingdoms and includes Table Mountain National Park, Robben Island and Kirstenbosch National Botanical Gardens which are classed as World Heritage Sites (SANParks, 2022). Cape Town is therefore recognised as being a biodiversity hotspot as it has numerous vegetation types and endemic species, with many considered threatened or extinct. This is mainly due to the impact of urbanisation and urban sprawl (Department of Sports and Culture, 2021).

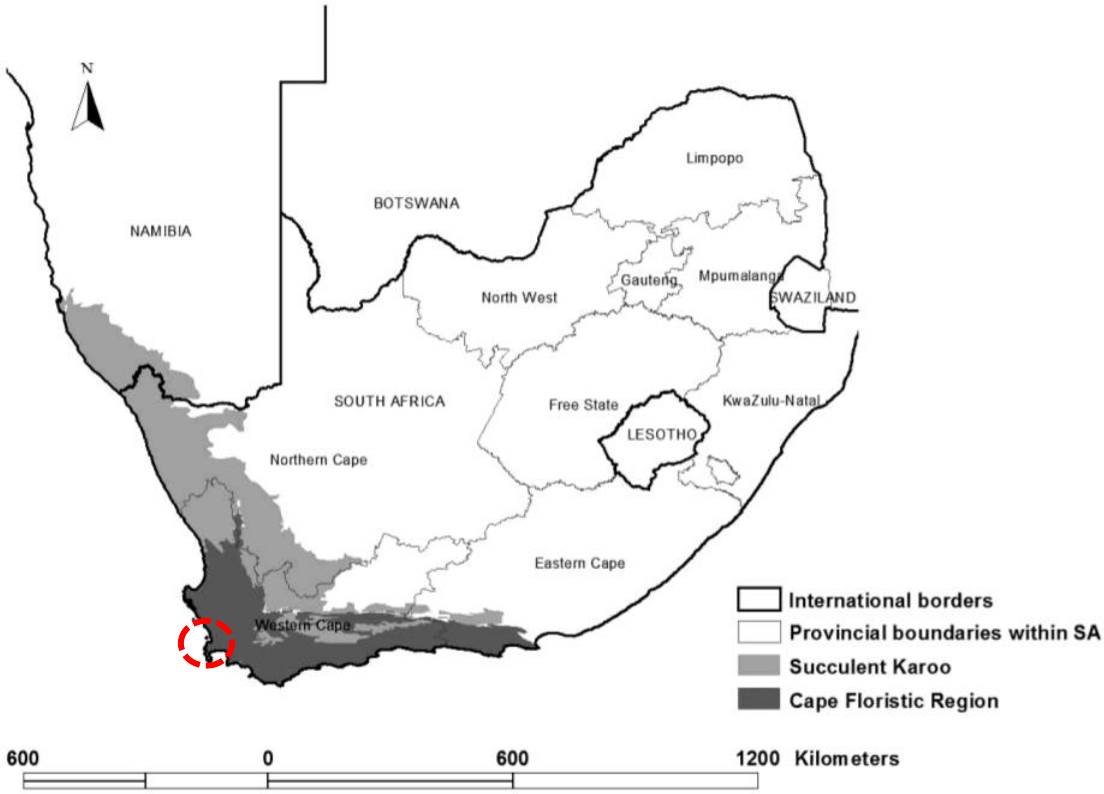


Figure 41: Cape Floristic Region and succulent karoo biodiversity hotspots (Brownlie, et al., 2005, p. 203).

Cape Town is considered to have a Mediterranean climate with mild Winters from June to August and warm Summers from December to March. Winter is considered as the rainy season with strong North Easterly winds and Summer is considered a drier season with strong South Easterly winds. The weather is affected by both the Atlantic and Indian Oceans as Cape Town metropole is geographically constrained by both. Figure 42 contains the climatic data from the World Meteorological Organisation, NOAA, SAWS and eNCA. In its most recent Water Strategy, the City of Cape Town has committed to becoming a water sensitive city by 2040 with a focus on equitable, accessible, and safe water usage (Liz Day Consulting, 2020). The health of urban rivers and watercourses in Cape Town reflects its urban management, specifically of pollutants which impacts on human health, aesthetics, recreation, tourism, and biodiversity within a sub-catchment (Liz Day Consulting, 2020). The preparation of a technical report in 2020 on the quality of water in Cape Town catchments in Addendum 5 is intended to educate and mobilise the public and private sector on pertinent issues pertaining to water quality, thereby changing attitudes and behaviour.

Climate data for Cape Town (1961–1990) [hide]													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	39.3 (102.7)	38.3 (100.9)	43.0 (109.4)	38.6 (101.5)	33.5 (92.3)	29.8 (85.6)	29.0 (84.2)	32.0 (89.6)	33.1 (91.6)	37.2 (99.0)	39.9 (103.8)	41.4 (106.5)	43.0 (109.4)
Mean maximum °C (°F)	33.6 (92.5)	34.1 (93.4)	33.2 (91.8)	31.7 (89.1)	29.1 (84.4)	26.3 (79.3)	25.1 (77.2)	26.9 (80.4)	28.3 (82.9)	31.0 (87.8)	31.6 (88.9)	32.5 (90.5)	34.1 (93.4)
Average high °C (°F)	26.1 (79.0)	26.5 (79.7)	25.4 (77.7)	23.0 (73.4)	20.3 (68.5)	18.1 (64.6)	17.5 (63.5)	17.8 (64.0)	19.2 (66.6)	21.3 (70.3)	23.5 (74.3)	24.9 (76.8)	22.0 (71.5)
Daily mean °C (°F)	20.4 (68.7)	20.4 (68.7)	19.2 (66.6)	16.9 (62.4)	14.4 (57.9)	12.5 (54.5)	11.9 (53.4)	12.4 (54.3)	13.7 (56.7)	15.6 (60.1)	17.9 (64.2)	19.5 (67.1)	16.2 (61.2)
Average low °C (°F)	15.7 (60.3)	15.6 (60.1)	14.2 (57.6)	11.9 (53.4)	9.4 (48.9)	7.8 (46.0)	7.0 (44.6)	7.5 (45.5)	8.7 (47.7)	10.6 (51.1)	13.2 (55.8)	14.9 (58.8)	11.4 (52.5)
Mean minimum °C (°F)	10.3 (50.5)	9.9 (49.8)	7.6 (45.7)	5.7 (42.3)	2.8 (37.0)	1.3 (34.3)	1.0 (33.8)	1.3 (34.3)	2.3 (36.1)	4.4 (39.9)	7.0 (44.6)	9.5 (49.1)	1.0 (33.8)
Record low °C (°F)	7.4 (45.3)	6.4 (43.5)	4.6 (40.3)	2.4 (36.3)	0.9 (33.6)	−1.2 (29.8)	−1.3 (29.7)	−0.4 (31.3)	0.2 (32.4)	1.0 (33.8)	3.9 (39.0)	6.2 (43.2)	−1.3 (29.7)
Average precipitation mm (inches)	15 (0.6)	17 (0.7)	20 (0.8)	41 (1.6)	69 (2.7)	93 (3.7)	82 (3.2)	77 (3.0)	40 (1.6)	30 (1.2)	14 (0.6)	17 (0.7)	515 (20.4)
Average precipitation days (≥ 0.1 mm)	5.5	4.6	4.8	8.3	11.4	13.3	11.8	13.7	10.4	8.7	4.9	6.3	103.7
Average relative humidity (%)	71	72	74	78	81	81	81	80	77	74	71	71	76
Mean monthly sunshine hours	337.9	297.4	292.9	233.5	205.3	175.4	193.1	212.1	224.7	277.7	309.8	334.2	3,094
Source: World Meteorological Organization,[39] NOAA,[40] South African Weather Service,[41] eNCA[42]													

Figure 42: Cape Town climatic data (Wikipedia, 2021).

4.2.2 The original site

Image 1: Aerial view of the Century City site, taken from the south prior to development (CCPOA, 2021).

Image 2: Pre-development aerial view of Century City, taken from the east (CCPOA, Unknown).

Century City is located within the West Coast sub-catchment as indicated in Figure 43. Intaka Island wetland is situated on the Blouvlei in Milnerton and located at Latitude -33.8883566 Longitude 18.5152128 Altitude 17.1187641m above M.S.L (Google Earth, 2021). The original site consisted of 187 hectares of undeveloped land (Respondent 3). The site that made up the Sewe Pannetjies consisted of overgrown alien invasive vegetation including Port Jackson and Rooikrans (Respondent 1; Respondent 3; Respondent 7). It was screened from the N1 and therefore went unrecognised (Respondent 3).

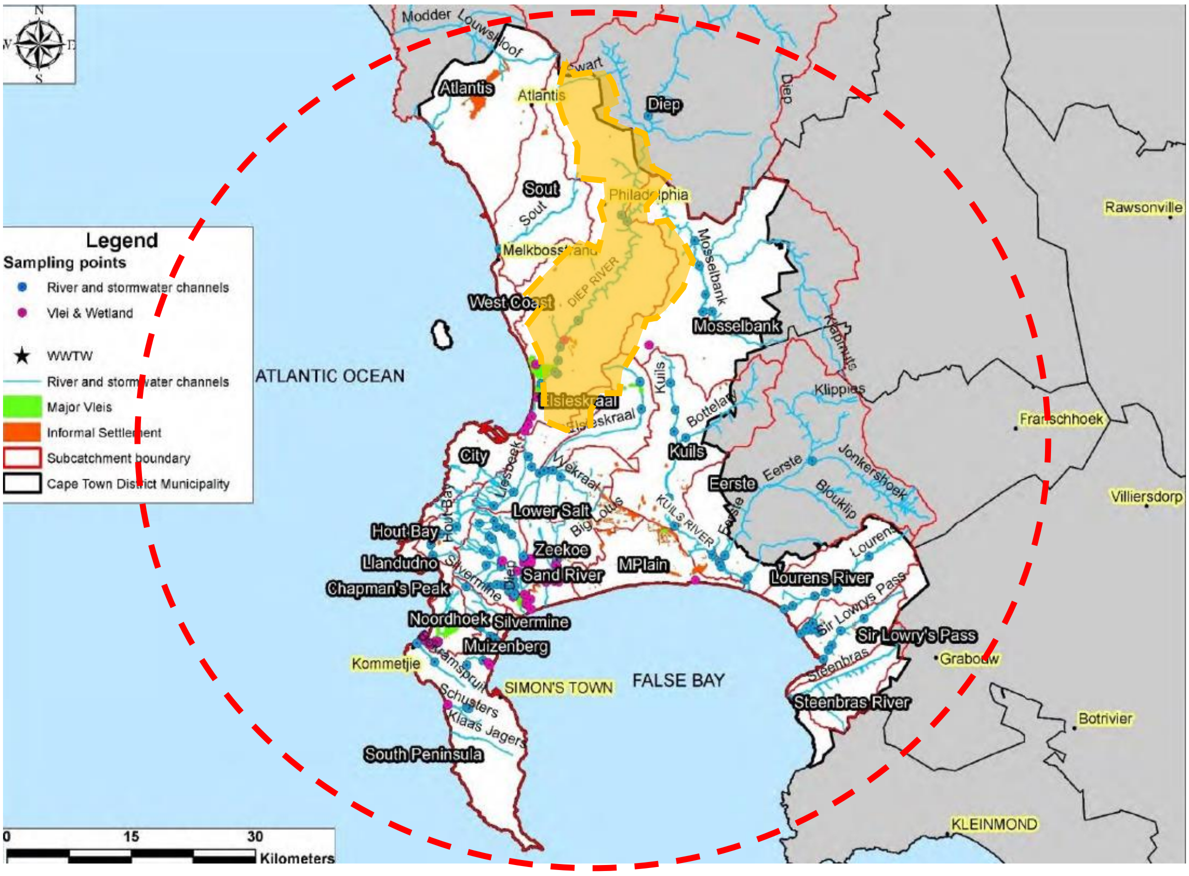
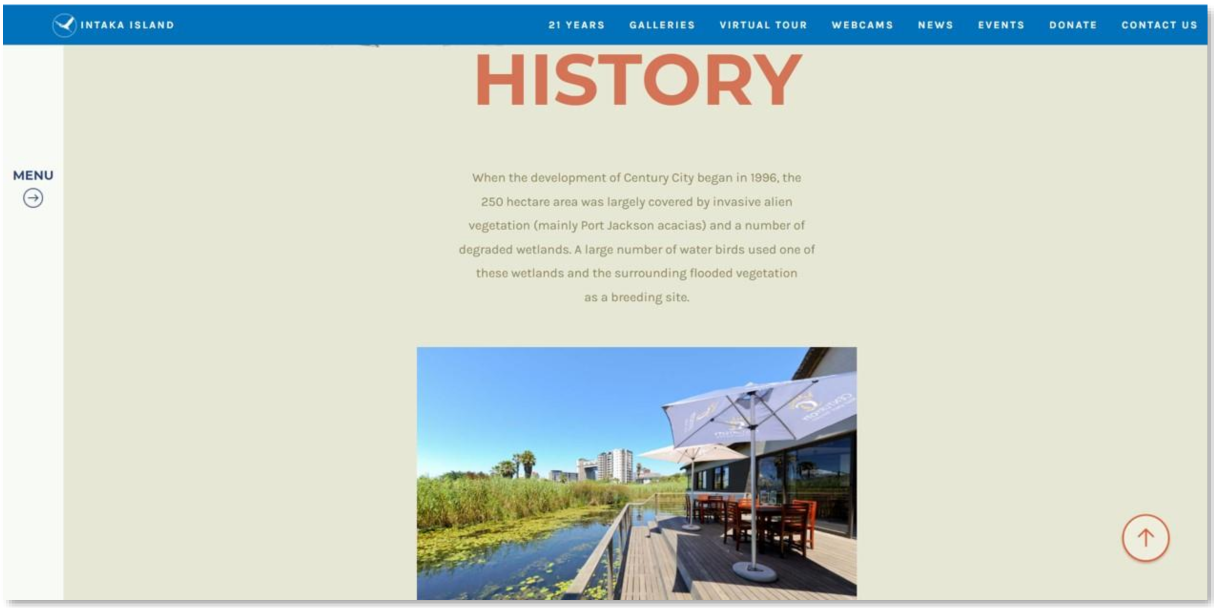


Figure 43: Main rivers and sub-catchments within the City of Cape Town (Liz Day Consulting, 2020, p. 7).

The main disturbance was from invasive plants after which grasses came into the area (Respondent 4; Respondent 6). Reports described it as characteristically waterlogged wasteland, or degraded wetland (CCPOA, 2021) and referred to the water as eutrifying and therefore unsustainable (Respondent 2; Respondent 3; Respondent 6). Stormwater was illegally redirected onto it from surrounding sites that had previously been developed, turning the ephemeral pan into a permanent lake with edges that were characteristically ephemeral (Respondent 1; Respondent 3). Alien trees on the edges of the pans were flooded and died, which attracted bird life (Respondent 1; Respondent 3). It was a biodiverse site as the vegetation provided breeding habitat for birds and colonial nesting for a large population of birds (University of Cape Town, 2004; CCPOA, 2021). This proved important from an ecological and birding perspective as "*It was the biggest colony of wetland birds in the Western Province. Surprisingly nobody knew anything about".* (Respondent 1). Birds were also observed to be migrating between this site and the nearby wetland habitats at Rietvlei for roosting and breeding activities, all of which was taken into consideration during the planning and approval phase of Intaka Island (Respondent 1; Respondent 7). A history of the site, dating back to 1996, has been outlined briefly on the Intaka Island website.



Web page 1: History (CCPOA, 2021).

4.2.3 Zoning information

According to the City Zoning Map of Cape Town, the greater Century City precinct is a mixed-use urban development within the Cape Town Metropole, Blaauwberg Region, Sub-council 15, Ward 55., Intaka Island consists of 2493,887945 hectares.

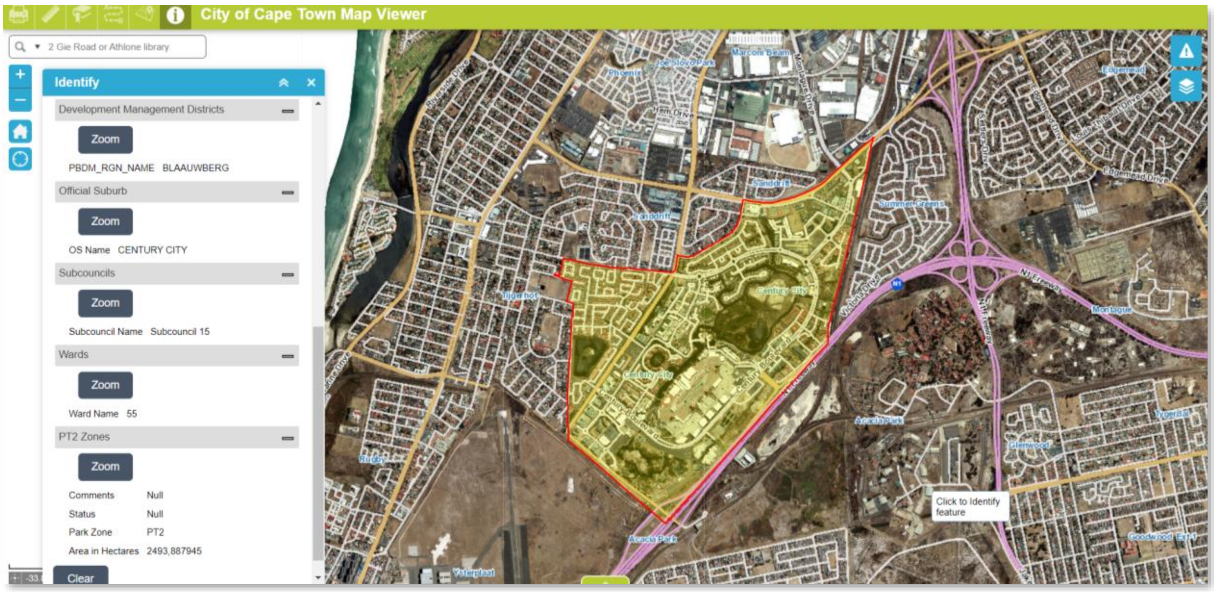


Image 3: Districts, suburbs, sub-councils, wards, and zones (Maps, 2021).

Intaka Island is zoned as Open Space 1: Environmental Conservation Area.

Image 4: Zoning map (Maps, 2021).

According to the Biodiversity Network data, the wetland cells are classed as having conservation value, but this is considered an irreversibly modified site. Even so, it provides locally significant habitat and assists with local ecosystem functioning. For this reason, it is regarded an important conservation site and the objective is to restore it as close to the original condition as possible over a medium-term period of 15 years.

Image 5: Biodiversity Network (Maps, 2021).

According to the Biodiversity Network data, the ephemeral pans are recognised as locally relevant private conservation areas that have attained voluntary conservation status but are not yet formally protected. Their habitat is considered significant locally, regionally, nationally, and internationally due to ongoing loss of habitat which continues to threaten species. The required actions are 1. the pursuit of ongoing conservation status; 2. Updated management plans that are implementable and audited. Low impact recreational and educational activities for the site outside of the Conservation and Biodiversity Areas (CBA's) are deemed appropriate (BIIEC, 2019).

Image 6: Biodiversity Network (Maps, 2021).

According to National Vegetation Types, this vegetation is classed as Cape Flats Sand Fynbos.

Image 7: Indigenous vegetation map (Maps, 2021).

According to the City of Cape Town soils map, the soils on site are classed as sandy acidic soils with leached nutrients and an upper layer of organic matter.

Image 8: Soil map (Maps, 2021).

According to the City of Cape Town wetland map data, the wetland cells have been classified as stormwater ponds with a high concentration of natural ecology and therefore have ecological value. They are described as permanently inundated with water and covered in reeds and herbaceous vegetation with an adjacent ephemeral pan.

Image 9: Wetland map (Maps, 2021).

4.2.4 Planning, design, and approvals

From an urban planning and development perspective, after the original wetland and extensive heronry were discovered and recorded, this provided a compelling motivation to address environmental concerns. The last of the Sewe Pannetjies was called Blouvlei (Respondent 1; Respondent 2; Respondent 3; Respondent 7). There were water quality concerns due to visible eutrophication in the original Blouvlei ephemeral pans (Respondent 2; Respondent 3). Also of concern was that stormwater from surrounding areas was contributing to increasing volumes (Respondent 3). However, this created a perfect habitat for a heronry with lots of bird life (Respondent 6; Respondent 7; University of Cape Town, 2004). This also provided clear motivation to set aside an area for the design of a multi-purpose nature reserve for conserving water birds and local vegetation (University of Cape Town, 2004). The conditions of approval outlined the requirements for the preservation of an area sufficiently representative of the ephemeral pans and a permanent water body to accommodate the diversity of species originally discovered at Blouvlei (BIIEC, 2019). Sixteen hectares were set aside with 8 hectares allocated for conservation of the ephemeral pans and 8 hectares for the constructed wetlands (Respondent 3).

The original concept focussed on replacing a degraded natural system and replicating the heronry to mitigate the negative impacts of lost habitat and to improve biodiversity (Respondent 1; Respondent 2; Respondent 3). This concept included a wetland for the purpose of stormwater management (Respondent 3). The wetland was designed to contain water quality treatment cells to polish the water entering the canal system (Respondent 2; Respondent 3). The constructed wetland design consists of four cells. Each of these cells fulfil specific functions in the treatment of water. The first two cells are covered with extensive reed growth for the absorption of nutrients such as phosphates and nitrates, the third cell is an open water body for aeration and the fourth cell is a shallow meadow for further nutrient treatment (Respondent 3; Respondent 6). There is only one small remnant patch of original natural wetland, which forms part of the seasonal pans and is visible due to visible ponding of water in the winter months (Respondent 2; Respondent 4). A retention facility was included for additional water holding capacity during heavy flood conditions and fills up during high flow periods, overflowing into the stormwater system (Respondent 2; Respondent 6). It also included a network of narrower canals which were to form the green lung at the core of the Century City development (CCPOA, 2005). This stormwater system design was proposed by the developer (Respondent 3). It was later approved by the City of Cape Town (Respondent 3).

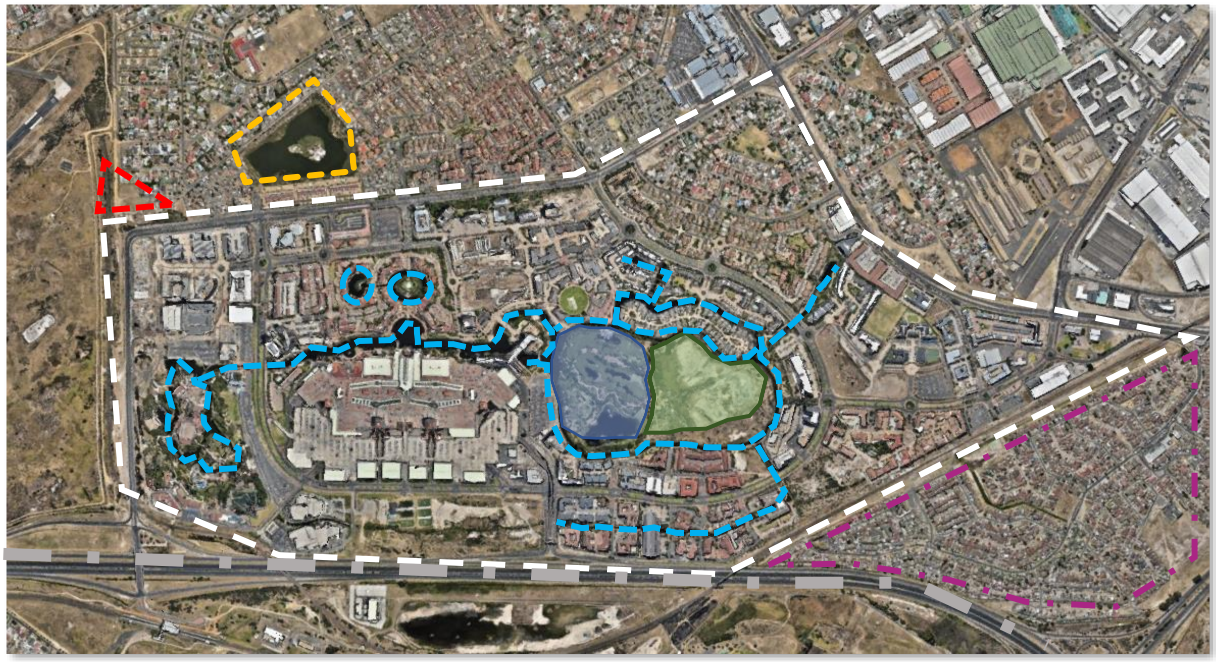


Image 10: Century City Precinct (Google Earth, 2021).

KEY

The constructed wetland

The nature reserve consisting of ephemeral pans

The canals

The Tygerhof detention facility

The outflow in the South-Western corner

The N1 national roadway

Summer Greens

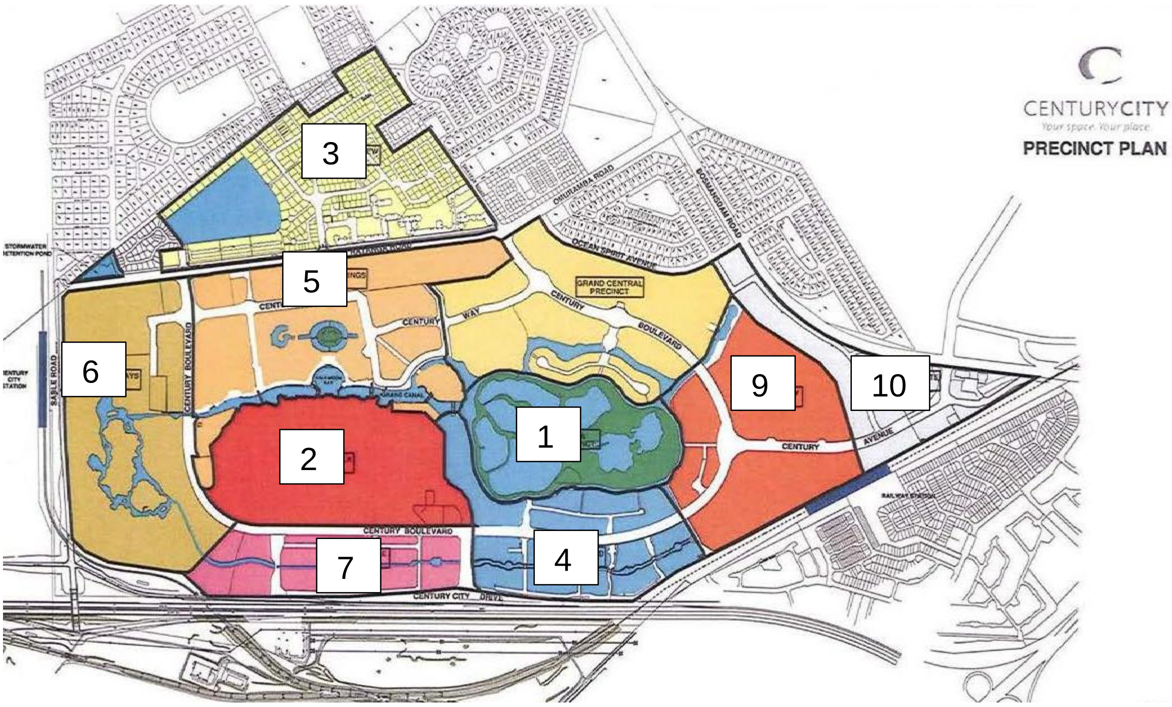


Figure 44: Century City Precinct Plan (CCPOA, 2017, p. 1). Refer to Addendum 6.

KEY

1	Intaka Precinct
2	Canal Walk precinct
3	Century View precinct
4	Waterford precinct
5	Grand Moorings precinct
6	Bridgewater precinct

7	Mercantile precinct
-	Grand Central precinct
9	The Estuary precinct
10	Century Gate precinct

4.2.5 The Environmental Impact Assessment (EIA) process

From an environmental legislation perspective, 1996 was in the time that the Department of Environmental Affairs in South Africa were formalising environmental regulations (Respondent 3). The National Environment Management Act, 1998 (Act No. 107 of 1998) upholds Section 24 of the Constitution of South Africa and outlines the Environmental Impact Assessment (EIA) process to mitigate and regulate social, economic, and environmental impacts during the planning and construction stages of development with a focus on sustainable development. The EIA process considers current and future human and environmental wellbeing (Department of Environmental Affairs, 2017). During the initial authorisation process, the significant seasonal wetland and heronry on the site went unidentified but was later included (Respondent 2; Respondent 3). An Environmental Impact Assessment (EIA) was undertaken on the site (University of Cape Town, 2004) which served to mitigate negative impacts of the proposed development on the environment (Department of Environmental Affairs, 2017). Regulatory bodies such as the Provincial Government of the Western Cape served as the responsible authority for issuing approvals (Department of Environmental Affaris, 2018).

In this instance, Cape Nature, the Provincial Government of the Western Cape, and the City of Cape Town imposed formal conditions on approval of the developer to protect and incorporate the wetland in the development of the design (Respondent 2, Respondent 3, Respondent 7). "At this time (in 1996) there were no formal EIA Regulations, and therefore the approval conditions relating to the wetlands were included under the legal requirements for the rezoning of the site (i.e. under the planning legislation). *Note from WC govt website: Legal provisions for EIA in South Africa were first incorporated in the Environment Conservation Act, 1989 (Act No. 73 of 1989) (ECA), and Regulations for EIA were promulgated in terms of Sections 21 and 26 of ECA on 5 September 1997"* (Respondent 3). This included a representative area of ephemeral pans of 16 hectares for a multi-purpose nature area (CCPOA, 2021) to conserve Sand Plain Fynbos and biodiversity and to address water quality and quantity issues through the functioning of these water bodies (University of Cape Town, 2004). Following the EIA, an environmental monitoring committee was formed (Respondent 3; Respondent 6). An operational Environmental Management Plan was prepared, which has been updated with more detail as time has progressed (Respondent 2; Respondent 3; Respondent 6, Respondent 7).

4.2.6 A complex site

The vegetation at Intaka Island is predominantly locally indigenous and the terrestrial areas contain important vegetation types (Respondent 4). This is of high conservation value (BIIEC, 2019), some of which are rare and threatened species of the rare Sand Plain fynbos habitats (BIIEC, 2019; Respondent 4). For this reason, Intaka Island has a high conservation and educational value and therefore attained formal conservation status as a declared "*Voluntary Conservation Site*" by Cape Nature in 2006 (BIIEC, 2019) which it has maintained. Due to the site's urban reserve status, the City of Cape Town is mandated to oversee this conservation area which lies within its boundaries (Respondent 3; Respondent 4). A 5-year Restoration Plan for the conservation area guides the maintenance, alien clearing and vegetation re-establishment programme which outlines different objectives and targets for the unique habitat types (Respondent 4; Respondent 6). Through these conservation objectives, many species have been re-established in disturbed areas of the nature reserve, recognising it as an extensive fynbos revegetation scheme (BIIEC, 2019).

4.2.7 Research focus

Adjacent to the ephemeral pans is an 8-hectare constructed wetland, designed to fulfil the original development conditions (Respondent 1; Respondent 2; Respondent 3; Respondent 6). This research specifically focuses on the wetland portion of the nature reserve. The ephemeral pans have been excluded from this research and the author has focussed solely on the constructed wetland with associated berms, terrestrial zones, the canal system, and the detention pond. The intention with this research was to establish the emergent themes that are dominant in the successful management of this system. These themes surfaced during the research process and have been formalised accordingly.

4.2.8 Critical Success Factor themes

The literature explores many of the Critical Success Factors commonly found on projects. Due to the nature of projects, there seems to be no clear consensus as to what they are. Rather, it seems increasingly clear that these factors are complex, subjective, and multi-dimensional, often continuing from the project phase into the operational phase. The literature points out specific strategic and adaptive management approaches that form part of the more recently researched and established Critical Success Factors. These align with the case study as follows:

Theme 1

Critical Success Factors in literature	Critical Success Factors evidenced in case study
Strategic management	A strategic focus
Strategic management and aligning of project initiatives with an organisations' short- and long-term goals.	Owing to the vision of the original developer and the ongoing commitment and consistency in management by the Century City Property Owners Association (CCPOA), Century City has emerged as offering a contemporary urban lifestyle, set in a high-quality environment, and contributing to the human lifestyle needs of its property owners (CCPOA, 2017).
The ability of a project or organisation to achieve its strategic goals and objectives.	Owing to the vision of the original developer and the ongoing commitment and consistency in management by the Century City Property Owners Association (CCPOA), Century City has emerged as offering a contemporary urban lifestyle, set in a high-quality environment, and contributing to the human lifestyle needs of its property owners (CCPOA, 2017).
The application of predetermined objectives by a project manager to achieve positive results.	"it was clear that he and the development company wanted to create something unique and outstanding" (Respondent 3: Respondent 6; Respondent 7; CCPOA, 2017). "*Century City intends to be a leader, where possible, in the pursuit of a sustainable future in the context of the conception, design, construction, use and management of buildings and localities. Determinants for this "green" future will be incorporated into its*
Increased organisational success is a direct result of a focus on organisational objectives, resulting in strategic and business benefits (McLeod, et al., 2012).	

	environment management policy and in the development controls of these regulations" (CCPOA, 2017).
Top management support and skills increases the likelihood of success.	The CPPOA as the operating company have adopted and moulded the original vision and have continued to show commitment and fulfilment or realisation of the objectives that lead to realisation of the vision.
A project champion is likely to increase success.	"…*the guy doing the development of that time and he had big ideas*" (Respondent 6). "…*and created - you know creative energy which he had his - um yeah - he had an incredible amount of energy*" (Respondent 3).

Theme 2

Critical Success Factor in literature	Critical Success Factor evidenced in case study
Adaptive management	A learning approach
Management system inputs that lead to success are inherently more organisational and behavioural. Competence, technical background, and administrative skills of the project team increase the likelihood of stakeholder satisfaction, project acceptance and project success.	The variety of specialists, employees and the workforce who act as a repository of organisational history and decision-making (Respondent 2; Respondent 3; Respondent 4; Respondent 7).
Project management success is dependent on variables such as intellect, leadership style and competence.	
Professional certification improves success and is required for high performance.	
The application of knowledge, tools and techniques is considered important.	They employ an academic botanist and numerous horticulturists who either have a National Diploma in Environmental Management, Conservation Tourism or a Horticultural Diploma (Respondent 1; Respondent 66). Most of the rangers have some level of training and have a certain level of skill (Respondent 6). Some staff are employed on an internship contract and do not have much experience but in these instances, the reserve management sees

	that as a learning opportunity (Respondent 1, Respondent 3, Respondent 4, Respondent 6).
Experience and expertise of the project manager enhances success.	The CCPOA employ qualified staff in management roles (Respondent 3; Respondent 6). Both positions require a management qualification (Respondent 6).
A learning approach accommodates flux and change and is key to adaptive management.	The CCPOA support continuous learning and provide opportunities for all staff to improve their skills related to their line of work.

Theme 3

Critical Success Factor in literature	Critical Success Factor evidenced in case study
Strategic management	Critical Success Factor evidenced in case study
Clearly defined goals. The success criteria need to be clearly defined and established early in the establishment phase and reviewed regularly.	Clear management objectives have been outlined in the EMP.

Theme 4

Critical Success Factor in literature	Critical Success Factor evidenced in case study
Adaptive management and tailoring of project processes and procedures to different contexts increases success. A degree of experimentation is required.	Adaptive, responsive, and experimental operations are important in the management of this wetland (Respondent 2, Respondent 3; Respondent 4; Respondent 6)

The four main themes have been outlined in detail below:

4.3 Emergent theme 1: Strategic management - A strategic vision with associated objectives

4.3.1 Description and findings

The original vision for Century City was borne out of a desire by the development company to do things differently and achieve a standard of excellence. It espoused the concept of a mixed-use development with residential, educational, commercial, retail, and recreational components. The CEO who is considered "*a very visionary person"* (Respondent 3) and developed a grand concept of a themed environment with creative landscape components and it was clear that he and the development company wanted to create something unique and outstanding (CCPOA, 2017; Respondent 3: Respondent 6; Respondent 7). The selected site was well-positioned with easy access to Cape Town, the West Coast, and the Northern suburbs of Cape Town but the uncovered "Sewe Pannetjie" ephemeral wetland system imposed a considerable constraint on the site. This may ordinarily have been considered a significant limitation by most development companies, but in this instance, water was effectively incorporated into the design as an artificially constructed wetland (Respondent 1; Respondent 2; Respondent 3). Owing to the vision of the original developer and the ongoing commitment and consistency in management by the Century City Property Owners Association (CCPOA), Century City has emerged as offering a contemporary urban lifestyle, set in a high-quality environment, and contributing to the human lifestyle needs of its property owners (CCPOA, 2017). The CCPOA also recognise the connection between values and personal attributes such as vision and reputation, as expressed in the following words: "their vision is their reputation" (Respondent 6).

Careful formation and structuring of the CCPOA has been crucial, as relayed in one interview:

> "…*the structure of our business is very well - well done and that was - that was a vision of the original developer*" (Respondent 6).

The use of words that allude to "*differen*t", "*creative ideas*" and "leadership" encapsulate the vision:

"Different"

- *"…he wanted to do something radically different"* (Respondent 3).
- "…he *was a developer who was prepared to do things differently and take on different ideas*" (Respondent 3).
- "…he wanted to create something different" (Respondent 3).

"Creative ideas":

- "…*he was very much very creative with lots of ideas*" (Respondent 3).

- "…*visions of like that it would be like Okavango and people could have a makorra's that go through the reeds and all those kind of visions he had for what he wanted to create*" (Respondent 3).
- "…*and created - you know creative energy which he had his - um yeah - he had an incredible amount of energy*" (Respondent 3).
- "…*all the along the canal were going to be windmills and pyramids and you name it. And that didn't come off and then we had things like we were going to put a Dakota plane on the bridge between this pan and the next pan and have it as a restaurant*" (Respondent 6).
- "…*the guy doing the development of that time and he had big ideas*" (Respondent 6).
- "*He wanted to turn the constructed wetlands sort of into a theme park…*" (Respondent 7).

"Leadership":

- "*Century City intends to be a leader, where possible, in the pursuit of a sustainable future*…" (CCPOA, 2017).

In addition to bringing the original creative vision, the original developer was actively involved from project inception, through the design stages of the development and became involved in the wetland design, showing an interest in all aspects by attending and actively participating in meetings (Respondent 3).

> *"To have the top developer come and sit in your meetings is I think fairly unusual. I mean it was quite amiable."* (Participant 1)

Much attention was paid, not only to the careful planning and implementation of the original vision, but also to infusing that vision into the culture of the stakeholders over the years, which is embodied in the statement of commitment from the Century City Property Owners Association towards sustainability as: "*Century City intends to be a leader, where possible, in the pursuit of a sustainable future in the context of the conception, design, construction, use and management of buildings and localities. Determinants for this "green" future will be incorporated into its environment* *management policy and in the development controls of these regulations*" (CCPOA, 2017). These objectives form the foundation of all decisions and actions and has led to much engagement and co-operation that has culminated in success. A co-operative spirit has been sought at environmental meetings and an amiable approach has led to a mutual understanding that is clear (Respondent 6). Century City is much more than an individual person. It is the collective that creates and stewards this unique environment that is filled with vitality, under the guidance of the various associations and committees (CCPOA, 2017).

> *"…over the time have come to a fairly good mutual understanding, so we get a lot of cooperation from an environmental point of view*" (Respondent 1).

> *"…ongoing commitment from the Property Owners Association. Their commitment has been - is very commendable and has been developed for the last sort-of 25 years."* (Respondent 2)

> *"Even design of the new canal system, we were heavily involved we - we you know they actually - we saw the designs, we engaged directly with the engineers, so and the developers so the - the relationship building is definitely between the developer and ourselves is the number one"* (Respondent 6).

> *"…the developer's invested in Century City, you know. They've been here for a very long time, you know. If - if there's a problem, we go back to them two, three years later….so now they get us involved in the design phase heavily like a lot. I mean, they - we really do."* (Respondent 6).

> *"…we know what Century City has got. We know what Century City needs to be, and it just has to be done."* (Respondent 6).

The original design vision is key to the determination of operational objectives. The vision of the Intaka Island wetlands is central to determining how it should look and function, which is different to that of a natural system (Respondent 2). The transition from planning and development to operations has followed a process of learning with an emphasis on governance. This ensured that the vision was supported practically through the processes of planning, design, and management. The Operational Environmental Management Plan (OEMP) is one such monitoring report that was compiled to formalise the environmental approach to management of Intaka Island, the associated canals and detention pond. As stated in the 2009 EMP document:

> *"I think there is a clear vision. It's kind of articulated in the management plan…but as I'm saying parts of that vision are not necessarily achievable, so some of it is around purification of water that's not necessarily realistic now but, but yes there's a clear vision. I think that their challenge is trying to get all the different parts of the vision to speak to each other."* (Respondent 2)

> *"…but that is like what the aim of the OEMP is, to try and have an overall vision."* (Respondent 4).

> *"…as long as I think everybody shares the same vision."* (Respondent 6).

> *"And we've also got a reputation and a vision for our own company now."* (Respondent 6).

This EMP includes environmental goals, objectives, management actions, monitoring requirements and targets/criteria for monitoring. The key aspects that are addressed are:

- Management of water quality and quantity;
- Maintenance of hydrological and ecological functioning of the pans and constructed wetlands;
- Establishment of fauna and flora, in particular, plants, birds, fishes, reptiles, amphibians, and small mammals;
- Integration with wider planning and development at Century City; and
- Promotion of tourism, recreational, educational and research opportunities.

(BIIEC, 2009).

4.3.2 Discussion and interpretation

The vision and establishment of objectives is considered a Critical Success Factor and starts long before the operational phase. It is rooted in the project inception phase and woven through the success of Intaka Island planning, design, construction, and operational phases. Active involvement by the original developer from project inception allowed him to proactively direct the project and set the standards upfront which improved outcomes significantly during the planning and development stage and established a solid basis for the future operational phase. The original vision was articulated in various forms, including the objectives of the construction, establishment phase and operational phase of the EMP documents. A desire to create an extraordinary environment that accommodated existing water bodies on the site and transform it into one that inspires and educates its users, turning constraints into opportunities. The vision ignites interest in something that otherwise may have been ordinary. It realigns stakeholders, interested parties and observers toward a mindset of "beyond the ordinary", but it requires significant effort to inculcate this vision into the culture of the organisation and to ensure it materialises in everyday operational practises. The CPPOA as the operating company have adopted and moulded the original vision and have continued to show commitment and fulfilment or realisation of the objectives. The EMP document outlines very specific goals, objectives, strategies, and actions to be followed so that physical outcomes are achieved, and success is evidenced through the visitor numbers as well as higher property values.

4.3.3 Recommendations

The original vision has been the driving force that has led to conceptualisation of the project (Respondent 1; Respondent 2; Respondent 3; Respondent 6; Respondent 7). It is important to continue to express that original vision in the form of a regularly updated vision statement and revised objectives, showing how it weaves through the project development, from inception into the current EMP objectives that guide the operational phase. This will provide a benchmark to reinforce consistency in approach and may be used as a to guide the ongoing refinement of goals and objectives at Intaka Island.

4.3.4 Summary

A description of the visionary as an individual "*Whose unswerving vision, creativity, courage, passion for excellence and commitment to the "guest experience have made Century City…a reality…"* (Unnamed, 2000) seems most apt as it captures the essence of the one whose original ideas were conceptualised and evolved into the Intaka Island legacy over twenty years later. This development took place prior to the

Management of Urban Impacts Policy of 2011 and the South African Guidelines for SuDS of 2013 were adopted by the City of Cape Town and therefore without the vision and the concerted efforts of the governing authority, Intaka Island, the development of the wetland and the application of SuDS principles may not have materialised.

> *"Century City intends to be a leader, where possible, in the pursuit of a sustainable future in the context of the conception, design, construction, use and management of buildings and localities. Determinants for this "green" future will be incorporated into its environment management policy and in the development controls of these regulations"* (BIIEC, 2019).

In addition, strong ongoing support of the original vision has been articulated in the EMP which sets the operational goals and objectives and are led by the CCPOA and supported by various internal and external stakeholders, such as the BIIEC and the City of Cape Town. This has been an important contributing factor to ongoing success at Intaka Island.

4.4 Emergent theme 2: Adaptive management - SuDS supports a culture of learning

4.4.1 Description and findings

> *"part of Century City and specifically this Intaka Island is about education"* (Respondent 6).

a) Educational signage

Education sits at the heart of Intaka Island. The signage located in the forecourt and reception provides an introduction and overview of the history and purpose of environmental and conservation aspects related to the wetlands and ephemeral pans in the three most prominent languages in the Western Cape Province, namely English, Afrikaans and isiXhosa, making it accessible across cultures. It provides a welcome to schools and interest groups or clubs, offering tailor made educational programmes and a variety of self-guided activities. Information on signage boards outlines the layout and functioning of the wetlands for the purpose of water quality enhancement and habitat improvement at Intaka Island (Spolander, 2021). Detail on the water system has been provided as follows:

- Cells 1 and 2

  These are large, shallow water bodies containing densely growing reeds which provide habitat for birds, slowing down the water and allowing sediment and nutrients to be trapped and settle around the plant roots, some of which is absorbed for plant growth. The water then passes through a raised, perforated metal pipe to enable oxygenation (CCPOA, 2021).
- Cell 3

  This is a large, deep, open water body where algae grow, absorbing nutrients. Wind serves to aerate water in the pond and as the algae dies, it sinks and is trapped at the base of the water body. Constructed heronries have been placed in these water bodies to attract birds (CCPOA, 2021). Refer to Addendum 7.
- Cell 4

  This is a large, shallow marsh with diverse vegetation, providing habitat and allowing oxygenation and sedimentation from the previous cell (CCPOA, 2021),

Information specifically relating to wetland vegetation types, namely indigenous and exotic aquatic plants has been inscribed on prominent signage with a section indicating various zones on the edges of wetlands such as submerged, emergent, floating plants and aquatics as seen in Images 12 and 13, alongside other pertinent information that supports sustainable approaches. In addition, detail is also offered on the various habitats and vegetation types in the ephemeral pans as seen in Images 12 and 13 (Respondent 6; Spolander, 2021).

Image 11: Information on the vegetation (CCPOA, 2021).

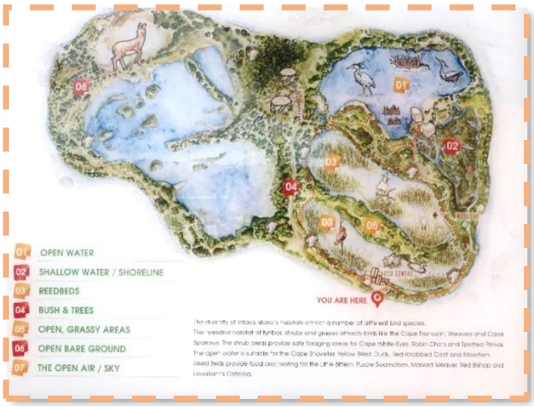
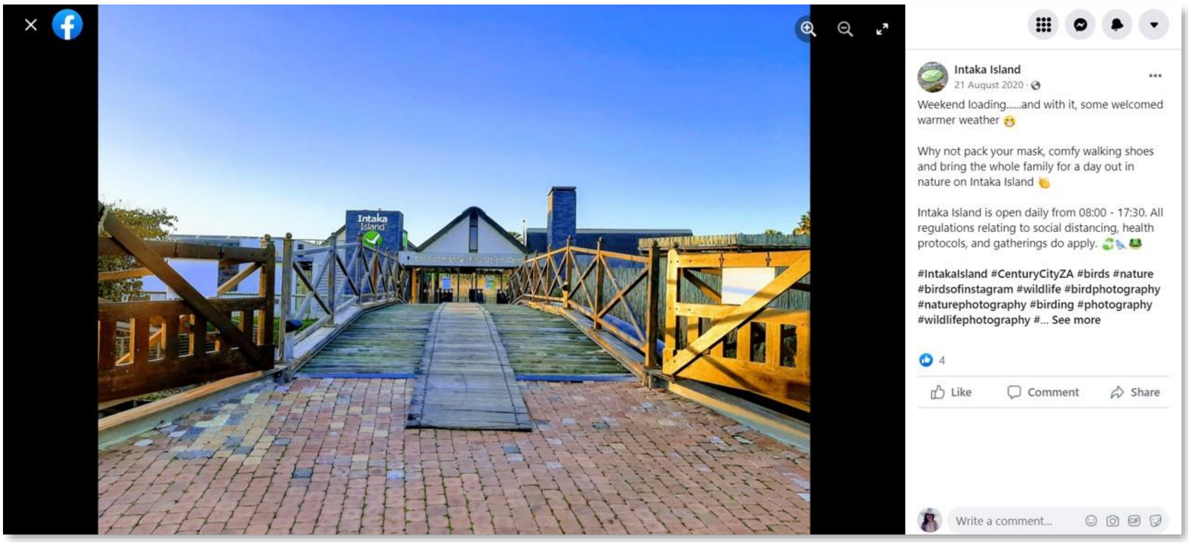


Image 12 & 13: Information on the various habitats and information on aquatic plants (CCPOA, 2021).

b) Educational facilities

The Eco-centre provides educational programmes for primary and secondary institutions and other organisations relating to the functioning of the nature reserve, with specific reference to the cleansing function of stormwater (Vice, 2011). It is also intended to be promoted as a research resource for tertiary institutions, as the monitoring and reporting database at Intaka Island can be used to facilitate ongoing research to further the objectives of the EMP, provide scientific value and broaden common knowledge of the island (BIIEC, 2019).



Social media post 1: Eco centre entrance (CCPOA, 2021).

c) Types of facilities

The wide range of facilities include but are not limited to numerous viewing platforms scattered along the nature trails, which offer space for seating and social interaction. Bird hides facilitate observations and photography of nature and birds for educational and recreational purposes by the birding community. A multipurpose lapa serves the wetland and the ephemeral pans and a dipping pond on the northern edge of cell 3 is used for educational water sampling to study water quality and observe living organisms in the wetland. Ferry boats provide views of the water's edge of the wetland and allow for observation of the flora and fauna as well as aquatic life in the canals. An educational garden and walking trails around the wetland contain educational signage all of which create awareness of the indigenous terrestrial and aquatic vegetation that support its cause (Spolander, 2021). Refer to Image 30.

Facilities are strategically and located on the island for optimal viewing and positioned at sufficient distances for ease of access and to avoid the encroachment of nearby facilities, activities, and view lines. An intricate network of sensitively designed pathways connects the various facilities with a limited footprint and environmental impact. Directional and educational signage have been designed to be unobtrusive and provide orientation and learning opportunities. The Eco-centre is the primary facility, Located at the only controlled entrance to the island, via a bridge over the perimeter canal and consists of a collection of indoor and outdoor classrooms and observation decks that are centred around sustainable activities such as composting, waste management and aquaponics which support the main functions of the wetland and nature reserve (Spolander, 2021).


Image 14 & 15: Classroom type educational learning opportunities (Spolander, 2021).


Image 16 & 17: Classroom type educational learning opportunities (Spolander, 2021).

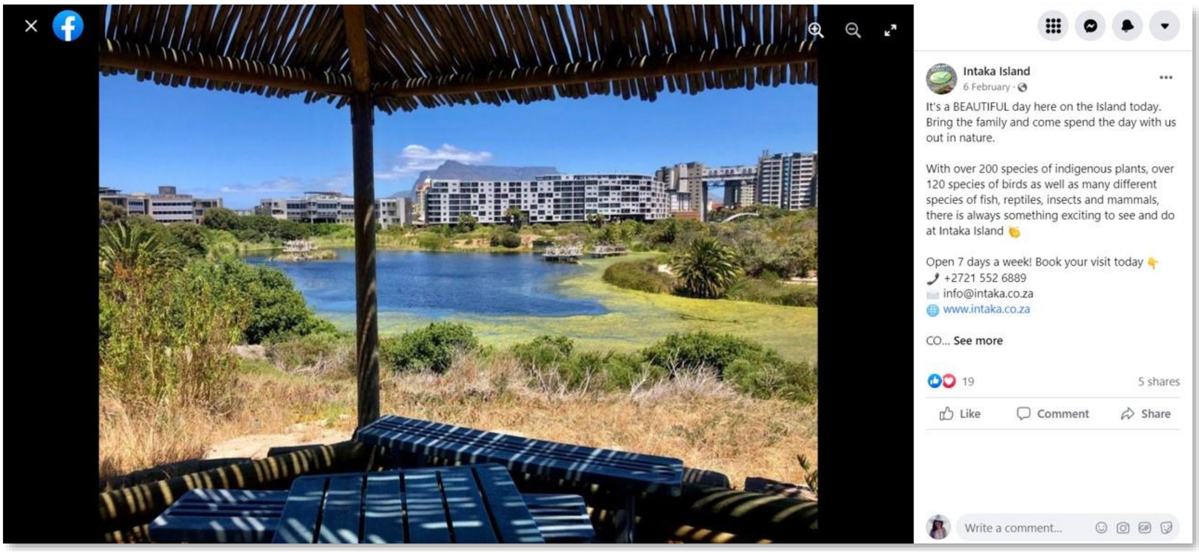
Second to the Eco-Centre, the lapa is the most prominent constructed facility and is geographically located in the centre of the island, serving as a central gathering space with views over the ephemeral pans and the wetland. From a topographical perspective, it is also located in the most prominent position on Bird Mountain, which is an elevated earth mound providing a high vantage point on the island which affords more panoramic views and scenic observations (Spolander, 2021; Respondent 6).

Social media post 2: Educational learning (CCPOA, 2021).

Image 18 & 19: Lapa and educational signage (Spolander, 2021).

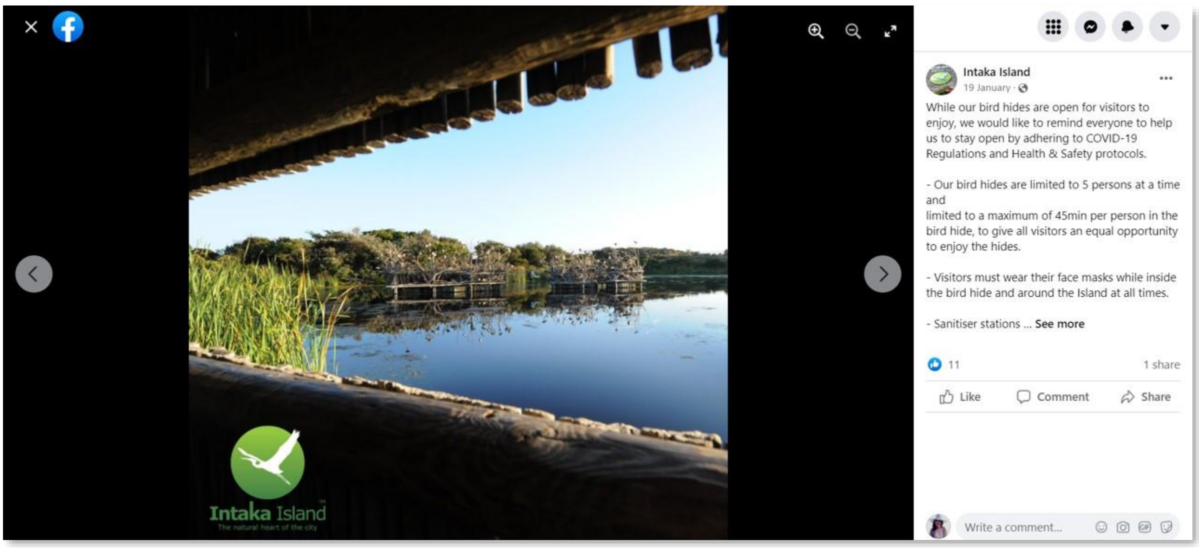
> *A neat system of pathways and boardwalks allows visitors to view the birds close up, and a bird hide on the water gives a grandstand view of the packed nesting islands"* (University of Cape Town, 2004).

The various viewing platforms and bird hides are dotted along the water's edge of the wetlands to optimise viewing and yet visually unobtrusive. Some of the platforms serve an educational function as well as a practical function. They also serve as maintenance access for equipment drops, cleaning and collection points. It is apparent that the educational and functional aspects on the island are mutually supportive and co-exist in an integrated manner. Visitors' exposure to maintenance activities is likely to reinforce the understanding that this is a dynamic, changing environment that requires attention beyond the bounds of what is deemed standard (Spolander, 2021).



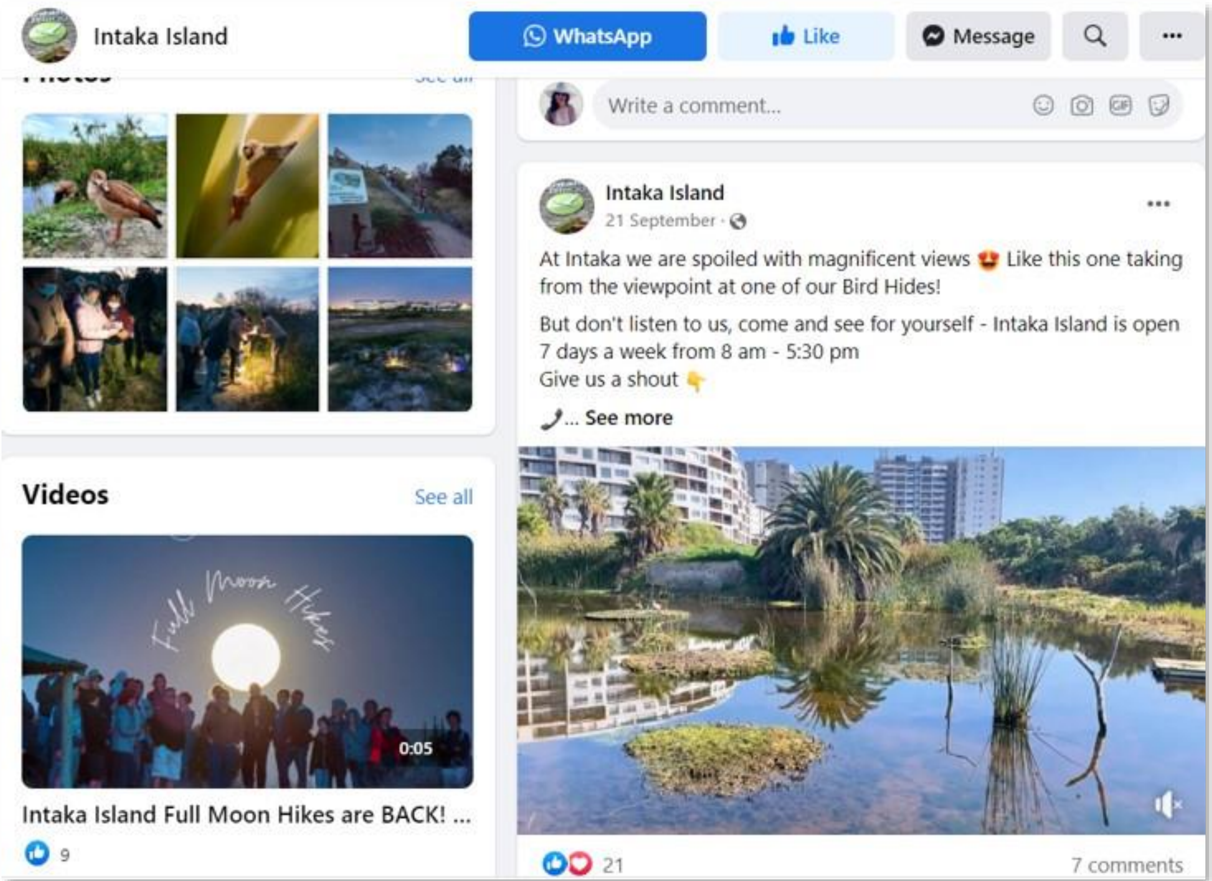
Social media post 3: Viewing platform (CCPOA, 2021).

This open space setting is a recreational and educational resource (University of Cape Town, 2004; Respondent 6). Intaka Island exists as a desirable amenity within the Century City precinct and yet provides some seclusion from its immediate context. It offers an alternative and convenient escape for residents and visitors from the bustle of everyday of life to connect with nature in a meaningful way, which is an inherent human need and desire (Respondent 1, Spolander, 2021).



Social media post 4: Bird hides (CCPOA, 2021).

Social media post 5: Birding photographers in the bird hides (CCPOA, 2021).



Social media post 6: Bird hide views (CCPOA, 2021).

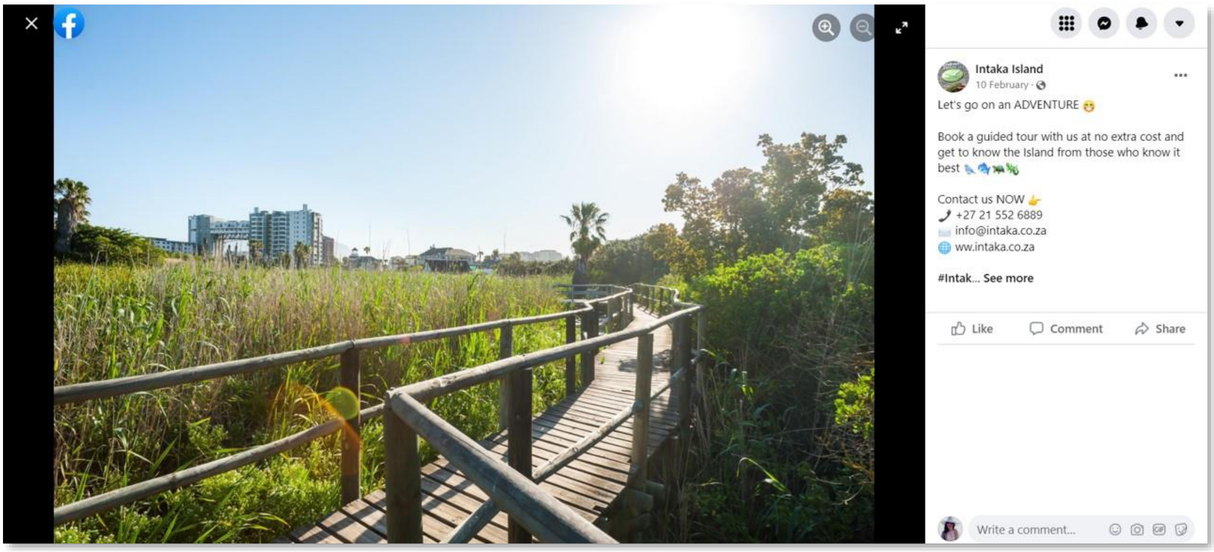
d) Educational activities

Social media post 7: School learners at the dipping pond (CCPOA, 2021).

The spatial layout on Intaka Island is sufficiently large and conducive for active and passive recreational use and for learning by observation. Several educational activities take place on Intaka Island that are linked to specific facilities in the wetland and ephemeral pans such as:

- The pathways provide opportunities for active guided walks between passive observation nodes.
- The dipping pond encourages participation and study of water quality and aquatic habitat.
- The educational garden serves as a showcase of indigenous and endemic flora but also displays how plants communities thrive or are constrained by climate, orientation, exposure, and saturation levels (Spolander, 2021).

> *“There's a lot of people who like to come here and sit in the hides and take photos which is why that caracal photo was taken. They sit longer than what a birder would do and so they pick up more, and they have a photo to prove it. And we can identify the thing off the photo when you go.”* (Respondent 1).



Social media post 8: Guided tours (CCPOA, 2021).

e) Scenic trails

Of the two trails on the island indicated in Figure 45, the Weaver Trail has been highlighted as it is specifically intended for observation of the periphery of the wetland cells and the surrounding canals. It meanders through the wetland, connecting all the cells as well as connecting the observation decks and operational facilities such as the nursery and the boat jetty. These trails are readily accessible almost every day of the year. In addition, guided evening hikes are arranged on a frequent basis to observe night activity in the reserve (Spolander, 2021).

Figure 45: Scenic trail map (CCPOA, 2021).

Social media post 9: Evening hikes (CCPOA, 2021).

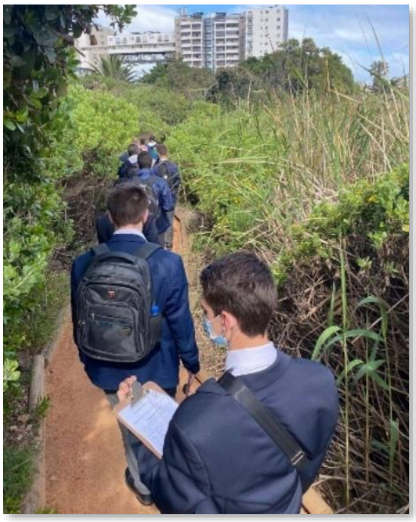
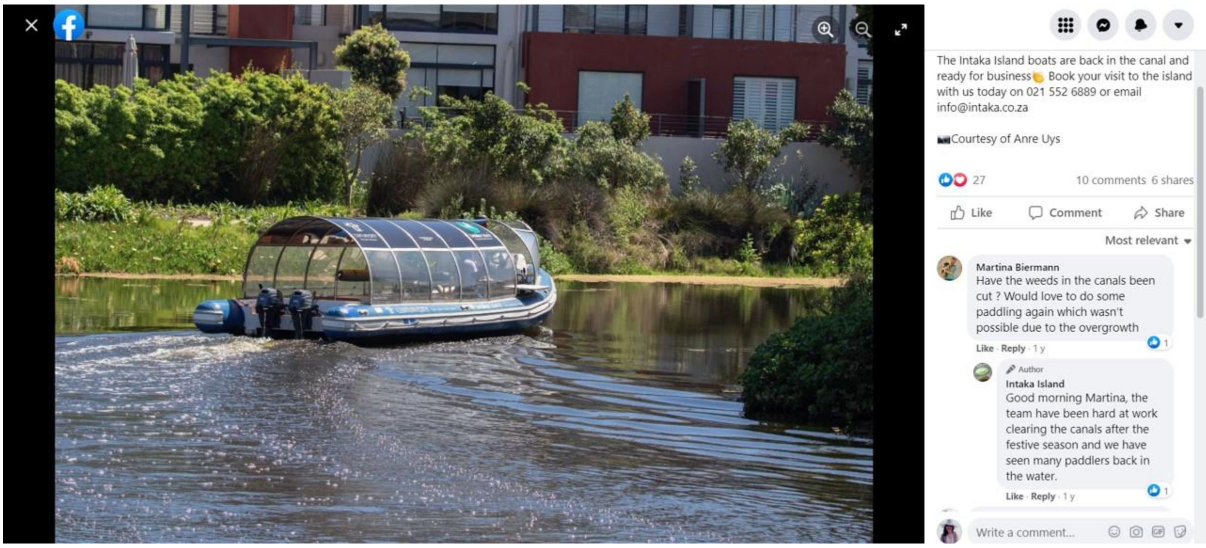


Image 20 & 21: Educational learning on the wetland pathways and observation deck with seating and educational signage at floating islands (Spolander, 2021).

The school programs have been linked to the educational programs to include boat trips on the canals around Intaka Island using two taxi boats which also serve as non-motorized transport for visitors to the precinct (Respondent 3; Respondent 6). These boat trips allow remote observation without a physical presence and impact on the island and may be manoeuvred to optimise the viewers perspective. They are not used for operational purposes but may be used by personnel on the Island (Respondent 6).



Social media post 10: Educational boat rides along the perimeter canal (CCPOA, 2021).


Image 22 & 23: Educational boat trips (CCPOA, 2021).

f) Waste management

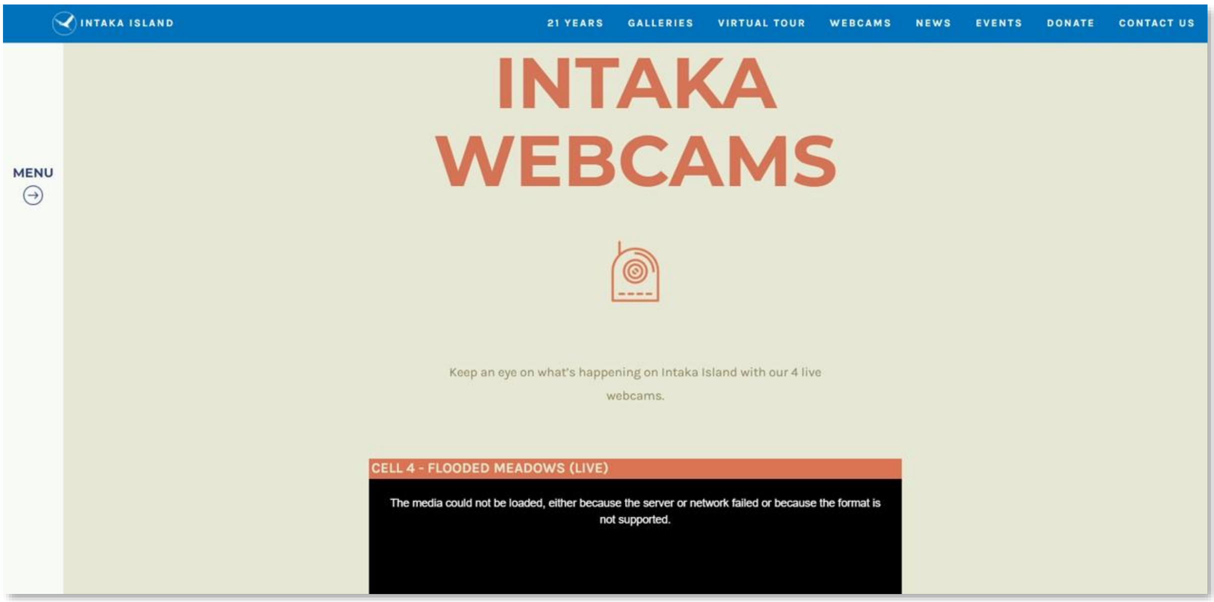
Initiatives such as waste separation and efficient waste management serve as supportive activities in the sustainable approach being pursued at Intaka Island, as these initiatives potentially have a positive impact on stormwater quality in the catchment (Vice, 2011; Respondent 6). Intaka Island operations include the recycling of much of the waste generated by harvesting of water weed and aquatic plants as well as terrestrial vegetation. This is supported by initiatives to recycle plastic, glass and other waste products (Spolander, 2021).



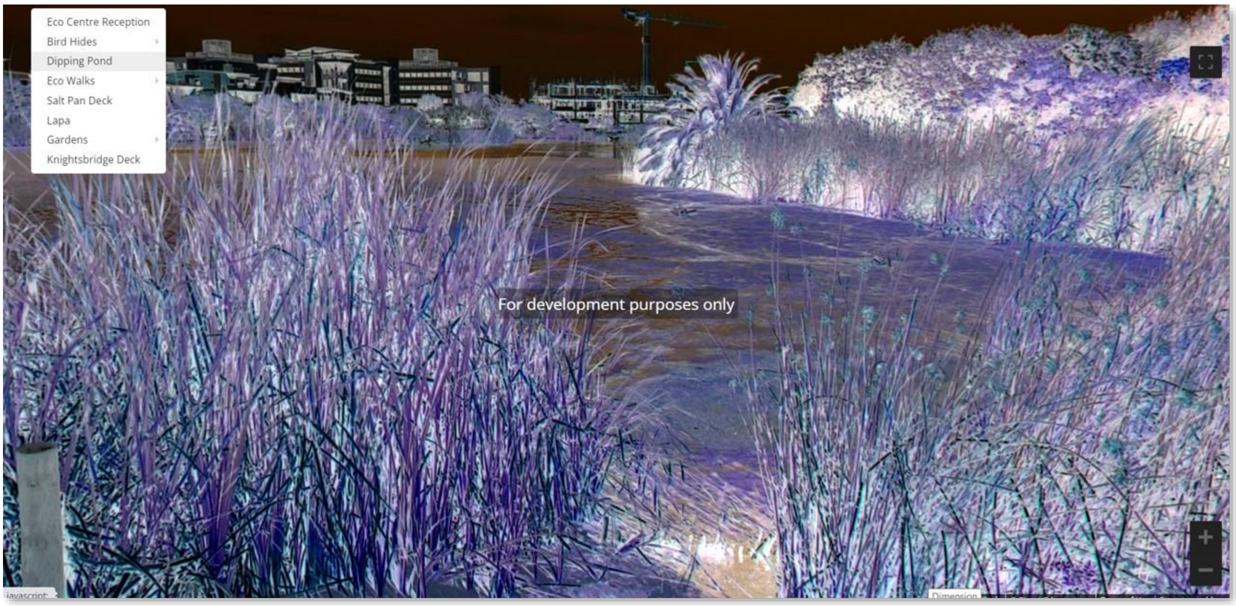

Image 24, 25, 26 & 27: Recycling, composting and waste management initiatives (Spolander, 2021).

g) Marketing and media

Marketing is the main activity associated with the strategy of attracting visitors, starting with the establishment of links between the island and schools and other interested and affected parties by a marketing and public relations officer. Through these initiatives, the website and social media platforms gained popularity initially and more recently provide information to interested parties. The Intaka Island website and social media pages are active with up-to-date educational, recreational, and operational information (BIIEC, 2019). Web cameras are now in the development stage on the website and able to provide real-time remote observations in specific locations of the wetland as indicated in Web page 3. Each year, annual activities are planned to promote the wetland and the resources for such activities are provided by the CCPOA (BIIEC, 2019).



Web page 2: Intaka webcams (CCPOA, 2021).



Web page 3: Intaka webcam at the wetland (CCPOA, 2021).

h) Educational brochures and maps

Brochures are available to visitors of Intaka Island and provide short, informative key notes as seen in Figure 46 and additional pertinent information may be accessed via online links or QR codes (Spolander, 2021).

Figure 46: Educational brochures (CCPOA, Intaka Island About & History, 2021).

i) Operational aspects

The CCPOA employ qualified staff in management roles (Respondent 3; Respondent 6). A Marketing and Public Relations Officer initiates contact with schools and heads up the virtual and social media platforms while an Eco Centre manager facilitates and co-ordinates the operations and the educational programmes develops the program in line with the school curriculum with the schools. Both positions require a management qualification (Respondent 6). They employ an academic botanist and numerous horticulturists who either have a National Diploma in Environmental Management, Conservation Tourism or a Horticultural Diploma (Respondent 1; Respondent 66). Most of the rangers have some level of training and have a certain level of skill (Respondent 6). Some staff are employed on an internship contract and do not have much experience but in these instances, the reserve management sees that as a learning opportunity (Respondent 1; Respondent 3; Respondent 4; Respondent 6).

In addition, the CCPOA support continuous learning and provide opportunities for all staff to improve their skills related to their line of work. Two of the security guards showed an interest and were trained to identify birds and carry out bird counts, with all the necessary tools and equipment to allow them to conduct monthly monitoring and they gained knowledge on site through this process (Respondent 1; Respondent 3). Other staff have been trained in plant propagation and nursery management (Respondent 3; Respondent 4; Respondent 6).

> *"…certainly, seems to be a - a focus on training and the staff from the top management certainly have a very good grasp on how the system is working and what is its condition is."* (Respondent 1).

> *"They are trained in-house. The herbicide applicators and chains operators attend formal training as this is a legal requirement and the skippers acquire their licences by attending accredited courses with SAMSA."* (Respondent 6).

Other learning opportunities exist on the job, which include learning through observation, learning through contact with seniors and mentoring opportunities, all of which focus on human development and organisational effectiveness (Respondent 1; Respondent 3; Respondent 6). The appointed specialists are encouraged spend time with semi-skilled workers to impart knowledge between through contact with staff implementing the management plan action items There is a recognition that this will ensure a good transfer of knowledge, especially since much of the work is pioneering and requires management to recognise and respond to this (Respondent 1; Respondent 4).

> *"…the reserve manager encouraged me. She always tries to get the staff on the ground to go out with me and see what I'm doing and try and learn something about the reserve."* (Respondent 4).

"…he's been almost like a pioneer of - of in terms of like a lot of the sort of concepts that I'm talking about now - I mean yeah - a lot less was known back then so - yeah he did things quite differently. But still see how it's good to learn from." (Respondent 4).

"…the City's got their own teams, doing the harvesting. So, what we'll do is we'll take our nursery staff and our conservation team and work with those guys…they specialize in - um specifically lowland fynbos.…we are also engaging with them to propagate some of the species that's harder to - to - to grow out." (Respondent 6).

There is a recognition of the value of continuity and assimilating human capital with expertise. This is manifest in the variety of specialists, employees and the workforce who act as a repository of organisational history and decision-making (Respondent 2; Respondent 3; Respondent 4; Respondent 7).

"We've got 20 years of bird monitoring…I sit there with my historical hat on to say oh remember we agreed this, and you said you would do that and so on which is an important role in these committees." (Respondent 1).

"You also need to have an experienced dedicated management team which I think they've got a very effective one…They've got a dedicated staff that understand the system." (Respondent 2).

"I suppose a skill is that in this integrated system with different areas of expertise, this is all about…making management decisions based on …multiple priorities. Priorities for water quality, for birds, for education, for plants and they're all conflicting each other." (Respondent 3).

This, together with high levels of technical competence, long standing commitment, and adherence to the EMP enables more effective operations and successful outcomes (Respondent 3; Respondent 4; Respondent 6). The importance of ongoing learning and developing of the organisational knowledge base is also acknowledged as important in the various specialist fields to remain current and relevant. The extracts below suggest this.

> *"…these rare species, so no one knows how to grow them."* (Respondent 4).

> *"We're learning what to do as well as how the birds respond."* (Respondent 1).

> *"So, we're learning as we're going."* (Respondent 1).

> *"…most of the committee and hadn't worked with big business in this sort of sense before and I guess big business hadn't worked with individual greenies to the same extent, so they were learning from both sides."* (Respondent 1).

> *"I think the key points of lessons learned is the – the two - the three key points update: the one is that we have an integrated set of skills. We have a diversity of experts and skills involved, working together to come up with a holistic plan and management plan."* (Respondent 3).

> *"Third thing is that there is a continuity of expertise in people…our specialists are experts, like the water specialist, the botanical specialist and have long-term involvement. So that for me is the success factors."* (Respondent 3).

Learning is an integral part of environmental management and is evidenced in new approaches and methods that are executed on a trial basis and monitored periodically, to establish the degree of success. Such examples include the erection of bird decoys in an effort to attract birds, constructed heronries that resemble natural habitat for birds, installation of guano tanks with pumps below the heronries to isolate high nutrient loads from the wetland water (Respondent 1, Respondent 2; Respondent 3; Respondent 4, Respondent 6, Respondent 7).

"… we put some plastic models of herons in the bushes on the on the lake. The manager then put some stakes in the water between the bank and that island. I'm not sure why the birds settled on that, and they thought this seems to work. And then they started to build these breeding platforms that we've got now. Initially we had six or seven and the bird numbers went right up." (Respondent 1).

"…there was a management problem, because when the birds were happy on there, they're pooping in the water and so the pollution level of water rose to an unacceptable level. So, then they put in …portapools around the bottom so the guano drops mainly within those portapools and they are able to suck that water out and use it as a fertilizer. We're learning what to do as well as how the birds respond." (Respondent 1).

4.4.2 Discussion and interpretation

Education and learning is considered a non-structural SuDS control and is integral to the success of the SuDS system at Intaka Island. The entrance fee and various fund sources allow the educational programme to perpetuate. In addition, the educational programme draws interest from surrounding communities, schools and interest groups while also facilitating passive learning through observation, which brings feet through the entrance and therefore funding for the imperatives contained in the EMP. Educational programmes create awareness and ignite interest in the subject matter due to the interactive nature of observing natural processes, habitat and various forms of life related to the wetland. The momentum created by school attendance results in further demand for the programme and a wider interest to pursue research opportunities that the wetland offers. For this reason, visitor numbers are monitored during peak seasons to ensure that any impact on the environment is contained and limited. This also results in continuous improvement and a feedback loop of educational initiatives that attract a larger range of individuals and school groups, thereby increasing opportunities for education.

The educational programme exposes various aspects of the island to the public and therefore also provides opportunities for feedback, which is welcomed by the CCPOA to continually improve. Intaka Island provides a platform for formal and informal observation, monitoring, and reporting by the public, which greatly assists management. For example, observations and first sighting of various bird species and mammals by the public have provided vital information to management. This type of open feedback and interaction between stakeholders and the greater public has proven very useful. In addition, informal feedback from stakeholders and the greater public regarding maintenance standards and general service levels at Intaka Island have also proven valuable as they relate user experiences which may be used for improvements. Therefore, all types of observation, monitoring and reporting have proved value and assist management.

4.4.3 Recommendations

The facilities at Intaka Island support activities for education and learning. Additional opportunities for outdoor learning through guided observations of the current maintenance programme on the island may be beneficial for learners, students, and visitors. Direct observation of maintenance and operations may afford the public greater insight and understanding of the way the system functions. In addition, there may be further opportunities for ad hoc informal training and mentoring initiatives by the CCPOA and BIIEC. It has been suggested that closer mentoring and skills development of individuals who are carrying out operations may improve the quality of accuracy of data collection, methods of monitoring and reporting.

4.4.4 Summary

Intaka Island was originally designed and constructed to meet specific environmental objectives at Century City. As operations have rolled-out on the island, public and stakeholder interest has gained momentum. This increasing interest has also developed through formal and informal marketing endeavours. From this, educational programmes have been developed and facilities constructed to accommodate formal and informal learning on the island. By providing these educational opportunities, funds have been acquired through a small entrance fee which is in turn used for operational activities on the island. Other activities such as waste management support the primary management objectives around water quality, biodiversity, and conservation. These activities serve a practical purpose of recycling and are located in close proximity to the Eco-centre and therefore provide further educational opportunities about recycling of waste. Recommendations have been made to extend learning through increased opportunities for direct observation of operational activities.

4.5 Emergent theme 3: Strategic management - Clearly defined management objectives underpin success

4.5.1 Description and findings

4.5.1.1 Environmental Management Plan (EMP)

The Environmental Management Plan (EMP) of 2019, Addendum 9 covers three spatially and functionally distinct areas at Century City. It also outlines timeframes and designation of responsibility for implementation of actions (BIIEC, 2019) for the areas identified as:

- The 8 ha Seasonal Pan Zone consisting of Cape Sand Fynbos vegetation.
- The 8 ha Constructed Wetlands Zone which includes berms with terrestrial vegetation.
- The Century City canals.
- The detention pond has not specifically been referenced above but is included as part of the SuDS design, management, and operations (BIIEC, 2019).

> *"…part of it was the biodiversity imperative that they tried to recreate this lost habitat, and also it's got the aesthetics they are a really important component, so it's got to add value to the development."* (Respondent 2).

The word cloud in Figure 47 of the 1000 most frequently used words indicates the prominence of the words "management", "environmental", "EMP", "water", "wetlands" and monitoring in this study.

Figure 47: Nvivo word cloud (QDA, 2021).

4.5.1.2 Requirements of the EIA

An Operational Management Plan was a product of the EIA process and was compiled for Intaka Island with the intention that it would be updated regularly (Respondent 2; Respondent 3; Respondent 6).

At Century City the intent is to reduce the carbon footprint and adopt a sustainable approach during the operational and management phases within the greater precinct (CCPOA, 2021). The constructed wetlands are not natural systems but rather mimic natural processes (Respondent 2). They have been built to serve two main functions, namely: a purifying system that filters water in the extensive on-site canal network, and as a natural habitat for wildlife and a place that enhances biodiversity of flora and fauna (CCPOA, 2017; Respondent 3). At Intaka Island, management hinges around the provision of services with a focus on water quality as fundamental to health, which is supported by ecological and social sustainability of the entire system (BIIEC, 2019; Respondent 2). The strategic management goals of this system are outlined in an Environmental Management Plan, not only to focus on water quality, but also with a focus on biodiversity, aesthetics, educational, recreational objectives (Respondent 2;

Respondent 3; Respondent 6). Regulatory documents have been compiled to ensure consistently high standards are achieved as a mechanism that protects the interests of property owners (CCPOA, 2017). The ISO 14001 focuses on environmental performance and is used by organisations to manage their environmental objectives and responsibilities sustainably (ISO, 2022). The standards also emphasise continuous improvement which is facilitated by reviewing and updating monitoring reports (BIIEC, 2009).

> *"…it's all got very different management objectives and design…as it is part of the - the general stormwater management in that area. The components have got very different design objectives."* (Respondent 2).

> *"…it's quite useful to kind of separate what the different areas - what the difference of management objectives are."* (Respondent 2).

> *"So, the ideal that has been set for that system. So, because it's an artificial system …theoretically you can say this is how we want to manage it"* (Respondent 2).

> *"Then when it comes to things like well how many birds are we trying to attract or how - what sort of plant species are we wanting to propagate and what sort of biodiversity we are trying to encourage, then they're not really the standards, it's more like agreed objectives."* (Respondent 3).

> *"When it comes to things like biodiversity and stuff like that…it's more about targets. What sort-of species diversity targets are we aiming for."* (Respondent 3).

4.5.1.3 Purpose of the Environmental Management Plan (EMP)

The Environmental Management Plan (EMP) fulfils one of the requirements of the EIA authorisation. It is intended to ensure that the original design vision is fulfilled and does so by providing a comprehensive set of management objectives, policies, and practices, aimed at balancing the various conflicting objectives (Respondent 2; Respondent 3). The first report containing the site, catchment history, environmental, technical, and legal requirements of the stormwater system was prepared by external specialists for the development company for in 1996 (Vice, 2011; Respondent 3). It was drawn up to meet the conditions of approval for the Site Development Plan. It contains comprehensive guidelines regarding: 1. Stormwater details; 2. Stormwater quality and quantity issues; 3. Control of stormwater outflow; and 4. Mitigation of source pollution (Vice, 2011; Respondent 2, Respondent 6). The EMP is the most significant document as all operational objectives are formally recorded in the EMP and have been refined after the original construction phase EMP (CEMP), which was superseded by the establishment phase EMP and later the operational EMP (OEMP). The OEMP was originally drafted in 2003 (Refer to Addendum 10) and then revised in 2009 (Refer to Addendum 11) and later in 2019 (Refer to Addendum 9 and Figure 48). Each EMP has incorporated previous monitoring data as well as lessons learned (BIIEC, 2019; Respondent 1; Respondent 2; Respondent 3; Respondent 6; Respondent 7). To optimise functioning of this system, the main management objective has been to maintain it as close to a static state as possible, which requires a high level of technical knowledge to inform the management approach and allow the recreation of natural land disturbances through mechanical or other interventions (Respondent 2; Respondent 3; Respondent 6).

> *"We can pull up the EMP. We've got enough water quality targets we're having to achieve."* (Respondent 3).

> *"I think it's a problem with a lot of systems in that they don't identify how much maintenance is needed and a lot of people go in with the idea that a wetland is a free service you know you create a wetland that will just miraculously perform a whole lot of functions and that just by having it, it'll work. So, you've got to you've got to produce a really thorough projection of this is the reality of what you've got to do but once you produce that, it's it can't be a static document because they're because …they do keep changing."* (Respondent 2).

4.5.1.4 Significance of the EMP

The Hierarchy Chart extract from Nvivo 12 in Figure 48 provides an indication of the value and importance of various aspects pertaining to the operations at Intaka Island.

The sizes of the folders that hold information indicate the proportion of reference data stored in these folders. This is important as it conclusively indicates that from the perspective of management of Intaka Island, there are no other aspects in the operations at Intaka Island that are as significant as the EMP and the objectives. Following from these are the stakeholders, namely the CCPOA and other external stakeholders. The third most significant reference was “monitoring” which contain subfolders of “Reports”, “Targets” and monitoring data. The EMP is based on the ISO 14001 standards for environmental management systems and contains consolidated, integrated management goals, objectives, actions, monitoring requirements and targets with a focus on water quality and quantity, the establishment of flora and fauna to enable ecological, hydrological and social sustainability, integration and the promotion of tourism, recreational, educational and research activities which is achieved through continuous improvement (BIIEC, 2019).

Figure 48: Hierarchy Chart (QSR International, 2022).

4.5.1.5 EMP timeline

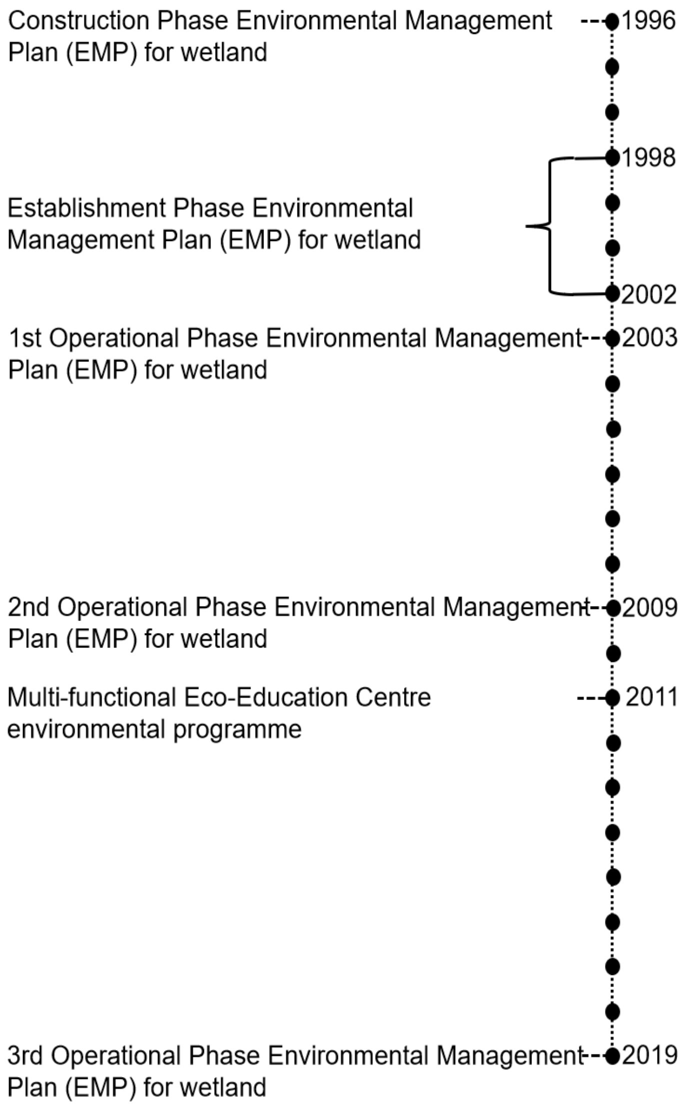


Figure 49: EMP timeline (Spolander, 2021).

4.5.1.6 Management of the EMP

An external monitoring committee, namely the Blouvlei Intaka Island Environmental Management Committee (BIIEC) was established in 1996 to guide the implementation of the EMP and promote co-operation between stakeholders in an integrated and structured manner that ensures optimal maintenance of environmental health through careful management of the water system and associated biodiversity for the benefit of society (Vice, 2011). Their task is to meet with representatives of the Century City Property Owners Association (CCPOA) at regular intervals. The BIIEC membership is composed of representatives from the City of Cape Town, Cape Nature, Friends of the Rietvlei and other specialist consultants (BIIEC, 2019). The BIIEC advise the CCPOA through the delivery of an annual report that outline action items that are intended to influence implementation of the EMP, which is the responsibility of the appointed Environmental Manager and associated operational teams, who are appointed by the CCPOA (CCPOA, 2017; Respondent 1; Respondent 3; Respondent 6). Environmental management activities such as monitoring and reporting have been taking place at Intaka Island since inception of the project and form the backbone of the operational methodology. This type of management shows a very strong focus on technical aspects and technical operational aspects that are managed in an integrated manner to achieve overall project objectives. Management of such systems are intricate, which is evident in the complexity of this artificial system. Management needs to respond and constantly adapt to the natural and man-made systems at hand to achieve the required balance. This is evident in respondent reports about the system and the emergent factors that need to be considered.

> *"The EMP - yes, I mean that's - that's our objective. and that sets the parameters we work to."* (Respondent 1).

> *"…that's what you're going to manage. So, ideally Century City should be in a kind of mesotrophic state which is moderate nutrients - enough that you've got plants that look nice, but not so much that you've got massive algal growth and massive reed growth."* (Respondent 2).

> *"So from a water quality point of view if you're just trying to improve the quality well, you shouldn't have birds…and you also should let the pond weed max out in the canals and manage it as a water quality plant … but you've got to have a compromise …so you don't you don't let the pond weed grow everywhere, but you make sure that there are areas where it's sustainable. So, it's…that kind of sustainable management."* (Respondent 2).

> *"Here the sort of the management…the general rule of thumb is to try and keep the system isolated. The only input of water is from rainfall or from groundwater…- it's a little fragment or an isolated like an island of natural habitat surrounded by development."* (Respondent 4).

Image 28: Aerial view of the Intaka Island in 2009 from the west with wetland cells in the foreground and the ephemeral pans in the background (Armitage, 2011, p. 4).

Intaka Island at Century City has evolved into an advanced SuDS system and is considered to have reached management maturity over time, following all the recorded lessons learned and is therefore an example of success (Vice, 2011). The CCPOA continue to play a leading role in managing this system according to the EMP. In fulfilment of some of the objectives for Intaka Island, a Restoration Plan was compiled by a botanical specialist in consultation with the BIIEC and the CCPOA for the period 2021-2026, specifically focussing on the nature reserve. It identifies a variety of habitat units such as Cape Flats Sand Fynbos, transitional areas, disturbed areas, and semi-saline freshwater habitats that are recognised through specific plant species and interesting and dynamic vegetation types (Respondent 1).

> *"…now that we've got a restoration plan in place that's also made a lot better to try and follow something and do something larger scale."* (Respondent 3).

> *"…if you look at the Restoration Plan, the whole conservation area was mapped out into habitat units." …Most of the plots have different type of objectives because they vary…Some of this the restoration success was - was better than others. So, it does vary from plot to plot as well…So you'll*

see in the Restoration Plan, there are different objectives for each habitat unit as well, with different targets to it as well." (Respondent 6).

4.5.1.7 EMP Goals and objectives

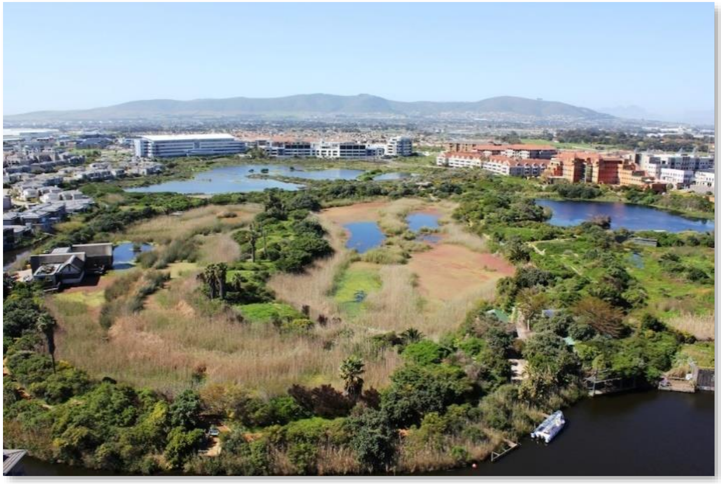


Image 29: Aerial view of the Intaka Island from the west with the wetland cells in the foreground (Cape Bird Club, 2022).

Wetlands are often considered opportunities for conservation and enhancement of biodiversity. However, the goals and objectives for wetlands extend well beyond these imperatives as outlined in the EMP for Intaka Island. A set of environmental goals and objectives were created with associated management actions, activities, targets, timeframes, monitoring requirements and responsibilities (BIIEC, 2019). In 1996, the Construction Environmental Management Plan (CEMP) for the construction phase of the project came into being, which identified and expanded on eight goals for the Blouvlei wetlands (BIIEC, 2003; Respondent 3; Respondent 6). The CEMP involved phasing in of infrastructure, construction, and landscaping, monitored by an Environmental Control Officer (ECO) (Respondent 7). Following the CEMP, an Establishment Environmental Management Plan (EEMP) was drafted in 2002 which laid out the obligations for an environmental audit (BIIEC, 2003; Respondent 3). This contained ten revised over-arching environmental goals that address management during the establishment phase of the wetlands from 1999 (BIIEC, 2019; Respondent 3). Thereafter, the first Operational Environmental Management Plan (OEMP) was compiled once the establishment phase was complete and the work formally handed over to the CCPOA.

An outline of Goal 3 that relates to management of the SuDS indicates a focus on effective management through support and active involvement of all stakeholders.

Goal 3: Provide effective management.

- Support and encourage active involvement and commitment of internal and external stakeholders.
- Make resources available (BIIEC, 2019).

The signage at the entrance to Intaka Island in Figure 50 reinforces and reiterates these goals as a series of six simplistic aims:

Figure 50: Intaka Island signage (Spolander, 2021).

A table is provided with the objectives, risks, actions, monitoring, and targets to achieve this goal and mainly deals with:

- The allocation of resources.
- Regular meetings and monitoring.
- Annual review of the EMP.
- Financial planning of the committee.

Feedback loops form part of the review process, allowing the management to assess the effectiveness of the work being carried out and of the organisation.

"…to see what we're doing right and where we can still improve on our management actions." (Respondent 6).

4.5.1.8 Stormwater objectives

The following objectives relate specifically to stormwater in the precinct:

- Stormwater quality.
- Stormwater quantity.
- Detention capacity.
- Quality of runoff and impact downstream.
- Managing outflows.
- Adhering to local regulations to mitigate property damage and loss of life (Vice, 2011).

The stormwater objectives are strengthened and supported by very specific goals and objectives, as contained in the EMP, namely.

GOAL 1:	***Promote the functioning, sustainability and value of the 16 ha nature area (Intaka Island) and associated canal system within the context of the ongoing planning and development of the Century City.***
GOAL 2:	***Maintain formal conservation status for the 16 ha nature area (Intaka Island) and investigate other potential designations.***
GOAL 2:	***Maintain formal conservation status for the 16 ha nature area (Intaka Island) and investigate other potential designations.***
GOAL 4:	***Sustain the natural hydrological and ecological functioning of the seasonal pans.***
GOAL 5:	***Maintain the water quality in the constructed wetlands and associated canals so that they fulfil the desired ecological and social purposes.***
GOAL 6:	***Re-establish and maintain locally indigenous[1] plants within the 8 ha Seasonal Pan Zone and establish and maintain Western Cape indigenous plants in the Constructed Wetlands Zone.***
GOAL 7:	***Manage the habitats at Intaka Island to support the feeding, roosting and breeding of wild birds.***

GOAL 8:	***Sustain viable populations of locally indigenous amphibians, fish, reptiles and small mammals on Intaka Island, provided that this is compatible with the sustainable ecological functioning of this area.***

GOAL 9:	***Develop and maintain the tourism, recreation and education potential of the 16 ha nature area in a manner compatible with the other goals.***

GOAL 10:	***Create awareness among Century City's tenants, residents, employees and visitors, as well as the general public, of the ecological and social value of the 16 ha nature area***

Overarching goals (Blouvlei Intaka Environmental Management Committee, 2019).

These goals and associated objectives are transferred into action items in the EMP and are monitored and assessed regularly to ensure that the targets are being met. This is clearly laid out in the EMP as follows:

- ***Goals:***

Over-arching environmental goals proposed for the establishment phase of the wetland and canal systems within Century City.

- ***Objectives:***

The objectives in order to meet the goals. These take into account the findings from existing studies and monitoring programmes.

- ***Management actions:***

The actions needed to achieve the objectives, taking into consideration factors such as responsibility, methods, frequency, resources required and prioritisation.

- ***Monitoring:***

The key monitoring actions required to check whether the objectives are being achieved, taking into consideration responsibility, frequency, methods and reporting.

- ***Criteria/targets:***

The criteria or targets that indicate the efficacy of the management programme. The targets should be readily measurable, understandable to the layperson, cost-effective to monitor, and meet legal requirements.

Management Programme (Blouvlei Intaka Environmental Management Committee, 2019, p. 17)

Scheduled monitoring of the planting and revegetation programme is carried out during the Spring and Summer months, in September and December as this is the plant growing season and provided in the annual operational plan in Table 13:

January	February	March	April
▪ Monthly bird monitoring	▪ Monthly bird monitoring ▪ Plants: summer fixed point photography ▪ World Wetlands Day	▪ Monthly bird monitoring ▪ Quarterly water quality monitoring feedback ▪ Annual Fish Survey	▪ Monthly bird monitoring
May	**June**	**July**	**August**
▪ Monthly bird monitoring	▪ Monthly bird monitoring ▪ Quarterly water quality monitoring feedback	▪ Monthly bird monitoring ▪ Present draft Annual Bird Monitoring Report	▪ Annual water Quality report presented ▪ Monthly bird monitoring ▪ Submit final Annual Bird Monitoring Report ▪ Plants: winter fixed point photography ▪ Winter restoration report
September	**October**	**November**	**December**
▪ Monthly bird monitoring ▪ Quarterly water quality monitoring feedback ▪ Annual plant survey conducted in spring ▪ Draft annual Budget	▪ Monthly bird monitoring ▪ Bi-annual survey (twice per year) of herpetofauna conducted (trapping could be done in-house but needs input from outside expert)	▪ Monthly bird monitoring ▪ Present draft Annual Plant Monitoring report ▪ Present findings of Annual survey of herpetofauna	▪ Monthly bird monitoring ▪ Quarterly water quality monitoring feedback ▪ Submit final Annual Plant Monitoring report ▪ Annual audit by BIIEC of the Operations EMP

Table 13: Annual plan of operations for Intaka Island (Blouvlei Intaka Environmental Management Committee, 2019, p. 5).

Goal 6 specifically relates to landscape and provides a typical example of the way the goals and objectives are expanded into objectives, action items, responsibility, targets, and monitoring. In this instance, there is only one objective, which is listed in Table 14, and forms the foundation for developing a set of action items which have very specific monitoring and targets, as evidenced below.

Objectives	Risks	Actions	Monitoring	Criteria/ targets
Seasonal Pan Zone (8 ha) **1) Maintain and improve habitat condition and plant species conservation at Intaka Island.**	1) Ecology affected by changes in drainage. 2) Spread of invasive alien plants (perennials and annuals). 3) Damaging pressure on rare species by herbivores. 4) Dominance of some species to the detriment of overall diversity. 5) Trampling of plants or flower picking by visitors (addressed in Goal 9). 6) Herbicides may kill non-target species. 7) Non-establishment of introduced species, either resulting from inappropriate planting sites for species specific requirements or incorrect management of sites before or after planting e.g. ineffective site preparation or	1) Ongoing removal of undesirable species, especially invasive alien plants as identified in monitoring surveys. 2) Restore basic vegetation structure through seeding of appropriate pioneer shrubs that can establish readily, complemented where necessary by planting. 3) Ongoing planting out of indigenous species sourced locally and propagated in the nursery, with emphasis on red data listed species, species that have not yet been re-established at Intaka Island, or those present in low numbers. 4) Manage the plant community to avoid excessive cover by a minority of dominating indigenous species. 5) If necessary, manage herbivores when/where they cause excessive damage to important plants. 6) Apply fire to remove senescent growth and to promote germination of dormant seeds in the soil taking into account constraints imposed by the urban context). 7) Maintain an on-site herbarium of species present on Intaka Island, for purposes of record and as an identification aid for the	1) Annual plant monitoring surveys are to be carried out in spring with report to be submitted by December of each year. Same report to cover progress at the nursery and within the Educational Garden. Separate brief descriptive surveys are also to be carried out for the other seasons. **Responsibility:** Botanical Specialist appointed by POA & BIIEC. 2) Horticulturist report to be compiled at the end of winter after annual restoration interventions have taken place. **Responsibility:** Restoration technician 3) Monitor overall plant structure and extent of habitats by means of fixed-point photography surveys in summer (February) and winter (August) of each year. **Responsibility:** Environmental Manager	1) Plant monitoring is designed to determine whether pre-development indigenous species on record, in addition to other recommended species, become established on site as viable populations. 2) Plant diversity has been increased and maintained relative to the 2002 benchmark. 3) Maintained stable occurrence of red data listed species, i.e., at very least non declining populations. 4) Vegetation structure and diversity is representative of the three threatened vegetation types being conserved. 5) Prevent terrestrial habitats from becoming dominated by a few species to the detriment of the biological community.

Table 14: Goal 6 (Blouvlei Intaka Environmental Management Committee, 2019, p. 23).

These action items are performed ensure the upholding of the goals and objectives. The following extracts reinforce action items 2,3 and 4 above and provide evidence of a certain level of experimentation.

> *"My approach is to try and establish a vegetation community that's relatively intact at least well in terms of…shrub cover, or we've got limited potential for invasive species to come in. And then also maximum opportunity to establish threatened species…to try and at least have viable populations of all the threatened species that are present in the reserve because at the moment a couple of the species they are literally one plant in the whole reserve and some species have died out completely since the reserve was proclaimed or species that were growing in the surrounding Century City area that they tried to translocate there and that didn't work."* (Respondent 4).

> *"It's a bit daunting sort of whether I'm doing the right thing… putting the right species the right places"* (Respondent 4).

"…in some places you don't know exactly what was there historically, but you still have pretty good data…within the Cape Flats and Peninsula…from whatever fragments are remaining of natural habitat within the urban or cultural matrix. So, I would select based on that, or like within a river system, what's growing higher up in the river system." (Respondent 4).

4.5.1.9 Stormwater Management Plan

The Stormwater Management Plan specified that 15% of the total area was to be used for the purpose of an urban water system with an additional detention facility in Tygerhof and revised outflow at the western Wingfield military base, handling the Century City and Tygerhof stormwater volumes (Vice, 2011). Storage capacity was based on 1:100-year event and runoff and flow balancing have been accommodated at the Tygerhof site (Vice, 2011).

SuDS regional controls:

a. Multipurpose Intaka Island constructed wetland and waterways with four treatment cells which filter stormwater (Vice, 2011).
b. The Tygerhof stormwater detention pond provides temporary storage of additional water volumes (Vice, 2011). It accommodates low flow from Century City and Summer Greens as piped stormwater.
c. The seasonal salt pans, which conserve the Cape Sand fynbos habitat.

The implemented stormwater management system diverges from the original concept, depicted in Image 30, consisting of a combination of conventional drainage and SuDS facilities that have been integrated as a transitional system with complex environmental and technical challenges which are addressed through a compromise in conventional and sustainable operational approaches (Vice, 2011). Surface stormwater from roads is directed from catchpits into the low flow canal network via silt traps. The silt traps arose as a suggestion from management to the developer and were considered a viable option to design and installed as a retrofit to dissipate water flows and trap sediment from surface flows (Vice, 2011; Respondent 3; Respondent 6). Through this, pollutants are captured by means of the first flush in the silt traps

(Vice, 2011). Surface flows and ground water enters the system and water is circulated in the constructed wetland using a system of pumps (Respondent, 2; Respondent 4; Respondent 6). The four wetland treatment cells have been carefully designed to attend to stormwater quality and quantity as well as provide ecological and social benefits and is considered a closed system (BIIEC, 2019; Respondent 2; Respondent 4; Respondent 6). Water flows through the wetland cells as a series of permanently inundated regional pools with shallow reed beds (Respondent 2). The first two cells contain reeds which absorb nutrients such as phosphates and nitrates. The third cell is a large open water body that facilitates aeration of water through surface winds and the fourth cell has been designed to function as a meadow with sedges and grasses that treat and polish the water (Respondent 2; Respondent 3; Respondent 6; Respondent 7). The wetland is surrounded by a perimeter canal as part of the greater canal network which receives the wetland water (BIIEC, 2019). This system acts as a buffer, cleaning the water and pumping it back into the wetland (Respondent 1; Respondent 2; Respondent 3; Respondent 6; Respondent 7). Constant flow of water through the wetland system aids oxygenation of water to support aquatic life (CCPOA, 2021).

The 8-hectare conservation area follows a “hands-off” approach regarding water management. The ephemeral pans do not accommodate stormwater flows as they only receive water through groundwater flows and local precipitation (Respondent 2; Respondent 4). This portion of Intaka Island also contains a small remnant patch of natural wetland habitat north of the constructed wetland, forming part of the seasonal pans, mainly visible during the wet season due to the presence of standing water (Respondent 2; Respondent 4; Respondent 6).

WETLAND EPHEMERAL PANS

Image 30: Map of Intaka Island with superimposed layout (Google Earth, 2021).

KEY

- Flow of water
- Eco centre
- Viewing platform
- Lapa
- Bird hide
- Constructed heronries / breeding platforms
- Dipping pond
- Nursery and operational jetties
- Pump for wetland and canal water
- Extent of wetland and ephemeral pan
- Grysbok trail
- Weaver trail

(Information extracted from Intaka Island signage, 2021).

The original wetland has been transformed into an artificially constructed wetland and therefore the rehabilitated area is not entirely representative of local indigenous vegetation types, but the objective is to revert to back to the original vegetation types, which aligns with recreational and conservation objectives (BIIEC, 2019; Respondent 4). The ephemeral pans, constructed wetland and canal system are interconnected. Then overarching approach to management of this system is one where each area has specific management objectives as outlined in the Environmental Management Plan (EMP) (Respondent 3; Respondent 6). Biodiversity imperatives include enhancement, habitat restoration, conservation, and education (Respondent 4; Respondent 6). This unique environment has required a tailored approach that involves a certain level of experimentation and pioneering in technical and management approaches. A certain level of uncertainty and expectation that some interventions may not have planned or desirable outcomes but form part of the learning approach for ultimate success. Any development on Intaka Island and the canals requires sensitivity to enhance the aesthetics and provide recreational amenity (BIIEC, 2019).

> *"I mean, there's not that much known about how to deal with these ecosystems or restoration is (yeah) really like - um it's a bit of a novel field"* (Respondent 3).

> *"…so yes, I've been using those approaches which haven't really been used before…I mean there hasn't been that much - there is some work being done, but it's sort of very small scale and kind of pioneering."* (Respondent 3).

4.5.1.10 The CCPOA

The Century City Property Owners Association (CCPOA) is a registered non-profit company (Refer to Addendum 12) which carries the responsibility for implementing the EMP and follows recommendations from the Blouvlei Environmental Management Committee (BIIEC) based on monitoring data. Century City functions as a mini-municipality and therefore the service of the CCPOA extends beyond Intaka Island into road reserves and services such as stormwater, sewerage, water, electricity. An Environmental Manager supported by operational teams, undertake maintenance to fulfil the requirements contained in the EMP (BIIEC, 2019). The effort and ongoing commitment from the Century City Property Owners Association is very commendable and has been developed over 25 years (Respondent 1; Respondent 2; Respondent 3; Respondent 6; Respondent 7).

The structure and formation of the Century City Property Owners Association (CCPOA) commenced with the original visionary developer (Respondent 1; Respondent 6). The CCPOA is considered as taking the lead in implementation and management but works closely with the Blouvlei Intaka Environmental Committee (BIIEC) who act as an external regulating body for monitoring and reporting activities which culminate in a set of recommendations (BIIEC, 2019). The CEO of the CCPOA reports to a Board of Directors who consult several sub-committees comprising voluntary representatives from the property owners with knowledge, experience, and expertise in various aspects of infrastructure, management, and finance such as professional quantity surveyors and engineers and work with the CCPOA management (Respondent 3; Respondent 6). This arrangement benefits both property owners and the CCPOA as their contribution ensures a greater level of service in the precinct as they have a vested interest in what happens (Respondent 6).

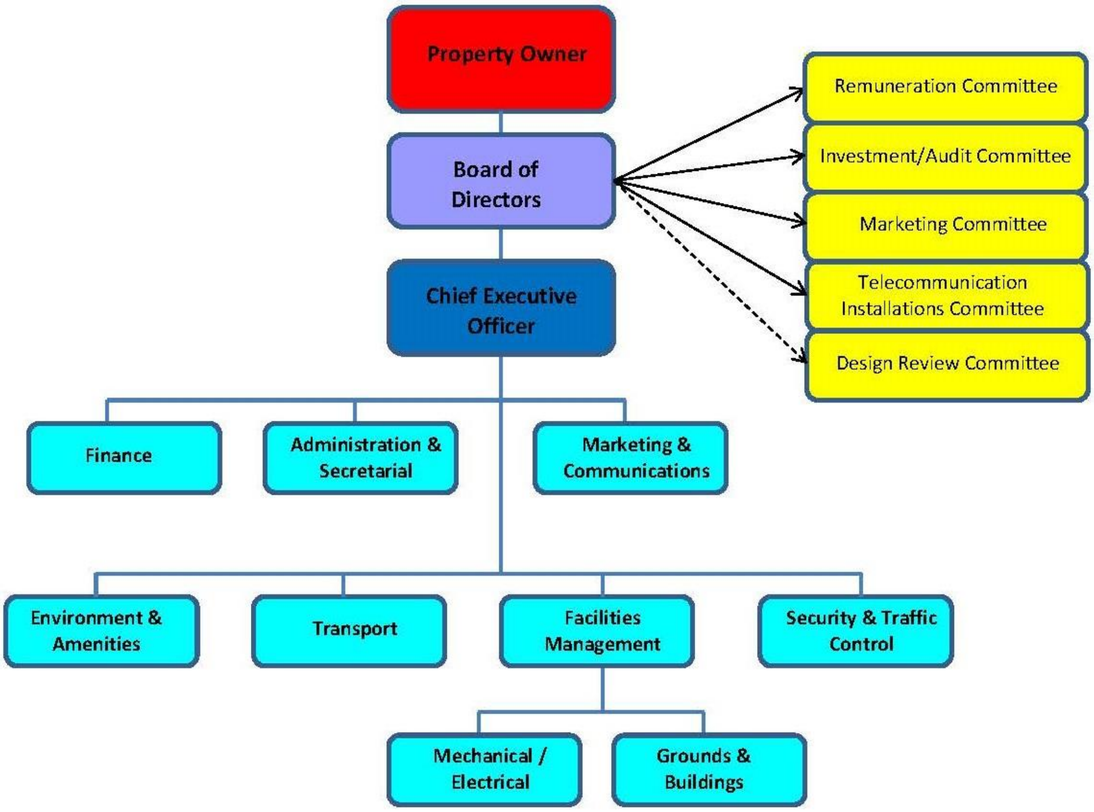


Figure 51: CCPOA structure (CCPOA, 2017, p. 6).

The structure and management of the CCPOA is unique and differs from general managing agents because it acts as an overarching body, overseeing individual Body Corporates and Property Owners Associations within the Century City precinct (Respondent 3; Respondent 6) by providing rules and regulations, guidelines and standards and requiring a certain level of accountability and reporting from these subsidiary bodies. In return, high standards in management and a greater level of commitment and dedication is offered to property owners (Respondent 2; Respondent 3; Respondent 6). The standards achieved by the organisation reflect in the value of the of the development and current property prices, considering that people pay a premium to reside at Century City due to the lifestyle it offers (Respondent 3; Respondent 6).

> "…*good governance – people appreciate the fact that – again they pay for it they pay a premium to be here"* (Respondent 6).

4.5.1.11 The BIIEC

Establishment of the Blouvlei and Intaka Island Environmental Committee (BIIEC) was a requirement of the environmental authorisation and approval process (Respondent 3; Respondent 7). This committee has been tasked with environmental guidance and monitoring as outlined in their Terms of Reference in Figure 52 and it serves as an advisory committee to the CCPOA (Respondent 6; Respondent 7). Monitoring is carried out to ensure that the recommendations made by the committee are implemented effectively (BIIEC, 2019). The committee has held regular meetings since the EMP became enforceable. Several representatives have attended these meetings for over 20 years (Respondent 3; Respondent 6; Respondent 7). This consistency and continuity have contributed to the success of the committee (Respondent 3; Respondent 7). Inputs received from the committee as an external body are crucial "*What's really good here is the financial support…and just listening to what the committee says*". (Respondent 6). Key stakeholders have been represented at the BIIEC meetings through the ongoing operational phase is most notably:

- Local authority
- Nature conservation bodies

- Environmental NGO’s
- Local ratepayers
- CSIR
- Developer
- Appointed specialist consultants

At the July 1996 meeting, the following **Terms of Reference** were proposed for the committee:

- Provide guidance on environmental matters
- Achieve consensus on a workable environmental management plan
- Review design options
- Develop a monitoring programme
- Negotiate controls
- Undertake field observations
- Identify environmental problems timeously
- Create public awareness.

Figure 52: BIIEC Terms of Reference (BIIEC, 2009).

There are a variety of specialists, each of whom who focus on their independent disciplines (Respondent 1; Respondent 2; Respondent 3; Respondent 7). It is vital that the recommendations from specialists are appropriately integrated by management during the decision-making process so that the multiple priorities, which often conflict each other, are attended to in a reasonable and balanced way (Respondent 3). Moderating the biases of independent specialists is important and focussing on meeting the objectives outlined in the EMP to ensure a functional and well-conserved ecosystem reserve (Respondent 6). Specific skills are required to assimilate all the information from these independent disciplines together in an integrated and coherent way that is adequately representative of the data and yet balanced.

4.5.1.12 Adaptive management

Management of this artificially constructed system, which emulates a natural system, is intended to achieve specific objectives through adaptive management so that when a problem arises that was not part of the original design intent, there is sufficient flexibility and resilience to find solutions that will ensure the integrity of the system and fulfilment of the objectives (Respondent 2). The Intaka Island wetland system cannot function as a natural system due to the absence of natural drivers and therefore requires hands on care and a degree of micro-management which has been expressed below:

> *"So, I think what's been really important is adaptive…"* (Respondent 2)

> *"…there are a lot of things that weren't a problem when they designed it, that became a problem and then they adapted their management to that. So, a good example would be the nesting platforms…"* (Respondent 2)

> "…*it's going to be quite - you know - adaptive and responsive to all the monitoring data. So, there's active monitoring. I mean the thing is that because it's a small managed system it's got to be quite hands-on…it needs a lot of extra hands-on management"* (Respondent 3).

> *"I would use the word adaptive, but I suppose that's all part of sustainability - yeah that there's definitely adaptive management that's been applied…and it is within the constraints of a - quite a small area like a 180 hectares with quite high densities of development…within that context it's sustainable up to a point – you know, it requires a lot of management intervention as well."* (Respondent 3).

Conventional approaches to stormwater management are linear and rigid, compartmentalising stormwater and separating it from other hydrological systems. In contrast to this, SUDS is underpinned by an understanding of systems theory and integrates water as part of a comprehensive system of water infrastructure and holistic green infrastructure as depicted in Figure 53. To achieve this level of integration, holistic, innovative, and adaptive approaches are required (Vice, 2011). Most environmental issues build up over time and do not necessarily require instant decision-making, but rather careful and consistent diligent attention (Respondent 3). Therefore, it is advantageous to develop an understanding of environmental complexity within a given context and foster effective communication between stakeholders with the ultimate intention of generating timeous and appropriate decisions that engender change (Vice, 2011).

"*Being in the midst of a growing urban development, the Intaka Island Nature Reserve has to be managed in an adaptive manner. This has required ongoing innovation in managing water quality in the wetlands*" (BIIEC, 2019).

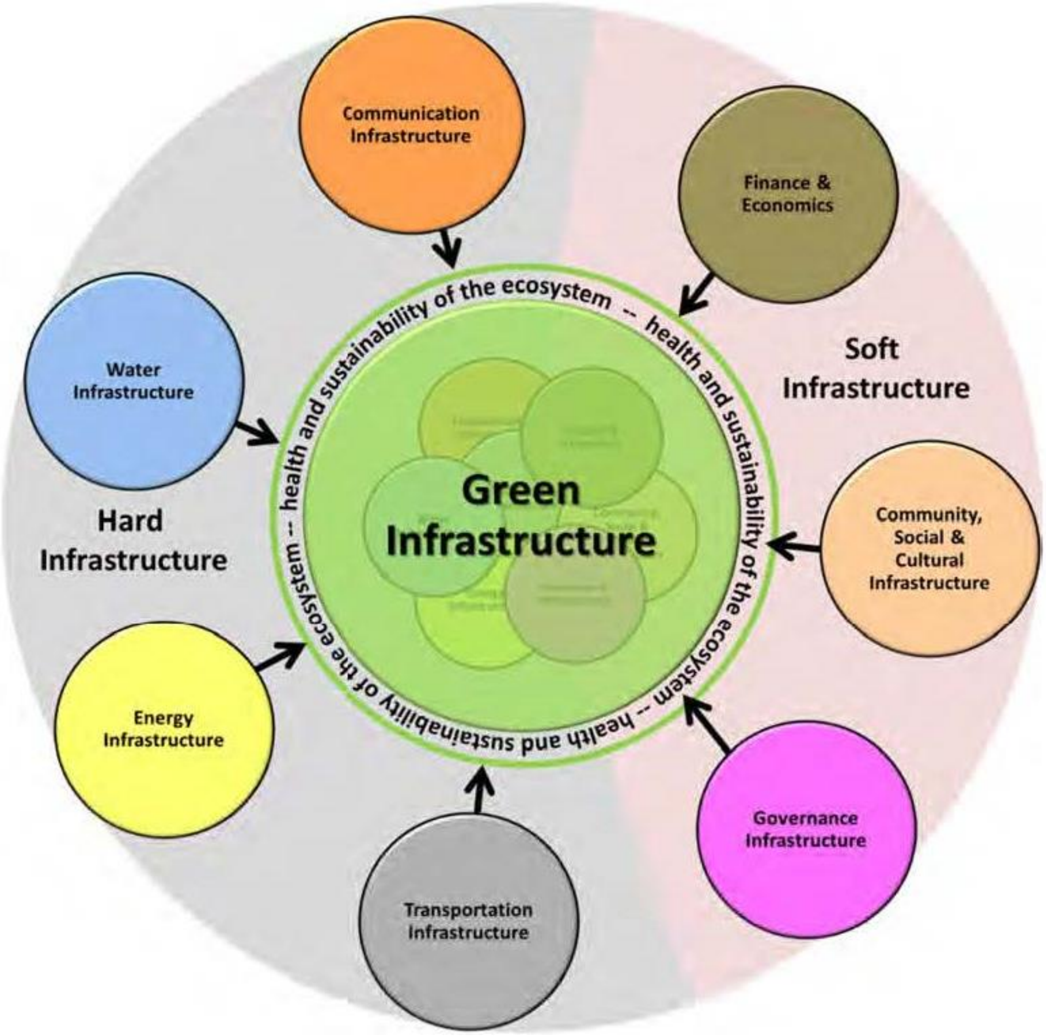


Figure 53: Green infrastructure (Armitage, et al., 2014, p. 21).

Adaptive approaches require frequent and detailed monitoring and reporting to meet conservation objectives (Vice, 2011). Methodological approaches to operations require regular review to align with the objectives in the EMP (Respondent 6). This aspect has been reinforced by respondents during interviews. Therefore, the data corroborates the importance of adaptive management in the face of constant flux and change. Adaptive management is a highly responsive strategy (Respondent 2; Respondent 6). It allows experimentation and circumvention to prevent intermittent system dysfunction (Respondent 1; Respondent 2; Respondent 3; Respondent 4; Respondent 6; Respondent 7). Adaptive management assumes a proactive approach that anticipates likely interventions and makes predictions in the short-, medium- and long-term s (Respondent 2; Respondent 6). An example of this type of responsive approach is evidenced in the departure from using the treated effluent that was originally directed into the system to top up the water in the wetland and canals (Respondent 1; Respondent 2; Respondent 3; Respondent 6; Respondent 7). The alternate response followed the discovery of high concentrations of e-coli and bacteria in the Potsdam Treatment Works effluent line with an excess of nutrients supplying the wetland system, leading to sedimentation, and clogging of the system (Respondent 3; Respondent 6). It requires an active presence on site to regularly monitor and check the data and observe the outcomes so that timeous adjustments may be made (Respondent 3; Respondent 6). Responsiveness may present itself in the form of proactive or reactive action: "*Yeah, look a lot of it is in a way reaction*" (Respondent 7) and *"…we have a discussion, hear different views and then see if we can agree on the way forward which meets some of the objectives which were captured in the EMP."* (Respondent 3). Since no ecosystem is in a consistently optimal state, there may be emergent factors that result in positive or negative impacts on a system that were not anticipated but may become obvious later. Through the process of learning and exposure to new information, new or revised action may be required and taken (Respondent 2; Respondent 6; Respondent 7).

4.5.1.13 Learning and innovation

The conditions at Intaka Island are due to the compromised nature of the ecosystem, which is located within a densely populated urban environment. Learning and experimentation has been prevalent during the incremental type of development that has taken place in the Century City precinct. Development in stages has allowed for lessons learned to inform subsequent development as well as operational approaches (Respondent 7). This is evidenced in the canal system depths, profile and edge treatments which evolved from learning, discussion, and consideration of alternative hard and soft approaches (Respondent 7).

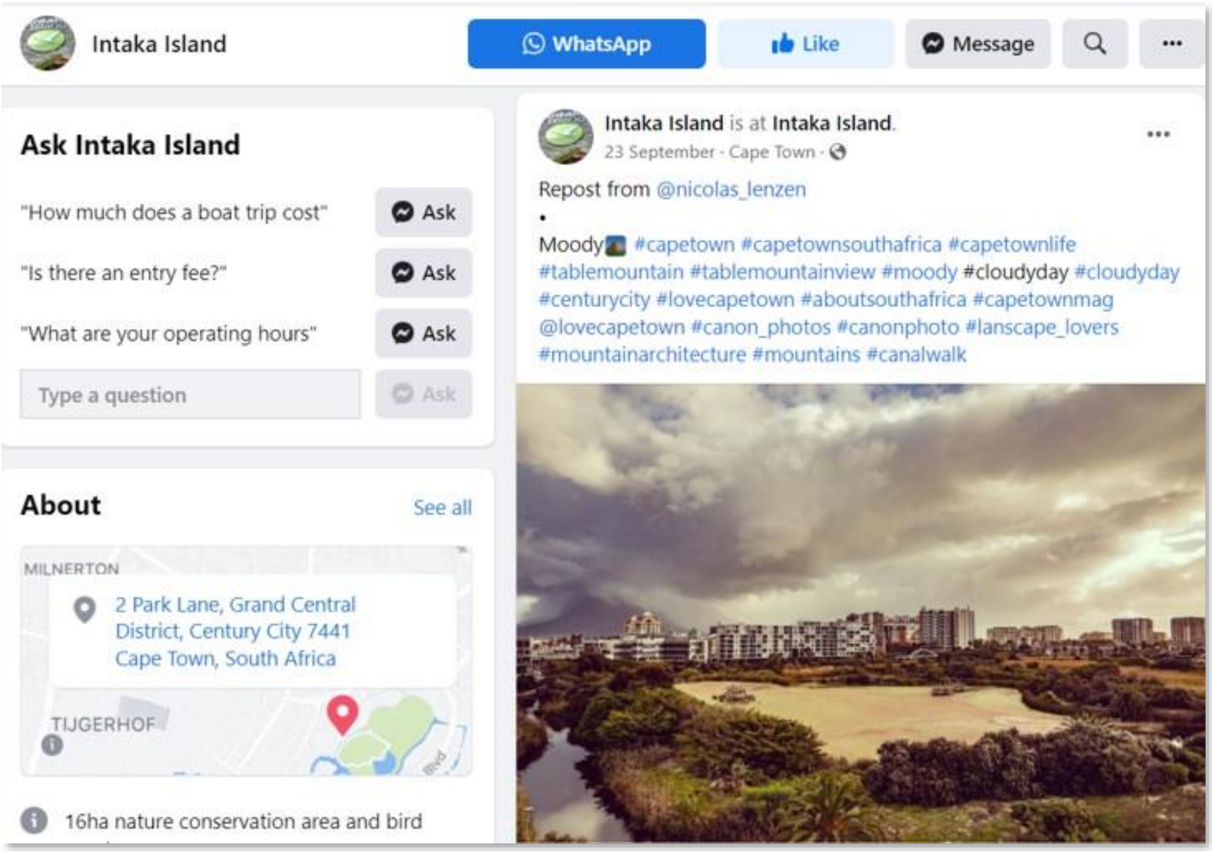
> *"…in our inputs as part of the design, we recommended that soft edges be used as much as possible, so there are parts of the canal which have hard*

concrete edges, but the vast majority of the whole canal system is gabions with rocks packed in the gabions and then we – so the main motivation for soft edges, gabion edges was so that you can have plants growing in amongst the gabions." (Respondent 3).

"…we proposed like a system where you could also have…almost a step where you could have gabions and then… there would be a flooded shelf where you could plant sedges and …little juvenile fish can swim away and hide in amongst the gabions and then not be preyed on by the bigger fish…and then also plants could root themselves in the gabions…it was for environmental reasons to have that rather than a solid concrete edge you know. So, the water seeps through the ground. And so basically the canals are the reflection of the water table." (Respondent 3).

The contextual environment and the acquisition of new knowledge has led to a change in approach over time (Respondent 2). Approaches have had to be innovative, which has also become a valued attribute in the management of Intaka Island (Vice, 2011) (BIIEC, 2019). Innovative approaches significantly challenge and divert from conventional landscape and water quality management protocols, as new concepts and novel ideas have been developed to mimic natural wetland system processes and compliment the natural habitat thereby mitigating development impact. This is most evident in the heronry structures in Image 31 which were constructed to re-attract birds to the precinct (BIIEC, 2019).

Image 31: Constructed heronries in the wetland – cell 3 (CCPOA, 2021).



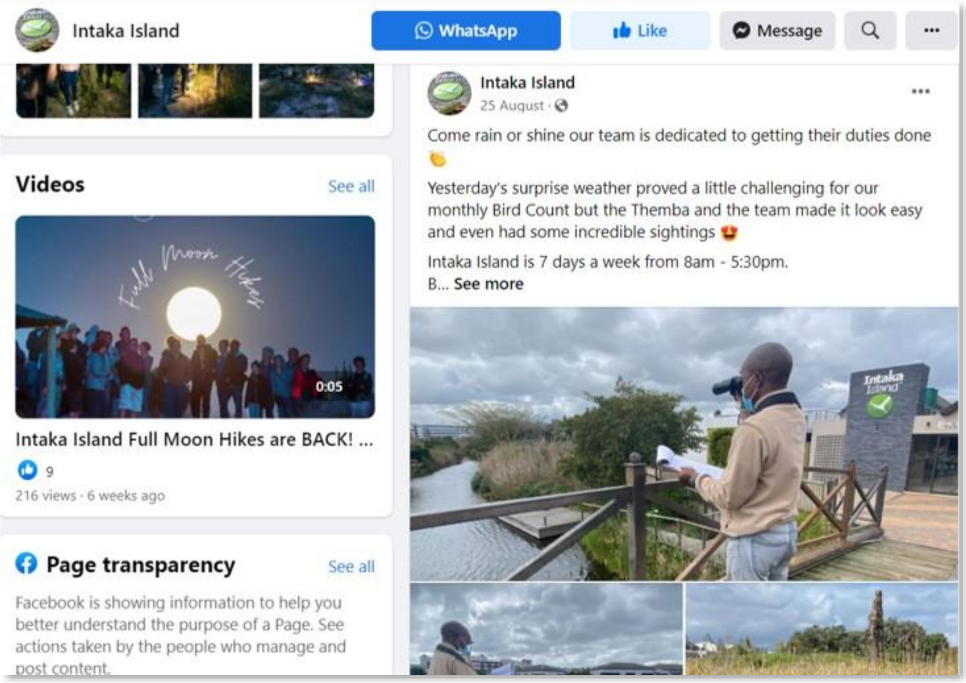
Social media post 11: Constructed heronries at wetland cell 3 (CCPOA, 2021).

Workshops have been held to understand individual and system issues and in-house technical training has been applied as a strategy to address site-specific challenges

(Respondent 6). The updated EMP documents the previous year's monitoring and auditing results in turn is used to refine operating instructions and protocols used by personnel on site (BIIEC, 2019). Operational improvements such as the new Century City app (Refer to Addendum 13) is used for new events, reports, and logging of incidents in the precinct. This reveals a strong emphasis on continuous improvement of this system to enhance environmental performance.

Human capital is considered a strategic focus by the CCPOA. Staff are considered an asset at Intaka Island and the competence of the staff is important as this increases effective and efficient work function and improves productivity (Respondent 1; Respondent 4; Respondent 6). All key first and second tier management positions are filled by qualified and experienced staff members, many who have been with the CCPOA for several years and therefore have acquired in-depth managerial insight and technical knowledge of the system as it has matured (Respondent 1; Respondent 2; Respondent 3; Respondent 4; Respondent 6; Respondent 7). Much of the formal training is mandatory, such as health and safety programmes that are aligned with career paths (Respondent 6).

Several operational staff are employed under internships or follow practical training with limited experience, but Intaka Island provides them with informal learning opportunities (Respondent 4; Respondent 6). A unique opportunity arose on Intaka Island where security guards showed interest in the in the biodiversity of flora and fauna on the reserve (Respondent 1; Respondent 3; Respondent 6; University of Cape Town, 2004) They were trained on bird identification through a sponsorship programme and given the tools which resulted in them carrying out bird monitoring and plant propagation, thereby contributing to one of the best bird data sets in Africa (BIIEC, 2019; Respondent 6). They were then promoted to ranger positions, received training, and became school tour guides on the island (Respondent 1; Respondent 3; Respondent 6). There is an annual training schedule but currently no formal career path process (Respondent 6). This is an aspect that can be considered for review by the management.



Social media post 12: Bird counts by rangers (CCPOA, 2021).

4.5.14 Monitoring and reporting

The first Operational Phase EMP was prepared in June 2003 and was updated after five years to form the second Operational EMP, prepared in May 2009, capturing the learning and monitoring requirements from the previous 5 years. The subsequent 10 years operations encompassed the opening of the multi-functional eco-education centre in early 2011 and the development of a comprehensive environmental education program (BIIEC, 2019). The EMP reflects that stringent monitoring and management of nutrients and oxygen levels among other data is required to meet the outlined objectives which include biodiversity and habitat provision, educational and recreational objectives. Water quality is an important indicator in this ecosystem as it indicates functionality of the wetland cells (Respondent 2; Respondent 3; Respondent 6). This is because the data indicates resilience of the system and management realities (Respondent 2). If water quality fails, the ecosystem changes, the system functions differently, the aesthetics change, all of which impacts on property values and therefore the success of this system hinges around water quality (Respondent 2). Hence, it is in the interests of the CCPOA, to obtain detailed data which is used to inform the management approach. Data monitoring protocols are aligned with the EMP and monitoring is undertaken by the BIIEC with its panel of specialists who perform a variety of tasks that mainly relate to data analysis, monitoring and reporting with associated recommendations that are formalised and presented to the CCPOA who fund the work on Intaka Island.

It is the developer and the CCPOA's responsibility to monitor water quality and ensure that it meets the government standards of water that is discharged into the sea (Respondent 7). Nutrients such as phosphorous and nitrogen are necessary in limited amounts for plant growth and health, although, excessively high amounts of nutrients from inputs such as treated effluent and other discharges into a system alter the functioning of an ecosystem and thereby create management problems such as algal blooms (Liz Day Consulting, 2020). Guidelines have been provided for the four trophic state categories which relate to nutrient levels available for plants: an oligotrophic state refers to low nutrients, mainly phosphorous and nitrogen, whereas eutrophic and hypertrophic states refer to increasingly high nutrient levels (Liz Day Consulting, 2020). The system at Century City is currently in a hypertrophic state due to the historical legacy of effluent inflow from the Potsdam Wastewater Treatment Works as well as other inflows from damages to sewerage pipes. (Respondent 2). A mesotrophic state is considered the ideal, as it reflects moderate nutrient levels which moderate algal and reed growth, but the differences between these states are negligible (Refer to Table 15). Careful monitoring and reporting allows for management of these states.

Note: PO_4-P = orthophosphate phosphorus; TIN=Total inorganic Nitrogen; DO=Dissolved oxygen; N:P= ratio of TIN:PO4P; NH_3-N = nitrogen in un-ionised ammonia; CHL-A= Chlorophyll-*a*. Note also that the terms "PO4-P", "NH3-N" are abbreviations and are not the full chemical notation for these ionic compounds.
See main report for dicussion of the various nutrient "trophic levels" – mesotrophic etc

City Water Quality Categories (CWQC)	Interpretation of CWQC	PO4-P mg/l	TIN	DO mg/l	N:P	NH3-N mg/l	RUNNING MEAN ANNUAL CHL-A µg/l
GOOD	TARGET	≤ 0.005 (oligotrophic)	≤ 0.7	> 6	>25	≤ 0.044	≤ 10
FAIR		>0.005-- 0.015 (mesotrophic)	>0.7 -1			>0.044 - 0.072	>10 -20
POOR	POOR	>0.015 - 0.025 (eutrophic)	>1.0-4.0	≥4 -6	10-25	>0.072-0.1	> 20 - 30
UNACCEPTABLE	UNACCEPTABLE	>0.025 (hypertrophic)	> 4	< 4	<10	>0.1	> 30

Table 15: Rating ranges for water quality variables in city vleis and dams (Liz Day Consulting, 2020, p. 9).

Technical data is collected monthly at specific locations to establish ecological activity and biodiversity dynamics against criteria in the EMP (Vice, 2011). Monitoring includes but is not limited to:

- Weekly and monthly water quality testing at specific locations (BIIEC, 2019,samples of which are sent away to the lab and the results analysed from a chemistry perspective (Respondent 6).
- Nutrient monitoring in the canals is carried out to establish the health of aquatic ecosystems using standard parameters such as phosphates, nitrates, dissolved oxygen, pH and temperature, the concentrations of which can indicate organic pollution levels (Liz Day Consulting, 2020, p. 6). Refer to Addendum 5.
- Sediment monitoring with routine data such as major nutrients, phytoplankton, EC, pH, dissolved oxygen, e coli and turbidity. (Respondent 2).
- Monitoring of the levels of siltation in the wetland cells is carried out (Respondent 6).
- Salt monitoring to establish if dredging is required in the future (Respondent 6).
- Monthly bird monitoring of various bird species which has led to the establishment of a fantastic data set, quite possibly one of the best in Africa (Respondent 2; Respondent 6).
- Aquatic plant species (including algae) monitoring in the canals with harvested volumes of aquatics weeds and reeds (Respondent 6).
- Fish species and population size monitoring is also carried out (BIIEC, 2019; Respondent 6).

Other monitoring:

- Annual visitor monitoring during peak visitor season to determine disturbances and the impacts caused by visitors (BIIEC, 2019).
- Land-bird diversity monitoring demonstrate changes that occur as a result of urbanisation. These are amongst the world’s best demonstrations urban bird mgrationsas they search for habitat islands (BIIEC, 2019).
- Selected species propagation in the nursery and seedbank storage, placement, labelling and planting out which includes observational monitoring of plant

species in general cultivation (BIIEC, 2019).

- Protocols for water quality, bird, fish, plants and fixed point photography (BIIEC, 2019).
- Rainfall statistics (Respondent 6).
- Subjective water quality monitoring of peripheral wetland areas using aerial photos to check for freshwater seepages which impact on the vegetation habitat units (Respondent 6).

6. The rangers often do the sampling and counts and feed the baseline data into the reports (Respondent 1; Respondent 6). There exists a significant amount of informal data capturing by interest groups and the public, which is used by the BIIEC (Respondent 1; Respondent 6) . These are analysed by the respective specialists and accounted for in the monthly, quarterly and annual reports and distributed at committee meetings with specific water bird and plant quality (BIIEC, 2019; Respondent 3). Harvested volumes of aquatic plants are also captured as a mass balance of biomass removed from site and included in the annual reports for the purpose of quantifying nutrients removed from the system (Respondent 3; Respondent 6). Data captured during the monitoring process is recorded on the central filing system and available to all relevant stakeholders who participate in the decision-making processes. (Respondent 6).

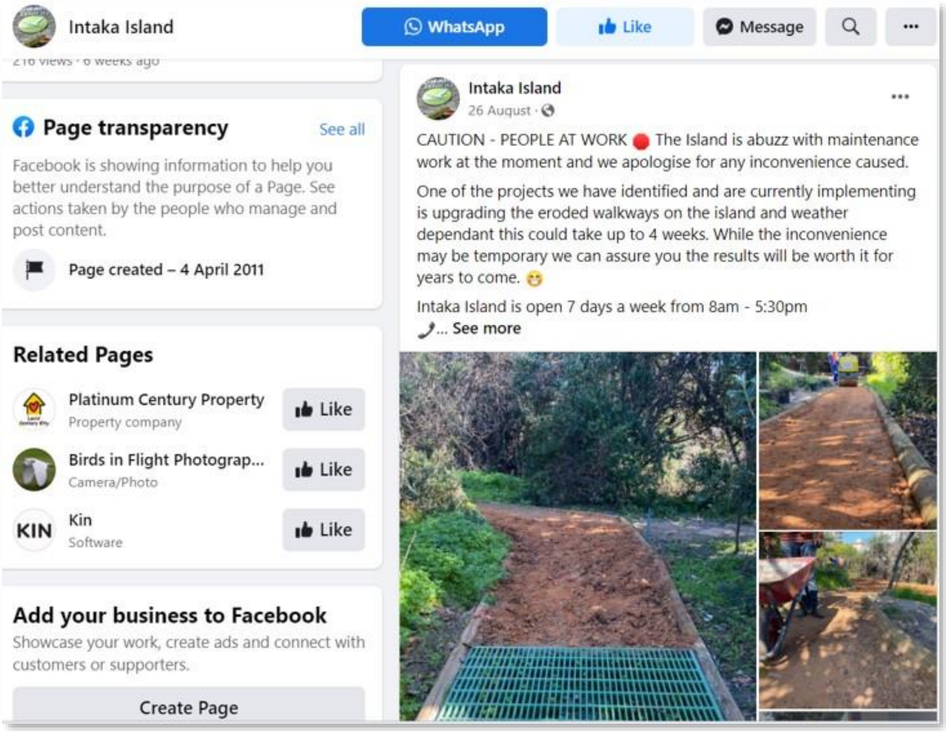
Even though monitoring often only affords retrospective reflection, decision-making and action the benefit of regular monitoring is that trends become evident and therefore the more frequently monitoring is carried out, the more reliable the information is (Respondent 1; Respondent 3, Respondent 6). Generally, there has been a great deal of monitoring over the 20 years of operations on Intaka Island, which has enabled learning about how water quality is managed through wetlands (Respondent 2; Respondent 6; Respondent 7). Less frequent is often accompanied by gaps in the data and less obvious indicators complicating the management thereof (Respondent 1; Respondent 6). Continuous active management of the system is particularly important when damage to the sewerage system results in spills, leaks, and disposal into the canal system (Respondent 3; Respondent 6). These uncommon occurrences typically occur with ad hoc data collection and require more intensive monitoring (Vice, 2011). This supplementary information offers vital water quality data which impacts ecological process, aesthetic appeal and subsequently property values Therefore, the data is used for planning purposes to enable swift decisions around technical interventions (Vice, 2011). Active and adaptive management and monitoring enables continuous review and swift remedial responses to regulate the system. The specialists appointed at Intaka Island provide an integrated set of skills that are combined to collectively produce a holistic management plan that is based on the available data. Continuity of involvement of the appointed specialists, such as the water specialist and the botanical specialist reinforces stability and enables success (Respondent 1; Respondent 2; Respondent 3; Respondent 4; Respondent 6; Respondent 7). Co-operation between operations and management, development and conservation bodies have been crucial to the harmonious collaboration between the CCPOA and BIIEC. This case demonstrates the benefits of co-operation between developers and conservation interests in monitoring, data collection and record-keeping (BIIEC, 2019).

4.5.1.15 The role of stakeholders

A SuDS approach to operations requires recognition of the collaborative work between stakeholders (Armitage, et al., 2014). In this context, there are several internal and external stakeholders who provide formal and informal input on the operations of SuDS, namely:

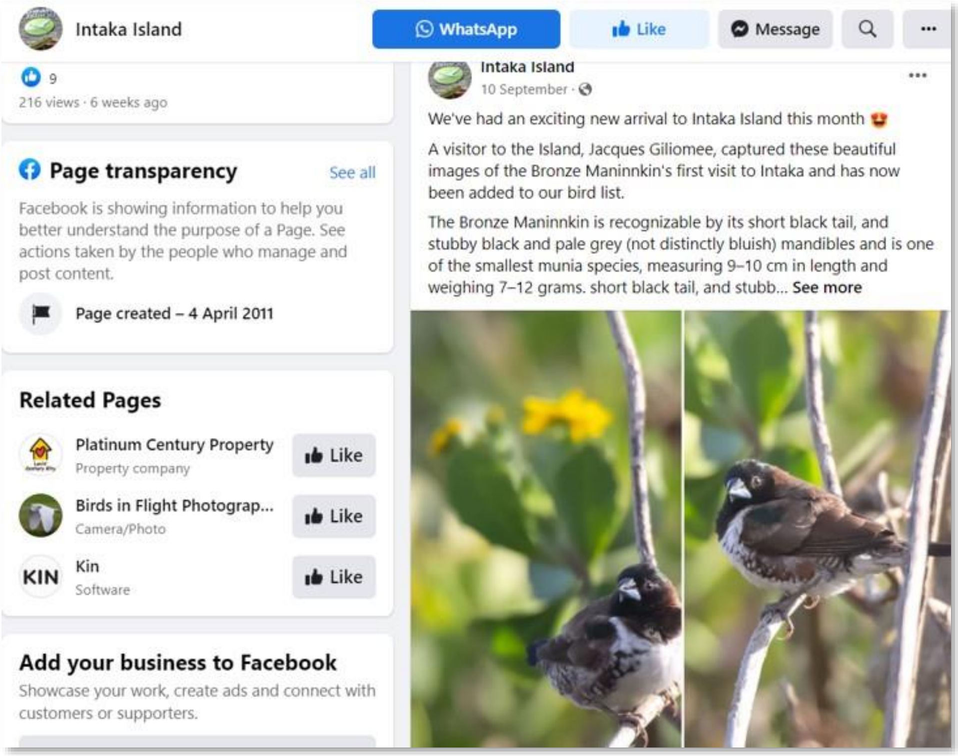
a. Century City Property Owners Association (CCPOA)
b. Blouvlei Intaka Environmental Committee (BIIEC)
c. Property developers
d. Property owners and tenants
e. Recreational and commercial users
f. Interest groups
g. Schools and educational institutions
h. Other

Aside from the formal data collection and monitoring processes, users and the public at Century City provide management with formal and informal feedback on the condition of the island and its associated facilities and amenities, the level of service and issues of concern, for instance Cladophora in the water (BIIEC, 2019; Respondent 2; Respondent 6). Much informal monitoring and reporting is also carried out by birders and nature lovers, which assists the CCPOA and BIIEC (Respondent 1; Respondent 6). For instance, the first spotting of a caracal was done by a member of the public who photographed it. Prior to this, there was no knowledge of its presence, which significantly impacted on the bird life there (Respondent 1; Respondent 4; Respondent 6). Following this discovery, a management decision was taken which required in-depth integration of the different disciplines (Respondent 3). Feedback is given either directly or via social media platforms, which is welcomed by the management (CCPOA, 2021). Social media platforms are an effective communication tool to provide information regarding operational activities and to create awareness (CCPOA, 2021). Social media post 15 is a typical example of wildlife photography by a member of the public who spotted a pair of bronze Mannikin birds, photographed them and they were then added to the Intaka Island bird list (CCPOA, 2021). This type of informal monitoring and reporting assists with bird identification, counts and education. A description of the birds was then provided on the social media platform to educate the public. In this way, the response by the CCPOA and BIIEC regarding feedback from users such as property owners, recreational users, interest groups and schools shows that their input is taken into consideration (CCPOA, 2021). In addition, stakeholders have a level of awareness of the maintenance activities that take place at Intaka Island and provide feedback to management. The management have a very good grasp of the state of the system and act in a responsive manner (Respondent 1; Respondent 2; Respondent 6) and address complaints regarding noise levels or general use of machinery and equipment such as maintenance boats and lawn edge trimmers. For example, residents in apartments have a bird’s eye view of the canals and wetland so when they look down and see undesirable aquatics, they will submit complaints (Respondent 2; Respondent 6). However, there is also a respect and appreciation from these stakeholders that there will be inconveniences associated with this level of maintenance (Respondent 1; Respondent 5; Respondent 6).



Social media post 13: General maintenance (CCPOA, 2021).

Social media post 14: Caracal sighting (CCPOA, 2021).



Social media post 15: Bird photography (CCPOA, 2021).

4.5.2 Discussion and interpretation

The Environmental Management Plan (EMP) is the most critical document in the operations of the SuDS wetland, canals, and detention pond as it provides a consolidated, integrated, and comprehensive set of management requirements which influence operational outcomes (BIIEC, 2019; Respondent 1; Respondent 2; Respondent 3; Respondent 4; Respondent 6; Respondent 7). The document links the original vision of the developer to the objectives for the operations and accounts for the historical successes and failures of approaches in previous years. It has a particular focus on water quality of Intaka Island and the surrounding water bodies (BIIEC, 2019). It identifies the parties mandated to act according to the EMP and sets out the approach as nature reserve-type management. The ten goals contained in the EMP are well-defined. Each goal is tabulated with a set of objectives that sets out the intent and drives the activities on site. Also tabulated are the associated potential risks to not achieving those operational objectives, the actions required to achieve each objective and the target/s or intended achievements (BIIEC, 2009). Each revised EMP document responds to the monitoring and reporting records of its predecessor and is aimed at improved implementation (BIIEC, 2019).

Often with these types of dynamic environmental systems, the level of expertise and maintenance required is underestimated, as decision-makers often regard them as a free service. However, because a system of this nature is dynamic and changing, it requires more detailed monitoring and adaptive management (Respondent 2; Respondent 3; Respondent 6). An operational model of Intaka Island management system has been compiled by the author in Figure 54 to graphically depict how this unique approach has achieved success. In this instance, the BIIEC is a key organisational stakeholder that influences operational outcomes because it serves as an external monitoring and reporting body that was formed to fulfil the requirements laid out in the conditions of approval and the EMP document (BIIEC, 2019). The BIIEC comprises key representatives from the CCPOA and has appointed a diverse range of specialists who understand the system and have set an exemplary standard, showing dedication, commitment, and attendance of regular meetings for over 20 years (CCPOA, 2021; Respondent 3). This broad and in-depth depth historical and operational memory may be drawn upon as a resource. Continuity in membership together with regular and consistent meetings has proven to play a part in the success of the committee. This committee report to the CCPOA who fund and manage ongoing operations at Century City and Intaka Island according to the EMP, and therefore the dynamic interactions between the BIEEC and CCPOA is also considered a key factor that influences outcomes. Communication is reported to be amiable and constructive which results in mutually beneficial outcomes. Together, the CCPOA and BIIEC follow an approach of adaptive management which is highly responsive to any challenges and changes in the system. This approach improves operational outcomes dramatically as there is flexibility and sufficient experience and resources to make well-informed decisions and implement interventions timeously (Respondent 2; Respondent 6).

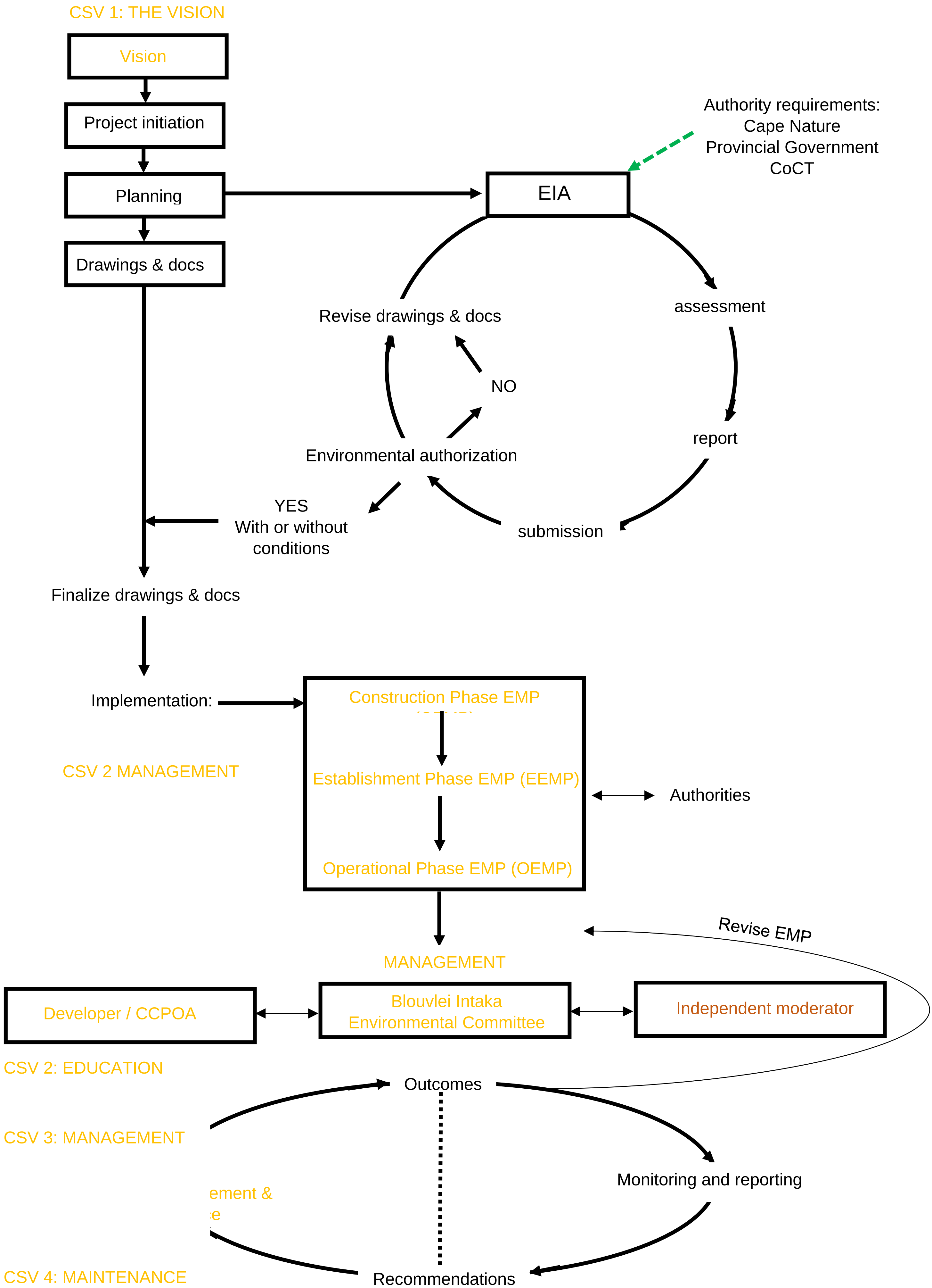


Figure 54:

MODEL OF PROGRESSION INTO THE OPERATIONAL PHASE AT INTAKA ISLAND

4.5.3 Recommendations

Currently individual specialists present their subjective data to be used as motivation on how to manage the system and debate potential solutions to a matter on site. An independent perspective where all the data is assimilated and weighted may be helpful during the final decision-making process. For this reason, there may be an opportunity to create a formal role for an independent organisation with broad environmental knowledge and insights to assimilate and process the various specialist assessments, reports, and recommendations in the process of making a formal final recommendation.

4.5.4 Summary

The Department of Rural Development and Land Reform, 2018 affirms that improvement of human and ecosystem health and integrity may be possible through long term behavioural changes that aim to protect and enhance natural resources and use efficient green technologies that are resilient in the face of stress, strains, and exposure to risk. These behavioural changes may be found in alternative design solutions, management approaches and stakeholder involvement. To effect this change, SuDS practises may be integrated with conventional drainage systems into SuDS “transitional” systems, but this requires intensive interaction and management.

Intaka Island has been managed through an Environmental Management Plan. The EMP is a key document that guides a sustainable vision. This EMP contains clear management goals and objectives, with consideration of the risks, allocation of tasks and responsibilities to achieve the intended targets. Some of the success factors to date have been outlined in the EMP of 2019 as:

- Enthusiasm, organisational knowledge, and ongoing commitment of the BIIEC and CCPOA.
- Active involvement and sufficient resources from the CCPOA.
- Regular monitoring, analysis, and reporting.
- Participation of stakeholders and the broader public.

The integration of engineering, landscape and environmental components at Intaka Island has been vital and contributes to the ongoing success at Intaka Island. This integration takes place at management level between the general operations division and the environmental management division who work closely together to ensure smooth and effective running of the system. The management of Intaka Island reflects a traditional tiered management system with lines of reporting to senior management. Both management divisions are headed up by managers who are qualified and have experience in their respective fields. The CEO and the General Operations Manager have been with the CCPOA almost since its inception and therefore carry an inherent, historical knowledge of the system. Key management positions such as the General Operational Manager and Environmental Manager, work closely together, are qualified and have extensive experience in their respective fields. The CCPOA is represented by the CEO and the Environmental Manager at BIIEC meetings, which ensures that there is a continuous stream of information in the form of monitoring, reporting and feedback between the CCPOA and BIIEC. All management and supervisory staff are qualified in their fields. Operational staff positions may be filled by staff with limited qualifications. Some of the teams have been trained in-house, particularly where there is a legal requirement to do so, such as in health and safety, alien clearing, species identification, herbicide applications and chainsaw operators. These requirements are met through the attendance of short courses by staff. Ongoing research into the operations and performance monitoring of WSUD is necessary to record improvements and long-term outcomes for stormwater and waterway health and to continue building resilience (Wong & Brown, 2009).

4.6 Emergent theme 4: Adaptive management - Organisational capacity and technical expertise facilitates adaptive, responsive, and experimental operations

4.6.1 Discussion and findings

> *"The development of the constructed wetlands at Century City is a world-class example of how development planning and environmental management can work together to achieve a win-win situation*" (BIIEC, 2019).

4.6.1.1 Regulatory and legislative aspects

Legislation is an informant in the management of this system and provides a set of controls. The EIA and EMP are legally enforceable documents and therefore provide additional measures to ensure legal environmental compliance and accountability. In South Africa, an EIA may result in a Record of Decision (ROD) with conditions that need to be fulfilled as part of the process of environmental authorisation. The formation of an Environmental Monitoring Committee was one such requirement for Intaka Island as it facilitates seamless implementation and operations to meet the legislative requirements of the EIA and ensures that the operational goals are achieved (Lochner, 2005; Respondent 2, Respondent 3, Respondent 6, Respondent 7).

Goals 5, 6 and 7 in the EMP pertain to landscape operations. These goals trace historical management approaches and provide tabulated objectives with associated risks, actions, monitoring, and targets. The original objective of the Intaka Island wetland was to purify and polish stormwater. The historical accumulation of nutrients which had been fed through the Potsdam treated effluent line, together with nutrient loads from the avifauna in the wetland resulted in an unacceptably high level of nutrients. These high levels became unmanageable for a wetland the size of Intaka Island and required reconsideration of the stormwater objectives around water quality. A set of revised objectives was developed which responded to the data, expressing the intention for the wetland to be self-cleaning rather than adding to nutrient loads in the canals. In addition, the water quality in the wetland and canals is to be maintained according to the Department of Water Affairs and Forestry (DWAF) standards. To increase the probability of the revised objectives being met, a responsive management decision was taken to terminate the treated effluent water supply line due to its high nutrient load and the nutrient rich guano tanks below the constructed heronries were isolated from the wetland system.

> *"…the original design of Century City had Intaka wetland areas designed as water quality treatment cells and the idea was…they would treat water ...That whole system that that was sort of turned on its head over the time that I've been there and actually those cells are now much more valued for their biodiversity." (*Respondent 2).

Goal 5: Maintain water quality for ecological and social functioning.

- Strictly control public access.
- Carry out rehabilitation programmes.
- Ensure optimal operations and functioning of the system.

Goal 6: Re-establish and maintain locally indigenous and endemic plants.

- Establish locally indigenous flora in the wetland to meet conservation criteria.
- Propagate plants at a nursery on site nursery using local stocks for educational purposes.

Goal 7: Manage habitats.

- Allow interventions in the wetlands.
- Introduce novel approaches to attract wildlife and stabilise the ecosystem.

` (BIIEC, 2019).

4.6.1.2 Scope of maintenance

> *"In a natural system, certain natural drivers are present that regulate the system and hold it in equilibrium such as fire, animal movement patterns and flooding. In contrast, this artificial system mimics a natural system and is intended to remain close to its original design condition for optimal functioning. Therefore, interventions are imperative as they act as artificial drivers."* (Respondent 2).

Within the Century City precinct, Intaka Island, the canal system and detention pond are maintained by the CCPOA (Respondent 3, Respondent 6). Two of the residential complexes pay the Intaka Island management to maintain their independent section of canals and other sections of the canal are maintained to ensure this water meets the CCPOA water quality standards. There are a few small water bodies that are not maintained by the CCPOA, but water quality testing is carried out to ensure that they meet the required standards (Respondent 2, Respondent 6). The standard of management is highly dependent and influenced by monitoring data and this is a key focus as an indicator of particular conditions (Respondent 2). Success is therefore proportionate to the level of monitoring and reporting (Respondent 1; Respondent 4, Respondent 6). If the water quality fails, the ecosystem changes and this impacts on the aesthetics which impacts property values and recreational value and therefore water quality monitoring and data reporting is vital to the ongoing success of this system.

> They have *"an intensive water quality monitoring program and I think that is one of the successes is that at all times they know what - what their water quality trajectory is, and it means they can pick up problems."* (Respondent 2).

> *"There is pretty detailed reporting right from the beginning…all the annual reports are documented, or like recorded…so there is some record of like - going back quite far"* (Respondent 4).

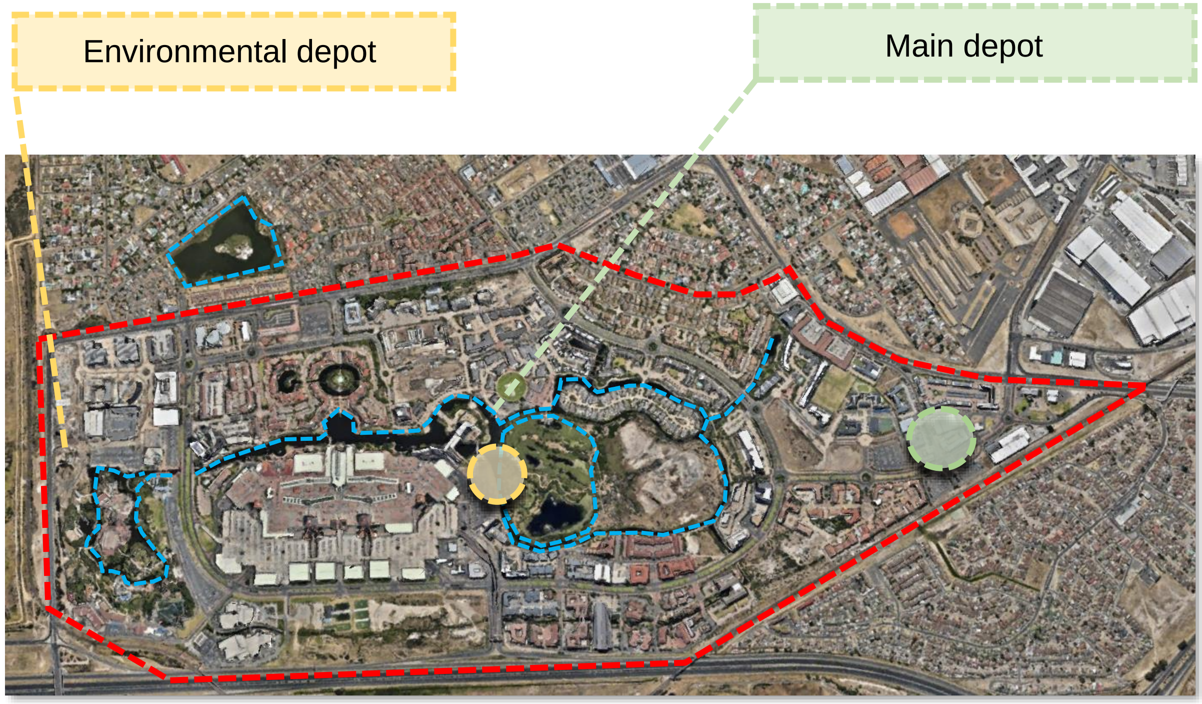
SUDS operations are facilitated by the CCPOA through three activity types, all of which are routinely monitored, recorded and reported on.

a. An annual routine maintenance programme as outlined in Table 16.
b. Response team maintenance
c. Ad hoc management and maintenance (Vice, 2011).

January ▪ Monthly bird monitoring	**February** ▪ Monthly bird monitoring ▪ Plants: summer fixed point photography ▪ World Wetlands Day	**March** ▪ Monthly bird monitoring ▪ Quarterly water quality monitoring feedback ▪ Annual Fish Survey	**April** ▪ Monthly bird monitoring
May ▪ Monthly bird monitoring	**June** ▪ Monthly bird monitoring ▪ Quarterly water quality monitoring feedback	**July** ▪ Monthly bird monitoring ▪ Present draft Annual Bird Monitoring Report	**August** ▪ Annual water Quality report presented ▪ Monthly bird monitoring ▪ Submit final Annual Bird Monitoring Report ▪ Plants: winter fixed point photography ▪ Winter restoration report
September ▪ Monthly bird monitoring ▪ Quarterly water quality monitoring feedback ▪ Annual plant survey conducted in spring ▪ Draft annual Budget	**October** ▪ Monthly bird monitoring ▪ Bi-annual survey (twice per year) of herpetofauna conducted (trapping could be done in-house but needs input from outside expert)	**November** ▪ Monthly bird monitoring ▪ Present draft Annual Plant Monitoring report ▪ Present findings of Annual survey of herpetofauna	**December** ▪ Monthly bird monitoring ▪ Quarterly water quality monitoring feedback ▪ Submit final Annual Plant Monitoring report ▪ Annual audit by BIIEC of the Operations EMP

Table 16: Annual operational plan (BIIEC, 2019).

4.6.1.3 Operations centre and depots



Main depot for the Century City precinct
Extent of the Century City precinct maintenance zone
Secondary depot for Intaka island
Extent of wetland, canal & detention pond maintenance

Image 32: Intaka Island depot (Google Earth, 2021).

The Central Operations Centre deals with incidents: injuries, vehicle incidents, faults, repairs, requests, and complaints are logged, and the precinct has dedicated emergency vehicles for such incidents (Respondent 6). The planting and maintenance work is carried out primarily from the Eco-Centre and the bolt jetty which also function as the environmental depot, as these facilities are centrally located in the precinct for easy access to the wetlands and canal system as indicated in Image 32 and 33 and 52 (Respondent 6). They also accommodate a plant nursery, which was established on site with the purpose of providing propagated plant material for the nature reserve and supplementary plant material for the greater precinct. Indigenous plants are specifically propagated for the nature reserve and a plant list has been compiled, which is regularly assessed and revised (BIIEC, 2019, Respondent 1; Respondent 4; Respondent 5; Respondent 6).

Image 33: Intaka Island depot (Google Earth, 2021).

Image 34: Intaka Island depot (Google Earth, 2021).

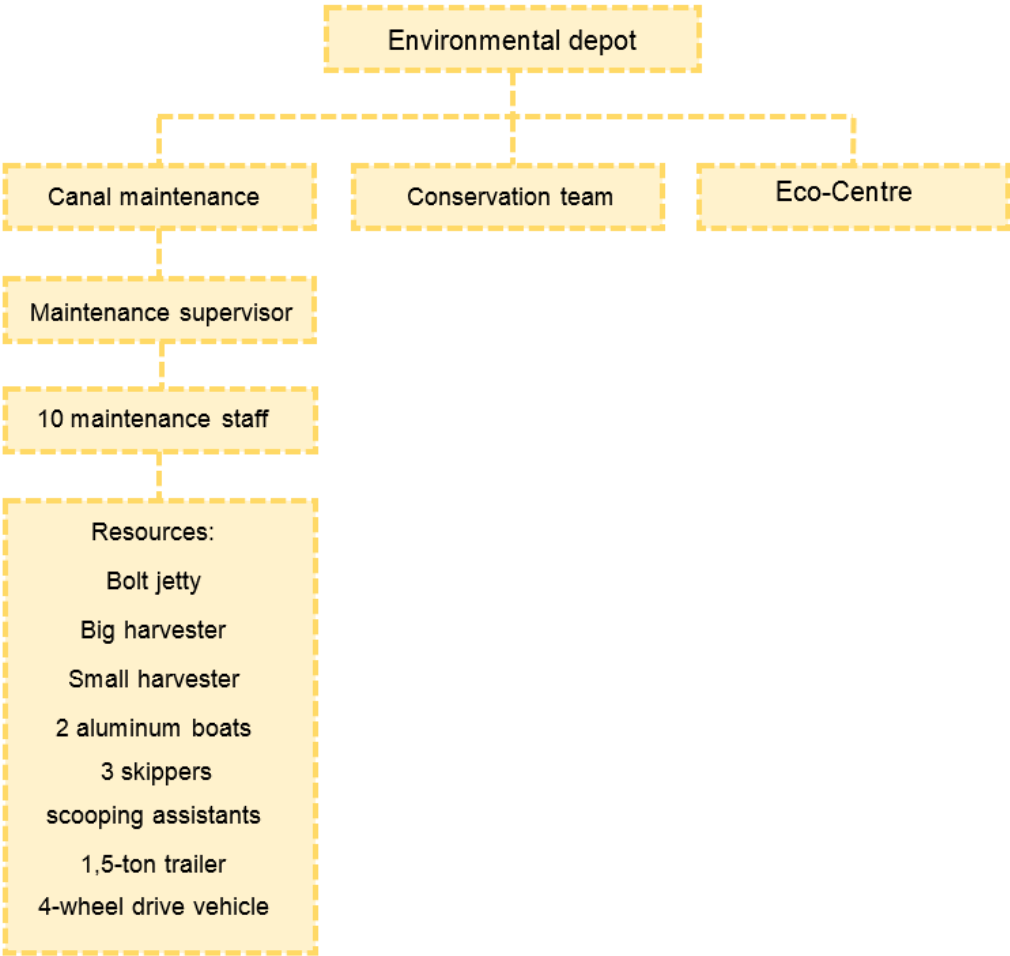


Figure 54: Authors interpretation of the composition of the secondary depot based on feedback from Respondent 6.

4.6.1.4 Operational teams

The Century City operational unit consists of several divisions, accommodated at the primary maintenance depot for the Century City precinct and the secondary environmental depot for Intaka Island, the latter of which concerns this case study. The CCPOA employ an Environmental Manager whose teams undertake the maintenance of the wetlands in accordance with the approved Century City Environmental Management Plan (BIIEC, 2019).

4.6.1.5 Major and minor operations

Respondent reported on problems that arise on projects when decision makers do not recognise and make provision for the level of operations required (Respondent 1, Respondent 2). In contrast to this, the CCPOA have ensured that there is adequate funding for all operations (Respondent 1; Respondent 2, Respondent 3; Respondent

6). They anticipate major and minor operational costs from the levy and donations which are used for security, landscaping, cleaning, maintenance, environmental aspects, transport, and administrative services and to develop and maintain the tourism, recreation, and education potential of Intaka Island. The CCPOA also has a long-term 50-year operations plan for bulk infrastructure which includes the 7-kilometre length of canal edges. All bulk infrastructure has been audited and projections have been prepared in a detailed long-term operational plan which contains anticipated dates for major interventions based on the expected lifespans of the various infrastructure components. These large-scale interventions are not funded from the general operational budget as the extent and timing of their failure is relatively unpredictable. For this reason, a reserve fund can be liquidated at any point for major infrastructure spend (Respondent 6).

4.6.1.6 Vegetation maintenance

a) Alien clearing

A restoration programme for the reintroduction of endemic and native plant species has been prescribed (Blouvlei Intaka Environmental Management Committee, 2019; CCPOA, Intaka Island About & History, 2021). Conservation area management forms part of the maintenance programme which prioritises alien invasive control using biocontrol measures, such as galls on the *Acacia saligna* and weevil on *Azolla filiculoides*, while the *Acacia cyclops*, *Parkia speciosa* and *Paraserianthes lophantha* have limited biocontrol measures due to low plant counts. *Schinus terebinthifolia* is a problem in the entire precinct as they reseed and resprout even though a preventative approach is followed to limit the invasion of these species in the wetland (Respondent 4, Respondent 6, Respondent 7).

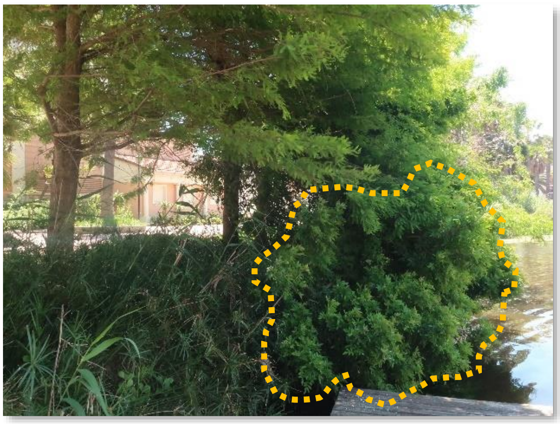
 

Image 35 & 36: *Schinus terebinthifolia* sprouting along the soft edges of the grand canal, Century City (Spolander, 2021).

b) Terrestrial plant maintenance

Intaka Island is managed as a 16-hectare nature reserve which is considered relatively small, and it is not managed as a manicured site (Respondent 4; Respondent Respondent 6; Respondent 7). It is managed as a self-contained and relatively isolated system as far as stormwater is concerned, with the only movement of water being from rainfall and groundwater seepage *(*Respondent 3; Respondent 4; Respondent 6)*.* Much of the terrestrial vegetation consists of a variety of indigenous species beyond the Cape Flats Sand Fynbos vegetation palette and includes species on the Species List 2009 (See Addendum 14), the Intaka Island Plant Species List (Addendum 15) and Plants Adapted for Life in the Western Cape (Addendum 8). Biodegradable products are used to suppress weed growth and no products that are detrimental to the environment are used. Only yellow label selective herbicides are used as these are water based and environmentally friendly (BIIEC, 2019; Respondent 6). Because a large portion of this system is Cape Sand Fynbos vegetation within a conservation area, there is a requirement to manage the vegetation based on science. Fire is natures mechanism of burning vegetation to release seeds, reproduce and regenerate. At Intaka Island, this natural process is mimicked to maintain the viability of the vegetation but due to the potential risks in this urban context, numerous stakeholders such as property owners are consulted, which requires long lead times (Respondent 1, Respondent 3).

c) Wetland vegetation

Plant vegetation providing habitat for biota and aquatic plants require larger expanses of shallow waters, typical of a wetland profile. Plant selection and landscaping are critical to the success of SuDS (Vice, 2011). Plants serve an important function as they absorb, transpire, filter, and volatilise stormwater, thereby purifying it (Vice, 2011; Respondent 3; Respondent 6). There is a strong connection between water quality, plant growth and vegetation enrichment cycles in the wetland (Respondent 2; Respondent 6). The pioneering work of vegetation, species selection and management has proven successful and effective (Respondent 4; Respondent 6; Vice, 2011). Generally, indigenous species are found to be more resilient and therefore able to treat stormwater all year, adding biodiversity and biomass (Vice, 2011). However, biodiversity in the wetland consists of exotic and indigenous plant species which provide habitat and change as the vegetation matures, impacting on bird movement patterns (Respondent 6).

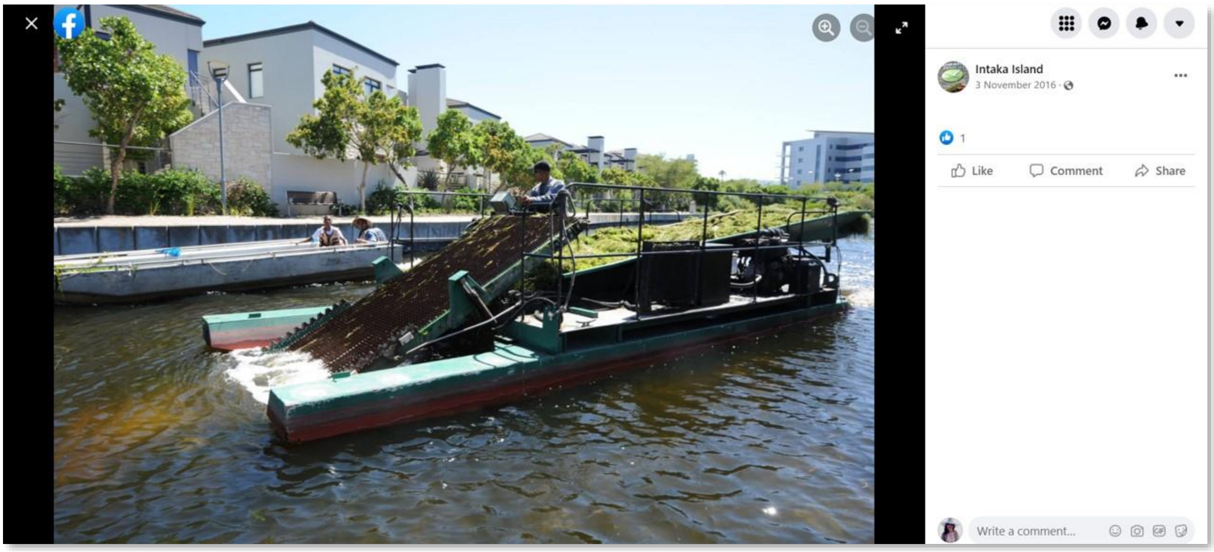
d) Macrophyte maintenance

Several useful restrictive operational, monitoring and maintenance approaches have proven effective, but SUDS may be considered maintenance intensive (Respondent 6; Vice, 2011). Macrophytes such as reeds require regular cutting and removal and the rate of reed growth is phenomenal as they serve the function of nutrient uptake. A biodegradable herbicide is used to subdue growth; however, this is not always effective as the rhizomes tend to reshoot in other locations (Respondent 6, Respondent 7). When plant matter reaches absorption capacity, excess nutrients are deposited in the wetland during the process of sedimentation, which potentially leads to damming and raised water levels which disrupts the system (Respondent 3, Respondent 6). For this reason, regular removal of reed biomass is carried out manually due to limitations in access to the wetland cells (Respondent 6). The reed biomass must be removed from site expediently when harvested, due to the high concentrations of nutrients that are taken up in the plants. This process is facilitated through an agreement with a composting company, who collect the harvested reeds by removing the biomass off site and using it in the manufacture of compost at a cost to the CCPOA (Respondent 3, Respondent 6).

Image 37: Floating jetty with nets and poles (Spolander, 2021).
Web page 6: sickle bar reed cutter on the harvester (CCPOA, 2021).

e) Aquatic weed maintenance

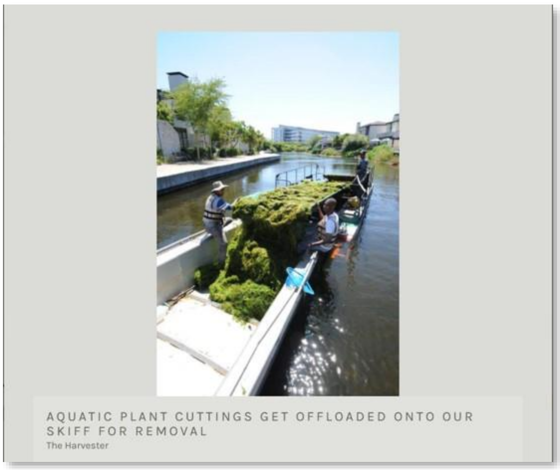
Various methods have been used to collect and harvest aquatic weed, including an imported weed harvester which has proven to be a large capital investment upfront but cost effective with a view of the long term operational lifecycle. After harvesting, the aquatic material is offloaded onto a skiff for removal by a truck and trailer. Other methods include utilising the three aluminium skiffs for the purpose of scooping the weed or using drag nets (Respondent 6). Prior to collection, biocontrol is applied to *Azolla filiculoides*, an algal weed, turning it red (Respondent 6). Property owners are aware of this process and if the algal weed or Cladophera sp. is sometimes visible on the surface of the water for extended periods of time, which can result in feedback or complaints (Respondent 2; Respondent 6; Respondent 7). *Potamogeton pectinatus* is an aquatic weed and *Ceratophyllum demersum* is a macrophyte that contributes to phosphorous uptake which is beneficial for the system, but their growth tends to restrict recreational use of the water bodies as well as impacting the aesthetics negatively and is therefore controlled canals (BIIEC, 2019; Respondent 2, Respondent 6, Respondent 7).



Social media post 16: Aquatic weed harvester (CCPOA, 2021).

Image 38 & 39: Catch nets and buoys (Spolander, 2021).

Image 40 & 41: Bolt jetty maintenance access with 3 aluminium skiffs for scooping aquatic weeds (Spolander, 2021).



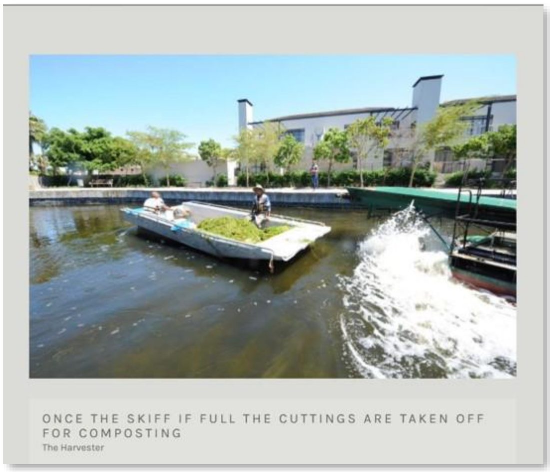
Web page 7 & 8: Aquatic weed harvester (CCPOA, 2021).

f) Terrestrial plant maintenance and screening

The aesthetics of the wetland and detention ponds have been improved by introducing appropriate vegetation (Respondent 2; Respondent 5; Vice, 2011) which requires ongoing annual pruning, weed control and management of plant succession to ensure longevity. Dominant plants are monitored and managed to prevent colonisation by certain species and to maintain an ecological balance (Respondent 4, Respondent 6).

g) Tools and equipment

The big harvester at Intaka Island has a conveyor belt system which offloads the water weed from the canals onto the trailer and transports the biomass to the in-house tip site after which it is collected by a composting company. The collected biomass from the small harvester is placed in a skip which is offloaded onto the trailer by the 10-maintenance staff who also carry out detention pond maintenance (Respondent 3; Respondent 6). The harvested vegetation may only be placed on the ground for a limited period before collection, to prevent in-situ decomposition and to and avoid the absorbed pollutants such as phosphorous, which is now stored in the plant material, leaching out into back into the ground and ground water table (Respondent 6).



Web page 4 and 5: Harvester (CCPOA, 2021).

4.6.1.7 Hard infrastructure maintenance

a) Maintenance of pathways

A vehicular maintenance track provides access for staff and servicing vehicles adjacent to the multifunctional educational and recreational laterite pathways. The service route is connected to the laterite pathways in various locations, sometimes visible and other times more discrete. Some of these links have been formalised while others appear as random and are evident as informal penetrations through the bush and shrub vegetation (Spolander, 2021).


Image 42 & 43: Interconnected educational pathway network with parallel maintenance jeep track.
Left – informal access point. Right – formal access point (Spolander, 2021).

b) Maintenance of gabions

The Century City canals were designed with a combination of soft vegetated and hard gabions or concrete edges. Gabions are the predominant edge type as they meet several design and maintenance criteria:

- Gabions allow a level of accessibility for pedestrians to the water's edge with safety mechanisms in place which improves amenity and recreational use.
- Gabions facilitate ground water movement.
- Gabions accommodate ground movements (Respondent 6).

The gabions at Century City fall under the long-term monitoring and management protocol. Failure of the gabion structures is reported to generally take place within the first 5 years after installation, but day-to-day public safety is crucial and therefore risks such as the escape of soil through the geofabric or bidim cloth gabion liners needs to be adequately managed, since this type of disintegration may result in collapse of paving and hard edges which may put safety and life at risk (Respondent 6).

The gabions are often positioned subsurface in the canals and are not visible for inspection (Respondent 6; Respondent 7). In the past, the CCPOA and developer have built relationships and worked together to adequately deal with this type of potential liability and the contractor has also been involved to resolve these types of issues. A monetary reserve is available for major failure such as that associated with the gabions. To avert such a situation, when the canal system was drained on two previous occasions, inspection, and accurate recording of the condition of the gabions was carried out (Respondent 6). The general approach, as advised in specialist reports, is to limit sewer leaks or attend to them timeously (Respondent 2; Respondent 3; Respondent 6; BIIEC, 2019).

Image 44 & 45: Gabions along the Grand Canal (Spolander, 2021).

c) Maintenance of the clay liner

Special interventions such as dredging may need to be undertaken to protect the clay lining at the base of the wetland which acts as an impenetrable water barrier that lines the base profile of the wetland. There is also concern that mechanical action caused by roots of macrophytes can lead to damage of the clay liner and ultimately cause leaking of water from the wetland into subsurface soil layers. *Phragmites sp*. and to a lesser extent, *Typha capensis* have the potential to damage the clay liner which is costly and onerous to reinstate (Respondent 6). Therefore, unlike conventional systems, vegetated systems require frequent maintenance to function optimally (Respondent 3; Respondent 6; Vice, 2011). Proactive and frequent maintenance is more likely to reduce the requirement for interventions such as dredging (Respondent 3, Respondent 6).

d) Remedial interventions

Natural systems have natural drivers that regulate them and result in changes to the system state over time. Intaka Island emulates a system of perennial pools that would follow the natural process of infilling with organic material over time, transitioning into a terrestrial system. Because the natural drivers are absent in this type of artificial system, mechanical interventions are required to perform the function of natural processes. This is typical of urban systems where a specific datum is established and requires artificial maintenance to ensure it remains in that state (Respondent 2).

“If you want them to function as whatever templates they've been designed around they still need management to achieve that.” (Respondent 2).

Interventions are considered an adaptive management strategy. The references below support tis:

“I mean the management has to be adaptive.” (Respondent 3).

“…you've got to have an adaptive management system. You have to keep like experimenting and trying new things and responding and there's always things breaking or going wrong so far in terms of the actual urban water quality management of the urban water system and stormwater system” (Respondent 3).

“those management plans adapt as you learn and as the system changes.” (Respondent 2).

”…certainly as a system is operated in a very different way and the design has changed quite fundamentally since it was first set in place, so again the management adapting so the management moving away from using effluent as a major adaptive strategy.” (Respondent 2).

“…it's going to be quite…adaptive and responsive to all the monitoring data. So, there's active monitoring.” (Respondent 3).

“I think it's like sustainable and I would use the word adaptive.” (Respondent 3).

The wetland was originally constructed to serve many roles such as water quality improvement, biodiversity enhancement, passive, and active recreation and educational amenity. Since natural drivers do not exist, this artificial wetland requires interventions that emulate those natural drivers. Therefore, for it to function and meet the objectives in the EMP, it needs to be maintained within stipulated tolerances and as close to a predetermined state which is based on the original datum or design condition (Respondent 2; Respondent 3, Respondent 8, Respondent 7). Management decisions around interventions are based on multiple priorities that may contradict each other and therefore it is important to consider the ecosystem holistically and integrate the various disciplines during the decision-making process (Respondent 1, Respondent 3; Respondent 6, Respondent 7). Some interventions are focussed on water quality as this has a significant impact on other aspects related to wetland functioning. However, because this system is complex, interventions may bring about unpredictable outcomes that are difficult to plan and budget for (Vice, 2011). For this reason-, short-, medium- and long-term budgeting and funding is required to manage a system like this as optimally as possible. Interventions reflect an adaptive type of technical management response with strict monitoring and reporting to ensure success.

> *"…they had to poison all the fish in the all the wetlands…I was commissioned to observe what… the effect might be on the birds which was positive…"* (Respondent 1).

> *"it's useful to show trends and we can pick up if there's a problem like we had water mongese invade the place… and the number of water birds went down and when they took out seven of the mongese the word numbers came up again."* (Respondent 1).

4.6.1.8 Major management interventions

a) Removal of carp

Carp fish were illegally introduced into the canal system and in 2006-2007, this was reported to have a negative impact on water quality and aquatic plant life, so an intervention was conducted in 2008 to rescue all other fish species prior to poisoning and removing the carp. The outcomes on the rest of the ecosystem were monitored and reported as positive (Respondent 1; Respondent 3; Respondent 6; BIIEC, 2019).

b) Removal of sediment / dredging

In 2008, coupled with the carp removal programme, the wetlands and canals required extensive rehabilitation to address water quality issues that were a result of high levels of nutrients and sedimentation, mainly from the treated effluent water supply line (BIIEC, 2019; Respondent 3; Resondent 6). This process resulted in temporary displacement of birds, increased nutrient levels and fast growth of dense root systems. It ultimately created blockages and resulted in raised water levels in cells 1 and 2. In response, the cells were dredged, and all the sediment and reed top growth was removed to improve functionality (Respondent 3; Respondent 6). More recently as part of the monitoring, reporting, prediction and planning process, salt, sediment and water quality monitoring has been commissioned as a proactive approach to managing these levels and determining whether the system is progressing towards a condition that will require dredging (Respondent 3; Respondent 6).

> *"I know that we're going to be faced with taking out these reed beds again in a few years' time. That would be a purely from the management side wouldn't be what I would want to see from a bird point of view, but it's not too critical…"* (Respondent 1).

4.6.1.9 Other management interventions

a) Use of treated effluent

Recycled treated effluent from the Potsdam Wastewater Treatment Works was used to top up the water level in the wetland and canals during the drier summer months (BIIEC, 2019; CCPOA, 2017; CCPOA, 2021; Respondent 1; Respondent 2; Respondent 3; Respondent 6; Respondent 7). It was later discovered that the nutrient levels from the effluent supply were contributing to water quality issues in the wetland and canals as macrophyte uptake had reached its ceiling and excess nutrients were being deposited as sediment in the wetland. Guano from the constructed heronries added to the nutrient load and high levels of phosphorous were recorded. In addition, the roots of the reeds were so matted and intertwined that it exacerbated clogging (Respondent 6). Clogging in the wetland system resulted in a rise in water levels. Water quality has been measured regularly since inception of operations, and decisions have been informed by subsequent reports, which has led to adjustments. As a response to existing conditions, management halted the use of treated effluent (Respondent 2; Respondent 3; Respondent 6). Responsive and experimental approaches were also followed to reduce and restructure the heronries to neutralise phosphorous in the system (Vice, 2011). Therefore, regular monitoring and early identification, thorough due diligence, regular communication, and reporting has resulted in success.

b) Construction of heronries

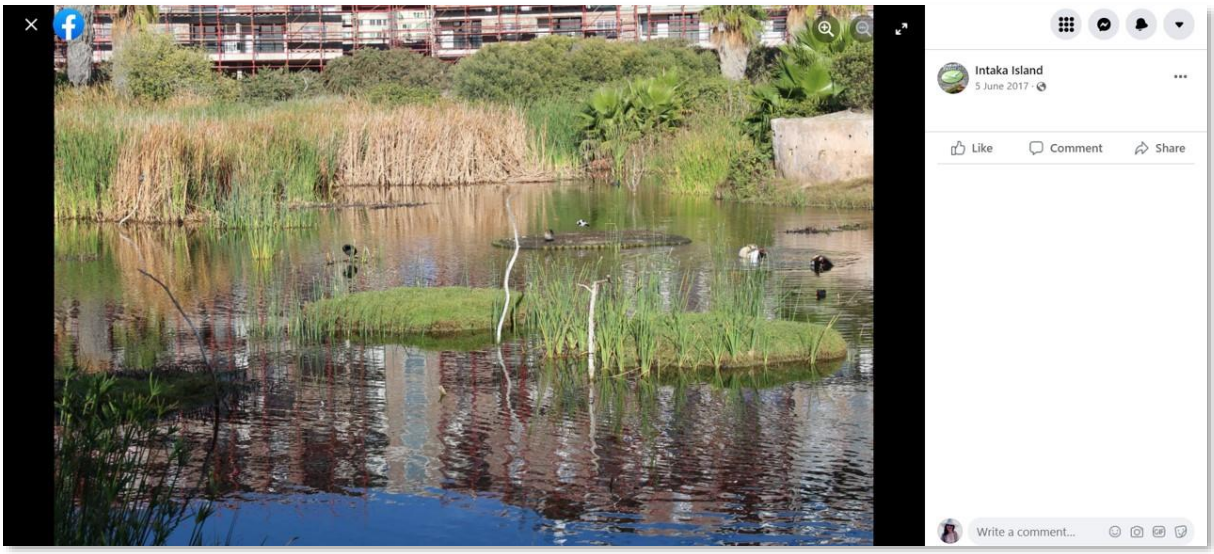
Social media post 17: Constructed heronry (CCPOA, 2021).

Globally novel approaches have been devised to attract the bird community back into the precinct (BIIEC, 2019; Respondent 2; Respondent 6; Respondent 7). Examples include plastic models or bird decoys that were placed in the cells to attract birds but were unsuccessful, after which stakes were installed near a few earth islands which were colonised by birds because they were located over deep water. This led to the construction of six breeding platforms in cell 3 with branches that emulate islands of the original Blouvlei wetland (BIIEC, 2019; Respondent 6; Respondent 7; University of Cape Town, 2004). In recognition of the pioneer and mastermind behind this clever response, these islands were then termed "Weyers Islands", in recognition of the originator (Respondent 6). Refer to Addendum 16 and Addendum 17 for further details on how the bird population was re-established successfully. Experimentation associated with the breeding platform levels and predators was also considered an adaptive management response technique

c) Collection barrels and removal of guano loads

. The existence of the heronries has led to further interventions, such as collection of guano loads in tanks or barrels, which was a direct result of learning and monitoring over time (BIIEC, 2019). The conceptualisation and installation of heronries and constructed roosting platforms led to increased nutrient loads in the wetland, due to guano loading from bird populations (BIIEC, 2019; Vice, 2011). This guided the new method of capturing and removing guano loads that were dropping beneath the platforms (BIIEC, 2019). Plastic drums were mounted around the base of the heronry structures to prevent nutrient rich water entering the wetlands and canal system (Respondent 2; Respondent 7). Based on learning and experimentation, the protocols were changed which gave rise to the need for an updated Operational EMP (BIIEC, 2019). This is evidence of the cyclical feedback loop learning and adaptation at Intaka Island.

d) Construction of floating islands and aquatic habitat



Social media post 18: Floating Island habitat (CCPOA, 2021).

Floating islands and shallow bays have been created to provide large surface areas for microbes that deliver additional filtration. Nesting tunnels have also been constructed on the canal edges to provide additional bird habitat (BIIEC, 2019). They form microclimates in cells 3 and 4 and provide birds with a diversity of safe habitat, remote from predators (BIIEC, 2019). In these areas, the reeds have encroached on occasion, resulting in the system needing to be opened and habitats restored.

Image 46-49: Floating islands and other habitat (Spolander, 2021).

e) Circulation and pumps

This closed system only allows rain and groundwater entry and circulation of water through the wetland at a level that is higher than that of the canal system (Respondent 2; Respondent 3; Respondent 6). Water flows from cell 1 through a perforated pipe which aerates the water, as seen in Images 51 and 52. Then through cells, 2,3 and 4 and into the canals which are 1700mm deep on average and assist with oxygenation (CCPOA, 2021). Water is then pumped back up into the wetland and recycled every 85 days (Viall, 2013). A weir serves as an overflow point from the canal system, where excess water runs via the Century City outfall pipe into the detention pond. This pond accommodates a 100-year flood with an overflow into the Wingfield outfall pipe and to the Atlantic Ocean at Milnerton Lagoon mouth (Respondent 6).

Image 51 & 52: Metal perforated aeration pipe under footbridge (Spolander, 2021).

The City of Cape Town has stipulated a maximum volume that may overflow at the Wingfield outfall and stormwater attenuation on site was a condition of approval, so excess stormwater only flows out in a massive storm event (Respondent 2; Respondent 3). When surplus litter enters the system higher up, causing blockages, this tends to compromise functionality of the pump and ultimately pollution may end up filtering through the system (Respondent 6). This circulatory wetland system does improve water quality but not sufficiently enough to offset the imported nutrients from bird guano, whereas the deeper, narrower canals are serving the function of improving water quality (Respondent 2).

Canal Water Level Data

The relevant design data is as follows:

Normal canal operating level:	13,3m MSL
50-year flood level:	13,9m MSL
100-year flood level:	14,0m MSL
Recommended walkway levels:	14,2m MSL
Recommended minimum floor level:	14,5m MSL

Image 50: Century City canals (Spolander, 2021) and canal levels (CCPOA, 2017).

f) Wetland cell linings and French drains

In 2001, groundwater monitoring exposed a leak along the western side of wetland cell 1 which allowed for ingress of water. A french drain was constructed to cut off this flow and some relining of the cells were carried out to prevent water leaching through from the ephemeral pans and to control the *Typha sp*. root system (Respondent 6). The location of the French drain was "*between the constructed wetlands (permanent waterbodies) and the ephemeral pans (seasonal waterbodies) to cut off the apparent subterranean seepage of fresh water into the pans and allow the natural drying out of the pans*" (Respondent 3). This is due to the strong fibrous root system of the plants which consist of rhizomes for anchorage (SANBI, 2021). Thereafter, monitoring was carried out to measure the effectiveness of this intervention (BIIEC, 2019).

g) Silt traps

The roads at Century City have been designed with conventional drainage systems which flow into silt traps. Silt traps act as a buffer and deliver a basic level of filtration (Respondent 6).

h) The use of barley bales

Barley bales have been used in the canals on an ongoing basis to suppress the spread of *Cladophera* sp. (BIIEC, 2019).

i) Biological control and herbicides

Terrestrial and aquatic weeds have been managed without the use of harmful chemicals and control measures (BIIEC, 2019; Respondent 6). The weevil *Stenopelmus rufinasus* is used to combat *Azolla filiculoides* when needed (BIIEC, 2019).

j) Use of ferric

Eutrophication caused by increased levels of phosphorous is increasingly managed through the addition of iron and aluminium compounds to large water bodies (Sherwood & Qualls, 2001). The chemical ferric is occasionally used in emergencies during algal blooms as a flocculant to remove phosphorous during periods of high nutrient load (Respondent 6).

k) Harvesters – Refer to 4.6.1.6 e.

l) Irrigation and watering

Government policies suggest that the long term use of potable water for the establishment of vast landscaped areas is not secure and therefore alternative sources of water supply for irrigation purposes has been an important component for the establishment of plant material at Intaka Island and the Century City precinct, due to the prohibitive cost of potable water (CCPOA, 2017; CCPOA, 2021) . The use of treated effluent for irrigation purposes is common practise within the Century City precinct The CCPOA pay the City of Cape Town for the supply of water and then pass the cost onto property owners. This supply is no longer used in or near the wetland and canal system.

The original irrigation system installed on Intaka Island was discontinued after the establishment phase on the island, but this infrastructure is still visible in some areas. Reeds, aquatics and much of the vegetation close to the water bodies do not require watering and terrestrial planting has already been well-established (Respondent 3; Respondent 4, Respondent 6). Where infill and supplementary terrestrial planting is required, the principle of planting in Autumn and Winter months during the rainy season, is followed for planting programmes. To supplement this, newly established plants in the ephemeral pans are hand watered where required (Respondent 4; Respondent 6). Currently this approach is proving effective and successful.

Image 53 & 54: Conventional irrigation standpipes (Spolander, 2021) and wetland semi-submerged reed growth (Spolander, 2021).

4.6.1.10 Detention Pond maintenance

Maintenance of the Tijgerhof detention pond has been included in the work regime of the nature reserve, even though it is geographically distinct and isolated. Functioning of the detention pond is critical during peak floods during the Winter season as it deals with overflow from the wetland and canal system and from Summer Greens. Blockages and unwanted inflows are treated as a priority to ensure optimal functioning at all times (Respondent 6). Water quality analysis, bird and fish counts at the detention pond have been included in the Intaka Island monitoring and reporting tasks (Respondent 6). This detention pond is maintained to a high standard, with indigenous vegetation and habitat along the internal and external embankments but currently may only be accessed by CCPOA and the City of Cape Town maintenance crews.

4.6.2 Discussion and interpretation

4.6.2.1 Wetland management

This artificial constructed wetland came into being after being inadvertently discovered while disguised in an overgrowth of alien invasive bush. The existing wetland then formed part of an EIA assessment during the planning stages of the project in the latter period of the 1990's. It was a flooded area that had been impacted by anthropogenic change and manipulation of ground levels in surrounding areas, resulting in an increase of stormwater on the site. Permission was granted for development of the Century City land parcel, with a set of development conditions stipulating that a portion of land was to be conserved as ephemeral pans and a wetland. An 8-hectare artificial wetland was constructed to serve a similar function as the natural wetland did.

The wetland is maintained as a nature reserve to meet conservation objectives and therefore standard horticultural and landscape operational practises do not apply in this context. From a stormwater perspective this wetland is considered a closed system with minimal entry of water from external sources, other than from groundwater and rainwater. It is maintained as far as possible within acceptable tolerances of a predetermined state so that it fulfils the objectives outlined in the EMP, which relate to water quality, habitat enhancement, recreational and aesthetic imperatives among others. To maintain it in an agreeable state of balance, varying interventions have been identified by the BIIEC and executed by the CCPOA, alongside regular operational activities appropriate for a nature reserve. This includes alien invasive control and the rehabilitation of endemic flora and fauna. This type of management requires a level of innovation, experimentation, and creativity. Regular, ad hoc, and special maintenance interventions require sufficient resources such as budget and funding, equipment, manpower and expertise, all of which are managed by the CCPOA.

Over time and with the extensive water quality monitoring programme, there has been a determination that the wetlands are no longer able to fulfil the function of purifying and polishing the water in the system. This is due to historical nutrient loads from the Potsdam Treated Effluent line and bird guano which was used to top up the water bodies. Therefore, the revised water quality objective in the updated EMP of 2019 has changed. It is no longer expected that the wetland polishes the water in the system, but rather that water from the wetland should not add to the nutrient load in the system. This is a more realistic expectation. From various interviews it has emerged that the canal water is now serving the role of purifying water in the water bodies rather than the wetland, mainly because the canals offer little bird and wildlife habitat and therefore do not draw considerable nutrient loads. This is in contradiction to the literature which asserts that wetlands serve a function of purifying and polishing stormwater. It is however recognised that this case is unique and that historic nutrient loads need to be taken into consideration.

The author challenges specific previous references to routine dredging: “The clearing of biomass is a critical maintenance procedure in treatment cells 1 and 2 which requires routine dredging” (Vice, 2011) as it has been clarified by CCPOA management and the BIIEC that dredging was carried out as a once-off activity due to clogging of the system with sedimentation and nutrient particulate and has not been an annual intervention. In this context, dredging is considered a special intervention only initiated if routine maintenance is insufficient, as the cost of machines and removal of the entire saturated zone without damaging the impervious clay liner base is an onerous and costly task. Respondent interviews, the EMP and observations lead the author to discard the claim by Vice, 2011 that annual draining and dredging of the wetland and removal of fish is carried out but rather includes the following:

- Annual manual removal of reeds and macrophytes in the wetland.
- Pruning of overgrowing plants and dead / diseased / damaged plant matter.
- Replanting bare areas.
- Application of biodegradable / environmentally safe and selective herbicides.
- Application of biocontrol of aquatics and macrophytes where required.
- Repair and reinstatement of furniture items, timber decking and railing items and footpaths.
- Items that are initiated to meet health and safety requirements.

Operational goals and objectives were detailed in the EMP to provide a comprehensive set of management requirements focussed on water quality and ecological and social sustainability with associated actions, targets, responsibilities and time frames so that the benefits of this system, such as enhanced ecosystem services, biodiversity and amenity may be fully realised (BIIEC, 2019). The operational approach taken at Intaka Island is based on the ISO 14001 standard for environmental management of systems which emphasises continuous improvement. Continuous improvement has been evidenced through the extensive monitoring and reporting at Intaka Island which enables adaptive, responsive, and experimental operations to improve environmental management performance. Through this process of monitoring, reporting and regular review, the EMP is altered and refined annually. This is indicative of the responsive and adaptable nature of operations for effective and efficient functioning of the system.

Concerning the SuDS literature, in addition to the information suggested by Woods-Ballard in the SuDS Manual, 2007, the author also recommends that the following are included in any SuDS operating manuals:

- Specific planting requirements and maintenance regimes.
- A set of manuals related to services and equipment such as pumps.
- Storage of maintenance equipment, tools, and materials.
- Descriptions of fauna and flora habitats.
- A clear strategy regarding aesthetic and amenity provision.
- Annual and monthly maintenance programmes.
- Identification of specific interventions.

The SuDS manual describes maintenance categories as: Occasional maintenance, regular maintenance, and remedial maintenance however, following the authors research, re-categorisation as follows is suggested:

1. Routine maintenance:
   To cover short- and long-term maintenance regimes.
2. Remedial maintenance:
   To correct and repair any areas affected or damaged by external factors.
3. Special interventions:

To cover unforeseen maintenance requirements that are carried out to stabilise the system such as dredging, culling of specific species to maintain ecosystem balance, special installations for habitat.

4.6.2.2 Funding and budget

Developments that include SUDS require careful planning to ensure sufficient allocation of resources for long-term functioning (Respondent 1; Respondent 6; Vice, 2011). The operational functions provided by the CCPOA as the overarching management company is funded by the property owners through an annual levy which comes at an additional cost. It is an additional fee that does not form part of the local government rates and taxes nor the levies of individual complexes at Century City. In return for this levy, the property owners receive several benefits, and they expect to receive a high standard "*so they pay premium to be here…and they expect that service in return*." (Respondent 6). Allowances are built into the levies and budgeted for routine work which is necessary for optimal functioning. These built-in costs may be prohibitive in other developments but in this context, provision is made for continued investment in the precinct to continue maintenance at the required standards (Vice, 2011). Thorough cost projections are important with allowances for updates according to revised system requirements (Respondent 3, Respondent 6).

> The CCPOA are proactive "*on an ongoing basis but - and they try to anticipate what the likely parts of need for intervention will be"* and they endeavour to *"make some level of prediction" …so, they can start setting aside the budgets - because that's really important…because wetlands are expensive to maintain*" (Respondent 2).

The annual levy is increased at the discretion of the CCPOA, as stated in the CCPOA budget for 2021 (Refer to Addendum 18). This provides an example of the basis for calculations of the general levies and as explained by one respondent as an annual budget measured against the calculated anticipated maintenance costs and then divided amongst the bulk services allocated to every property and based on a percentage per square meter ownership calculation (Respondent 6).

Routine operations are described by Vice, 2011 as:

- Monthly addition of barley straw to prevent algal blooms and prevent sedimentation.
- Biweekly removal of (water) weed.
- Weekly grass cutting and removal.
- Bimonthly pumping and removal of bird faeces.
- Annual draining and dredging of wetland for improved flow.
- Annual removal of fish to balance population numbers.

(Vice, 2011).

The BIIEC is also funded by the CCPOA and has an annual budget that covers meetings, the preparation of monitoring protocols, monitoring time, data analysis and the preparation of reports by specialists which are reviewed by the committee annually (BIIEC, 2019; Respondent 3; Respondent 6). The CCPOA provided the resources for detailed data collection which is then assimilated by the various appointed specialists for analysis (Respondent 2).

4.6.2.3 Financial Management

Sufficient and accessible financial resources are vitally important for the level of maintenance required at Intaka Island. This distinguishes the precinct from smaller developments which are often under-resourced and less likely to adequately meet their management objectives. The CCPOA has sufficient available resources and the funding for all operations is secured and managed by a panel of specialists with financial expertise and a long-standing organisational insight and history.

> *"You need…to have financial resources. You also need to have an experienced dedicated management team - which I think they've got a very effective one. So, Century City provide ongoing maintenance they've got a dedicated staff that understand the system and can see when something's going wrong or something needs intervention"* (Respondent 2).

The CCPOA invests a lump-sum amount which is managed by an investment sub-committee of the CCPOA as a long-term investment that accrues interest and is used to fund unanticipated maintenance expenses (Respondent 6). In this case study, adaptive and responsive management require financial backing, flexibility and freedom to make decisions and act decisively and swiftly if necessary (Respondent 2; Respondent 3; Respondent 6; Respondent 7).

> *"…but compared with what I saw in nature conservation itself, this is far superior because we have money…on the ground decision taking."* (Respondent 1).

> *"They've also got financial resources so it's a big enough development that… when they need to intervene, they can. Whereas the other examples in small developments that have completely failed because they don't have the managements resources."* (Respondent 2).

> *"We've got…an investment to cater for infrastructure replacement over 50-year period…So, if there was a major infrastructure intervention, it wouldn't come out of my normal operational budget."* (Respondent 6).

> *"We in a fortunate position where we can pull that money very quickly if we need to."* (Respondent 6).

4.6.3 Recommendations

a) Wetland or canal system

As mentioned earlier in the chapter, wetland vegetation is an important component of SuDS stormwater management as it serves a dual function of providing habitat and filtering water. Wide surface areas are required to establish plants in shallow waters which are typical of wetlands. However, increased habitat results in bird population surges which negatively impact water quality, due to the rise in guano loads, which tend to have high levels of nutrients (BIIEC, 2019). A surge in bird populations in SUDS water bodies such as wetlands potentially results in decreased water quality. Therefore, biodiverse aquatic systems are not necessarily conducive to improved water quality. Conversely, alternative narrow, deep-water bodies with lower levels of biodiversity may be more likely to yield improved water quality. For this reason, it may be beneficial to establish this through further research and categorically determine whether counterpart water bodies located alongside wetlands will better facilitate water quality improvement. As is the case at Intaka Island, this type of complimentary system of wetland and canals seem more likely to provide improved water quality outcomes.

b) Detention pond

The detention pond provides an opportunity for an extension of the SuDS facilities available for educational and recreational purposes. This is currently inaccessible to the public but possible future planning and design linkages may provide options to incorporate this within the existing SuDS open space network at Century City.

c) Maintenance network and access to SuDS

While pedestrian connections at Intaka Island provide access for educational and maintenance purposes, it seems equally important to ensure that the conservation and vegetated areas beyond the edges of formalised pathways are not infringed upon. For this reason, it will be important to continue to limit and prevent uncontrolled informal access through the vegetation. For this reason, the author suggests careful access management.

4.6.4 Summary

Intaka Island is an artificially constructed wetland that consists of a series of perennial pools. If these pools existed in their natural form, they would be impacted by other natural processes such as fire, sedimentation, and animal disturbance, which would result in a gradual infilling of soil, debris, and other material over time, consistent with a natural system. This would ultimately lead to it becoming a terrestrial system. Since Intaka Island is an artificially constructed wetland, intended to fulfil several functions that hinge around the quality of water, the objective of the system is to maintain it as close to its original design condition or original operating state as possible, so that it may continue to function in a specific way to achieve the intended objectives. This requires a degree of mechanisation and interventions that replace the natural drivers. Careful management of this system is key to ensuring ongoing function. Changes in water quality in the constructed wetlands over the past 20 years due to nutrient loading has led to a revision in management objectives for water quality in the wetland. The concept of Intaka Island fulfilling the role of a water quality treatment facility required reconsideration. One of the main objectives of habitat creation to enhance biodiversity has resulted in it being a net importer of nutrients. Therefore, the wetland is now considered more valuable for its biodiversity than for water purification purposes and the associated canals fulfil the role of water polishing and purification.

CHAPTER 5: CONCLUSION

5.1 Introduction

This chapter documents the findings of Chapter 4. The purpose of this chapter is to provide a brief overview of the findings, review the research objectives, repeat the assertions, and conclude the research. This case study of the Critical Success Factors of Sustainable Urban Drainage Systems (SuDS) during the operational phase at Intaka Island, Century City was selected due to it meeting specific criteria as outlined in Chapter 3. The author has been working in the pragmatic paradigm since the problem was located at the centre of the research question and it is therefore appropriate in the context of this research.

5.2 Revisiting the research objectives

The research objectives:

- To determine whether Critical Success Factors exist for SuDS during the operational phase of a project.
- To identify these Critical Success Factors and organisational approaches that are likely to best influence successful outcomes in SuDS landscape operations.

In fulfilling these research objectives, a critical literature review and a single case study research methodology were conducted to investigate the operations of the Sustainable Urban Drainage Systems (SuDS) at Intaka Island, Century City, Cape Town through thematic analysis. The research design included a desktop literature review over a period of five to six months and data collection in the field over a period of one month. Various data sources included observations in the field, social media and website sources, publicly available published documents, and semi-structured interviews. Research questions for the semi-structured interviews evolved over time, since the author understood that a standard set of questions would not suffice due to the wide range of participants who are specialized in various fields. Following this, a rich description was produced and then analysed, and interpreted in Chapter 4. This led to the establishment of four emergent themes as four prominent Critical Success Factors, each with their own summary.

5.3 Revisiting the research question

Critical Success Factors have been researched extensively on the implementation phase of projects. To ascertain project success, success criteria need to be clearly defined early on during the initiation phase and then assessed to establish whether specific Critical Success Factors exist during the operational phase of SuDS landscape projects. It is also imperative to determine whether the Critical Success Factors in the operational phase are similar to those researched in the implementation phase. The author argues that such success criteria need to be reviewed regularly during the course of the project and into the operational phase, since projects evolve and change. Therefore, research of SuDS landscape operations and management have formed part of this research, to establish some of the key success factors and build on practise.

The Research question is:

What are the key Critical Success Factors in the post-completion and operational phase of Sustainable Urban Drainage Systems (SuDS) landscape projects?

5.4 Brief discussion of the key findings

A few common Critical Success Factors identified in the literature on projects include:

- Qualitative organisational factors, most notably top management support and skills, led by a project champion increases the likelihood of access to resources to meet project objectives however project-manager and team-related factors such as technical competence and commitment are considered critical,

- The competency, technical background and administrative skills of the project manager and project team to plan, implement and terminate project phases are vital and may be enhanced by qualities such as project commitment, which in turn increase stakeholder satisfaction and project acceptance.

- Several variables such as intellect, emotional intelligence, leadership style and competence are regarded as important. Literature shows that professional certification improves success and is required for high performance but is insufficient to guarantee performance. Organisational change literature refers to the important dimensions of technical and organisational validity to achieve organisational effectiveness.

- The PMBOK refers to success as: “the application of knowledge, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations.” But much of the literature shows a change in the traditional definition of project success and moving away from the iron triangle, as this does not guarantee delivery of benefits or stakeholder satisfaction. Professional bodies are also increasingly recognising the requirement for different management approaches and tailoring of project processes and procedures.

Frameworks were developed by researchers in the field to enable a clearer understanding of success, such as the comprehensive **four-dimensional framework** compiled by Shenhar et al. This framework is dynamic and differentiates between operationally and strategically managed projects to support successful performance to achieve short- and long-term objectives. The third dimension is measured during the operational phase and refers to the impact of the project on the parent organisation in terms of meeting short and long term strategic organisational goals and objectives.

Some researchers separated internal and external project success factors and refer to common factors, identified as:

- Project mission
- Top management support
- Project schedule
- Sponsor consultation
- Technology
- Monitoring and feedback
- Communication and troubleshooting

Considering these references to literature, it is clear that the strategic focus of an organisation requires early planning and setting of goals and objectives to achieve project success with direction provided by top management which should be reinforced through appropriate management strategies.

Four themes emerged from the data. The emergent themes are documented as the findings of Intaka Island, Century City. These themes describe the Critical Success Factors as:

1. A strategic vision with associated objectives.

The strategic vision was founded on the principles of building an ideal development that fulfils multiple needs of society including residential, commercial, retail, educational, recreational, social and environmental needs. The originating organisation and founder considered creating a living environment that exists outside the norms of everyday development and achieved a level of creative excellence.

The site on which the development was located had obvious constraints associated with existing ephemeral pans that required environmental care and protection. These constraints were considered as opportunities in an endeavour to design a place that would meet human needs but also consider and address environmental sensitivities and become a leader in the pursuit of a sustainable future.

2. SuDS supports a culture of learning.

A culture of learning at Intaka Island underpins the operational approach. Much of the operations is centred around education. This is evident in the facilities and activities on the island that relate to environmental aspects such as learning about flora and fauna, waste management and learning the skill of observation. Learning is an integral part of environmental management and is evidenced in new approaches and methods that are executed on a trial basis and monitored periodically. Learning is also evidenced in the school programmes that make explicit the functioning of Intaka Island and may be used as a research resource that may further the objectives in the EMP through scientific enquiry. Staff also form part of the continuous learning approach as opportunities are provided to grow and improve, either through formal learning or informally through mentoring and observation. The organisation and management are considered to value human capital and there has been continuity and long-term commitment over a long time period which provides an organisational repository of the history, progress and decision-making, contributing to successful outcomes

3. **Clearly defined management objectives underpin success.**

The Environmental Management Plan (EMP) of 2019 outlines the strategic goals, objectives, management actions, monitoring requirements and targets, timeframes and designation of responsibility for implementation. This comprehensive set of management objectives, policies, and practices balances the various conflicting objectives, which were identified as:

- Management of water quality and quantity;
- Maintenance of hydrological and ecological functioning of the pans and constructed wetlands;
- Establishment of fauna and flora, in particular, plants, birds, fishes, reptiles, amphibians, and small mammals;
- Integration with wider planning and development at Century City; and
- Promotion of tourism, recreational, educational and research opportunities.

Management of Intaka Island hinges around the provision of environmental services as a key to long-term sustainability, with a strategic management focus on water quality as a key indicator of system health, supported by biodiversity, aethetic, educational, recreational and economic objectives. An external monitoring committee was established to guide the implementation of the EMP in line with these objectives and promote co-operation between the various stakeholders to ensure optimal management and maintenance of environmental health of this system.

4. **Organisational capacity and technical expertise facilitate adaptive, responsive, and experimental operations.**

SUDS operations are facilitated by the CCPOA and include water management, vegetation maintenance, hard landscape maintenance and special interventions. Regular, ad hoc, and special maintenance interventions require sufficient resources such as budget and funding, equipment, manpower and expertise to adequately maintain the wetland and nature reserve in alignment with conservation objectives. It therefore deviates from standard operational practises and the system is maintained within acceptable tolerances of a predetermined state to fulfil the objectives outlined in the EMP, which relate to conservation, water quality, habitat enhancement, recreational and aesthetic imperatives among others. The management of this system requires a high level of innovation, experimentation, and creativity to achieve this. The operational approach taken at Intaka Island is based on the ISO 14001 standard for environmental management of systems which emphasises continuous improvement. Continuous improvement has been evidenced through the extensive monitoring and reporting at Intaka Island which enables adaptive, responsive, and experimental operations to improve environmental management performance.

5.5 Recommendations

The following passage documents the recommendations for this study:

Vision:

- Develop a coherent overarching vision statement that ties the original design intent and development of the project to the current operational context.
- Link the original vision and the current goals and objectives stated in the EMP for the purpose of long-term reviewof operational change.

Education:

- Explore additional opportunities for teaching and learning at Intaka Island in the form of direct observational learning of operations to provide greater insight into the workings of this system.
- Assist with closer mentoring of individuals and skills development to carry out to improve the quality of monitoring data and ultimately operational outcomes.

Management:

- Create a formal role for an independent organisation to serve in assimilating and processing the various specialist assessments and reports and make final recommendations and decisions.

Maintenance:

- Link the detention pond as part of the open space system and make it accessible for teaching, learning and recreational purposes.
- Protect and conserve the surrounding wetland vegetation from informal and ad hoc maintenance activities.

General recommendations:

- On other SuDS projects, consider the design of narrow, deep-water bodies as complimentary to a biodiverse wetland system for the purpose of water quality enhancement.

5.6 Final Conclusion

The earths limited natural resources are increasingly under pressure from population growth and urbanization, causing progressive pressure on the natural environment. Awareness of this has led to a strong movement worldwide towards more sustainable ways of doing things. This is most evident in the built environment where conventional design and practice has been challenged in recent years. Research has been carried out into alternatives to remedy the situation and mitigate further environmental damage through appropriate design responses. These responses reflect more considered approaches and a reduced impact on the environment by considering ecological cycles. Water is one such resource that has been managed in conventional systems by separating piped water systems that primarily focus risk management. Ironically, these approaches have impacted human life more negatively and increased risk in the long term as they have not proven environmentally sustainable.

The development and diversion from conventional approaches to managing water and stormwater through urban drainage systems to more sustainable ways of managing urban drainage such as Water Sensitive Urban Design (WSUD) and Sustainable Urban Drainage Systems (SuDS) has been well established from an engineering research and practice perspective. However, because sustainable systems mimic natural systems, the operational aspects are more complex. They cannot be managed to exist in a static state nor in the same condition they were in at completion of a project and yet there are often operational objectives that require active management to meet static design objectives. Intaka Island provides a typical example of the complexity of these types of systems which are often unpredictable and need to evolve. This unpredictability is usually caused by emergent factors during the operational phase. A system impacted by emergent factors requires more dynamic, interactive, and proactive approaches which adapt to change. The case study shows that in sustainable infrastructure such as SuDS, responses need to be highly adaptable, responsive and in addition, there needs to be allowances for a degree of trail and researched experimentation with adequate funding.

Managed landscapes are adaptive systems but traditionally the operational practices on projects have often been predefined and clearly outlined in specifications relating to a specific system. This type of rigidity does not make allowance for unpredictability and adaptability, which is increasingly proving necessary. Environmental systems require a great deal of flexibility in management. In this context, regular and detailed monitoring, reporting and record-keeping is key to ensuring consistency and continuity during operations, thereby affecting outcomes positively. To enable this type of active involvement, sufficient resource allocation is crucial. Monitoring and reporting need to be holistic and comprehensive but also allow for foreseen and unforeseen interventions. Interventions are often used to keep a system functioning optimally, but they require detailed analysis of a systems perspective, with inputs from a variety of specialists and stakeholders. Formal and informal education and involvement of all stakeholders is also key for operational teams and vital to the success of such systems. All these dynamic factors contribute to the outcomes of operations, particularly on Sustainable Urban Drainage Systems (SuDS) projects.

More research is required to definitively determine where and how these success factors can be expanded upon and whether other SuDS facilities not described and studied in this case study have other equally important but different success factors. Nevertheless, the author suggests from this research that four key critical success factors emerge as important for the operations of Sustainable Urban Drainage Systems (SuDS) landscapes in the operational phase of a project.

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