

Exploring the practical, social, and governance realities of a Water-Energy-Food (WEF) Nexus Governance approach: A case study of the V&A Waterfront in Cape Town, South Africa

by

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Declaration

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Abstract

Urban spaces worldwide, including Cape Town, are reported to be the loci of sustainability challenges and solutions. This creates the necessity for governments and institutions to enhance urban social-ecological systems (SES) resilience to mitigate and leverage shocks. This includes shocks such as the interrelated water, energy, food, and waste resource challenges faced worldwide. However, there is a gap between commitments to SES resilience and the practical ability to govern for resilience, creating a dichotomy between resilience theory and practice. In response to this dichotomy, the Water-Energy-Food (WEF) Nexus framework has been proposed as a supporting instrument for SES resilience. This is because it represents a form of resource governance that manages resources interrelatedly rather than siloed, as approached traditionally.

To test these SES resilience-enhancing claims, a transdisciplinary research approach is adopted first to understand how the WEF Nexus is understood from a theoretical and practical point of view. It is found that a gap exists between academic ambitions for the WEF Nexus framework and the practical implementation of the framework, making it difficult for these resilience-supporting claims to be substantiated. In this regard, the WEF Nexus is under-explored practically, socially, and in terms of governance. To identify a practical nexus governance approach, the governance and management systems of the V&A Waterfront, including their Global Carbon Exchange (GCX) system, are explored. It is found that a nexus governance approach has been adopted by the V&A Waterfront, making it the perfect case study to test if a configured bridge between nexus theory and governance in practice (nexus governance) enhanced the practically demonstrated ability to govern for SES resilience. The practical, social and governance implications of the nexus governance approach at the V&A Waterfront are explored to test this claim. This is followed by an in-depth analysis of these implications and if they hold any potential for enhanced SES resilience. Findings suggest that the nexus governance approach at the V&A Waterfront has implications that strengthen the capacity to govern for SES resilience in the V&A Waterfront context. The conclusion is then made that the nexus governance approach also strengthens the capacity to govern for SES resilience in the Cape Town context. Results also suggest the most crucial element for the success of the nexus governance approach is a material flow analysis (MFA) based decision support system (DSS) exemplified by GCX Data Analytics and Sustainability Hub- (DASH-).

Opsomming

Stedelike gebiede, insluitend Kaapstad, word wêreldwyd as die lokus van volhoubaarheid uitdagings, asook oplossings beskou. Hieruit ontstaan die behoefte vir regerings en instellings om die veerkragtigheid van die sosio-ekologiese stelsels (SES) te versterk en sodoende die impak van uitdagings te versag. Uitdagings met betrekking tot onderling verwante hulpbronne soos water, energie, voedsel en afval word hierby ingesluit. Daar is egter 'n gaping tussen die toegewydheid aan veerkragtigheid van SES en die praktiese vermoë om te bestuur vir SES veerkragtigheid. Die 'Water-Energy-Food (WEF) Nexus' raamwerk word voorgestel as 'n instrument om veerkragtigheid van die SES te versterk en die gaping tussen teorie en praktyk met betrekking tot SES veerkragtigheid te oorbrug. Die 'WEF Nexus' raamwerk beweeg weg van die tradisionele benadering wat hulpbronne in isolasie bestuur, en stel dat dit eerder as onderling verwant bestuur en benader moet word.

'n Trans-dissiplinêre navorsing benadering was gebruik om die bewering tot versterking van SES veerkragtigheid te toets. Om die bewering te toets het die navorsing eerste aangedui hoe die 'WEF Nexus' raamwerk vanuit 'n teoretiese en praktiese standpunt verstaan word. Die bevinding was dat daar 'n gaping tussen akademiese aspirasies en die praktiese implementering van die 'WEF Nexus' raamwerk is, met die gevolg dat bewerings tot die versterking van SES veerkragtigheid nie sonder uitdaging gestaaf kan word nie. Verdere uitdagings wat na vore kom as gevolg van die tekort aan praktiese implimentering van die 'WEF Nexus' raamwerk is dat die raamwerk tot dusver nie prakties, sosiaal, of in terme van bestuur ondersoek is nie. Om die 'n praktiese nexus-bestuur benadering te identifiseer, word die bestuur van die V&A Waterfront en hul GCX-stelsel ondersoek. Bevindinge dui aan dat die V&A Waterfront nexus-bestuur raamwerk gebruik en is dus 'n gepaste gevallestudie om te toets of 'n oorbrugging tussen nexus-teorie en praktyk (nexus-bestuur) lei tot 'n verhoogte vermoë om die bestuur vir SES veerkragtigheid. Die praktiese, sosiale en bestuur-implikasies van die nexus-bestuur benadering by die V&A Waterfront word dus nagegaan om die stelling te toets. 'n In-diepte ondersoek dui dat die nexus-bestuur benadering by die V&A Waterfront implikasies inhou wat lei tot die bevordering van SES veerkragtigheid in die konteks van die V&A Waterfront. Die gevolgtrekking is daarna gemaak dat die nexus-bestuur benadering ook die bestuur vir SES veerkragtigheid in Kaapstad kan versterk. Die resultate dui ook daarop dat die mees deurslaggewende element vir die sukses van die nexus-bestuur benadering 'n materiaal vloei-analise gebaseerde besluit ondersteuningstelsel is en word deur GCX DASH- geïllustreer.

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List of Acronyms and Abbreviations

CAPEX	Capital Expenditure
CCT	City of Cape Town
CEO	Chief Executive Officer
CSI	Corporate Social Investment
CTO	Chief Technical Officer
DASH-	The GCX Data Analytics and Sustainability Hub
DSS	Decision Support System
ED	Executive Director
ES	Ecosystem Services
FAO	Food and Agriculture Organisation of the United States
FEW	Food, Energy & Water
FY	Financial Year
GBCSA	Green Building Council South Africa
GCX	Global Carbon Exchange
GDP	Gross Domestic Product
GLA	Gross Leasable Area

IAMs	Integrated Assessment Models
ICLEI	Local Governments for Sustainability
IE	Industrial Ecology
IRP	Integrated Resource Panel
IEG	Integrative Environmental Governance
IFPRI	International Food Policy Research Institute
IRENA	International Renewable Energy Agency
KPIs	Key Performance Indicators
LM	Last Month
MFA	Material Flow Analysis
MOCAA	Museum of Contemporary Art Africa
MoM	Month on Month
MTD	Month to Date
NDP	National Development Plan
NWO	Dutch Research Council
PIE	Political Industrial Ecology
PSG	Practical, Social and Governance

PV	Photovoltaic
SD	Systems Dynamics
SES	Social-Ecological Systems
SLR	Systematic Literature Review
SMLY	Same Month Last Year
SMMEs	Small and Medium- Sized Enterprises
SPLY	Same Period Last Year
SU	Stellenbosch University
TD	Transdisciplinary
UIS	Urban Immune System
UMFA	Utility Management for Africa
UWC	University of the Western Cape
WEF	Water-Energy-Food
WEW	Water-Energy-Waste
WCEDP	Western Cape Economic Development Partnership
WWF	World Wide Fund for Nature

YoY Year on Year

YTD Year to Date

Chapter 1: Introduction

1.1 Background

Water, energy, and food are some of the most essential resources required for society to function; it is, therefore, essential that these systems be governed conscientiously (Weitz, Strambo, Kemp-Benedict & Nilsson, 2017). Global demand for water, energy, and food is rising due to rapid urbanisation, changes in user practices, and unsustainable social and economic growth, perpetuating resource-intensive consumption patterns (Mguni & van Vliet, 2021). These global development trends are especially prevalent in urban areas — areas where more than half of the world’s population currently resides. And, increasingly, more of the world’s population is expected to move to urban areas in the future (Shlör, Venghaus & Hake, 2018). In South Africa, 80% of the population is expected to live in urban areas by 2050 (Battersby, 2011); a trend that will significantly impact resource consumption in the country.

Urban development patterns place increased ecological, economic, and social pressure on the earth’s systems, especially with regard to water, energy, and food (Allen, Lampis & Swilling, 2015; Shlör, Venghaus & Hake, 2018). Urban spaces are, therefore, the loci of sustainability challenges and possible solutions (Derickson, 2018). However, sustainability problems and solutions are complex due to the reciprocal relation shared by the social and ecological systems in cities, and the external systems with which they relate (Derickson, 2018; Shlör *et al.*, 2018; Swilling, 2020).

The interaction between the need to develop and the need to maintain the ecosystem services (ES) that enable development is precisely the social-ecological systems (SES) dynamics dealt with in the case of the City of Cape Town (CCT)¹ — a city with increased water scarcity, overdependence on centralised coal-based energy production, and high levels of food insecurity (Crush, Caeser & Haysom, 2018). As the CCT faces triple exposure to interrelated water, energy, and food crises, there is a great need for enhanced resilience enabled by increased governance capacity, to mitigate, cope, prepare, and adapt to such interrelated resource complexities (City of Cape Town (CCT), 2017a; CCT, 2017b).

¹ CCT refers to the government, while Cape Town and Cape Town Metropolitan area refers to the geographical area which the CCT governs.

Traditionally, governance approaches to resource systems have occurred using individual sectors and scales of governance — basically, managing systems in isolation (Weitz, Strambo, Kemp- Benedict & Nilsson, 2017; Newell, Goldstein & Foster, 2019). However, as complex cascading effects and trade-offs occur between these systems and the external systems with which they relate, integrated resource management is required to mitigate trade-offs, leverage vulnerabilities, and reinforce the resilience of these systems in harmony with one another (Smajl, Ward, Pluschke, 2016; Weitz *et al.*, 2017; Newell *et al.*, 2019).

Fortunately, the literature expresses excellent potential in the water-energy-food (WEF) Nexus framework in response to the need for integrated governance. The WEF Nexus framework involves cross-boundary collaboration and systematic co-management of WEF systems in light of coordinated resilience strategies (Smajl *et al.*, 2016; Weitz *et al.*, 2017; Newell *et al.*, 2019).

Authors argue that urban socio-ecological resilience is paramount for mitigating inevitable climate change-induced system shocks and related resource insecurities (Wagenaar & Wilkinson, 2015). Accordingly, the CCT has released a ‘Resilience Strategy’ (2019) to mitigate and prepare for crises and shocks while challenging social inequalities. In line with the need to consciously govern for resilience, the WEF Nexus framework is argued to be a supporting instrument for both a green economy and resilient global development, with cities spearheading these transformation processes (Shlör *et al.*, 2018).

As a result of Cape Town’s commitment to resilience and the possible role of WEF Nexus in supporting this agenda, a research project called “Nexusing Water, Energy and Food to Increase Resilience in the Cape Town Metropolitan Region” has been launched. This project is a four-year research agenda (running from 2019-2023) involving a consortium of three universities — University of the Western Cape (UWC), Stellenbosch University (SU), and Utrecht University — and two intermediaries — Local Governments for Sustainability (ICLEI) Africa and the Western Cape Economic Development Partnership (WCEDP) — researching the WEF Nexus in Cape Town.

The broader research project mentioned above proposes to develop a WEF Nexus approach that increases the resilience capabilities of the Cape Town Metropolitan Region. The reasoning for conducting such research stems from a gap between policy ambitions and the practical

demonstrated ability to govern for resilience, with the nexus approach offering opportunities for enhanced capacity to govern for resilience (Weitz *et al.*, 2017; Mguni & van Vliet, 2021).

Although the nexus framework offers this opportunity, it is identified that the literature on the concept far outweighs practical adoption of the framework, and even less so the social considerations (Weitz *et al.*, 2017; Mguni & van Vliet, 2021; Urbinatti, Benites-Lazaro, de Carvalho & Giatti, 2020). Another gap identified in the literature is that the concept of governance is underdeveloped in relation to the concept of the nexus (Weitz *et al.*, 2017; Urbanitti *et al.*, 2020).

The broader research project, therefore, proposes to increase the social and scientific value of the nexus approach by rethinking and refining current frameworks. Such refinement will occur by exploring how WEF crises interrelate, how they materialise differently across socio-spatial contexts, and how governance complexities are and can be addressed, all within the context of Cape Town. As an outcome, the broader research project proposes to develop multi-scale procedural guidelines and policy briefs to inform nexus practices. My research will align with this larger project and is outlined following a concise problem statement.

1.2 Problem statement

Urban spaces are key loci of sustainability challenges and solutions (Derickson, 2018). For this reason, there is a need for enhanced urban resilience to mitigate and leverage shocks (CCT, 2019). There is, however, a gap between advocacy for resilience and the practice of governing for resilience (Weitz *et al.*, 2017; Mguni & van Vliet, 2020). The WEF Nexus framework has been proposed as a supporting instrument for resilience, with cities spearheading these transformation processes (Shlör *et al.*, 2018). There is, however, a gap between literature/policy ambitions and the practical adoption of the nexus governance approach, with practical implementation lagging far behind policy ambitions (Weitz *et al.*, 2017; Schlör *et al.*, 2018; Newell *et al.*, 2019; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021). In this regard, the WEF Nexus is under-explored practically, socially, and in terms of governance (Weitz *et al.*, 2017; Schlör *et al.*, 2018; Newell *et al.*, 2019; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021).

1.3 Rationale for this research

Given the gap in nexus literature concerning social, practical and governance considerations, my research will be dedicated to investigating the practical implementation of an existing nexus approach at the V&A Waterfront from a practical, social, governance, and social-ecological resilience perspective. The V&A Waterfront is one of six neighbourhoods researched in the larger project, based on the assumption that nexuses materialise differently depending on socio-spatial and institutional contexts.

The more extensive study explores how WEF domains shape and are shaped by specific place-based contexts including livelihoods, economic, ecological, and technical conditions. The reasoning behind this is to assess the spatially varied vulnerabilities to interrelated WEF crises and the resilience capacity of local stakeholders to mitigate, cope with, adapt to, and learn from crises.

The V&A Waterfront's context is of interest because of the scale, mix of property types, and, most importantly, its existing and operational nexus resource analysis and governance approach (GCX, 2020). The nexus approach at the V&A is made possible by the incorporation of Global Carbon Exchange (GCX), a private environmental sustainability company, into the practical and governance realm of the V&A Waterfront (GCX, 2020).

Driven by the desire to be the greenest precinct in South Africa, the V&A Waterfront aligns all existing and new buildings with the Green Building Council South Africa (GBCSA) Green Star Certification (GCX, 2020). Driven by this vision, the V&A Waterfront partnered with GCX in 2018 to achieve its Corporate Social Investment (CSI) and Sustainability goals by providing critical sustainability insights and strategies to address critical challenges (GCX, 2020). Thus far, the results have been impressive, allowing the V&A Waterfront to be on the fast track to achieving its goals with increased data confidence and actionable interventions.

GCX offer innovative sustainability tools and expertise, sub-categorised into GCX Digital, GCX Climate, and GCX Zero Waste (GCX, 2020). GCX Digital provides real-time, on-demand, meaningful data analytics of resource flows (water, energy, and waste), something made possible by the GCX DASH- (GCX, 2020). GCX Climate uses data-driven tools and expertise to assist businesses in transforming their operations into sustainable enterprise (GCX,

2020). Finally, GCX Zero Waste assists businesses in redefining their waste value-chains while assisting them in sending zero-waste to landfills with their expertly designed waste management systems (GCX, 2020).

The V&A Waterfront's partnership with GCX offers an interesting case study of a WEF Nexus approach implemented in practice, with the physical analysis of resource flows (enabled by GCX-DASH-²) acting as a catalyst for improved decision-making, governance, and behaviour while also having social and practical repercussions. All of these effects combined have an impact on the ability to govern for SES resilience. Although GCX analyses water, energy, and waste, I believe it is still suited to the nexus literature because a lot of waste is the problematic remnants of unused food³ (CSIR, 2021).

Therefore, the intention of my thesis is to come to grips with the social and governance complexities, practicalities, and realities of the nexus approach at the V&A Waterfront, while considering the role of GCX in this approach. These complexities will be investigated with a continued consideration for resilience, as the nexus approach is studied concerning what it has to offer in terms of the capacity to govern for resilience.

The V&A Waterfront serves as a well-suited case study that aligns with the more extensive study of the nexus in Cape Town. It will represent valuable context-specific information, contributing to the broader multi-institutional WEF Nexus research project mentioned earlier.

1.4 Research questions

Main research question: How does the nexus governance⁴ approach at the V&A Waterfront enhance the capacity to govern for resilience in the Cape Town context?

- How is the WEF Nexus framework understood, with particular reference to the practical, social, and governance (PSG) implications?

² Discussed in Chapter 4.

³ According to a CSIR publication (2021), 45% of available food supply in South-Africa is wasted.

⁴ Here specifically referring to WEF nexus governance approach, or simply nexus governance as the practical implementation of the WEF Nexus framework in a given governance sphere.

- What governance and management systems have been developed by the V&A Waterfront, including the GCX system?
- What are the practical, social and governance implications of the nexus governance approach at the V&A Waterfront, and do these implications hold any potential for enhanced resilience in the Cape Town context?

1.5 Chapter Outline

Chapter 1 sets a brief introduction to the research, providing background information, setting the context, and drawing connections between the problem statement, the rationale for this research, and the research questions. Chapter 2 is dedicated to discussing the transdisciplinary research methodology and related methods adopted in this study, providing reasoning and justifications for the research approach in relation to generating the required information.

Part A: Systems Knowledge

Chapter 3 undertakes a literature review, further exploring concepts introduced in Chapter 1 to generate systems knowledge regarding the WEF Nexus framework. Here the WEF Nexus literature, SES resilience literature and Nexus Governance literature are reviewed for their importance concerning the problem statement and research questions.

Part B: Target Knowledge

Chapter 4 presents the research findings concerning each research question, generating target knowledge pertaining to an example of how resources should be governed for increased resilience.

Part C: Transformation Knowledge

Chapter 5 further discusses the findings chapter with specific emphasis on the resilience implications of the findings as well as how these implications apply to the Cape Town context and its necessity to transform. In Chapter 6, the research project is concluded by outlining the main arguments in relation to each research question while also offering recommendations for future research.

Chapter 2: Research Methodologies

2.1 Research approach

This study uses a transdisciplinary (TD) research approach. Transdisciplinary research, according to Lang et al. (2012:27), can be described as follows:

Transdisciplinarity is a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge.

It, therefore, represents a methodology of doing science with society, involving engagement with non-academics and practitioners, as well as academics in other fields, in enabling problem formulation, analysis, and transformation (van Breda & Swilling, 2018).

Transdisciplinarity is seen as a beneficial, and some may argue necessary, way to research complex societal issues, such as sustainable development challenges more broadly, and more specifically, issues such as how to manage resources interrelatedly for the sake of increased resilience. This is because TD research yields practically applicable outcomes in social and/or environmental contexts rather than dealing with theoretical and conceptual quarrels in isolation, allowing for a degree of change in those contexts (Fazey *et al.*, 2018). Since the intention of this study was to test the practical applicability/ of a theoretically claimed solution to a transdisciplinary identified problem, TD was identified as the most well-suited methodology/research approach for this research project.

2.1.1 Transdisciplinary research approach

In designing the research approach the work of Pohl and Hirsch Hadorn (2007), van Breda and Swilling (2018), as well as Henshilwood, Swilling and Naidoo (2019) provided the necessary methodological guidance concerning the directionality of this study. *Principles for Designing Transdisciplinary Research* by Pohl and Hirsch Hadorn (2007) proved especially beneficial for understanding the requirements for a study to be regarded as TD.

According to Henshilwood, Swilling and Naidoo (2019), TD research involves three actions:

- Identifying and structuring the problem
- Co-convening/creating solutions assessment
- Applying and testing new knowledge (solution)

Furthermore, according to Pohl & Hirsch Hadorn (2007), TD research needs to adhere to four requirements which surface in the “identifying and structuring the problem” phase. These requirements include:

1. Come to terms with complexity
2. Consider diversity
3. Develop case-specific and practice-orientated knowledge that can be transferred
4. Oriented towards what is perceived to be the common good

It is, however, not necessary to meet all these prerequisites, for Pohl & Hirsch Hadorn (2007) warn that an attempt at overloading the research project with requirements can have a stagnating effect. To prevent this, the authors offer four principles that should inform the methodological design of the research project, inevitably leading to adherence to the four requirements discussed. These are:

1. Reduce complexity by specifying the need for knowledge and identifying those involved
2. Achieve effectiveness through contextualisation
3. Achieve integration through open encounters
4. Develop reflexivity through recursiveness

In line with suggestions made by Pohl & Hirsch Hadorn (2007), this research project has been guided by these four TD principles to decide on appropriate research methods. This process is outlined in what follows.

2.1.1.1 Reduce complexity by specifying the need for knowledge and identifying those involved

Two means of adequately reducing complexity are to specify the need for knowledge (stemming from the problem) and to identify relevant practice-oriented problem-solving people for the sake of generating this decided-on knowledge.

TD research is aimed at generating three sets of knowledge, namely (Henshilwood, Swilling and Naidoo (2019:21):

- Systems Knowledge: concerning the current state of the system
- Targeted Knowledge: concerning the desired end state of the system
- Transformational Knowledge: concerning the evolution from the current state to the desired state.

In this particular study, the researcher is concerned with generating Systems Knowledge in Part A (concerned with how resources are currently governed in ways that are not optimal for resilience), and Targeted Knowledge in Part B (concerned with how resources should be governed for the sake of increased resilience). Although Transformational Knowledge is to some extent touched on (presenting a practical example of how a governance structure evolved from the current state to the desired state), it is more directly dealt with in the larger study of which this project forms part.

2.1.1.2. Achieve effectiveness through contextualisation

TD research is aimed at generating knowledge that can help solve socially and/or environmentally relevant issues. This makes it necessary for researchers to pay attention to the “impact-related contextualisation of a project” (Pohl & Hadron, 2007:21). Paying attention to impact-related contextualisations, on the one hand, requires a thorough assessment of the state of knowledge, as well as social practices and issues in the real world. This, according to Pohl & Hadron (2007:21), includes “...existing technologies, regulations, practices, power relations and potential for change”. Contextualisation, on the other hand, calls for the proper embeddedness of the researcher in the most contemporary scientific context allowing research efforts to be linked with the most relevant disciplines and scientific approaches (Yin, 2011). This principle is especially important when problems are identified and structured.

This research project adequately adheres to the principle of contextualisation because the identification of a research problem stemmed from a thorough assessment of the state of knowledge and practices in the real world, as well as via the embeddedness of the researcher in the most contemporary scientific context. This was enabled via an up-to-date literature review, the situatedness of the researcher in a research consortium of three universities and two intermediaries, as well as practitioner workshops with scientists (from various fields) and practitioners who conduct work in fields and contexts related to the context researched here.

2.1.1.3 Achieve integration through open encounters

Open encounters and communication between disciplines and various social groups are the most important principles for successful collaboration, as required for TD research (Pohl & Hadron, 2007). Open encounters and communication involves being aware of one's perspective as one among many while simultaneously accepting the viewpoints of collaborators as equally important.

The way in which this collaboration and integration between disparate perspectives manifests can take various forms and will eventually inform the degree to which particular perspectives come to light, as well as the relationship established between different perspectives. The collaborative and integrative approach adopted in this research project will be discussed in section 2.2.2 in relation to constructing a TD design method.

2.1.1.4. Develop reflexivity through recursiveness

Because an attempt to fulfil all four TD research requirements (discussed above) can lead to stagnation, there is a need for recursiveness/iteration. According to Pohl & Hirsch Hadorn (2007:22) recursiveness/iteration "...implies foreseeing that project steps may be repeated several times in case of need" to allow for corrections based on experimentation and learning. This is necessary in all three phases of the research process and involves a level of reflexivity in identifying underlying assumptions that, in turn, allows for consolidations and correction in favour of an improved research project.

The research project involved a high degree of recursiveness in all three of its phases. This was especially the case regarding identifying and structuring the problems and co-convened/created solutions assessment as it involved high levels of reflection stemming from communication

and collaboration with the study supervisor, PhD students in the research consortium, and practitioners in the field (WCEDP, Local Governments for Sustainability (ICLEI) Africa). These interactions led to the identification of a case study, namely the V&A Waterfront, which had already implemented, perhaps unknowingly, the solution we assessed as most fitting (practical nexus-governance) for the problem we identified (siloed approach to resource governance and accompanied lower levels of resilience). Applying and testing new knowledge (solution) also involved iterative processes as the researcher worked with the V&A Waterfront on including food flows in the system to optimise its functionality.

2.2 Research design and methods

TD research is, by nature, context-specific research, meaning there are no universally applicable TD research methods. Instead, TD allows for a holistic leap of imagination, allowing pluralistic approaches combining research methods to involve a diverse set of local actors (Henshilwood, Swilling & Naidoo, 2019). Following this pluralistic approach, this research project will be conducted using a mixed method approach, including both non-empirical (literature review) and empirical (TD design process, case study [semi-structured interviews & field visits]).

2.2.1 Literature review

The first method adopted within this research project was a literature review. The process of conducting literature analysis essentially began during the researcher's BPhil (Sustainable Development) studies. During this year, a large body of literature on Complexity Theory and Systems Thinking, Sustainable Cities, Renewable Energy, Food System Transitions, Globalisation, Governance, and Development were explored. It was not until writing the proposal for this project that an in-depth analysis of literature on the Water-Energy-Food (WEF) Nexus began. This allowed the researcher to develop a high-level understanding of the concept — both situating the researcher within current debates and allowing for gaps to be identified (Yin, 2011).

a) Search process

Searching for literature of relevance to the study was conducted predominantly using the J S Gericke Library (Stellenbosch University) as well as its online website. To learn about the most effective ways to conduct literature searches, the researcher attended a seminar at the J S

Gericke Library called “Improving your literature search strategy”. This allowed for a thorough understanding of how to conduct advanced literature searches and deal with the gathered literature in a concise manner conducive to proper analysis in a structured way.

Keywords that were used during literature searches include:

- Water, Energy & Food (WEF) Nexus
- Food, Energy & Water (FEW) Nexus
- Complex Adaptive Systems (CAS)
- Social-Ecological Systems (SES) Resilience
- Urban Resilience
- Urban Metabolisms
- Material Flow Analysis (MFA)
- Nexus Governance
- Rethinking Governance

These keywords were searched on different e-databases, but predominantly on the J S Gericke Library (Stellenbosch University) online website — a platform that gives access to a plethora of academic databases and journals. Using the advanced search tab on the library website different combinations of the selected keywords were searched. For example: combinations like ‘Complex Adaptive Systems or Urban Resilience and WEF Nexus’ or ‘Governance and Urban Resilience and WEF Nexus’ were searched. Various combinations were used to yield a diverse set of results. Using such combined searchers provided methodological substantiation for the combined application of SES and Urban Metabolism (supported by MFA) as a methodological foundation for researching the WEF Nexus. This is further substantiated with the literature review and the findings chapter, where the paired use of SES and urban metabolisms in dealing with nexus issues is further brought to light

Grey literature is described by Fieuw (2011:10) as “...a body of materials that cannot be easily found through conventional channels such as publishers but remain highly original”. Grey literature on the WEF Nexus was accessed via websites such as “The Water, Energy & Food Security Resource Platform” and “WEF Nexus in Africa Initiative”. Government policy documents such as the National Development Plan (NDP), and the Integrated Resource Plan

(IRP) were downloaded directly from South African Government Websites. Other websites that proved beneficial for understanding the context were the V&A Waterfront's website as well as GCX's website.

More literature also came forward when reading primary sources. References were followed up from the bibliography of primary sources, searched on the library website, and analysed to form part of the literature review.

b) Structuring of literature

Selecting relevant literature was approached by means of first downloading files that seemed relevant based on the title to a folder called WEF Nexus Literature. From here, reading abstracts and conclusions led to the formation of thematic folders within the WEF Nexus Literature folder, while irrelevant literature was discarded. This process led to the formation of seven subfolders within the WEF Nexus Literature folder, namely: WEF Nexus, Complex Adaptive Systems (CAS), Urban Resilience, Nexus Governance, Case Studies, Urban Metabolism (MFA & Modelling) and Other. After placing all relevant files in a thematic subfolder, a red tag would be placed on each file (representing unread); once they were read, the red tag was replaced with a green tag (representing read). This proved to be a valuable system as subfolders later corresponded to the thematic structuring of the literature review, while also providing a way for the researcher to adequately manage literature spanning wide themes.

c) Data analysis

When process for analysing the literature involved having a tab on the computer for the file being read, while another tab next to it contained a blank page with the name of the article or book being read as a heading. While reading through the file, highlights and comments would be made in the file itself, and any ideas or summaries were typed on the blank page. This process allowed for any themes, connections, and/or gaps to be noted immediately and accessed easily, allowing for the complex interaction between themes to emerge. It also provided a system for revisiting summarised ideas of any file, while highlights and comments pointed towards important content.

2.2.2 Transdisciplinary design process

The consortium of which this research project forms part is, by nature, a TD design. This is because it involves two intermediary governance institutions (Western Cape Economic Development Partnership [WCEDP]⁵ & ICLEI Africa⁶), and three Universities (Stellenbosch University [SU], University of the Western Cape [UWC] & Utrecht University [UU]) collaborating on research for a project called “Nexus Water, Energy and Food to Increase Resilience in the Cape Town Metropolitan Region”. These three universities each consist of a team of MPhil, PhD, Postdoc researchers and Professors spanning a diverse set of disciplines, all collaborating on an overarching project via their individual projects. These individual projects were developed from objectives in the larger study and are also collaborated on throughout the research project.

While conducting research, the researcher also worked at the WCEDP as an embedded researcher, working with programme lead Amanda Gcanga (later on Jessica Wilson) on any project-related matters. This allowed for further insight into the daily operations of an intermediary governance institute that works closely with the City of Cape Town (CCT), expanding the disciplines influencing the research approach.

a) Stakeholder identification and collaboration approach

Since this research project formed part of a larger research project, the researcher entered an already established consortium of three universities and two institutions who cooperatively identified academics and stakeholders to collaborate on the overarching project. These

⁵ The WCEDP is a public benefit collaborative intermediary organisation that supports diverse stakeholders to harness each other’s energy, knowledge and resources for collective impact and change (EDP 1, 2021).

⁶ ICLEI – Local Governments for Sustainability is a global network working with more than 2 500 local and regional governments committed to sustainable urban development. Active in 125+ countries, we influence sustainability policy and drive local action for low emission, nature-based, equitable, resilient and circular development. Our members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability (ICLEI Africa, 2022).

academics, including the researcher, were selected by their host university, while other stakeholders (practitioners, government employees, and experts in water, energy and food-related topics) were collaboratively selected by all five consortium institutions. The mapping of all academics and stakeholders, as well as their respective disciplines involved in the project, can be found in Appendix B — Stakeholder and Discipline Mapping.

To construct Appendix B, the Pohl and Hirsch Hadorn (2007) tool for identifying the actors and disciplines necessary to satisfy the requirements of TD was adapted to reflect the multitude of disciplines involved in this project. After analysis of Appendix B, it is clear that the research project reflects the requirements for TD research. Although stakeholders were already identified by the consortium research project, the researcher had to establish how collaboration with these stakeholders, for the sake of the V&A Waterfront research project would manifest.

To design the collaborative approach, Rossini and Porter's (1979) Socio-cognitive framework for collaboration was used. The framework outlines four different models for collaboration in TD, namely, common group learning, modelling, negotiation among experts, and integration by leader. Out of these four, the common group learning and integration by leader models seemed most suited to the objectives of the research project. Although the common group learning framework would have allowed for equal integration of various sources of knowledge, it was difficult to implement in practice due to the wide range of academics and stakeholders involved, each with individual schedules and projects. For this reason, the integration by leader framework was selected, allowing for selective inputs based on emerging demands and stakeholder availability. This turned out to be a very productive form of stakeholder collaboration, as emerging demands would be posited to stakeholders based on their respective expertise and schedule, allowing for an efficient and adaptable form of collaboration.

c) Applying transdisciplinary research design

The first point of transdisciplinary collaboration began where through collective literature and policy analysis and practitioner workshops with contextually experienced stakeholders (practitioners & government), the research problem was identified and structured. The problem identified was a lack of practical ability to govern resilience in the Cape Town context — a severe problem for the CCT regarding practically achieving what is set out in their Resilience Policy.

Expanding/persisting with these collaborative networks in parallel with the literature analysis, the second TD action involved co-convening solutions assessment. This is where the WEF Nexus governance approach was identified as a potential supporting tool for resilience. Identifying the WEF Nexus governance approach led to the construction of the overarching research project, which has the following research objectives:

- To elaborate upon the multi-dimensional character of WEF Nexuses
- To understand and assess place based WEF Nexuses
- To understand and assess the multi-level, cross-domain and territorial governance of urban WEF Nexuses
- To develop recommendations for coordinating resilience strategies

Although the WEF Nexus was identified as a possible enabling tool for resilience, another problem collectively identified (and eventually researched in my project) was the lack of practical examples of nexus governance. This problem was identified during a practitioner workshop⁷ called “What is Nexus Workshop” (discussed in the findings chapter), revolving around academic and practitioner (see Appendix C) understandings of the WEF Nexus in practice, specifically in the Cape Town context. The workshop revealed the WEF Nexus to be underdeveloped in practice, making it necessary to identify practical examples of nexus governance to inform the government.

Following the recursive nature of TD research, the necessity to identify a practical example of nexus governance led to another solutions assessment, which was to find an existing practical example of nexus governance. This led to the identification of the V&A Waterfront as a practical example of nexus governance — a location that is, in essence, applying and testing the solution identified in the TD process. Because of this, the V&A Waterfront was selected as one of six neighbourhood case studies to be investigated in the overarching research project. I was subsequently appointed project lead for the V&A Waterfront case study.

⁷ The practitioner workshop was facilitated by the WCEDP and took place at the Sustainability Institute.

Throughout the process of conducting research at the V&A Waterfront, support was given to the researcher via continued collaboration with consortium members, as well as interactions with stakeholders via practitioner workshops. The interactions and collaborations enabled a continued revision of research questions considering finding the most contextually valuable information.

2.2.3 Empirical data: V&A Waterfront case study

a) Semi-structured interviews & field visits

Semi-structured interviews, see (Appendix D), were a crucial methodological approach used in this research project, especially during the ‘testing new knowledge phase’. This is because theoretical claims that a nexus governance approach causes resilience-enhancing effects had to be practically tested. Since the V&A Waterfront had an already operationalised nexus governance approach, it became necessary to interrogate the actual qualitative effects of the approach, and semi-structured interviews were found to be the best method to do so (Yin, 2011). Semi-structured interviews allow for deep insights into the daily operations of users of the system, making it possible to explore how the dashboard benefitted or disadvantaged them and their department while also getting a sense of their perceptions and knowledge about the system.

b) Interview preparations

Interview preparations involved doing as much research about both the V&A Waterfront and GCX individually, as well as the integration of GCX and their GCX DASH- into the governance realm of the V&A Waterfront. This was done parallel to the literature analysis to get a more precise idea of what implications are expected from a nexus approach. This led to the construction of an interview guide revolving around the practical, social, and governance implications of the system. Exploring effects as they emerged in these three spheres was found to be critical for eventually testing if these implications hold any impact on the ability to govern for resilience. The interview guide was comprised of three themes — practical, social and governance implications — all of which were open for discussion. Under each theme some guiding questions were created. In addition to the three themes any discussions veering towards other themes were welcomed, as any emerging information related to the context and system was seen as potentially valuable. This allowed for a good balance between finding precise

information and allowing for the natural flow of the conversation to lead to any emerging information.

c) Data collection

Data collection in all cases began with a signed consent form from participants giving the researcher permission to interview for the research project. Out of the nine interviews, seven were conducted in person, while two were conducted over Microsoft Teams. In all cases, permission was granted to record the interview on the researcher's phone. This enabled the researcher to take as few possible notes during the interview because the whole conversation would be transcribed immediately after the event using Otter AI. The researcher's full attention was given to the unfolding conversation as well as any non-verbal or gestural signs pointing toward further topics (Yin, 2011). In all cases, an hour-long interview was scheduled for as early in the day as possible enabling the immediate transcription and analysis of data after the event. This also allowed for any emerging occurrences to be capitalised on, such as the day-long site visit of the V&A Waterfront after an interview with Iekraam Kariem and Lee-Harvey King. The Interview Mapping can be found under Appendix E.

d) Data analysis

Interviews were transcribed immediately after the conclusion of a given interview using Otter AI. While the transcription was being processed, the researcher would write down his own impressions of the interview, allowing for reflection on any non-verbal and noteworthy occurrences that may not have been picked up by the recording. Once this process was completed the researcher would begin to edit the transcriptions they are not always perfectly transcribed through Otter AI. As the editing process occurred, noteworthy sentences would be highlighted, while key points that need clarification or further research were noted. Once this process was complete, the researcher would again read through the edited and highlighted transcription making notes, constructing themes, and copying any relevant sentences/speech into a blank document with the relevant interview as the title. This proved to be a practical approach, as summarised versions of interviews with constructed themes enabled efficient writing of the findings chapter.

2.3 Limitations of the research

It would be an oversimplification to claim that a 20-month research project can adequately capture all the complex subject matter in this thesis, especially regarding how the findings apply to the larger Cape Town context. Fortunately, this thesis makes up one of six case studies in Cape Town researched in the more extensive research project. This means the applicability of the findings for the Cape Town context will be scrutinised in great detail by consortium researchers.

Another possible limitation to the study include the fact that at the V&A Waterfront: i) WEF (including waste) systems may be weighted equally, yet partially due to the fact that ii) within the scale of the study there is limited administrative prevalence of different sectors (water, energy, food) as well as iii) scales of governance (provincial and national government). This means there are limited political and institutional interferences inhibiting cooperation compared to if the study was done at a national scale.

Part A: Systems Knowledge

Chapter 3: Literature Review

3.1 Introduction

Studying the water-energy-food (WEF) nexus is essentially a study of complex social-ecological systems (SES) as it encompasses both ecological systems and how they relate (e.g. WEF), social systems and how they relate (e.g., governance), as well as how social and ecological systems relate with one another and the larger systems in which they are embedded (Schoon & Van der Leeuw, 2015; Hammond, 2017; Preiser, Biggs, De Vos & Folke, 2018; Newell *et al.*, 2019). SES are not seen as merely social plus ecological systems, but rather as systems centred on feedbacks between ecological and social system components that are found at the interface between ecological and social systems. This understanding is represented in Figure 3.1.

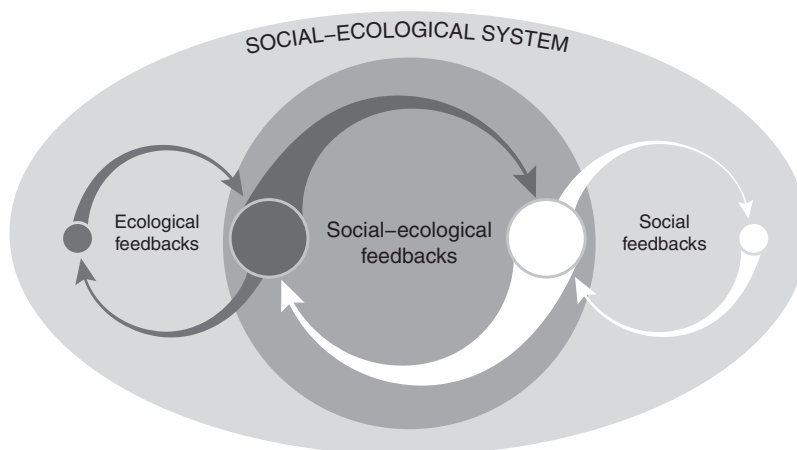


Figure 3.1. Functioning of social-ecological systems

(source: Biggs *et al.*, 2015:8)

SES research is a prevalent and growing field of study that essentially views the relationship between humans and nature (SES) as complex adaptive systems (CAS) (Schoon & Van der Leeuw, 2015; Folke, 2016). Emerging from the study of CAS is complexity thinking and systems thinking, which has formed a critical part of studying SES since their framing as CAS (Preiser *et al.*, 2018).

Studying the WEF Nexus as SES is indeed prevalent in the literature and is confirmed by Newell *et al.* (2019), who wrote a 40-year review of WEF literature and Urbinatti (2020), who writes about the centrality of systems thinking in nexus thinking. Newell *et al.* (2019:6) write: “As the nexus consists of individual components interacting in unforeseen ways, systems thinking dominated the modelling approaches”.

For these reasons, my research will adopt a CAS perspective in viewing the multidimensional nature of social and ecological interaction regarding the WEF Nexus. Urban Metabolism (UM) represents a crucial interdisciplinary boundary concept (Magoni, 2017; Newell *et al.*, 2019) and will be relevant throughout the study. UM will assist in describing the metabolic flows of resources through the V&A Waterfront, so as to describe the workings of GCX DASH-, and will be deployed in tandem with literature on WEF Nexus governance (Newell *et al.*, 2019) as well as SES resilience (Magoni, 2017).

However, most notable for this study is the concept of resilience — a prominent feature of research on SES (Folke, 2016). Resilience is an important concept for this research because the WEF Nexus is studied here in relation to SES resilience and for the sake of acting as a supporting instrument for urban resilience (CCT, 2019). The assumption is that a practically viable nexus approach increases the ability to govern for resilience (Schlor *et al.*, 2018; Mguni & van Vliet, 2021). My research will apply the same thinking to a local scale, namely the V&A Waterfront, as it attempts to come to grips with the resilience possibilities opened by a practical WEF Nexus governance approach.

The literature on WEF Nexus naturally becomes the first significant body of literature of relevance to the study (Weitz *et al.*, 2017; Schlör *et al.*, 2018; Newell *et al.*, 2019; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021). It is responsible for shaping the context and will be the main thread weaving throughout the other central literature.

The broader view of nexus is framed through the conceptual lens of resilience, making SES resilience, investigated from an ecosystem services (ES) resilience perspective (Biggs *et al.*, 2015) the second main body of literature relevant to the study (Schlor *et al.*, 2018; Mguni & van Vliet, 2021).

The WEF Nexus approach is essentially a matter of governance, with governance in this context referring to the structures and systems by which an organisation/government manages its operations, including resources management (Foran, 2015, Weitz *et al.*, 2017; Urbinatti *et al.*, 2020). By investigating how such an approach materialises in practice, the literature on governance becomes the third body of literature relevant to the study. The positioning of the governance literature comes from my understanding and focus on governance being informed by SES and resilience thinking but situated in the context of WEF Nexus.

Structuring my literature review in such a way will both highlight gaps to formulate all the research objectives/questions while at the same time providing answers to research question one. In summary, using these three concepts — WEF Nexus, SES resilience, and governance — with one another is based on the reasoning that a nexus approach is needed for increased urban resilience, and the success of a nexus approach is linked to governance. Next, I will outline the relevant literature on WEF Nexus, SES resilience as well as governance, discussing them in isolation and in relation to one another.

3.2 WEF Nexus literature

Literature on the WEF Nexus is a rather new but fast-growing body of literature with the first publication appearing in 1988 (Cohen & Allsop, 1988). 2016 alone saw 213 publications of the total 1 399 publications identified in Newell *et al.*'s (2019) 44 year review. Newell *et al.* (2019) evaluate two broad categories of WEF Nexus literature namely: “General WEF Nexus literature” and “Urban WEF Nexus literature” — an emerging community focused on WEF systems at the urban scale (Newell *et al.*, 2019:4). My research falls within the latter, an adolescent and small category with only 213 publications of which more than 80 percent were published after 2010 (Newell *et al.*, 2019).

3.2.1 Conceptual clarity

There is still uncertainty about what the term ‘WEF Nexus’ represents (Urbinatti *et al.*, 2020). Throughout the literature on the WEF Nexus writers express frustration at the lack of a clearly defined concept, yet as it will become clear, the ambition to construct a clearly defined concept is an unfounded and unrealistic given the complex and context-specific nature of SES. According to Katz, Padowski, Golsdby, Brady and Hampton (2020), conceptual clarity is required for the sake of better identifying what is and what is not a WEF Nexus problem. Katz

et al. (2020:1) write: “Without this conceptual clarity, it can be difficult to defend the position that FEW innovations will produce desired outcomes and avoid unintended consequences”.

It is clear that this conceptual clarity is not yet achieved. Smajgl *et al.* (2016) explain how WEF Nexus studies, conferences, and approaches differ in scope, objectives, and understanding of either interdependencies or causal factors. Benson, Gain, and Rouillard (2015) agree, arguing that nexus conceptualisations are far from unified and vary according to geopolitical context, empirical focus, and focus/form of sectoral integration.

Although many argue for the need to have a rigid conceptualisation of the WEF Nexus (Katz *et al.*, 2020; Urbinatti *et al.*, 2020) others warn against this arguing instead for fluidity depending on goals, contexts, and sector objectives stating that rigidity could stunt impacts (Märker, Venghaus & Hake, 2018).

What is clearer than the debate about conceptual rigidity versus flexibility is that better cooperation/collaboration is required; it is, however, less clear how this cooperation can and should manifest as well as the tools, techniques, and frameworks required to make the proposed form of cooperation practically possible. For example, some authors propose complete sector integration (Märker *et al.*, 2018), while others call for better collaboration among sectors, scales, policy-makers, researchers, and actors (Weitz *et al.*, 2017; Märker *et al.*, 2018; Urbinatti *et al.*, 2020).

The debate about conceptual clarity, or rather, possibility, therefore, becomes a debate about proposed forms of cooperation. I will return to this particular point when investigating the different proposed forms of possible cooperation – as either collaboration versus integration into a WEF Nexus. Before doing so I will discuss the emergence of the nexus debate, its call for cooperation across sectors and scales, as well as the need for analytical tools, and interdisciplinarity.

Although my research will not grapple directly with conceptual clarity, I believe valuable conceptual contributions, in the form of guiding principles and not unified conceptualisation, can be drawn from my qualitative case study analysis of how an existing nexus approach manifests in practice

3.2.2 The emergence of the nexus debate

The first organisation to bring the nexus debate into the international arena was the World Economic Forum. At their annual meeting in 2008 the WEF called for a better understanding of the interlinkages among water, energy and food (Smajgl *et al.*, 2016). This discussion was, however, water-centric with water security explored in relation to food and energy systems, human security challenges, and economic growth (Smajgl *et al.*, 2016).

Further development of the WEF Nexus concept was sparked by the Bonn 2011 Conference: ‘The Water, Energy and Food Security Nexus Solutions for the Green Economy’ (Martin-Nagle, Howard, Wiltse & Duncan, 2012). At this conference various international stakeholders — including the International Food Policy Research Institute (IFPRI), the WEF, the World Wide Fund for Nature (WWF), and more than 50 contributing partners from around the world — met to discuss the importance of a nexus perspective for the following resource security and sustainability opportunities/challenges (see Table 3.1).

From the challenges outlined in Table 3.1 an understanding of the nexus framework emerges which will be used throughout this study (Martin-Nagle *et al.*, 2012:25):

A nexus perspective increases the understanding of the interdependencies across water, energy, food and other policies such as climate and biodiversity. The nexus perspective thus helps to move beyond silos and ivory towers that preclude interdisciplinary solutions. It opens the eyes for mutually beneficial responses and the potential of cooperation. We need to think and act interlinked to realise direct and indirect synergy potentials.

Table 3.1. Key opportunities/challenges addressed by a nexus perspective

Importance of a nexus perspective for the following resource security and sustainability opportunities/challenges:	
Increased productivity and efficiency of resources	Decoupling economic development from resource use (Hoff, 2011; Martin-Nagle <i>et al.</i> , 2012).
Waste as a resource in multi-use systems	Cross-sectoral management can allow waste and by-products to be turned into resources for other products and services, boosting overall resource use efficiency (Hoff, 2011).
Stimulating development through economic incentives	Economic instruments ⁸ are required to stimulate investment towards innovations that help improve resource use efficiency ⁹ (Hoff, 2011).
Governance, institutions and policy coherence	Multi-level governance and collective action requires enabling conditions for horizontal and vertical policy coherence ¹⁰ (Hoff, 2011).
Benefiting from productive ecosystems	A nexus perspective provides opportunities for improved ecosystem investment and management; a critical task given our dependence on these ecosystem services (Hoff, 2011).
Accelerating access (integrated poverty alleviation and green growth)	By sustaining our ecosystem services via a nexus approach we are in effect maintaining our life support system. The poor depend on these ecosystem services most directly, making it crucial to accelerate access to resources and to sustain their functioning in a coordinated way (Hoff, 2011).
Capacity building and awareness raising	With a cross-sectoral approach comes increased complexity, a factor which needs to be addressed via social learning and capacity building ¹¹ (Hoff, 2011; Martin-Nagle <i>et al.</i> , 2012).

⁸ e.g., pricing of resources and ecosystem service (Hoff, 2011)

⁹ “A nexus approach can also help to avoid ‘sunk costs’, i.e., investments that lock development into non-sustainable pathways” (Hoff, 2011: 5).

¹⁰ Includes institutional capacity building, change agents, political will, and awareness-raising (Hoff, 2011).

¹¹ “Awareness raising (and supporting governance) can promote sustainable lifestyles and consumption patterns. New and targeted trans-disciplinary nexus research, fully integrated assessments of water, energy and food at all scales, and Green Economy metrics and indicators will enable quantitative trade-off analyses” (Hoff, 2011: 6).

Importance of a nexus perspective for the following resource security and sustainability opportunities/challenges:	
Towards a Green Economy	Nexus can assist in creating an economy that results in improved social equity and human well-being, while significantly reducing ecological scarcities and environmental risks (Hoff, 2011).

(adapted from Hoff, 2011; Martin-Nagle *et al.*, 2012)

3.2.3 A call for cooperation across sectors and scales

This particular understanding highlights the need for cooperation, including cross-sector cooperation (water, energy, food), cooperation across multiple levels of state (national, provincial, local), cross-domain cooperation (public, private, and civil society) as well as interdisciplinarity (Martin-Nagle *et al.*, 2012). When it comes to cooperation, spatial and governance scales and sectors are identified as important in many WEF Nexus studies, but consideration of multi-scale and multi-sector interactions is not common (Foley, DeFries, Asner, Barford, Bonan, Carpenter, Chapin, Coe, Daily, Gibbs, Helkowski, Holloway, Howard, Kucharik, Monfreda, Patz, Prentice, Ramankutty & Snyder, 2005; Newell *et al.*, 2019; Mguni & van Vliet, 2021).

Instead, Newell *et al.* (2019) found that most studies were either sector-specific (e.g., concentrated on water), not concerned with all levels of state (national, provincial, local), and/or not focused on all cross-domain actors (public, private, and civil society). Although my research does not contribute to this gap in its full complexity, it will eventually contribute to a holistic understanding of scale and sectors as it links up with the larger study of which it is a part. My research will contribute to a holistic understanding because the objectives of the larger study involve investigating six neighbourhoods, of which the V&A Waterfront is one. Additionally, the larger study will consider influential factors pertaining to multiple levels of state (national, provincial, municipal), cross-sectorial factors (water, energy, and food), as well as cross-domain governance factors (civil society, public, private).

The contribution of this research lies in the more granular analysis of a neighbourhood-level, cross-sector (water, energy, waste) system that involves civil society-private (more precisely private-landlord-tenant) cooperation and coordination. Coordination and cooperation between usually unrelated/uncooperative actors/governance units is the responsibility of GCX DASH— a quantitative information tool that allows for many practical, social, and governance repercussions, the likes of which need to be analysed qualitatively.

3.2.4 Analytical capacity as a catalyst for cooperation and coordination

An important point is raised in Table 3.1 with regards to “Capacity building and awareness raising”. As Hoff (2011:6) writes:

Awareness-raising (and supporting governance) can promote sustainable lifestyles and consumption patterns. New and targeted trans-disciplinary nexus research, fully integrated assessments of water, energy and food at all scales, and Green Economy metrics and indicators will enable quantitative trade-off analyses

WEF Nexus challenges, therefore, necessitate a means of analysis that can capture complex systems component interactions, reactions, and ripples (Smajgl *et al.*, 2016; Newell *et al.*, 2019). One proposed means to do so is through the concepts, perspectives, and analytical tools emerging from the field of Urban Metabolism (UM) — a field used to explain the physical material flows of resources (Newell *et al.*, 2019).

GCX DASH- represents such an analytical tool; it tracks physical material flows of shared resources throughout the V&A Waterfront. UM will therefore be used in this study as a boundary concept to communicate the quantitative aspects of GCX DASH- (Newell *et al.*, 2019). Newell *et al.* (2019:12) describe boundary concepts as:

Useful devices to leverage respective disciplinary expertise, boundary objects are malleable concepts that enable communication across disciplines through use of shared terminology, even though how a term may be conceptualised will vary by discipline.

UM represents a boundary concept that numerous academics have identified as appropriate for interdisciplinary cooperation because it travels fields ranging across engineering, natural sciences, and the social sciences (Newell *et al.*, 2019). Using UM thinking and terminology I am able to make sense of and describe GCX DASH-, which is essentially a UM analytics tool. This, in turn, allows me to communicate how the system functions thereby allowing me to interpret what the physical analysis of resource flows has allowed practically, socially, and in terms of governance.

My aim is not to do a quantitative analysis, but rather to describe an existing quantitative analytical tool (GCX DASH-) using UM terminology. Having painted the quantitative context for myself and the reader (research question 2), I am equipped with the necessary understanding to do qualitative research on the practical, social, and governance effects such a quantitative analytical tool tends to catalyse.

The literature therefore confirms my practical, social, and governance-oriented analysis as well as the use of UM as an interdisciplinary conceptual tool for communicating the workings of an already operationalised tool for the analysis of resource flows. The need for qualitative research, in tandem with analytical capabilities, will be elaborated on in what follows.

3.2.5 Interdisciplinarity

Across the WEF Nexus literature academics express the need for interdisciplinarity to be at the core of the WEF Nexus research agenda (Berman, Shwom & Cuite, 2019; Newell *et al.*, 2019). Methodological approaches within the nexus literature are largely quantitative, demarcating an underrepresentation of social science perspectives (Foran, 2015, Newell *et al.*, 2019). This is important given the complex nature of the WEF Nexus research agenda, requiring both quantitative and qualitative exploration and understanding.

In terms of modelling most papers make use of existing UM modelling tools found in Industrial Ecology (IE), such as Material Flow Analysis (MFA), Integrated Assessment Models (IAM) and Systems Dynamics (SD). These tools are, however, not often combined with qualitative approaches such as the critical social science perspective suggested by Foran (2015). As is made clear in Table 3.1 under “Capacity building and awareness raising”: the WEF Nexus challenges also necessitate social learning, an essentially qualitative affair that needs to be combined with insights emerging from the quantitative analysis of resource flows.

With regards to the ‘Urban WEF Nexus literature’ similar patterns are identified to those identified in the general literature. The literature comes mainly from scholars in the field of IE making use of UM modelling such as MFA to quantify energy and material flows and stocks (Newell *et al.*, 2019).

While it can be argued that such an approach has immensely advanced knowledge in the field of urban environmental burdens, these approaches are argued to be insensitive to multi-sectoral interactions, while being static and weak with regards to socio-economic, governance and political analysis (Newell, *et al.*, 2019; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021). As Newell *et al.* (2019:12) attest: “Some of these ‘metabolists’ are themselves sceptical that simply reporting UM parameters had salience for policy, since demand-drivers and related governance levers are indeed black-boxed”. By taking a qualitative case study approach, my research will seek to contribute to this body of literature by exploring social and governance dynamics of a WEF Nexus approach in practice, deciphering what it means for SES resilience.

Märker *et al.* (2018) bring our attention to the importance of social perspectives as path-dependent prevailing governance patterns (e.g., sectorised siloes) that are the result of historically evolved responsibilities of organisations, ministries, and administrations. For this reason, institutional analysis within SES is required to bring about institutional change (Märker *et al.*, 2018). Foran (2015:655) indicates the importance of social perspectives with elaborations on the ways in which socio-political regimes, called ‘regimes of provisioning’, restrict consideration of, and investment in, nodes of nexus that are critical for equitable access to and the sustainable management of resources.

Newell *et al.* (2019) make similar suggestions to Foran (2015); they suggest a merger between IE’s quantitative UM approach and qualitative socio-political considerations for a new form of analysis referred to as Political Industrial Ecology (PIE). PIE essentially brings together UM analytical tools such as MFA common to IE, with the social-political-economic perspective of political ecology (Foran, 2015; Newell *et al.*, 2019). The reason why the merger of quantitative and qualitative research is so important is raised by Newell *et al.* (2020) who suggest that quantitative research has had little to say about the distribution of resources, as access — as well as the politics and institutions and regimes shaping access — is not nearly as well-studied as the availability of resources. In order to better grapple with the problem of access, quantitative analysis has to be coupled with qualitative analysis (Newell *et al.*, 2020).

My research seeks to contribute to this mixed-methods approach by investigating an existing quantitative UM analytical MFA facilitated by GCX DASH- through a practical-social-governance perspective. This will allow my research to decipher the practical, social (economic

and political), and governance repercussions of a quantitative dashboard analysing the resource flows at the V&A Waterfront. This will, in turn, allow my study to grapple with the effects of these repercussions on the ability to govern for enhanced resilience in the Cape Town context.

3.2.6 Cooperation: collaboration versus holistic integration

The literature makes it very clear that cooperation among sectors, scales, actors, and disciplines is paramount. But, as mentioned, it is less clear how this cooperation can and should occur. Should cooperation come from the manifestation of fully integrated units of governance into a single WEF Nexus department, or should autonomous units be strongly linked towards better collaboration?

This debate is of critical importance as it shifts the debate from one about conceptual rigidity versus flexibility toward one about structural idealisation and practical possibility. These different proposed forms of governance — collaboration versus integration — therefore, represent different understandings and idealisations of the WEF Nexus and how its call for cross-sector cooperation can and should manifest. These are very important theoretical considerations when setting up and attempting such WEF Nexus cooperation in practice, but as will become clear, context is key, and conceptual clarity needs to emerge from the analysis of practical WEF Nexus governance applications in different contexts.

From the 30 papers evaluated in the two main categories by Newell *et al.* (2019) — General WEF Nexus literature and Urban WEF Nexus literature — it is clear that approaches, frameworks, and techniques are needed that can help sectors, scales, policy-makers, researchers, and actors cooperate. Some suggestions are offered by Smajgl *et al.*, (2016) and Urbinatti *et al.*, (2020), who argue that current nexus frameworks are partial and water-centric.

Smajgl *et al.*, (2016:538) argue for a “sectorally balanced, dynamic nexus framework” that attempts to understand (or diagnose) ripple effects and relationships in equally considered and weighted sectors. This is in contrast to a partial and static-comparative approach which compares states before and after change while giving unequal consideration to a specific sector (Smajgl *et al.*, 2016).

Märker *et al.* (2018) caution against a framework that argues for the idea that full integration of sectors into one system is what is needed; they argue that this approach can lead to collaborative inertia¹². Similarly, Urbinatti *et al.* (2020) bring into focus the benefits and disadvantages of perceived governance integration (sector and scale) by drawing attention to the fact that rigid integration may be disadvantageous; instead, they promote flexible governance arrangements. This point is also raised by Weitz *et al.* (2017) who propose the importance of neutral spaces rather than the formal merging of sectors.

Both Urbinatti *et al.* (2020) and Weitz *et al.* (2017) agree with Märker *et al.* (2018) and caution against full integration of sectors because of collaborative inertia. This is an important point to consider in relation to generating the adaptive capacity needed when governing for resilience as cross-scale coordination is needed without numbing the ability to be adaptive and creative — a factor that in many ways is determined by diversity (Biggs *et al.*, 2015; Wagenaar & Wilkinson, 2015).

In order to better grapple with these propositions, I will unpack what Smajgl *et al.* (2016) suggest by a sectorally-balanced, Dynamic Nexus Framework, before returning to the argument presented by Märker *et al.* (2018).

After practical implementation of the nexus framework in the trans-boundary context of the Mekong Basin, Smajgl *et al.* (2016) argue that a Dynamic Nexus Framework that seeks to weight sectoral objectives equally can create a paradigm for diagnosis and intervention that produces novel insights for cross-sectoral dynamics. As Smajgl *et al.* (2016:532) write:

The dynamic approach revealed how the occurrence, valency and magnitude of sectoral connections emerge and are altered as a consequence of single sector interventions in a water–food–energy Nexus.

The dynamic approach identified here emphasises the continuous interaction between:

- i) the three sectors and between
- ii) the Nexus core and the three Nexus sectors (Smajgl *et al.*, 2018:535).

¹² Refers to the stunted and negative effects that may be experienced when collaboration is not properly facilitated.

The Nexus core consists of drivers impacting water, energy, and food dynamics simultaneously thus resulting in cross-sector feedback. These drivers include, for example, climate change and population growth¹³, both of which seriously impact the status of ecosystem services (Smajgl *et al.*, 2016). Figure 3.2 illustrates the Dynamic Nexus Framework proposed by Smajgl *et al.* (2016: 535). The applicability of the Dynamic Nexus Framework will be returned to in parallel to an argument presented by Märker *et al.* (2018) which will be presented next.

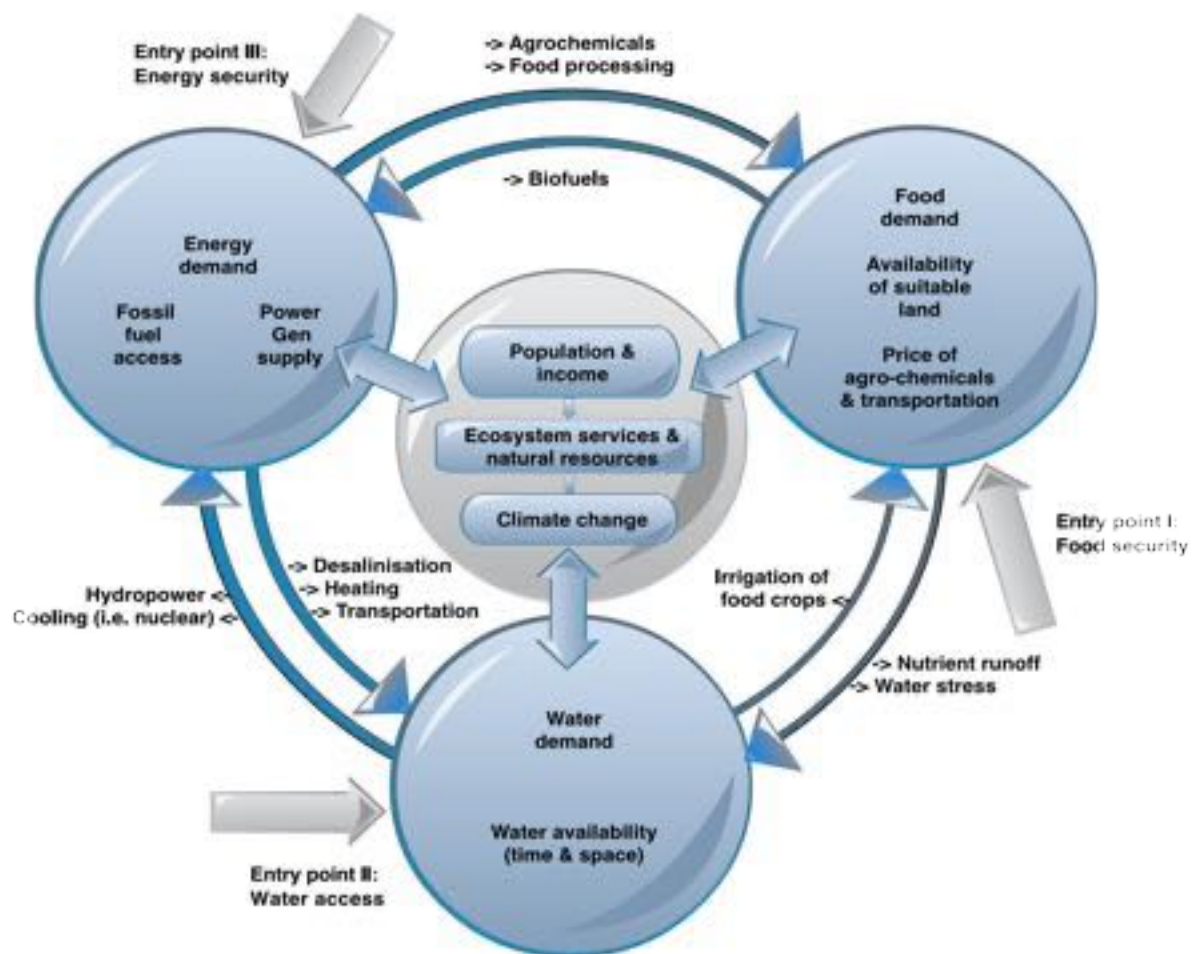


Figure 3.2. Dynamic Nexus Framework

(source: Smajgl *et al.*, 2018: 535)

In comparison to Smajgl *et al.*, (2016), Märker *et al.* (2018) take a governance, policy, and institutional approach to their proposed form of WEF Nexus integration. Märker *et al.* (2018) realise that the WEF Nexus debate is, in principle, a debate about governance, much like Weitz

¹³ These are two prominent examples of many; urbanisation is another example.

et al. (2017) and Urbinatti *et al.* (2020) argue, and that the enactment of that governance will rely on policy and institutional transformation according to the best-suited form of collaboration/integration.

The reality is that the establishment of a WEF Nexus can only be achieved by introducing new governance systems or by adapting existing ones. However, as Märker *et al.* (2018:290) write: “Little research has sufficiently addressed the changes in policy structures and processes required for effective, integrated governance of the nexus resources”. Urbinatti *et al.* (2020) agree and state that the proposed governance structures are much more uncertain possibilities than achieved characteristics.

Urbinatti *et al.* (2020) argue that for these possibilities to become achieved characteristics, much more development is required with regards to the nexus-governance interface. Urbinatti *et al.* (2020) will therefore be further explored in Section 3.4 when examining political and institutional inhibiting factors, the nexus-integrative environmental governance (IEG) interface (also found in Weitz *et al.* 2017), as well as the needs of the WEF Nexus which requires the incorporation of systems theory into the policy-making process.

Märker *et al.* (2018) approach their argument by means of first exploring possible pathways for achieving an integrated WEF Nexus governance framework by highlighting major problems regarding policy integration and institutional change. Märker *et al.* (2018) then use this information to develop and explore two possible, yet different, conceptual WEF Nexus frameworks.

The first, illustrated in Figure 3.3, describes a horizontal policy integration framework that defines the WEF Nexus as a single, fully integrated system (characterised as Holistic WEF Nexus Integration Framework). The second, illustrated by Figure 3.4, represents a vertical policy interaction, and is largely based on existing structures and a reframing of the present institutional setting towards more collaboration (characterised as Collaborative WEF Nexus Framework).

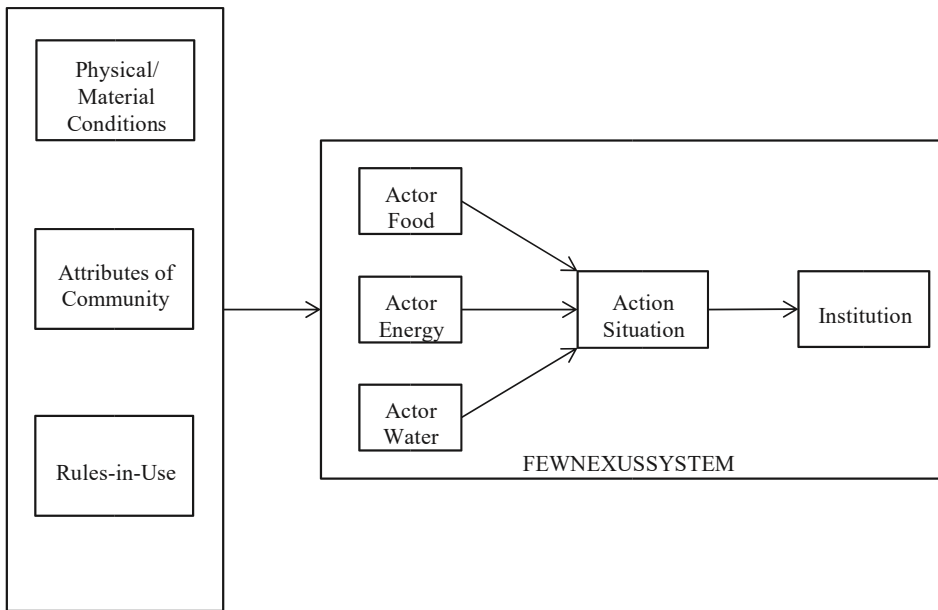


Figure 3.3. Holistic WEF Nexus Integration Framework

(source: Märker *et al.*, 2018:294)

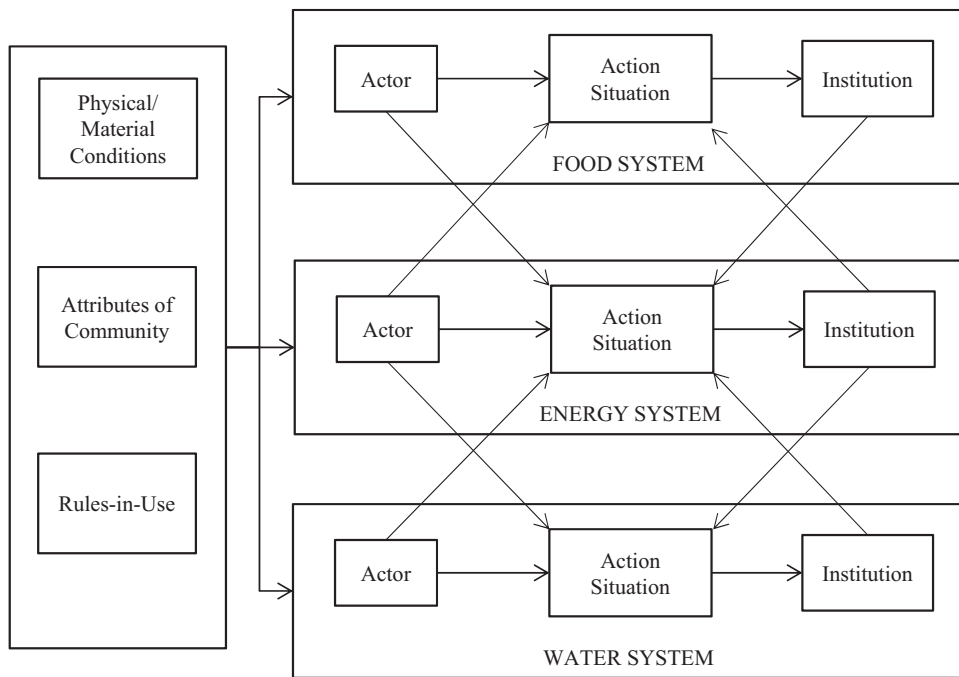


Figure 3.4. Collaborative WEF Nexus Framework

(source: Märker *et al.*, 2018:295)

The two hypothetical frameworks are then analysed for weaknesses and strengths in governing the WEF Nexus using two cases of integrated WEF Nexus governance in Germany. After analysis Märker *et al.* (2018) argue that effective WEF Nexus governance requires aspects of both policy integration options depending on the context. As they explain:

Since vertical policy integration requires lower levels of learning, it would appear to be easier to achieve. It builds on existing institutions and increased cooperation and is assumed to have a higher impact on policy implementation. However, in terms of the overarching goal of sustainable development, it must be questioned whether various nexus-smart sector policies alone would equate to an effective governance concept for sustainable development (Märker *et al.*, 2018:297).

3.2.7 Key learnings

In essence, the argument by Smajgl *et al.* (2016) represents more of a nested perspective¹⁴ rather than conceptualisations of institutional collaboration/integration as discussed by Märker *et al.* (2018). However, valuable insights can be drawn from both groups of researchers regarding the WEF Nexus.

Smajgl *et al.* (2016) are successful in bringing our attention to workings of a proposed nexus perspective, one that is dynamic and sectorally balanced. Although Märker *et al.* (2018) explore political and institutional integration possibilities, they also bring valuable insights with regards to perspective. Weitz *et al.* (2017), Märker *et al.* (2018), and Urbinatti *et al.* (2020) agree with Smajgl *et al.* (2016) in that a dynamic, nested perspective is required, but cautions against a perspective where sectors are balanced in a manner that turns them into a single sector (although this is necessary at times).

Suggestions are made by Al-Saidi and Elagib (2016) who argue one must consider a prism-view of one sector that takes links to the other two sectors, much like the nested view proposed by Smajgl *et al.* (2016)). These three arguments, collectively, suggest that a collaborative,

¹⁴ Refers to the intertwined view of WEF resources, as a lense of interpretation rather than a formal means of departmental merger.

dynamic WEF Nexus framework is required which makes use of a nested view/prism-view, but not full sector integration — although this can be beneficial in specific contexts.

3.2.8 What do these key findings mean for this research project?

From this theoretical background comes one of the most important points drawn from these arguments: researchers need to move away from quarrels about abstract conceptual clarity and rather move towards empirical analysis of application; from where real conceptual clarity can emerge. This move is promoted by Smajgl *et al.* (2016) who argue for a move from abstract considerations to practical application, and then empirical observation.

In order to better understand which conditions and forms of cooperation are suitable for a given context, Märker *et al.* (2018) urge researchers to investigate practical examples of WEF Nexus governance. This is necessary as context is such a crucial determining factor when it comes to what is politically and institutionally possible with regards to collaboration/integration as well as what form of collaboration/integration will be suitable for the context. Context coupled with the need to understand path dependency highlights the necessity of research focusing on practical institutional analysis of WEF Nexus governance within SES¹⁵.

The WEF Nexus literature with all its identified gaps therefore confirms, and to a degree (with the exception of the governance aspect) answers, research question 1: How is the WEF Nexus framework understood with particular reference to practical, social and governance (PSG) implications. Section 3.4 on nexus governance will provide the necessary information on how the nexus is understood with particular reference to governance.

I will now review literature on SES and resilience (specifically Biggs *et al.*'s. 2015 seven principles for enhanced resilience) to be equipped with a comprehensive understanding of well-established factors/elements/governance options/actions/principles that are argued to contribute to the enhancement of resilience. This will enable me to understand if the WEF Nexus governance approach as it is currently formulated holds any potential as a resilience-enhancing governance approach. It will also enable me to explore connections and possibilities

¹⁵ Section 3.4 will be dedicated to unpacking these institutional and governance problems and solutions, such as path dependency, policy integration, and institutional change.

for enhanced resilience opened by the V&A Waterfront WEF Nexus approach (research question 3).

The section on SES and resilience thinking will be followed by a discussion on the WEF Nexus–governance interface, with specific attention given to papers by Weitz *et al.* (2017), Urbinatti *et al.* (2020), and Wagenaar and Wilkinson (2015).

3.3 Social-ecological systems and resilience thinking

It is important to be reminded that the connection between SES resilience and the WEF Nexus in this study emerges from the overarching larger study goal of researching WEF Nexus materialisations and governance in Cape Town for the sake of supporting the City of Cape Town’s resilience strategy. This reasoning comes from theoretical claims that the WEF Nexus approach can be a supporting instrument for enhanced resilience.

In this study it therefore becomes necessary for resilience to be unpacked so as to see what opportunities the WEF Nexus holds for enhancing resilience. In order to do so, I will deploy Biggs *et al.*’s. (2015) seven principles for enhanced ecosystem services (ES) resilience to test the idea that the PSG implications of the GCX system enhance or undermine the capacity to govern for resilience. I am therefore taking an ES resilience perspective on SES resilience, as ES are understood as the outcome of SES dynamics and reciprocal processes.

Resilience and resilience thinking are critical concepts in social-ecological systems research; they embrace complexity and systems thinking in making sense of social-ecological systems (SES) as complex-adaptive systems (CAS)¹⁶ (Folke, Carpenter, Walker, Scheffer, Chapin & Rockström, 2010; Folke, 2016; Preiser *et al.*, 2018). As mentioned earlier, there is a large prevalence of researchers that study the WEF Nexus as SES thus necessitating a CAS perspective on the WEF Nexus.

In essence, resilience can be described as an emergent property of a system which displays the ability to absorb or recover from shocks, avoid undesirable tipping points (regime shifts), or transform when exposed to change (Folke, 2006; Biggs *et al.*, 2015). According to Folke *et al.*

¹⁶ Meaning SES are understood to behave as CAS.

(2010) the definition includes three main aspects: i) adaptability (learn and adjust), ii) persistence (maintain structure and function), and iii) transformability (ability to completely change).

Applied to urban social-ecological systems (SES), resilience can be understood as the following:

Urban resilience is the capacity of individuals, communities, institutions, businesses and systems in a city to survive, overcome, adapt and grow, no matter what chronic stresses and acute shocks they experience (CCT, 2017a:80):

From these understandings emerges a definition of resilience that will be used throughout this study (Biggs *et al.*, 2015:xix):

Resilience as used here is about having the ability to live with change, and develop with it. It is about cultivating the capacity to sustain development in the face of change, incremental and abrupt, expected and surprising. Resilience is about persisting with change on the current path of development, improving and innovating on that path. Sometimes actions lead to path dependency and to traps that are difficult to get out of. The resilience of the system has become too robust and too rigid. In such situations the challenge is to reduce resilience and try to shift away from the current path into new ones. Sometimes those shifts may be smooth, other times revolutionary.

It is important to note that resilience essentially has to do with both the ecological and social dimensions of SES, as equal ecological and social resilience is required for holistic system resilience (Folke, 2016). The literature, however, expresses an underappreciation for the social aspects of resilience, as most literature focusing on SES resilience relates to the management of these systems from an ecological and physical perspective (Quinlan, Berbés-Blázquez, Haider & Peterson, 2016; Schlör *et al.*, 2018; Mguni & van Vliet, 2021).

It is not that one aspect is more important than the other, but rather that equal attention needs to be given to both. This point is also raised in the nexus literature as there is unequal attention

given to the physical flows of resources¹⁷, and less attention to the socio-economic and political aspects of the nexus shaping those flows (Schlör *et al.*, 2018; Newell *et al.*, 2019; Mguni & van Vliet, 2021).

In the following section I will convey reasons why both ecological (studied from the quantitative MFA-based UM assessment) and social consideration (studied from a qualitative perspective) are so important for understanding and managing holistic SES resilience. To do so I will rely on the work of Bristow and Mohareb (2020), Kennedy and Hoornweg (2012) as well as Newell *et al.* (2019, Foran (2015), and Biggs *et al.* (2015).

3.3.1 The importance of quantitative material flow analysis-based urban metabolism assessment

Bristow and Mohareb (2020) bring together the need for complexity-based resilience considerations across scale, sectors, and hazards, with possibilities presented by MFA-based UM assessment. Bristow and Mohareb (2020) are convinced that UM should be applied beyond the usual consumption patterns it tracks and should in addition be applied to study resilience and adaptation, across sectors and scales.

Kennedy and Hoornweg (2012) agree arguing that UM is essential for communicating urban functions, resource demands, distribution of resources, and thus for comprehending urban sustainability.

Kennedy and Hoornweg (2012:781) write:

In the industrial ecology realm, MFA-based UM assessment serves as a metric of resource demand that serves to convey the scale of a city's dependence on its hinterlands, to which sustainability assessments can be based.

Bristow and Mohareb (2020) and Kennedy and Hoornweg (2012) make it clear that an analytical void exists in the urban resilience space; it is Bristow and Mohareb (2020) who take formative charge through the development of a new concept called Urban Immune System

¹⁷ Availability and efficiency of resources is studied, but not distribution.

(UIS). The aim of this concept is to usher a path towards advancing methods directed at quantitatively assessing urban resilience and adaptive capacity from an IE perspective. As Bristow and Mohareb (2020) explain:

The aim is to more completely integrate the study of urban risks into IE in order to expand its understanding and relationship to UM and other aspects of sustainability and to provide the base of knowledge to eventually inform its complete study through a complex systems theory lens.

Analytical MFA-based UM assessment — as suggested by Newell *et al.* (2019 and Foran (2015) in Section 3.2 with regards to the interdisciplinary needed in the WEF nexus — serves as one side of what makes a true interdisciplinary approach. The same is true when studying resilience, as quantitative ecological analysis is of great importance, but will be futile without qualitative socio-political considerations. Bristow and Mohareb (2020) admit this but argue that IE and its MFA-based UM assessment represents the quantitative base from which such qualitative considerations can be made, together resulting in a holistic understanding (ecological and social) of what is conceptualised as the UIS.

3.3.2 The importance of qualitative perspectives

The importance of qualitative social considerations for a complexity-based, holistic SES resilience understanding is now going to be expanded on in relation to the literature on the WEF nexus and ES resilience.

Newell *et al.* (2019) argue that some of the most prevalent gaps in the general WEF Nexus literature is lack of consideration for socio-political factors, problems of institutional structure, and resource access. With regards to ES resilience, Biggs *et al.* (2015) bring our attention to the fact that “decisions about which ES to sustain are inherently political¹⁸”, and more often than not the marginalised are not accounted for (a statement that rings true in light of Foran’s (2015) description of a ‘regime of provisioning’).

¹⁸ Biggs *et al.* (2015) however do not directly contribute such political analysis in their paper, and rather “...assume that some desired mix of ES has been legitimately agreed upon...”, focusing on how the resilience of these ES may be enhanced, while also allowing for the possibility of changes in the preferred mix of ES over time.

The reality is that trade-offs will exist when selecting which ES to sustain thus presenting detrimental possibilities for the well-being of those who inherently rely on ES but who are unequally accounted for in decision-making. Similarly, Foran (2015) highlights problems of equity in resource use and access (e.g., WEF) — a major sustainability challenge that stems from social, political, and institutional dynamics — making it crucial for transformation in these spheres, a task which first requires a deep level of qualitative understanding.

Together Biggs *et al.* (2015) and Foran (2015) shed light on the need for qualitative socio-political analysis in relation to resource access and ES resilience, a suggestion in accordance with the gaps identified by Newell *et al.* (2019). Biggs *et al.* (2015), Foran (2015), and Newell *et al.* (2019) are convinced that such qualitative socio-political investigations are needed to bring forward social, political, institutional, and behavioural insights and suggestions. If implemented, these can positively impact equity in resource access, as well as enhance considerations for trade-offs and equity in SES thus effectively enhancing ES resilience capabilities.

3.3.3 Qualitative and quantitative research (transdisciplinary)

In essence the dialogue between Kennedy and Hoornweg (2012) and Bristow and Mohareb (2020) as well as among Biggs *et al.* (2012), Foran (2015), and Newell *et al.* (2020) confirms that to maintain ES resilience, holistic social-ecological system perspectives are needed. To do so this requires defining the levels of possible trade-offs and synergies among different values (environmental, economic, social, cultural, territorial) of a system (Magoni, 2017). On the one hand, this calls for analytical tools that make sense of reality and identify thresholds for the proper use of different resources, such as the application of MFA-based UM assessment (of which the monitoring of UMs done by GCX represents an example) (Magoni, 2017). On the other hand, it calls for a better understanding of social, political, governance and institutional dynamics-shaping behaviour surrounding resources in SES (Schlör *et al.*, 2018).

Intertwining concepts of resilience, UM, and WEF Nexus presents fruitful possibilities. Resilience thinking opens the possibility to give equal consideration to social and ecological factors. UM tools, concepts (e.g., UIS), criteria, and principles help to improve the quality of analysis and evaluations of resilience factors that require quantifying available resources and identifying thresholds for possible instability in the system (Magoni, 2017). In this conceptual

(resilience, Um and WEF Nexus) relationship, the WEF Nexus presents a critical demarcation of three intertwined, unstable, and highly important resources, as well as a mode of governance that integrates management across usually disparate social (private, civil, public) and resource (water, energy, and food) domains.

To better understand the possibilities for enhanced SES resilience facilitated by a WEF Nexus approach (research question 3), the PSG implications findings will be analysed as they have emerged in the context drawing on the “seven generic policy-relevant principles for enhancing the resilience of desired ES in the face of disturbance and ongoing change in social ecological systems (SES)” (Biggs *et al.*, 2015:21) where appropriate. In doing so I am adopting an ES resilience perspective on SES resilience.

3.3.4 An ecosystem services resilience perspective on social-ecological systems resilience

Taking an ES resilience perspective more fully illustrates the reciprocal effects taking place between social and ecological systems as ES are understood as the outcome of these SES interactions.

As Biggs *et al.* (2012:423) explain:

All social ecological systems (SES) produce a “bundle” of ES, including provisioning (e.g., freshwater, crops, meat), regulating (e.g., flood and climate regulation), and cultural services (e.g., recreation, spiritual values).

Biggs *et al.*, (2012:424) further elaborate by writing:

We assume that ES are typically coproduced by the interaction of social and ecological factors, so that, for instance, cereal crops are produced by the interplay of ecological factors (e.g., fertile soil, rainfall) with social factors (e.g., demand for crops, agricultural technology, market access).

This understanding of ES reflects how the interplay between social (e.g., governance) and ecological (e.g., climate change) factors produce and influence ES directly and thus affects ES

resilience. ES resilience is defined by Biggs *et al.* (2015:7) as: "...the capacity of the SES to sustain a desired set of ES in the face of disturbance and ongoing changes in SES."

Factors such as population growth, urbanisation, and climate change have seriously affected provisioning, regulating, and cultural ES, all of which have declined as a result of these anthropogenic changes (Preiser *et al.*, 2018). The enhancement of ES resilience is, therefore, a very important task and policy challenge, as these ES underpin human well-being. Biggs *et al.* (2012:422) write: "Enhancing the resilience of ecosystem services (ES) that underpin human well-being is critical for meeting current and future societal needs and requires specific governance and management policies".

Using an understanding of ES as the outcome of SES, Biggs *et al.* (2015) bring our attention to the way in which shifts in management and governance, stemming from the social sphere, can have effects on the entire SES and in effect enhance ES resilience. In line with this, Biggs *et al.* (2015) propose seven governance and management policy-relevant principles for enhancing the resilience of ES. Only three of the seven principles focus on generic SES processes and properties, while the other four are focused on the way SES are governed.

The seven principles presented by Biggs *et al.* (2015) will, in effect, serve as the theoretical bases against which the effectiveness of the WEF Nexus governance approach can be evaluated for resilience capabilities. The intention is not to prove these seven principles as correct but rather to deploy them to make sense of the reality I am exploring.

The seven principles are illustrated by Figure 3.5, which clearly demonstrates that three of the seven principles focus on the generic SES processes and properties to be managed, while the other four are focused on the way SES are governed.

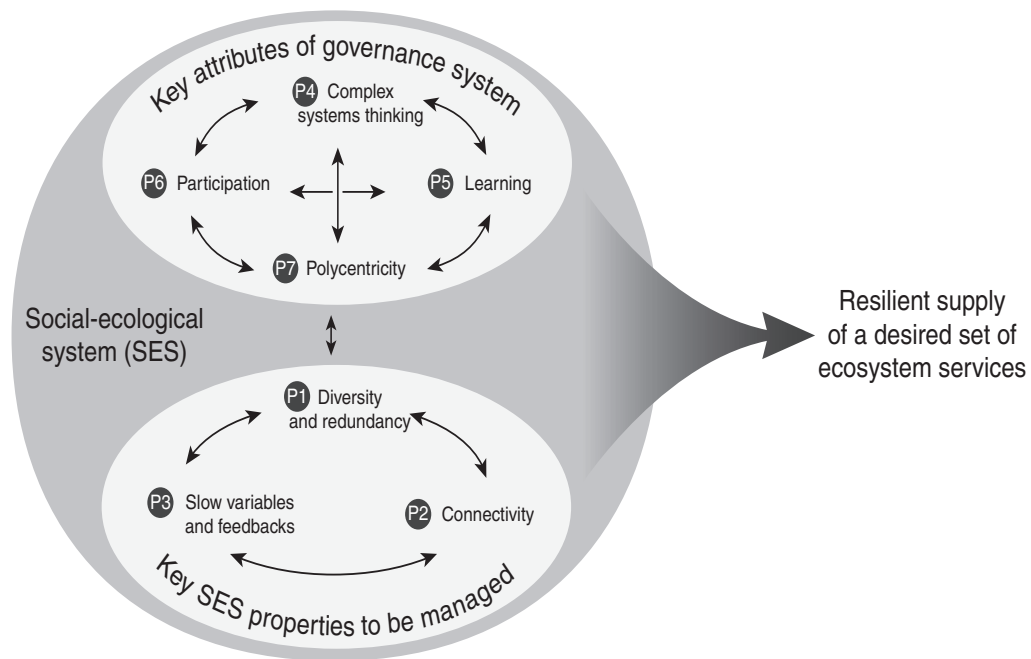


Figure 3.5. Seven principles for enhanced ecosystem services resilience

(source: Biggs *et al.*, 2015:25)

3.3.5 Seven principles for enhanced resilience

Principle 1: Maintain diversity and redundancy

Diversity in SES includes factors such as biodiversity, genes, spatial heterogeneity, and institutional diversity; it can also include software and hardware components when investigating network resilience (Alleg, Ahmed, Mosbah & Boutaba, 2020). Diversity does not simply refer to variety (how many different elements); disparity (how different the elements are from one another), and balance (how many of each element) all need to be considered (Biggs *et al.*, 2015).

The importance of diverse system elements (such as species, management approaches, and institutions) is explained to provide the basis for learning, innovation, and adaption (Principle 5) (Biggs *et al.*, 2015). Redundancy, on the other hand, refers to the replication of certain elements and/or pathways in a system and can, in effect, act as insurance for ES provisioning as some system elements are allowed to compensate for failure or loss of others (Lamothe, Alofs, Jackson & Somers, 2018). Regarding both variety and redundancy, Biggs *et al.* (2012:425) write:

There is wide consensus from a variety of disciplines that diversity and redundancy are important for resilience because they provide options for responding to change and disturbance.

With regards to the potential for enhanced ES resilience in the face of a disturbance, combined response diversity and functional redundancy are argued to be of critical importance (Lamothe *et al.*, 2018). Response diversity is the “variety of ways in which different species, actors, or SES elements respond to a disturbance, such as a fire or drought” (Biggs *et al.*, 2012:425). Functional redundancy is the “capacity of functionally similar elements to partly or fully substitute for each other” (Biggs *et al.*, 2012:425).

With regards to governance: variety is noted as important, as a multitude of organisational forms (private, government, community) provide for a diversity of responses, especially in the presence of overlapping domains of authority (Biggs *et al.*, 2015). This understanding can be placed in analogue to how diverse software and hardware components can allow for continued network functioning in the face of disturbances (Alleg *et al.*, 2020). These understandings provide support for the WEF Nexus argument that diverse sectors need to work together from a resilience perspective.

With regards to the success of diversity, especially institutional and political diversity, it is paramount to consider connectivity because diversity without connectivity is futile¹⁹ (Olds, Pitt, Maxwell & Connolly 2012). If connectivity is adequately accounted for, the provision of a diversity of responses allows for the maintenance of ES in the face of political or economic upheaval. Diverse management approaches are argued to support learning (Principle 5) and understanding of the best ways to manage SES, ensuring the sustained provision of ES and to facilitate adaptation to changes in ES over time (Biggs *et al.*, 2015).

There is, however, an appropriate balance between low and high levels of both diversity and redundancy required, as overtly high redundancy in management organisations for example, tend to increase the administrative costs of managing ES, interdepartmental

¹⁹ A point returned to when investigating Principle 2.

power struggles, and contradictory regulation, which can compromise the resilience of ES.

More generally this can be understood from the perspective of increased complexity that comes when diversity and redundancy increase as this leads to increased interactions between entities and non-linear system dynamics (Alleg *et al.*, 2020). As a result, the processing of information, energy and matter becomes more difficult because the establishment of directional, efficient pathways is hindered by the increased complexity thus leading to the inability of SES to adapt to disturbances and change²⁰ (Biggs *et al.*, 2015; Alleg *et al.*, 2020). According to Biggs *et al.* (2012:427):

Maintaining the resilience of ES therefore requires levels of diversity and redundancy that balance the danger of system brittleness (associated with low levels of diversity or redundancy) against that of system stagnation (associated with high levels of diversity and redundancy).

Investing in diversity and redundancy for enhanced ES resilience therefore requires the appropriate balance between brittleness/efficiency and stagnation/inefficiency associated with high and low levels of redundancy and diversity. The aforementioned interplay is represented in Figure 3.6, where it is made clear that spatial and temporal scale needs to be accounted for (as represented in the diagram by three dotted lines indicating variations of possible outcomes).

Principle 1 thus provides valuable insights for the WEF Nexus debate as it indicates the stagnation that can come from fully integrating sectors into a single WEF Nexus sector. It therefore provides supporting arguments for a collaborative WEF Nexus approach, where diverse sectors maintain autonomy, yet warn of the necessity for this diversity to be accompanied by high levels of connectivity. It will be argued that with regards to the WEF Nexus, connectivity needs to be manifested in the form of shared information (connected via shared information).

²⁰ This once again raises the importance of connectivity.

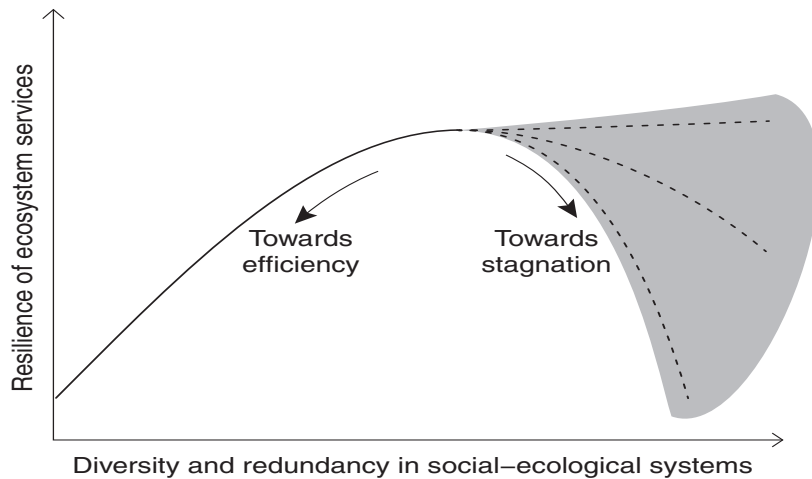


Figure 3.6. Balance between brittleness/efficiency and stagnation/inefficiency associated with low and high levels of redundancy and diversity

(source: Biggs *et al.*, 2015:62)

As a final point of suggestion, Biggs *et al.* (2015) point out that there is a lack of research on the impacts of economic and social redundancy and diversity on ES resilience.

Principle 2: Manage connectivity

Connectivity is defined by Biggs *et al.* (2015:80) as:

The structure and strength with which resources, species, or social actors disperse, migrate, or interact across ecological and social landscapes.

Connectivity is important in SES as it enables the facilitation of material and/or information exchanges — a necessity for the functioning of ecological and social processes (Olds *et al.*, 2012; Biggs *et al.*, 2015). The facilitation of information and/or material exchanges enabled by connectivity also increases the ability to recover disturbed SES components (Biggs *et al.*, 2015). This ability to recover as enabled by connectivity has been researched and identified many times in the ecological sciences. Olds *et al.* (2012) represent such a study — one that explored the synergistic effects of reserves and connectivity on ecological resilience.

There are, however, very few studies looking at the potential of connectivity from the social perspective, and even fewer investigating what social connectivity can mean for entire SES

and their accompanied ES. Biggs *et al.* (2015) represent an exception to this dearth and argue that enhanced governance opportunities enabled by connectivity in social networks can, in turn, facilitate and enhance ES resilience. This comes due to the increased information sharing, trust, and reciprocity that come from connectivity between different social groups — all of which are requirements for collective action (Principle 6) (Biggs *et al.*, 2012).

Actors connected to other landscapes can also facilitate the exchange of ideas thus bringing outside and new perspectives to local issues (Principle 5) (Biggs *et al.*, 2015). As mentioned, connectivity is also required to accompany increased diversity and redundancy for the sake of assisting with the increased complexity that comes with these two system properties.

Increased connectivity cannot be seen as synonymous with an increased capacity to respond to disturbances because strongly connected systems may have the inverse effect and be less resilient to disturbances (Biggs *et al.*, 2015). An example of this is the globalised world; a highly connected system where disturbances propagate rapidly and lead to widespread impacts on SES and associated ES (such as those experienced during the COVID-19 pandemic).

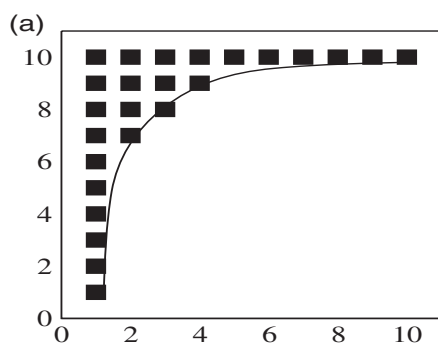
It therefore seems like there is a convergence point between connectivity and diversity that needs to be respected; responses to disturbances are found to be impactful in systems that are less connected than the globalised system, but at the same time heterogeneous. This comes since increased heterogeneity in landscapes, or between actor groups, is associated with greater diversity in connections between nodes (Olds *et al.*, 2012; Biggs *et al.*, 2012; Biggs *et al.*, 2015)

The above mentioned in effect brings the discussion about connectivity to the matter of structure, as it is not simply the amount and strengths of SES links that determine ES resilience, but also system structure (i.e., the way in which nodes are connected) (Fortuna, Stouffer, Olesen, Jordano, Mouillot, Krasnov, Poullin & Bascompte, 2010). Fortuna *et al.* (2010) and Biggs *et al.* (2015: 88) investigate two system structures namely, Modularity and Nestedness:

Modularity (or compartmentalisation) refers to the extent to which subsets of densely connected nodes are loosely connected to other subsets of nodes, creating in essence distinct compartments within a network. Nestedness is the degree to which specialist

nodes (nodes with few links) interact with subsets of generalist nodes (nodes with a lot of links).

These structures are different in how connections manifest, yet both represent structures unlike random configurations (Fortuna *et al.*, 2010). Nested structures are usually made of nodes belonging to distinct groups (meaning they are bipartite) where nodes interact hierarchically with subsets of nodes (see Figure 3.7) (Fortuna *et al.*, 2010; Biggs *et al.*, 2015). Modular network structures manifest where nodes are organised into distinct compartments, connected to one another with few links (see Figure 3.8) (Fortuna *et al.*, 2010; Biggs *et al.*, 2015).



Nested structure

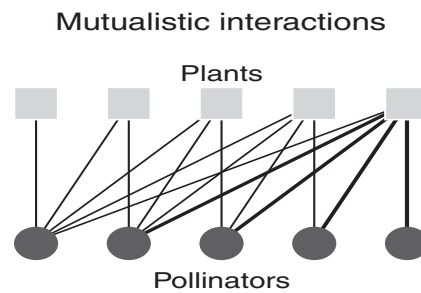
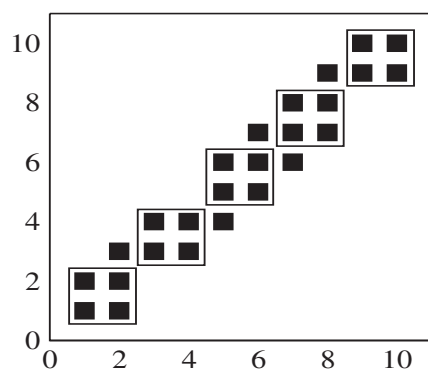


Figure 3.7. Nested system structure

(source: Fortuna *et al.*, 2010:812; Biggs *et al.*, 2015:83)



Modular structure

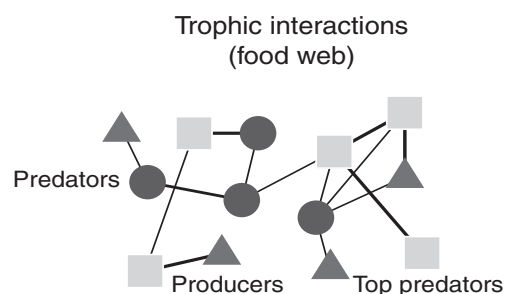


Figure 3.8. Modular system structure

(source: Fortuna *et al.*, 2010:812; Biggs *et al.*, 2015:83)

I believe a comparison can be made here between these system structures and the proposed WEF nexus frameworks, making it possible for valuable structural insights to be transposed from the SES literature to the WEF nexus framework debate.

The modular structure can be compared to currently isolated water, energy, and food departments which connect to one another with few links (Märker *et al.*, 2018). The nested structure can be compared to the collaborative WEF Nexus framework that takes a nested/prism view (Al-Saidi & Elagib, 2016; Smajgl *et al.*, 2016; Märker *et al.*, 2018). The holistic WEF Nexus framework, where it is one fully integrated system, is not represented by either of these structures yet there is already substantial evidence that such an integrated system has a large potential to lead to collaborative inertia (Märker *et al.*, 2018) and brittleness²¹ (Biggs *et al.*, 2015).

According to the SES resilience literature, modular systems (compared to currently isolated WEF departments) make it difficult for disturbances to cascade or spread across modules (departments), lowering the likeliness that disturbances to a particular node will spread widely across the rest of the system (Biggs *et al.*, 2015; Märker *et al.*, 2018).

Nested structures (compared to collaborative and the nested/prism WEF Nexus framework) can deal with higher levels of disturbances, yet the risk is larger for the entire system to collapse if a threshold is passed (Biggs *et al.*, 2015; Märker *et al.*, 2018). Both modular and nested systems therefore present possibilities and problems, but it is with specific regards to social networks (such as the case of WEF resource departments) that the argument can be made in favour of a nested structure.

Social networks with strong connections between actors with similar characteristics, perspectives, and knowledge (e.g., isolated water department) can lead to highly connected modular systems with few connections to other modules (such as energy and food departments) (Biggs *et al.*, 2015). In this relationship critical knowledge of holistic systems' functioning and monitoring will be missed (Principle 5) if subgroups who use or manage ES (e.g., energy and

²¹ Refers to an inability for social (including governance) or ecological structures to be maintained or evolved in face of disturbance, leading to weakness in the system.

food departments) are not engaged (by water department in this example) (Biggs *et al.*, 2015). This will in effect seriously reduce the potential for collective action (Principle 6).

When comparing this information with the proposed WEF nexus frameworks, the problems created by modular structures in social networks presents further evidence in favour of a collaborative nexus framework adopting a nested/prism view (Al-Saidi & Elagib, 2016; Smajgl *et al.*, 2016; Biggs *et al.*, 2015; Märker *et al.*, 2018).

Both ecological recovery after a disturbance (Olds *et al.*, 2012) as well as the development of the necessary trust to facilitate collective action (Biggs *et al.*, 2015) comes from connectivity. It is, however, made clear that highly connected systems, especially modular structures, can increase the risk of knowledge homogenisation, which decreases the potential for optimal management, while also increasing the changes for disturbance to spread. Biggs *et al.* (2012: 429) explain in conclusion:

Consequently, there is a trade-off in costs and benefits with increasing levels of connectivity, so that the resilience of ES appears to be highest in moderately connected systems, especially when heterogeneity is high.

Comparing this information with WEF nexus frameworks therefore strengthens the case against currently isolated WEF departments, warns against complete integration and homogenisation, and sheds light on the resilience-enhancing possibilities of a collaborative nexus framework. This is because the collaborative nexus framework is based on existing structures (heterogeneity), yet the institutional setting is reframed towards more collaboration (which must stem from increased connectivity).

In terms of research required Biggs *et al.* (2015) highlight the need to explore practical applications of managing connectivity in SES for enhanced ES resilience because there are not many empirical studies that test the relationship between connectivity and resilience.

Principle 3: Manage slow variables and feedbacks

The underlying structure of SES are determined by slow variables, while the dynamics of the system arise from feedback and interactions between fast variables and conditions shaped by the slow variables in the system (Biggs *et al.*, 2015). Biggs *et al.* (2012:429) explain:

In relation to ES, such as crop production and drinking water (which represent fast variables), slow variables include, for example, soil composition and phosphorous concentrations in lake sediment.

There is an apparent link between slow ecological variables and regulating ES (e.g., flood regulation, disease control, and climate regulation) (Li, Li, Kappas & Pavao-Zuckerman, 2018). Simultaneously, slow social variables (e.g., traditions, values, and legal systems) are deterministically linked to provisioning and cultural ES (Biggs *et al.*, 2015). These variables are at the same time linked to one another creating a multitude of possible system variables/properties that exhibit the potential to either propagate or stifle (understood as feedback) when introduced to disturbances and shocks (Biggs *et al.*, 2015; Li *et al.*, 2018). Biggs *et al.* (2012:430) explain:

Feedbacks occur when a change in a particular variable, process or signal either reinforces (positive feedback) or dampens (negative feedback) subsequent changes of the same type.

Feedback can either be caused unfavourably and unwillingly due to unforeseen disturbances (Maja, Marguitti, Vaghan, Memmott & Raimundo, 2021) or introduced willingly and thoughtfully in response to the unfavourable conditions created by unforeseen disturbances (Biggs *et al.*, 2015).

Monitoring where information regarding the state and responses of the SES are analysed, represents a type of feedback as this information can feedback to actors, in turn, influencing the way they manage, affect, or utilise a SES (Li *et al.*, 2018). This is especially important to consider regarding the WEF Nexus, as it is argued that monitorisation (such as the MFA at the V&A Waterfront done by GCX) is required to provide information on the current state of the system, informing strategies, and decision-making going forward. It furthermore provides shared information that can enable the right kind of connectivity between sectors (Märker *et al.*, 2018).

Persistent changes to slow variables and feedback can ultimately lead to non-linear system alterations or even regime shifts in the SES if a threshold is surpassed (Maja *et al.*, 2021). With the occurrence of a regime shift, ES produced by the SES will be significantly impacted. Biggs *et al.* (2012:430) write:

Regime shifts are large, persistent, and often abrupt changes in the structure and dynamics of SES that occur when there is a reorganization [SIC]of the dominant feedbacks in a system and are a common feature in CAS.

Most commonly, studies investigating regime shifts have researched ecological regime shifts caused by human activities, and the resultant impacts on human society (Maja *et al.*, 2021). Social regime shifts do exist and arise from social feedback processes that have consequences for ecosystems (Biggs *et al.*, 2015). The proposed shift to a WEF Nexus represents an example of a social regime shift that could have adverse effects on ecosystems. Some regime shifts, however, occur entirely as a result of the interaction between social and ecological factors. As Biggs *et al.* (2015:132) explain: “This regime shift happens despite the fact that neither the resource nor social system exhibit regime shifts on their own.”

The understanding presented above shows how it becomes possible to willingly strengthen the stabilising feedbacks in a system to assist in maintaining a particular SES regime and associated ES in the face of external disturbances, such as climate change. In some cases, it could be necessary to disrupt or weaken specific feedbacks that hold SES in a resilient yet undesired regime (Biggs *et al.*, 2015).

It is, however, made clear that such understanding, with all its possibilities for enhancing the resilience of SES and their resultant ES, is difficult to act upon in the absence of information about feedback and slow variables (Li *et al.*, 2018). For this information to become available, monitorisation enabled by analytical tools is required (Principle 5). This is an important aspect lacking when it comes to managing slow variables and feedbacks to maintain or change SES regimes (Biggs *et al.*, 2015). This lack of information is crucial, as such understandings, in the presence of the correct monitorisation, can help humanity shift to SES regimes which produce desired ES, or shift out of SES regimes which produce undesirable ES.

Here the WEF Nexus framework becomes important as it represents a new framing of system dependencies and interactions, allowing for a new understanding of trade-offs and potential synergies that would not be noticed given current sector isolation. Biggs *et al.* (2015) indicate the lack of practical adoption of such approaches in the SES management setting.

Together with the need for better monitorisation and practical adoption, scholars argue for the improvement of the statistical detection of regime shifts in situations where dynamics of the slow variables and feedbacks underlying the shift are poorly understood (Biggs *et al.*, 2015; Li *et al.*, 2018; Maja *et al.*, 2021). This once again highlights the call for analytical tools as catalysts for increased monitorisation, cooperation (WEF Nexus literature) and connectivity (resilience literature).

Principle 4: Foster an understanding of social-ecological systems as complex adaptive systems

Principle 4 refers to an appreciation and understanding among scientists and managers regarding the characteristics and properties of CAS, as well as the implications for the management of SES when understanding them as CAS (Preiser *et al.*, 2018). Biggs *et al.* (2012:430) explain:

Understanding SES as CAS constitutes a particular mental model, or cognitive framework, used to interpret and understand the world and decide on appropriate actions

Properties of CAS include the ability to adapt based on experience, self-organise, characteristics of emergent non-linear behaviour, and the ability to produce immense uncertainties that are in some cases irreducible (Biggs *et al.*, 2015). Key understandings emerging from understanding SES as CAS include the continuous adaptation of SES in response to internal system feedback — responses which are simultaneously affected by both internal and external connections (Preiser *et al.*, 2018).

System connections therefore interact in a manner resembling the holarchic nature of reality first described by Arthur Koestler in his 1967 book *The Ghost in the Machine* (Hammond, 2017). The notion of holons (holarchic nature of reality) described by Koestler was subsequently used to describe how systems exist within systems, and how actions in one system

may affect another seemingly unrelated system (Hammond, 2017). This concept applies all the way down to the most microscopic level and all the way up to galaxies (Hammond, 2017) thus necessitating an acknowledgment of the prevalence of uncertainty in SES (Biggs *et al.*, 2015).

By fostering an understanding of SES as CAS among actors involved with the management of SES, Biggs *et al.* (2012:432) argue the resilience of ES can be enhanced in the following ways:

Emphasizing [SIC] holistic (rather than reductionist) approaches, the management of multiple ES and trade-offs in an integrated way, and the importance of slow variables, lags, and feedbacks in SES dynamics (Principle 3). A CAS worldview also emphasises the substantial uncertainties surrounding SES and therefore the need to continually learn and experiment (Principle 5) and adaptively manage uncertainty, disturbance, and surprise rather than attempt to eliminate it. Understanding SES as CAS therefore does not directly influence the resilience of ES but affects the choice of management approaches.

Much of the evidence for the use of Principle 4 comes from the realisations and consequences from a lack of such a perspective, making it clear that underlying mental models require change from reductionism to complexity (Biggs *et al.*, 2015). There are, however, many examples of improved ES resilience due to transformation in ecosystem management because of changes in the underlying mental model towards perceiving SES as CAS (Arlinghuas, Alós, Beardmore, Deadlow, Dorrow, Fujitani, Hühn, Haider, Hunt, Johnson, Johnston, Klefoth, Matsumura, Monk, Pagel, Post, Rapp, Riepe, Ward & Wolter, 2017). It is clear that fostering such an understanding first requires a shift in worldview and institutional arrangements, which will face substantial opposition since it represents a more cooperative approach. The requirement of cooperation comes as a result of the reality that with increased complexity comes increased need for usually disparate disciplines to work together (Presier *et al.*, 2018). This collaboration is tricky to address across governance units that are usually isolated and separate (e.g., energy, water, food) (Biggs *et al.*, 2015).

The exact same case can be made regarding the water, energy, and food departments, making it possible for insights about the cooperation needed for increased complexity to feed into the way we conceptualise the cooperation of a WEF Nexus (Biggs *et al.*, 2015). As mentioned, the

WEF Nexus can essentially be framed as a SES, making it very important for CAS understandings and approaches to be present when enabling this new form of governance. Understanding SES as CAS essentially represents a managerial paradigm shift from causality and control to coping with change and uncertainty — a shift that is difficult to manifest in a context of meeting targets and accountability (Chaffin & Gunderson, 2016).

For those that do alter managerial operations towards such a perspective, substantial analytical frameworks and tools will be required (e.g., monitoring and data collection) (Edwards, Sharma-Wallace, Wreford, Cradock-Henry, Flood & Verlarde, 2019). Importantly, these monitoring and data collection tools cannot work without encouragement of adaptive approaches that allow for uncertainty (Biggs *et al.*, 2015; Chaffin & Gunderson, 2016; Edwards *et al.*, 2019).

This delicate balance between certainty and uncertainty will assist in not viewing complexity as an unknown trend and resultantly leading to stagnation and gridlock due to overwhelmed managers (Biggs *et al.*, 2015). The importance for adaptive management in congruence with monitorisation will be returned to when exploring the WEF Nexus- governance interface.

Although understanding SES as CAS can enable the management of SES in ways that enhance ES resilience — via for example, management approaches that allow for uncertainty, variability, disturbance and change — it is less clear to what extent an understanding of SES as CAS can lead to adaptive management approaches being adopted and importance of such understanding for ES resilience

Principle 5: Encourage learning and experimentation

Biggs *et al.* (2012:434) define learning as: “...the process of modifying existing or acquiring new knowledge, behaviours, skills, values, or preferences.” Learning is a phenomenon that can occur at both the individual and social level (organisations, communities of practice), the latter of which is known as social learning (de Kraker, 2017). Social learning occurs via social interactions which can be the outcome of intentionally facilitated processes, or as a result of an emergent outcome (Biggs *et al.*, 2015).

According to Biggs *et al.* (2015) learning can occur at three levels; each level is explained in Table 3.2. Since a WEF Nexus can essentially be framed as a SES (requiring CAS thinking),

insights and suggestions regarding how to encourage learning and experimentation are of valuable importance.

In today’s world monitoring and experimentation are effective tools for facilitating learning in the natural resource management sphere and have, for this reason, been used widely (Sengers, Beerkhout, Wiczorek, & Raven, 2016). The effectiveness of these tools is best summed up by the words of Biggs *et al.* (2012:434):

Monitoring provides information about changes in SES and ES, whereas experimentation involves the active manipulation of particular SES processes and structures to observe and compare outcomes.

Table 3.2. Three types of learning

Type of Learning	Characteristics	Question?
Single-loop learning	Comprises a change in skills, practices, or actions to meet existing goals and expectations	Are we doing things right?
Double-loop learning	Actively questions the assumptions that underlie action	Are we doing the right things?
Triple-loop learning	Deep-seated questioning of values and norms that underlie institutions and actions	How do we know what the right thing to do is?

(adapted from Biggs *et al.*, 2015)

The current problem with monitorisation and experimentation lies in the separatist and specialist way in which it has occurred up until now requiring a shift in the learning process towards broader participation (Principle 6) to all parties affected by SES management and governance (Biggs *et al.*, 2015; Sengers *et al.*, 2016; Presier *et al.*, 2018). The same can be said for the WEF Nexus where monitorisation and experimentation (for the sake of learning) need to happen under the condition of broad participation.

Broadened participation in parallel with monitorisation and experimentation is important as learning, resulting from participative experimentation and monitorisation, is critical for adaptive management and co-management (Sengers *et al.*, 2016; Edwards *et al.*, 2019). Both these processes involve management experiments that observe SES responses to disturbances or management actions, enabling and supporting learning about SES (Biggs *et al.*, 2015). In fact, research suggests that learning can lead to improved governance processes which impact ES resilience (de Kraker, 2017). As Biggs *et al.* (2012:435) explain:

For example, participatory learning processes can help actors learn about each other's mental models (Principle 4), which builds social capital, in turn supporting institutional change and conflict resolution.

It is clear that learning and experimentation are important for understanding SES and are critical requirements for the adaptive management needed for continued provisioning of ES in the face of change (Biggs *et al.*, 2015; Sengers *et al.*, 2016; de Kraker, 2017; Presier *et al.*, 2018; Edwards *et al.*, 2019). It is also clear that worldviews can be shaped (Principle 4) through the processes of learning, monitoring and experimentation. These processes, however, need to be both long-term and collaborative (Principle 6), while displaying the ability to withstand elements such as short-term politics (Biggs *et al.*, 2015; Sengers *et al.*, 2016; de Kraker, 2017).

Awareness of power dynamics, including powerful stakeholders, that influence how learning takes place needs to be considered, and can include "...who is learning, the linkages between learners, what type of learning takes place, whose knowledge is included and integrated or discarded, and what is monitored" (Biggs *et al.*, 2012:435).

Experimentation also needs to be applied at the correct scale and when social capital is adequate; failure to do so can lead to inappropriate management decisions (Biggs *et al.*, 2015; Sengers *et al.*, 2016). Institutional settings are important for guarding against maladaptive learning and should instead facilitate learning at different levels (Biggs *et al.*, 2015).

What is less clear is what type of learning is best and under what conditions making it necessary to research the institutions and conditions that support learning (Biggs *et al.*, 2015; Sengers *et al.*, 2016). A better understanding of institutions and conditions that support learning can assist

in shaping a better understanding to inform the design of learning processes in practice (Sengers *et al.*, 2016). Further suggestions made by Biggs *et al.* (2012) pertain to different types of knowledge used in the same scale or across scales to facilitate learning, as well as the need for the negotiation of power asymmetries in the learning process.

The literature on encouraging learning and experimentation as a principle for enhanced resilience simultaneously provides valuable insights for the WEF Nexus framework. This since it emphasises the value of usually separatist approaches participating, experimenting and learning from the process and one another for the sake of common goals. It also sheds light on the importance of monitorisation as a means for effective learning from experimentation and participation. In line with this, participation will be the following principle discussed.

Principle 6: Broaden participation

Participation and collaboration have been discussed for their importance with regards to learning and experimentation (Principle 5) (Biggs *et al.*, 2015) and refer to the process of actively engaging all relevant stakeholders (civil, private, public/ water, energy, and food/ local, provincial, and national) in governance and management processes (Swilling, 2020). This is exactly what is required when it comes to the WEF Nexus, making insights stemming from this principle of valuable importance.

The process of broadening participation can happen at different stages of the management process and can range from a complete devolution of power as promoted in the commons literature (Cumbers, 2015), to simply informing stakeholders regarding projects/research.

Participation in the resilience literature usually focuses on stakeholders with relevant scientific or local knowledge and an active interest in the management of ES (Hung, Yang, Chien & Liu, 2016). For this reason, participation is grounded in pragmatic considerations rather than ideological ones and seems to underlie the facilitated collective action required for appropriate responses to disturbances and changes in SES and ES that are so prevalent today (Biggs *et al.*, 2015; Chatterton, 2016, Simone & Pieterse, 2017; Swilling, 2020).

According to Biggs *et al.* (2012:436), a diversity of stakeholders participating in SES management improves:

Legitimacy, facilitates monitoring and enforcement, promotes understanding of system dynamics, and improves a management system's capacity to detect and interpret shocks and disturbances.

Research has demonstrated that participatory processes can lead to higher levels of actor cooperation and increase the ability to directly feed information into management decisions, while also boosting transparency via greater sharing of information (Boland, Fox-Rogers & McKay, 2020). Participation can thus be described as enhancing the link between information gathering and decision-making — a vital connection for effective decision-making and ongoing learning (Principle 5) (Biggs *et al.*, 2015).

Ongoing learning can facilitate a shift in attitudes and perceptions, creating questions surrounding existing decision-making and institutions and ultimately causing a transition to more appropriate governance arrangements which enhance ES resilience (Principle 4) (Biggs *et al.*, 2015; Ramalho, 2019). Relying on only traditional scientific processes restricts the range of ecological, social, and political perspectives that can be accessed, and restricts the possibility of promoting understandings of SES dynamics that can emerge from experiential or non-scientific knowledge (Biggs *et al.*, 2015).

It is important to note how systems thinking and Complexity Theory, with its conceptualisation of CAS, emerged due to shortcomings in the traditional scientific framework (Hammond, 2017). Dissatisfaction with the traditional scientific framework is what led to the adoption of complexity thinking in SES investigations by Elinor Ostrom in 1990 (Schoon & Van der Leeuw, 2015), eventually leading to the study of SES as CAS (Preiser *et al.*, 2018). It is in fact the application of Complexity Theory to socio-ecological issues, and the resultant realisation of increased exogenous variables and complexity that sparked the need for cross-disciplinary collaborations. The need for cross-disciplinary collaborations is what led Ostrom to pilot some of the first attempts to integrate social science and ecology at the Askö Workshops in 1993 (Schoon & Van der Leeuw, 2015)

The success of participation, whether planned (Askö Workshops) or emergent (The Commons literature), deeply depends on context, a factor Ostrom brilliantly demonstrated in her 1990 book '*Governing the Commons*'. Participation will not always lead to increased resilience of

ES and participation will depend on factors such as the social environment, the ability to build social capital, the process, the ability to link natural systems, the participants, the institutional setting, as well as if short gains are the focus rather than long-term resilience (Schoon & van der Leeuw, 2015).

Context is a very important determining factor when it comes to the success of participation with the enhancement of ES resilience in mind (Biggs *et al.*, 2015). Context can be described as existing out of what Ostrom refers to as an “action arena”. Schoon & Van der Leeuw (2015:169) describe action arenas (with reference to Ostrom) (1990) as follows:

The action arena is where multiple actors — individuals and formally or informally organized [SIC] groups of people — interact and lead to outcomes, whether social, ecological or social-ecological. These interactions serve as building blocks for understanding how institutions and people co-produce outcomes.

In response to SES change, participation enables the process of learning (Principle 5) and collective action. It is important to bear in mind that context seems to influence this as there are demonstrated examples where participation undermined ES resilience (Biggs *et al.*, 2015, Ostrom, 2009). Cases of participation undermining ES resilience suggests the necessity of a nuanced understanding of contextual variation, cautioning against the idea that stakeholder participation will benefit ES resilience in all cases (Ostrom, 1990; Ostrom, 2009).

The key research gaps with regards to participation are best summarised by Biggs *et al.* (2012) who write:

A key research challenge is to better understand how participatory processes support resilience under different conditions, such as different institutional settings, resource-poor versus resource-rich contexts, and urban versus rural systems.

Wagenaar and Wilkenson (2015) place emphasis on the need to understand how these collaborative dynamics are dealt with in practice.

With regards to the WEF Nexus, the principle of broadened participation essentially reinforces the main conceptual value placed on the WEF Nexus framework as a form of integrated governance in response to isolated resource governance. It strengthens the idea of improved

governance that stems from participatory approaches, yet at the same time, highlights the importance of context as a determining factor behind the success of participation.

Principle 7: Promote polycentric governance systems

Governance is defined by Biggs *et al.* (2012:437) as:

The exercise of deliberation and decision making [SIC] among groups of people who have various sources of authority to act and may be practiced through a variety of organizational [SIC] forms (e.g., bureaucratic department, watershed council, non-profit organization).

Polycentricity refers to a governance system with multiple governing authorities at differing scales (local, provincial, national/water, energy, food/civil society, private, public) (Araral, 2014). It therefore refers to a diversity of possible institutional arrangements — multi-level (local, provincial, national), multi-stakeholder and multi-sector (civil society, private, public), multipurpose (general purpose ‘nested jurisdiction’ and special purpose cross-jurisdiction units), and multi-functional units (specialised units, e.g., monitoring) — with ability and authority to react to varied problems across scales (Ostrom, 2010).

This system of governance was first explained by Vincent Ostrom as a “...pattern of organisation where many independent elements are capable of mutual adjustment for ordering their relationship with one another within a general system of rules” (cited in Araral, 2014:14). Ostrom (2010:664) expands on the necessity for polycentric governance by writing:

Moving away from the presumption that the government must solve all common-pool resource problems while recognizing [SIC] the important role of government is a big step forward. Hopefully, in the future, more national officials will learn to work with local and regional officials, non-government organizations [SIC], and local groups of citizens.

At first interpretation, polycentric governance seems to represent a form of governance unlike the proposed WEF Nexus framework and its proposed integration. Yet, when investigating the literature, it becomes clear that valuable insights can be drawn from the way in which

polycentric governance promotes variation but with the condition of strong cooperation between governance units. As Biggs *et al.* (2012:437) explain:

In polycentric systems, each governance unit has independence within a specified geographic area and domain of authority, and each unit may link with others horizontally on common issues and be nested within broader governance units vertically.

Polycentric governance therefore confirms suspicions in current isolated approaches to WEF systems and it gives further caution against the idea of full integration (Biggs *et al.*, 2015). These insights are valuable for the WEF Nexus literature which in its nascency is still grappling with what it is proposing in terms of governance structure. Literature on polycentric governance in a sense proposes collaborative autonomy, a form of governance where a multitude of governance units autonomously coexist in a larger collaborative system (Ostrom, 2010; Bauwens, 2017).

Cumbers (2015) argues in favour of a centralised structure that can provide the necessary means to link and scale up the autonomous units allowing for effective coordination and cooperation. According to Cumbers (2015) the state represents the best possibility for such a structure, but Swilling (2020) cautions this will depend on a relational concept of state, and not a structural state as it is currently conceptualised.

Regardless of who represents the needed centralised structure, such polycentricity requires an overarching system/tool/dashboard²² where governance units can be linked via information (Biggs *et al.*, 2015) which should ideally be commons-based (Carlisle & Gruby; 2019; Swilling, 2020). The literature on polycentric governance therefore strengthens the case for a collaborative nexus framework rather than a fully integrated nexus framework and highlights the criticality for such autonomous collaborative units to be strongly linked via information. Each of these shifts once again necessitates the need for analytical tools and monitorisation.

²² GCX DASH-.

Biggs *et al.* (2015) argue that this monitorisation and resultant information can come from specialised governance units added to the already present mix of units, linking them via information, without sacrificing autonomy.

According to Biggs *et al.* (2012) one of the key abilities of polycentricity is being able to match governance levels to the scale of the problem. This ability stems from the multiscale characteristics of polycentricity that link with the task of managing for ES resilience, as ES issues display themselves at multiple levels of society and ecology (Spreng, Savocool, Spreng, 2016). Polycentric governance allows for a multitude of governance units at different levels, creating a greater chance for an ES issue at a certain scale to be dealt with appropriately via governance intervention.

Polycentric structures are also argued to enhance the ability of SES to sustain desired ES by its ability to confer functional redundancy, resulting in the preservation of key SES elements despite changes and disturbances faced (Principle 1, Principle 2) (Biggs *et al.*, 2015). This essentially means polycentricity allows for modules/units that fail to be replaced by functionally similar modules/units thus displaying the characteristic of functional redundancy (Biggs *et al.*, 2015).

Additionally, these structures provide opportunities for learning and experimentation (Principles 5), while also increasing participation (Principle 6) in governance (Biggs *et al.*, 2015). The collaborative autonomy of polycentric governance is summed up by Biggs *et al.* (2012:438)

Polycentricity helps capitalize [SIC] on scale specific [SIC] knowledge (e.g., traditional and local knowledge) to aid learning through sharing of information, experience, and knowledge across scales.

Polycentric governance, however, presents its own challenges, which, if not addressed may result in the degradation of ES at one or a series of scales. Although also a substantial opportunity, the call for scale-specific governance arrangements presents one such a challenge given the wide range of scales in which ES are produced (Bauwens, 2017). To match governance units/levels to the various scales of different ES, an impractically large number of

governance arrangements will be required (Hamilton & Lubell, 2019). Polycentric governance therefore necessitates a fine balance between scale specificity and practicality. As Biggs *et al.* (2012:439) explain:

However, where a mismatch exists between the scale of governance and a particular ES, lack of understanding, enforcement, and resources at the appropriate scale may lead to failures, as, for example, in the lack of institutions governing global marine fisheries.

Another key challenge with polycentric governance is the problem of trade-offs that need to be negotiated between the various ES users/managers/stakeholders (Biggs *et al.*, 2015). Biggs *et al.* (2012:438) note that:

Trade-offs may occur when impacts are incurred by those not affecting or benefiting from an ES, or between conflicting goals and needs among users of current or potential ES.

In these cases, a polycentric approach may cause the degradation of ES at scales, especially in a situation where powerful elites can externalise trade-offs in their area of interest (Biggs *et al.*, 2015; Spreng *et al.*, 2016). Polycentricity should therefore not be hierarchical and should instead strive for a synergistic collaboration between all ES users/managers/stakeholders (Biggs *et al.*, 2015).

There will, however, always remain conflicts of interests, a factor both admitted and grappled with in the literature. This makes conflict resolution and collective decisions over how to allocate trade-offs some of the biggest challenges in polycentric governance systems (Ostrom, 2010; Biggs *et al.*, 2015, Spreng *et al.*, 2016; Bauwens, 2017; Thiel & Moser, 2018; Hamilton & Lubell, 2019; Carlisle & Gruby, 2019). As Biggs *et al.* (2012:439) write: “One of the largest problems in SES governance arises from who bears the costs and who benefits from enhancing resilience in favour of particular ES”.

Although the challenge of conflict resolution, collective decisions, and allocating trade-offs requires much attention and research, evidence indicates how open communication, transparency, accountability, connectivity (Principle 2), and time to build social capital and

trust can create the most effective polycentric governance structures for securing ES resilience (Biggs *et al.*, 2015; Hamilton & Lubell, 2019).

Furthermore, polycentric governance allows for much more flexibility in terms of political will, enabling those dissatisfied with political processes at a specific scale to find and support a more favourable political scale to frame a specific issue (Biggs *et al.*, 2015; Carlisle & Gruby, 2019). An example is “...when local non-governmental organizations [SIC] dissatisfied with their national government’s policies advocate for international regimes over the same issue” (Biggs *et al.*, 2012:439).

It is also crucial to remember that the polycentric approach represents a single tool of governance; others include top-down coercion or market approaches. The determinant behind which of these tools to use is context (Thiel & Moser, 2018). Thiel and Moser (2018) thus argue in favour of comparative institutional analysis when it comes to differing governance tools as well as between different institutions using the same tool — for example, polycentricity.

Polycentric governance represents a governance structure that is very successful in enabling other principles known to enhance resilience. These include redundancy (Principle 1), modularity (Principle 2), learning and experimentation (Principle 5), and participation (Principle 6) (Biggs *et al.*, 2015).

The success of polycentric governance is very dependent on the ability to develop and maintain the required social processes (social capital, trust, strong leadership, bridging scales with explicit strategies) to facilitate polycentric governance; it is not simply a matter of setting up polycentric institutions (Hamilton & Lubell, 2019).

The importance of coordination and collaboration among units/scales/sectors is often highlighted in the literature. Some authors argue that coordination and collaboration requires specialised units/a centralised body (Biggs *et al.*, 2015; Cumbers 2015). Most crucially, centralised/shared information allowing collaboration and coordination among units is also highlighted as important for polycentric governance to be effective (Biggs *et al.*, 2015).

The implementation, experimentation, and evaluation of polycentric governance is identified as a critical research gap which can assist in understanding how polycentricity functions given contextual variation (Ostrom, 2010; Biggs *et al.*, 2015; Spreng *et al.*, 2016; Thiel & Moser; 2018). This requires a better understanding of mechanisms for success and failure. As Biggs *et al.* (2012) put it: “Is it due to the polycentric structures themselves, poor implementation of polycentric principles, or some other cause?”. It is, therefore, clear as Thiel & Moser (2018) argue, that a need exists for a comparative analysis of implemented polycentric governance in different contexts.

My research will contribute to this need by grappling with the practical dynamics of the private-landlord-tenant collaboration at the V & A Waterfront. This research therefore serves as a link in the larger study which will give serious consideration to factors involving spatial and governance scales, while adding the comparative element lacking in my research.

3.3.6 Key findings

Humans are currently placing large amounts of pressure on urban SES, leading to the deterioration/destruction of ES (produced by these SES) on which society depends for its well-being. To mitigate these challenges and create resilient urban SES (i.e., SES that maintain and enhance the ES they produce), there is a need for interventions that decrease the amount of pressure we place on ecological systems. There is also a need for humans to enhance social cohesion, while also fostering the correct managerial and governance structure that allows for the fruition of the seven principles discussed.

In essence resilient urban SES will stem from a chiasmic/harmonious relationship between minimising the pressure we place on ecological systems and enhancing the required social interventions to assist in minimising these pressures. Schlör *et al.* (2018) explain that comprehensive socio-economic-ecological resilience requires ecological resilience of the surrounding WEF system, as well as social/governance resilience of the urban system to mitigate challenges of the globalised economy. As Biggs *et al.* (2015) write:

A resilience thinking approach tries to investigate how these interacting systems of people and nature – or social-ecological systems – can best be managed to ensure the

sustainable and resilient supply of the essential ecosystems services on which humanity depends.

Urban resilience is a leading global challenge²³ (Mguni & van Vliet, 2021) making it of critical importance to understand the complexities of fostering system resilience in as much as managerially possible. Resilience management and governance is required to shape comprehensive resilience; it is argued that a WEF Nexus approach represents such a form of governance because it essentially represents a collaborative mode of governance (Weitz *et al.*, 2017; Schlör *et al.*, 2018; Newell *et al.*, 2019; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021).

My research aims to investigate if a comprehensive practical WEF Nexus-governance approach presents possibilities for enhanced socio-ecological resilience. In order to do so I will evaluate what the nexus approach at the V&A Waterfront offers, (practically, socially, and in terms of governance), and deploy Biggs *et al.*'s (2015) proposed seven principles for enhanced resilience where relevant to make sense of the resilience capabilities that emerged at the V&A Waterfront as a result of the system (answering research question 3) (Weitz *et al.*, 2017; Schlör *et al.*, 2018; Newell *et al.*, 2019; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021).

Answering research question 2 will thus entail writing about the nexus governance approach as it has emerged at the V&A Waterfront. Thereafter, drawing on the seven principles, where appropriate, answering research question 3 will entail analysing the PSG repercussions, allowing me to understand if the nexus approach at the V&A Waterfront enhances, or possibly undermines, the ability to govern for SES resilience.

These seven principles are in no way used for the sake of proving Resilience Theory; this research does not seek alignment with the principles for the sake of proving the relevance or correctness of the principles. Instead, resilience is a normative goal; it is a preferred state at the V&A Waterfront and in the Cape Town context. This research acknowledges that resilience can mean many things, such as the capacity for a system to stay the same; in this particular case it refers to the capacity to use data to make transparent flows of resources for the sake of a more institutionally robust system. Resilience here refers to a continues process rather than

²³ Sustainable Development Goals and the New Urban Agenda.

an outcome, making it a verb rather than a noun that can be tested for degrees of prevalence but not as an achieved state.

In the context of the V&A Waterfront resilience refers to the degree of institutional capacity to maintain diversity and redundancy, manage connectivity, manage slow variables and feedbacks, foster complex adaptive systems thinking, encourage learning, broaden participation, promote polycentric governance, as well as the ability to adapt, collaborate, improve, and continue to function (via adaptive co-management) in face of wicked problems. The same perspective is taken with regards to the City of Cape Town (CCT), as the prevalence of the institutional resilience at the V&A Waterfront could imply that if scaled, the system may also enhance the capacity to govern for resilience in the Cape Town context.

This research therefore asks: Does the GCX system enable PSG implications that allow the V&A Waterfront, and therefore by implication Cape Town as an urban system (if the system is extended to Cape Town), to be more resilient? The intention is to explore the reality as it is, as it emerges in terms of PSG implications, and then to see how this reality speaks to the principles.

The literature on SES and resilience, therefore, confirms research question 3 — What are the practical, social and governance implications of the nexus governance system at the V&A Waterfront, and do these implications hold any potential for enhanced resilience in the Cape Town Context? — while also presenting a way in which to answer it.

In what follows I will review the WEF Nexus-governance interface — an underexplored relationship which, if successful, could prove beneficial for SES resilience. This makes the nexus governance interface an important avenue to explore, especially with regards to political, social, and institutional constraining factors, as well as possibly enabling lessons for adequate nexus governance from other bodies of literature on governance.

A deliberate focus on the WEF Nexus-governance interface also makes it possible to further explore a more nuanced understanding of nexus governance and its emergent possibilities. Drawing on Biggs *et al.*'s seven principles for enhanced ES resilience when analysing these possibilities will facilitate an understanding of whether the WEF Nexus – governance approach

might be better at building/strengthening the resilience of ES than other governance modes/types.

3.4 Nexus governance

The sections above make clear that adaptive and cooperative governance is required to deal with the increasingly complex problems humanity faces. In other words, humanity needs governance that enables resilience (Mguni & van Vliet, 2021).

There is, however, an apparent gap between advocacy for resilience and the practically demonstrated ability to govern for resilience (Wagenaar & Wilkinson, 2015). In line with this the WEF Nexus governance framework is proposed as a catalyst and tool for such cooperative and adaptive governance — a new paradigm for the enactment of resilience (Mguni & van Vliet, 2021, or as Mguni & van Vliet (2021) characterise it: a supporting instrument for resilience.

The arguments by Wagenaar & Wilkinson (2015) and Mguni & van Vliet (2021) essentially draws governance to the centre of the WEF Nexus debate as it is in the governance sphere where these adaptive, cooperative and relational nexus characteristics need to take shape. However, as Weitz *et al.* (2017); Newell *et al.* (2019) and Urbinatti *et al.* (2020) point out, the concept of governance is underdeveloped in the nexus literature, creating a disjunction between the call for a nexus approach and the understanding of governance required to enable such an approach.

The work by Weitz *et al.* (2017) and Urbinatti *et al.* (2020) represent the most comprehensive analyses of what the concepts ‘WEF Nexus’ and ‘governance’ actually mean in relation to one another, together resulting in an emerging concept which henceforth will be referred to as ‘nexus governance’. According to Urbinatti *et al.* (2020:22):

Nexus governance seems to appear as an umbrella concept for integrated decision-making and solutions for environmental issues. However, although this association is becoming increasingly common, it is not possible to say that it is an already well-defined concept.

Through a systematic literature review (SLR) Urbinatti *et al.* (2020:23) find that there are three existing nexus governance perspectives, each revolving around: “risk, economic rationality, and political economy”. This represents the first effort to categorise seemingly unrelated studies under the umbrella of nexus governance.

There are eight themes central to the literature on nexus governance: i) water centrism; ii) systems; iii) policy integration; iv) sustainable development v) environmental governance; vi) social-economics and management; vii) resource security; and viii) climate change (Urbinatti *et al.*, 2020:36).

Urbinatti *et al.* (2020:38) also identify three gaps in the nexus literature, namely: i) a lack of theoretical approaches that define the concept of nexus governance more densely, ii) the necessity to enhance focus on participatory approaches, and iii) a lack of critical analysis of the WEF Nexus perspective.”

3.4.1 Constraints for nexus governance

The most obvious constraint for nexus governance and its participatory approach is the overlapping decision-making possibilities which face the challenge of promoting collaboration among pre-existing ‘siloed’ governance structures (Weitz *et al.*, 2017; Urbinatti *et al.*, 2020). As Urbinatti *et al.* (2020) note:

For any of the nexus governance structures to be achievable, it would be necessary to change the intersection between material flows, financing and institutions; the vertical and horizontal interaction between economy, politics and society; and the analysis based on hybridity and transdisciplinarity. To some extent, this approach interacts with many governance concepts, focusing on integrative governance across diverse sectors and actors.

Unfortunately there are many social, political, governance and institutional dynamics (Schlör *et al.*, 2018) creating problems of path dependency, inhibiting policy integration, and the institutional change required to allow for nexus governance (Märker *et al.*, 2018). nexus governance essentially calls for trans-sectoral cooperation/integration/collaboration. Despite

the fact that there are uncertainties surrounding structure²⁴ — if this should be holistic integration (single sector) or collaboration (multi-sectoral interdependencies) — there are even more uncertainties surrounding how to actualise any of the proposed structures (Weitz *et al.*, 2017; Märker *et al.*, 2018).

As mentioned, the dominant governance patterns (siloed) are the result of ministries, administrations, and organisations that have evolved over the course of history (Märker *et al.*, 2018). This process leads to a path-dependent institutional setting creating “humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints, and formal rules” (Märker *et al.*, 2018:97). There are many individuals, organisations, and governing bodies who rely on the continuation and development of the current institutional setting. The reality is that institutional change results in costs, creating what Märker *et al.* (2018:97) explain as “...a certain inertia in terms of adapting to changing environmental, political, and economic contexts”.

The problem of path-dependent institutional settings is a major constraint when it comes to actualising nexus governance but will not be specifically addressed in this study as it falls outside the scope. There are also many other WEF Nexus Governance constraints, such as gross domestic product (GDP) per capita, governance quality, and political stability (Ding, Gunda & Hornberger, 2019) — all of which are critical, but also fall outside the scope of this study.

One of the most important factors is policy (Weitz *et al.*, 2017; Märker *et al.*, 2018; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021), a topic that also falls outside the scope of this study, but which will briefly be discussed after a discussion on connecting nexus governance gaps and constraints with the relevant Governance Theory. Although these problems are all equally important, they are more fully addressed in the larger WEF Nexus study of which this research is a part.

²⁴ Discussed in the WEF Nexus literature section.

3.4.2 Connecting nexus governance constraints with relevant Governance Theory

The prevalence of gaps and constraining factors, coupled with the adolescence of nexus governance, means nexus governance has many insights to gain from research (especially practical), but also from other bodies of literature on governance (such as Integrative Environmental Governance, polycentric governance, pro-environmental behaviour literature, and resilience literature), so as to find the most suitable and successful ways to circumnavigate gaps and inhibiting factors (Weitz *et al.*, 2017; Märker *et al.*, 2018; Mguni & van Vliet, 2021). There is thus an academic need to connect nexus governance gaps with relevant governance theory.

Both Weitz *et al.* (2017) and Urbinatti *et al.* (2020) explore the possibilities for nexus governance to gain insights from literature on integrated environmental governance (IEG). This connection exists since Weitz *et al.* (2017) argue nexus governance is to some extent a question of environmental governance, and both nexus governance and IEG represent integrated resource management approaches. IEG is, however, far more developed practically and theoretically.

Via literature on IEG, Weitz *et al.* (2017) and Urbinatti *et al.* (2020) set out to gain insights for three gaps identified in the nexus governance literature. These gaps are ((Weitz *et al.*, 2017:165):

- i) Conditions for cross-sector coordination and collaboration
- ii) Dynamics beyond cross-sector interactions
- iii) Political and cognitive factors as determinants of change.

After analysis of the literature on IEG, Weitz *et al.* (2017) and Urbinatti *et al.* (2020) make suggestions to address these gaps, including:

- Understanding drivers/conditions for coordination
- The need for integration instruments
- Coordination agencies
- Broadening the actors/units involved in governance

- Creating neutral spaces rather than formal merging of governance units.

These suggestions feed nicely into the reality of the nexus approach at the V&A Waterfront, confirming the relevance of the second question this research seeks to investigate: What governance and management systems have been developed by the V&A Waterfront, including the GCX system)?

This question is important since it can be argued that GCX, introduced by broadening the actors/units involved in governance at the V&A Waterfront, represent a coordination agency deploying GCX DASH- as an analytical/monitorisation tool, that by sharing information on shared resources, works as an integration instrument allowing autonomous units of governance (departments) to work together. The reality of the nexus approach at the V&A Waterfront therefore fits the governance suggestions made for addressing gaps identified in the nexus literature.

The necessity to broaden actors/units (following polycentric governance), introduce specialised/coordination agencies (linking units through information), and use integration instruments (analytics and monitorisation) for cross-scale collaboration is also identified in the nexus literature (Smajgl, 2016; Newell *et al.*, 2019) and resilience literature (Biggs *et al.*, 2015). These above-mentioned necessities serve as a further reason for researching the role of GXC as a specialised governance unit that enables ‘Collaborative and Adaptive Nexus Governance’ via shared information that stems from analytics and monitorisation.

The importance of information and technology (integration instruments) for shaping behaviour towards sustainability in WEF systems is also explored by Berman, Shwom & Cuite (2019:1) who link “...emerging FEW nexus research with existing literature examining household consumption and pro-environmental behaviours”. Berman *et al.*, (2019) investigate how proposed behaviour and structural interventions found in the household consumption and pro-environmental behaviour literature, can offer the WEF Nexus literature. Simultaneously, Berman *et al.* (2019) investigate how the WEF Nexus framework presents a possibility to rethink dominant approaches in household behaviour change science.

Taking this fresh perspective Berman *et al.* (2019:14-15) make suggestions relating to the importance of information enabled by technology. They argue:

- Moving towards a true nexus approach means having the tools and resources to accurately track food, energy, and water use in the household
- Information can provide initial learning experiences and begin to change social contexts through normative messaging, current research design often continues to lack structural and contextual focus
- Action interventions can help to establish household practices, form habits, and create environmental identity. Practices that were previously difficult, or constrained, can change through structural interventions.

Although there are many studies investigating such paths/interventions for changing behaviour towards sustainability (Hargreaves, 2011) there is a lack of research testing interventions in multiple WEF resource categories (Albrecht, Crootof & Scott, 2017). Additionally, material/technology provision is effective but utilised in very few studies (Berman *et al.*, 2019).

It is clear that trade-off and decision-support tools are required for WEF Nexus-oriented management (Berman *et al.*, 2019). According to Daher, Mohtar, Pistikopoulos, Portney, Kaiser & Saad (2018) existing assessment and decision-supporting tools have limited application to real-world WEF Nexus challenges. As Daher *et al.* (2018:153) explain: “Integrated assessment approaches are often discipline-specific or highly theoretical, lacking grounding in real-world FEW issues”. The reality is that WEF systems necessitate the use of integrated techniques that address “...multiple attributes of trade-off analyses, dynamic and disparate datasets, and difficult decision contexts” (Daher *et al.*, 2018:153).

No single or existing modelling tool is capable of capturing all conceivable interactions and trade-offs within the WEF Nexus (Food and Agriculture Organisation of the United States (FAO), 2014; International Renewable Energy Agency (IRENA), 2015; Mohtar & Daher, 2016). The task requires new, interactive, and analytical tools that can be used to analyse, model and optimise the stakeholder decision-making process with regards to system optimisation, resource allocation, and resilience (Mohtar & Daher, 2016; Daher *et al.*, 2018).

What is needed is a nexus-oriented decision support system (DSS). According to Daher *et al.*, (2018:153) such a system needs to be:

...embedded in a comprehensive knowledge management system that goes full circle, taking into account: defining the nexus problem at hand, defining data requirements, respective monitoring programs, etc., to visualization of outcomes and communication of these outcomes to stakeholders”.

Findings of analyses need to be provided to all stakeholders since the purpose of such a DSS is to support decision makers at multiple levels and scales in making evidence-based decisions (Mohtar & Daher, 2016). At the same time a DSS needs to be flexible in terms of sourcing data, requiring “...(near) real-time data” (Daher *et al.*, 2018:156). It is also crucial for monitoring to create new questions while answering questions about future monitoring needs (FAO, 2014; IRENA, 2015). Context is once again a very important factor as every stakeholder or stakeholder group will most probably require a unique approach and a different manner of communicating the recommendation and outcomes of the DSS (Mohtar & Daher, 2016). With regards to developing countries Daher *et al.* (2018:156) have the following to say:

A comprehensive, scalable, user-friendly, easy to understand, multi-purpose, flexible, extensible, and easy to access (web-based) DSS appropriate for developing countries and that can simulate and predict the influence of future land management practices and considering climate change, is still lacking.

Daher *et al.* (2018) — supported by FAO (2014), IRENA (2015), and Mohtar & Daher (2016) — argue that within the WEF Nexus, trade-offs analysis and decision-making can be supported by technology, methodologies, policy/governance, and community building (see Table 3.3).

Table 3.3. Tools for supporting WEF Nexus decision-making

Within the WEF nexus, trade-offs analysis and decision-making can be supported by:	
Technology	“Analysis and visualization provide the means by which ‘data’ is transformed into information, insight, and knowledge.”
Methodologies	“Game-theoretic and integrated modelling tools provide a set of methods that can be used to model the way in which resources can be efficiently allocated across the FEW Nexus.”
Policy/governance:	“Integrated modelling, decision support, and game theoretic approaches are natural frameworks to model interactions of FEW systems and the interactions between stakeholders. These approaches lend themselves to participatory and co-design with decision makers or stakeholders so that any candidate solution may achieve a higher chance of implementation”
Community building:	“To leverage innovation in the three pillars of the nexus, there is a need to build integrated, interdisciplinary communities of researchers that cut across engineering, behavioural economics, social sciences, and information technologies.”

(adapted from Daher *et al.*, 2018)

In line with these supporting suggestions Daher *et al.* (2018) argue research must:

Enable appropriate tool sets matched with FEW Nexus hotspots; customising existing tools to fit local specifics; compatibility between collected data and integrative nexus assessment tool needs; evaluation of these assessments through incorporation of stakeholder input, and guidance forward for solution implementation.

The new, distinct and unique reality of GCX DASH- further aligns with the need to research specialised assessment and decision support tools rather than existing ones. This once again supports the reasoning behind investigating the role of a specialised governance unit, equipped

with a new and district trade-off and decision supporting system/tool (GCX DASH-), in enabling adaptive nexus co-management.

After consideration of the argument presented by Daher *et al.* (2018) it must be noted that the nexus approach at the V&A Waterfront is not researched with the assumption that it can serve as a panacea for all contexts; rather it is researched for gaining context-specific insights that can contribute to the common pool of contextual knowledge about DSS. This will allow for deeper knowledge and understanding that can assist in finding the best solution or group of solutions for the given context²⁵. As Daher *et al.* (2018:158) write:

Improving the developed nexus analytics and trade-off assessment tools would allow us to be better prepared to address the interconnected resource challenges. It would allow policy makers to have the information needed for informed decisions and would put incentives in place to push towards future, sustainable resource allocation. Realizing [SIC] the need for such analytical tools would also provide impetus towards building scientific and institutional capacities for professionals to carry forward those assessments and communicate them to stakeholders.

Due to the functioning reality of a private (specialised governance unit)-landlord-tenant governance arrangement present at the V&A Waterfront, investigating it will furthermore align with the already identified gap of exploring practically demonstratable examples of WEF Nexus Governance. This further allows the study to better come to grips with ‘drivers/conditions for cross-sector coordination and collaboration’.

3.4.3 Adaptive co-management

Since WEF systems are essentially multifaceted SES (Schoon & Van der Leeuw, 2015; Hammond, 2017; Preiser *et al.*, 2016 Newell *et al.*, 2019) that need to be understood as CAS, the resilience literature is of great importance when seeking insights for the WEF Nexus

²⁵ This is important to consider given the fact that the V&A System will potentially inform a larger City of Cape Town dashboard that is being developed by a Stellenbosch University PhD student who wishes to scale up a GCX-type DSS dashboard.

Governance debate. The resilience literature emphasises Systems Theory and Complexity Theory as necessities for dealing with increasingly complex and multifaceted SES (Biggs *et al.*, 2015; Preiser *et al.*, 2018). Accordingly, Urbinatti *et al.* (2020) stress the need to incorporate Systems Theory into the policy-making process surrounding WEF Nexus Governance.

The resilience literature further expresses the need for monitorisation and analytical tools that can help make sense of this complexity (Biggs *et al.*, 2015). However, due to the ever-present uncertainty in CAS (Preiser *et al.*, 2018), monitorisation and analytics are futile without adaptive capacity²⁶ (Edwards *et al.*, 2019; Chaffin & Gunderson, 2019) — itself an aspect of resilience particularly relevant in the context of social systems (and in some way equivalent to resilience) (Biggs *et al.*, 2015). Märker *et al.* (2018:292) note:

Adaptive management is [...] a systematic process for improving management policies and practices by systemic learning from the outcomes of implemented management strategies and by taking into account changes in external factors in a pro-active manner.”

High levels of adaptive capacity are especially important for WEF Nexus Governance systems since they span the link between a multitude of ecological and socio-economic subsystems (Märker *et al.*, 2018). Monitorisation, learning, and experimentation (needed for making sense of complexity in as much as possible detail), adaptive capacity (required for ever persistent uncertainty), and the already discussed requirement of cooperation between polycentric units, are together needed for ‘adaptive co-management’, something expressed as highly important in the resilience literature (Biggs *et al.*, 2015; Chaffin & Gunderson, 2016; Senger *et al.*, 2016; Edwards *et al.*, 2019).

²⁶ The importance of monitorization, learning, experimentation, and the institutional setting for enabling adaptive management and co-management was explored when discussing Principle 5: ‘Encourage Learning and Experimentation’ (Biggs *et al.*, 2015).

According to Wagenaar and Wilkinson (2015:127):

Adaptive co-management refers to recent efforts to bring together two emerging programmatic approaches to natural resource management that attempt to deal more effectively with uncertainties and complexities: ‘co-management’ (Holling, 1986), with its attention to user participation in decision-making, and ‘adaptive management’, with its focus on “learning by doing in a scientific way to deal with uncertainty”

Following the resilience literature, adaptive co-management is dependent on a diversity of governance units (multiscale complexity) whose actions derive from the everyday mangle, uncertainty, and unpredictability of practice, while being strongly linked via information (Wagenaar & Wilkinson, 2015; Biggs *et al.*, 2015). This information needs to stem from monitorisation/analytical tools, as well as learning and experimentation²⁷ (Biggs *et al.*, 2015; Chaffin & Gunderson, 2016; Sengers *et al.*, 2016).

Adaptive co-management is therefore about the interplay between predictability (via analyses) and unpredictability (countered by adaptability), coupled with collaboration (due to multiscale complexities), necessitated when interpreting/managing SES (e.g., WEF) as a CAS. Since the resilience literature can be used to draw insights into how to govern WEF systems (SES), these suggestions need to be considered as important contributions to the discussion about ‘nexus governance’.

This argument therefore solidifies the importance of monitorisation (enabled by specialised governance units) in support and in congruence with adaptive and collaborative polycentric governance units strongly linked via the analysed information. This study’s point of departure is that the monitoring of urban metabolisms (UM) done by GCX represents an example of such a specialised governance unit (monitorisation) and will be treated as such by the study when investigating its role in enabling collaborative and adaptive nexus governance (research question 3) (Magoni, 2017).

²⁷ The importance of monitorization, learning, experimentation, and the institutional setting for enabling adaptive management and co-management was explored more elaborately when discussing Principle 5: ‘Encourage Learning and Experimentation’ (Biggs *et al.*, 2015).

It is interesting to note that in line with this Urbinatti *et al.* (2020) emphasise the importance of both IEG and polycentric governance as appropriate concepts to provide insights for the use of adaptive co-governance mechanisms at multiple scales in coordinated and collaborative ways, something that to a large extent depends on shared information. It is, however, not an objective of this study to link these insights with gaps, but rather to investigate how the approach at the V&A Waterfront enables adaptive and collaborative nexus governance.

3.4.4 The importance of policy (politics)

It must be noted that although there is much possibility in the suggestions explored up to this point, and important learning to take place from what seems to be a practical example of these suggestions, a largely untouched subject of great importance is the topic of policy (Weitz *et al.*, 2017; Märker *et al.*, 2018; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021).

The policy cycle is the most critical point that is slowing progress in the effective deployment of the nexus approach, and the need to understand political, cognitive, and ideological factors as determinants of change is discussed in depth by Weitz *et al.* (2017). This quote by Weitz *et al.* (2017:171) therefore sums up the greatest limitation of this study:

The nexus literature identifies barriers to policy coherence and options for overcoming them, but largely reflects a technical-administrative view on governance that distances it from the reality of decision-making processes. This distance results from a dearth of analysis on why barriers to collaboration and cross-sector coordination are present and how the nexus is shaped by political and cognitive factors and dynamics at higher or lower administrative levels.

A discussion of policy tends to refer to the formal policies adopted and implemented by governments. The discussion encompasses who the policymakers are, the structures of governance and policy-making, the policy formation and adoption processes, and the wider political dynamics that result in the formulation and adoption of specific projects. To the extent that the V&A Waterfront is not a government body with a mandate to formulate policy, this study does not address policy as such, but it will be addressed in the larger study of which this research forms a part.

Although this is admittedly a great limitation, the intention of this study is to create sufficient neighbourhood-level understanding for the larger study, which if connected with insights from the other five neighbourhoods will provide sufficient understanding to address these very important political, cognitive, and geographical questions.

The politics of the V&A Waterfront's context is important to understand, especially when seeking to link up these understandings with other case studies to create comprehensive political, cognitive and ideological factors as determinants of change that can eventually inform policy. The V&A Waterfront makes decisions that have a major impact on how that precinct operates. The GCX system enables a particular set of decisions, but the processes involved are profoundly political. The wider dynamics that led the V&A Waterfront to adopt the GCX system in the first place are political, i.e., pressures and dysfunctions from the wider society, shareholders, funders, citizens, and so forth - these are perceptions that trigger profoundly political dynamics. The information that GCX unleashes that is fed back into the V&A Waterfront system results in tenants and the V&A Waterfront management perceiving things differently. Some will welcome it; others will not — that is political²⁸. These political aspects will be dealt with in Chapter 4.

3.4.5 Some key points and considerations

Wagenaar & Wilkinson (2015) bring into focus the gap between advocacy for resilience in literature and policy, and the practical demonstrated ability to govern for resilience. In line with this, the WEF Nexus framework is proposed as a new mode of governance that enhances the ability to govern for resilience via proper consideration of trade-offs and synergies.

There is, however, an apparent gap between the ideal of a WEF Nexus and the practical realities of governance. In other words, although the WEF Nexus framework holds potential as a framework for enhanced resilience, it is not developed enough regarding the governance complexities and realities that need to take shape for this framework to be enacted in practice.

²⁸ My interpretation of political for the purposes of this research: Anything that is about power dynamics is political. Politics is the description given to the unfolding power dynamics in any context. There is no context that is free of power dynamics, and this research intends to explore these dynamics, describe them, and flesh out how they manifest in the context of the V&A Waterfront.

This is crucial since the WEF Nexus approach is essentially about governance, as it is in the governance sphere where these proposed nexus characteristics manifest.

For these reasons this chapter first explored the relational approach of the WEF Nexus and related governance implications, as ‘nexus governance’, identified as a critical concept to explore for the enactment of the WEF Nexus approach. Many gaps were then identified that constrain nexus governance, some of which are explored, yet most fall outside the scope of this study.

It was then argued that in order to overcome these constraints, there is a great need for practical research of nexus governance examples. It was also argued that nexus governance has to gain insights from literatures on governance, so as to identify the best way to circumnavigate these gaps and constraints. By connecting nexus governance constraints with relevant governance theory, many suggestions were raised. These suggestions are found to resemble the practical case of nexus governance researched in this study, confirming research question 2: What governance and management systems have been developed by the V&A Waterfront, including the GCX system?

3.5 Conclusion

A deep understanding of the WEF Nexus can provide the informed and transparent framework that is required to meet increasing global demands without compromising sustainability. The nexus approach can also allow decision-makers to develop appropriate policies, strategies, and investments to explore and exploit synergies, and to identify and mitigate trade-offs among the development goals related to water, energy, and food security. The WEF Nexus framework requires active participation by and among government agencies, the private sector, and civil society. The WEF Nexus framework is also promoted as a supporting instrument for resilience.

Unfortunately, the WEF Nexus literature makes it clear that the approach is too underdeveloped, under-implemented, and under-explored practically, socially, and in terms of governance. The WEF Nexus literature therefore confirms and answers, together with the SES reliance literature and nexus governance literature, research question 1: How is the WEF Nexus framework understood with particular reference to the PSG implications?

In order to understand if the PSG findings regarding research question 3 hold the possibility to enhance, or potentially undermine, the capacity to govern for resilience the SES and resilience literatures were explored. Exploring the seven principles approach by Biggs *et al.* (2015) for enhanced resilience helps to frame the thinking/action/governance required for resilience. The literature on SES and resilience was therefore explored to provide the basis for evaluating the emergent potential for enhanced resilience offered by the nexus approach at the V&A Waterfront. In other words, SES resilience literature provides me with principles against which to evaluate the PSG findings of research question 3: What are the social, governance and practical impacts/implications of the nexus governance system at the V&A, and in turn, allows me to answer the resilience aspect of research question 3: Do these implications hold any potential for enhanced resilience in the Cape Town context?

Since the WEF Nexus essentially has to do with governance, it was important to explore the nexus-governance interface as ‘nexus governance’. It was found that there are many governance gaps and constraining factors inhibiting nexus governance. It therefore became necessary to connect nexus governance constraints with relevant Governance Theory. Specialised governance units focusing especially on monitorisation and analysis, are of critical importance for enabling the collaborative and adaptive nexus governance (due to the ability to link governance units through shared information). This was found to be in line with much of the governance approach present at the V&A Waterfront and thus, in effect, confirming research question 2: What governance and management systems have been developed by the V&A Waterfront, including the GCX system?

My research intends to understand if a configured bridge between nexus literature and governance in practice can be established — what has been referred to as ‘nexus governance’. A case study will help to bridge the gap between the advocacy for resilience and the ability to govern for resilience. In other words, can a practically viable nexus governance approach enhance the practically demonstrated ability to govern for resilience?

In the next Chapter, findings for all three research questions will be presented.

Part B: Target Knowledge: How does the nexus governance approach at the V&A Waterfront enhance the capacity to govern for resilience in the Cape Town context?

Chapter 4: Findings

4.1 How is the WEF Nexus framework understood, with particular reference to the practical, social, and governance (PSG) implications?

By conducting an emergent practitioner workshop (Appendix C) and a literature review (Chapter 2) of various sources related to the WEF Nexus, my research found the necessary information to decipher how the WEF Nexus is currently understood socially, practically and in terms of governance. The literature review and workshop enabled me to construct a sufficient comprehension of the WEF Nexus, including identifying gaps and misconceptions.

At the same time, the literature also enabled the exploration of possible paths toward proper conceptualisation while providing me with information on how to reconfigure gaps through relevant and more established theories and empirical research.

It is for this reason that the literature review and practitioner workshop serve as findings for research question 1, namely: How is the WEF Nexus framework understood regarding the social, governance, and practical impacts and implications?

4.1.1 WEF Nexus from a theoretical point of view

From a theoretical point of view, the WEF Nexus is proposed as a ground-breaking framework for the integrated governance of resources among different sectors, scales and levels of governance (Shlör *et al.*, 2018). It is proposed as a means of governance which involves being conscious of complex cascading effects and trade-offs when decisions are made concerning interrelated resources such as water, energy, and food (Newell *et al.*, 2019).

This is in contrast to the traditional approach to resource governance, where resources are governed in isolation from one another, as they are assumed to be mutually exclusive (Weitz *et al.*, 2017). Nexus as a governance approach, therefore, includes not only making decisions

about interrelated resources but also extends the concept to include the necessity for integrated and collaborative governance among different sectors, scales and levels of government. (Urbanatti *et al.*, 2020).

It is for this reason that the WEF Nexus is very often studied as a complex social-ecological systems (SES), as it includes both ecological systems and how they relate (WEF), social systems and how they relate (e.g., governance), as well as how social and ecological systems relate with one another and larger systems in which they are embedded (Schoon & Van der Leeuw, 2015; Hammond, 2017; Preiser *et al.*; Newell *et al.*, 2019).

It was, however, found that there is a lack of conceptual clarity with regard to what the WEF Nexus actually represents (Urbanitti *et al.*, 2020), making it difficult to identify what is and what is not a nexus problem. Suggestions for rigid conceptualisation (Katz *et al.*, 2020; Urbanitti *et al.*, 2020) are compared to arguments in favour of fluidity depending on the context and objectives (Märker *et al.*, 2018).

This argument extends to arguments in the WEF Nexus literature surrounding different proposed forms of cooperation; it is clear that cooperation is required but it is not clear in what form. Debates for two different forms of cooperation were presented, namely the Holistic WEF Nexus Integration Framework (defines the WEF nexus as a single, fully integrated system) and the Collaborative WEF Nexus Framework (WEF Nexus largely based on existing structures and a reframing of the present institutional setting towards more collaboration) (Märker *et al.*, 2018).

After analysis of these debates, it became apparent that each has its benefits and disadvantages depending on the context, leading to the conclusion that fluidity is essential and that researchers need to move in the direction of empirical analysis of application rather than debates surrounding abstract conceptual clarity.

Although there is still much uncertainty in the literature surrounding the WEF Nexus, what is more clearly expressed is the need for better analytical capacity and monitorisation, specifically surrounding resource data, to better cooperate and coordinate different sectors, scales and levels (Smajgl, 2016; Newell *et al.*, 2019). It was, however, made apparent that such

monitorisation needs to be accompanied by adaptive co-management (Urbinatti *et al.*, 2020). This was expressed as equally important as the need for interdisciplinarity at the core of the nexus research agenda (Berman *et al.*, 2019) as there is a need for qualitative social science perspectives in congruence with quantitative industrial ecology perspectives (Foran, 2015).

4.1.2 WEF Nexus from a practitioner point of view

Some more understandings of the WEF Nexus held by researchers and practitioners situated in the Cape Town context were explored during the “What is Nexus Workshop” (Appendix C). Practitioner 16 (2021), for instance, explained that for him:

Nexus thinking is about making the interdependencies and relationships between resource sectors clear and coherent. It is an approach for increasing the co-benefits and reducing the co-impacts across sectors and for nature. Implementation of nexus in land-use management, urban and regional planning, and governance can improve resource efficiency, protect biodiversity, contribute to climate mitigation and adaptation, and achieve food, water and energy security for all.

As mentioned, there are six case studies investigated in the more extensive study, and all the researchers involved in the larger study were present at the practitioner workshop. From discussions with them, I could extrapolate some understandings of their experience of “what constitutes the nexus in Cape Town?” specifically from a practical, social and governance (PSG) perspective.

Practitioner 2 (2021) mentioned that his research suggests a lack of trust between departments, sectors and government scales while suggesting that government employees are “disincentivised to do anything beyond their own department”. At the same time, Practitioner 17 (2021) made apparent the lack of interaction and collaboration between small-scale farmers and the government.

These suggestions fed into the suggestion made by Practitioner 15 (2021), which is that for the WEF Nexus as an approach to be implementable, we “... need more than a good concept, there is a need to look at power dynamics and vested interests”. This was related to another point made by practitioner 13 (2021), who mentioned the importance of understanding who drives decision-making, as there is a clear need to challenge how decisions are made. This is a critical

aspect to understand when looking at the implementability of the nexus from a PSG perspective.

What all these insights pointed toward was once again the need for the integration of data (Practitioner 8, 2021), or as Practitioner 2 (2021) explained: “We need to look at how data is generated, including small examples, and how to share this data with decision-makers in a way that can complement decisions”. This insight was supported by Practitioner 9 (2021), who explained the importance of a “data-driven decision support system that can understand the reality, leverage funding, influence governance, and track effectiveness.”

Practitioners furthermore expressed that the WEF Nexus as an approach to resource governance is proposed as an instrument for increasing resilience capabilities. According to Practitioner 1 (2021), a resilience perspective focuses on three key questions, namely: “how to absorb shocks, increase capacity to recover, and transformation of the systems”. This implies that the WEF Nexus is seen as an approach which will assist SES in better absorbing shocks, increasing its capacity to recover, and enabling better transformative capacity.

Practitioner 1 (2021), however, expressed that the WEF Nexus is a “Wicked governance problem that is not yet organised in an integrated way”. It is this sentiment that expresses the rift that exists between theoretical ambitions for the WEF Nexus and the practical implementation of it as an approach. This furthermore implies a lack of understanding when it comes to the actual PSG effects that may come from the implementation of the WEF Nexus as a governance approach.

4.1.3 Bridging theoretic perspectives and practitioner perspectives: WEF Nexus as a tool for resilience

These practitioner-held understandings are synonymous with the literature on the WEF Nexus. According to the literature, the WEF Nexus is proposed as a supporting governance instrument for resilience and the ability to manage resilience in practice (Weitz *et al.*, 2017). Literature on SES resilience was therefore explored to better grasp what resilience from a governance perspective entails, creating a richer understanding of the types of governance that may bring about these resilience-enhancing characteristics. This was necessary to understand if the WEF Nexus governance approach as it is currently formulated holds any potential as a resilience-

enhancing governance approach. It also enables my research to grapple with adequate resilience literature to eventually analyse/evaluate the PSG implications of the nexus governance approach at the V&A Waterfront for resilience-enhancing qualities.

Although the WEF Nexus approach is theoretically proposed as a supporting instrument for resilience, it was found that there is a gap between theoretical ambitions and the practical implementation and empirical analysis of its practical, social and governance effects (Weitz *et al.*, 2017; Schlör *et al.*, 2018; Newell *et al.*, 2019; Urbinatti *et al.*, 2020; Mguni & van Vliet, 2021). There is also, more specifically, a gap in the WEF Nexus- governance interface, as the connection between WEF Nexus and governance is underexplored.

In other words, although the WEF Nexus framework holds potential as a framework for enhanced resilience, it is not developed enough regarding the governance complexities and realities that need to take shape for this framework to be enacted in practice (Urbinatti *et al.*, 2020). This is crucial since the WEF Nexus approach is essentially about governance, as it is in the governance sphere where these proposed nexus characteristics manifest.

This realisation led to analysing the WEF Nexus-governance interface as ‘nexus governance’. Upon analysis, it was found that many gaps exist, creating the need for exploration of other governance literatures for the sake of identifying the best ways to circumnavigate these gaps. By connecting nexus governance gaps and constraints with the relevant governance theories, many suggestions were raised. The bulk indicated the need for practical case study research of nexus governance (Weitz *et al.*, 2017), once again confirming the directionality of my research.

4.1.4 Synopsis

Findings stemming from research question 1 have made it clear that researchers need to investigate practical examples of WEF Nexus governance as the PSG effects are not very well understood. The literature and practitioner workshop furthermore highlight the importance of practical empirical analysis since context is such a critical determining factor when it comes to what is politically and institutionally possible concerning collaboration/integration, as well as what form of collaboration/integration will be suited for the context. This, coupled with the need to understand path dependency, highlights the necessity of research focusing on practical institutional analysis of WEF Nexus governance within SES.

The literature and workshop therefore confirm research question 2: ‘What governance and management systems have been developed by the V&A Waterfront, including the GCX system’. As well as research question 3: “What are the social, governance and practical implications of the nexus governance approach at the V&A Waterfront, and do these implications hold any potential for enhanced resilience in the Cape Town context?”.

Given the gap in nexus literature concerning practical, social and governance considerations, the next two chapters are dedicated to presenting findings stemming from empirically exploring the practical implementation of an existing nexus approach at the V&A Waterfront. More precisely it is an exploration into the application of a dynamic resource analytics and decision support system (DSS), called the GCX DASH- that has allowed for the integrated governance of resource systems at the V&A Waterfront. This empirical analysis is done from a PSG perspective, via semi-structured interviews with relevant stakeholders at the V&A Waterfront and GCX. Information stemming from these interviews will thus be used as findings for research question 2: What governance and management systems have been developed by the V&A Waterfront, including the GCX system. These findings will be presented in the following section.

4.2 What governance and management systems have been developed by the V&A Waterfront, including the GCX system?

4.2.1 Context

The Victoria & Alfred (V&A) Waterfront is situated on the shores of the Atlantic Ocean, between Robben Island and Table Mountain, in the heart of Cape Town’s harbour (see Figure 4.1 & Figure 4.2). The V&A Waterfront is essentially an inner-city, high-end commercial waterfront development consisting of mixed-property types, including fisheries, residential and commercial real estate, hotels, retail districts, extensive dining, arts and culture, leisure and entertainment facilities, as well as ocean-related work, leisure, and tourism. The major urban economic precinct sits on 123 hectares of property that attracts roughly 23 million international and local visitors annually, making it a massive economic (social) and resource-intensive (ecological) operation (V&A Waterfront, 2022a).



Figure 4.1. The Victoria & Alfred Waterfront

(source: Pierotti, 2018)

The V&A Waterfront is the oldest working harbour in the Southern hemisphere and was established as such between 1860-1920 when construction began to connect the Alfred Basin of the Cape Town Harbour with the Victoria Basin (V&A Waterfront, 2022a). In 1988 the state-owned transport cooperation, Transnet Limited, established the V&A Waterfront as Victoria and Alfred Waterfront (Pty) Ltd., for the first time allowing official commercial trading. In 2007 Transnet Limited placed the V&A Waterfront on the market where it remained until 2011 when Growthpoint and the Public Investment Cooperation (PIC) jointly acquired the company, and it has since become an example of a successful private-public partnership (V&A Waterfront, 2022a).

Today the company states that: “The V&A is a symbol of heritage and diversity, where people from all walks of life can play, live, shop, dine and work while immersed in the vibrant spirit and authentic local culture that exists in this bustling ecosystem” (V&A Waterfront, 2022a: no pagination). The company also takes a very direct social and ecological stance by stating (V&A Waterfront, 2022b: no pagination):

It [the V&A Waterfront] sees its role on the continent to be a platform that facilitates and champions art and design, to support entrepreneurship and innovation, lead the charge on sustainability, and drive positive social and economic change. By prioritising people and the planet, the V&A is an example of how working with communities, respecting the environment and operating with passion and integrity is a better, more productive and kinder way of doing business.

The V&A Waterfront management acknowledges the plethora of internal and external changes and challenges they face yet takes an appreciative stance in leading the way developmentally. Its unique positioning as a private neighbourhood with access to the ocean makes it a vastly adjacent, responsive, and flexible entity. There are several key trends that have informed and driven the shifts made by the V&A Waterfront in recent years. These will be discussed briefly in Table 4.1.

Table 4.1. V&A Waterfront perception of key business trends

Trend	Description
Purpose and shared value	Refers to the fact that most relevant and successful organisations do not concentrate only on generating commercial returns for shareholders but rather on delivering value to all of their stakeholders. This is a crucial factor and expectation for organisations in South Africa, especially Cape Town, as it is seen as the least transformed city in South Africa (V&A Waterfront, 2022b).
Customer-centricity and data-centricity	Refers to how these two elements are fundamentally required for remaining competitive in today's digital economy and social media-dominated world (V&A Waterfront, 2022b).
Working in a systemic nature and across silos	Indicative of the nexus and resilience literature explored in the second chapter of this thesis. For the V&A Waterfront it represents a fundamental operational approach that is essential to “activate and gain the benefit of under- realised value”, especially in a purpose-led and digital world ²⁹ (V&A Waterfront, 2022b: no pagination).
Global retail shifts	Refers to how these global shifts are placing conventional retail environments under immense pressure, even before COVID. As stated by the V&A Waterfront (2022b: no pagination): “The seismic shift of the pandemic accelerated trends, and all indications are that this will continue and even escalate”.
The depressed macro-economic environment	Reality that necessitates innovative, creative, and radical responses from commercial entities (V&A Waterfront, 2022b).

²⁹ This is indicative of the type of governance approach adopted by the V&A Waterfront to govern the WEF Nexus, where departments collaborate to manage resources in an integrated way. As it will soon become apparent, this collaborative approach has been made possible with the use of GCX Dash-, argued to be the key link in enablement of a nexus governance approach at the V&A Waterfront.

Trend	Description
South African socio-political climate	Reality that necessitates innovative, creative, and radical responses from commercial entities (V&A Waterfront, 2022b).
Waste, water, energy, climate, and traffic challenges	The seventh trend simply reads “Waste, water, energy, climate and traffic challenges”, and points to the way in which we face problems in all five of these spheres, requiring radical transformation and innovation ³⁰ (V&A Waterfront, 2022b).

(adapted from: V&A Waterfront, 2022c)

³⁰ This points to the V&A Waterfront’s awareness of the problems faced in these spheres, indicating their willingness for innovative approaches to governing these resources. This is exactly what they have done with the introduction of GCX and their DSS, a topic discussed in more detail later in this section.

The positioning of the V&A Waterfront as a leading developer within the South African context makes these trends important when considering the company's purpose, which reads: “Collectively creating the world’s most inspiring waterfront neighbourhood” (V&A Waterfront, 2022b: no pagination).



Figure 4.2. The V&A Waterfront Harbour

(source: V&A Waterfront, 2022a)

To achieve this, the V&A Waterfront sets out a concise indication of ‘how’ and ‘what’ they have decided with regard to their purpose. As for ‘how’, the V&A Waterfront (2022b) says the following:

- We recognise what has come before us, while we look to the future
- We celebrate and protect our environment and our oceans
- We add value through the big things, and the smallest details too
- We design and develop for the benefit of all
- We keep people and opportunity at the centre of what we do, so all who come here know they belong in this space

With regards to ‘what’, the V&A Waterfront states they strive to curate an inclusive and authentic place which inspires and invites discovery, joy, and growth. The company commits to using the structural break provided by the COVID-19 pandemic as an opportunity to build back stronger in areas of sustainability, opportunity, and inclusivity by setting ambitious goals in these areas. Some of these goals include (V&A Waterfront, 2022b):

- To be carbon-neutral by 2035
- To integrate affordable housing into the Waterfront precinct, which includes accessible supporting services
- Positively impacting 50 000 small and medium-sized enterprises (SMEs) by 2030.

4.2.1.1 Ecological governance and sustainable development

In terms of environmental responsibility, the V&A Waterfront took its first steps on the road to sustainability in 2008 by increasing waste recycling, water-saving, and energy efficiency across the entire property. The company has committed to a culture of sustainability and environmental responsibility — a commitment they wish to promote, maintain, and improve continuously (V&A Waterfront, 2022c). The company has therefore committed to the best sustainable practice and governance for the sake of achieving an equitable balance between socio-economic and environmental sustainability.

Considering its strong ecological positioning, the V&A Waterfront has committed to an array of environmental objectives through their “Sustainability Policy” (2022c) which commits the V&A Waterfront to best practices and governance systems in environmental management. These objectives are outlined in Table 4.2.

Table 4.2. V&A Waterfront Sustainability Policy objectives

V&A Waterfront Sustainability Policy Objectives	Description
Objective 1	Commitment to comply with all local, national and international regulations, laws and standards that apply to the business.
Objective 2	Commitment to the objective of managing the environment to minimise and improve environmental impacts related to the V&A Waterfront via water, energy, y and waste interventions (V&A Waterfront, 2022c). This includes the adoption of GCX DASH- as a DSS surrounding these interrelated resources, argued to be the key development in allowing for a collaborative and nexus governance approach at the V&A Waterfront.
Objective 3	The third objective is critical for the sake of this research project and commits to the monitoring and reporting of environmental objectives by “...including environmental targets in the key performance indicators” (Waterfront, 2022: no pagination). This commitment has been revolutionised by the incorporation of GCX DASH-, as will become apparent when exploring the system in more detail.
Objective 4	The next objective considers the local community surrounding the V&A Waterfront and commits to taking into consideration the effects operations may have on this community (V&A Waterfront, 2022c).

V&A Waterfront Sustainability Policy Objectives	Description
Objective 5	The fifth objective is for environmental awareness to be promoted among contractors, suppliers and partners of the V&A Waterfront through the use and implementation of operational procedure.
Objective 6	The next objective revolves around incident reporting, control and investigation and refers to the commitment of the V&A to be expedient and efficient in this regard.
Objective 7	Another objective undertakes the task of making all employees aware of their environmental responsibilities by documenting, maintaining and implementing these objectives and ensuring they are adequately communicated to employees.
Objective 8	The second last objective is concerned with the applicability of this policy and seeks to display these objectives publicly to make them available to all interested and affected parties.
Objective 9	The last objective of the so-called Sustainability Policy is for the V&A to continuously review the policy on an annual basis, ensuring it remains appropriate and relevant to global, national and local trends as well as the V&A Waterfront itself.

(adapted from: V&A Waterfront, 2022c)

In order to ensure that their tenants' activities are also environmentally conscious, the V&A Waterfront has implemented what is referred to as a "Green Lease Tenant Criteria Reference Manual" or "Green Lease System" which are essential criteria that any new or resigning tenants need to agree and adhere to obtain their lease (V&A Waterfront, 2022c). These criteria involve anything from water and energy-saving techniques to recycling practices that need to be adhered to to guarantee that all tenants' activities contribute positively to the sustainability goals and objectives of the V&A Waterfront (Pierotti, 2018). It also allows for measuring tenants' performance in water and energy consumption and waste recycling practice — an essential requirement to enable GCX' DASH- to function.

Sustainable development is fundamental to the V&A Waterfront's development strategy, with rigorous green construction approaches, sustainable design principles, and efficient use of natural and energy resources woven into the strategy (V&A Waterfront, 2022e).

The V&A Waterfront has developed just over two-thirds of the original 600 000 square metres of building rights that were given to them. The scope of new developments is large, including a variety of retail, residential, leisure-orientated, and commercial buildings. With regards to these developments, the V&A Waterfront retains ownership of these and once complete will remain as the landlord. According to the V&A Waterfront website: "The only exception to this is some residential development which is sold Sectional Title" (V&A Waterfront, 2022e). Flexible lease structures are allowed by the shareholdings of the V&A Waterfront in order to maximise the benefits for both the tenant and the V&A Waterfront.

When the V&A Waterfront takes on development projects such as the Zeitz Museum of Contemporary Art Africa (MOCAA) (see Figure 4.3) which is situated in a converted grain silo, they make sure to acknowledge and preserve the building's history while having to reverse engineer sustainability into the property. This is achieved by using the very best techniques of green design, ensuring that material is reused and recycled and thereby minimising the carbon footprint of the project (Pierotti, 2018).

When buildings are developed from scratch such as residential buildings or commercial offices, the V&A Waterfront makes use of the latest green engineering practices so as to ensure that the building will meet the criteria for the green star rating set by the Green Building Council of South Africa (GBCSA) (Pierotti, 2018).



Figure 4.3. Aerial photo of the Zeitz Museum of Contemporary Art Africa (MOCAA)

(source: Pierotti, 2018)

The V&A Waterfront has set a precedent concerning the direction they have taken when it comes to ecological sustainability. This positioning and action have not gone unnoticed with V&A Waterfront being named as “...one of the environmentally greenest precincts in Africa” by Manfred Braune, the Executive Director (ED) and Chief Technical Officer (CTO) of the Green Building Council of South Africa (GBCSA) (News 24, 2018). In fact, in one week in 2018 alone, the V&A Waterfront received five Green Star Ratings from the GBCSA, bringing the total number of buildings in the V&A with the award up to 12 (News 24, 2018). Figure 4.4 shows the Chief Executive Officer (CEO) of GBCSA awarding the CEO of the V&A Waterfront with a Green Star Rating.

Some of the other development awards that the V&A Waterfront hold include: the “Gold Heritage Certification” (2012 & 2013), the “Energy Efficiency Forum Award for Commercial Buildings” (2012), the “Eskom ETA Award in the Commercial Category” (2012), Two “Lilizela-Imvelo Awards for Waste & Energy” (2013), No. 1 Silo: “6 star Green Star SA rating for Design by GBCSA” (2013), No. 2 Silo: “4 star Green Star SA rating for Design by GBCSA”, “No. 1 Silo GBCSA as built award” (2014), as well as the Five “Green Star SA Awards” (2014) for No.1 Silo, No.5 Silo, No.6 Silo, Watershed and the West Quay office building.



Figure 4.4. Dorah Modise, GBCSA CEO awarding David Green, V&A Waterfront CEO with Green Star Rating

(source: Pierotti, 2018)

4.2.1.2 Social governance

a) Gross Domestic Product

As an organisation, the V&A Waterfront prioritises job creation and income generation via the development of mixed-use, inclusive spaces. According to the V&A Waterfront (2020), the value it adds to society can best be described and understood in terms of gross domestic production (GDP), employment figures and land use. “GDP refers to the total value of goods and services produced in the country, or the income people have available to spend” (V&A Waterfront, 2020:7). Figures 4.4 and 4.5 explain the V&A Waterfront’s contribution towards national GDP over the review period which covers the 2019 and 2020 financial years (April 2018 to March 2020).

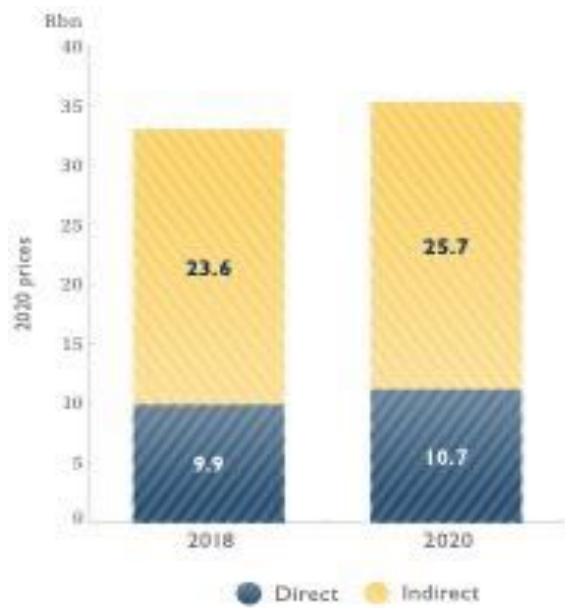


Figure 4.5. Real GDP contribution
(source: V&A Waterfront, 2020:8)

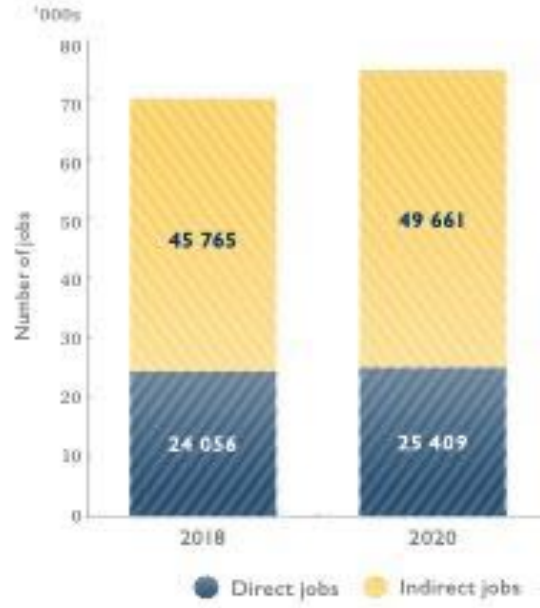


Figure 4.6: Jobs contribution
(source: V&A Waterfront, 2020:9)

Direct contributions come from capital expenditure (CAPEX) and operations expenditure by the V&A Management company or through tenant spending and refer to jobs created and output produced within the V&A Waterfront itself (V&A Waterfront, 2020). Indirect contributions are catalysed by direct contributions, “for example as management or tenants purchase inputs for production, or employees spend their salaries” (V&A Waterfront, 2020: 10). Table 4.3 represents the annual average GDP and employment growth at the V&A Waterfront and indicates the reality that 2018 was affected by very low economic growth; these trends were somewhat recovered in 2020.

Table 4.3. Annual average Gross Domestic Product and employment growth

	Real* direct GDP	Real* total GDP	Direct jobs	Total jobs
2018 – 2020	3.9%	4.2%	2.8%	3.7%
2019 – 2020	7.9%	8.1%	7.1%	7.4%
2002 – 2020	4.9%	5%	4.2%	4.9%

* Real GDP is adjusted for inflation, i.e. all amounts are measured in 2020 prices for comparison.

(source: V&A Waterfront, 2020:10)

It is, however, important to note that the report does not include the repercussion of COVID-19 mitigation measures which had a severe impact on the V&A Waterfront due to drops in events, retail activities, and international tourism.

Although the national economy has stagnated, the V&A Waterfront saw continuous growth between 2018 and 2019 and contributed “R36.4 billion in the gross domestic product in 2020, up from R33.5 billion in 2018 (in inflation-adjusted terms)” (V&A Waterfront, 2020:12). To contextualise the V&A Waterfront’s economic contribution, it helps to create a comparison among its growth (sector measures) and that of the Western Province (provincial) and South African (national).

This comparison is represented in Figure 4.6, which indicates the economic growth of the V&A Waterfront, the Western Province and South Africa (V&A Waterfront, 2020). Figure 4.7 contextualises these differences by displaying the comparative average growth between the V&A Waterfront and provincial sectors; this comparison indicates a more rapid growth at the V&A Waterfront than any of the provincial sectors, resulting in the fact that the V&A Waterfront represents almost 2% of the provincial economy (V&A Waterfront, 2020)

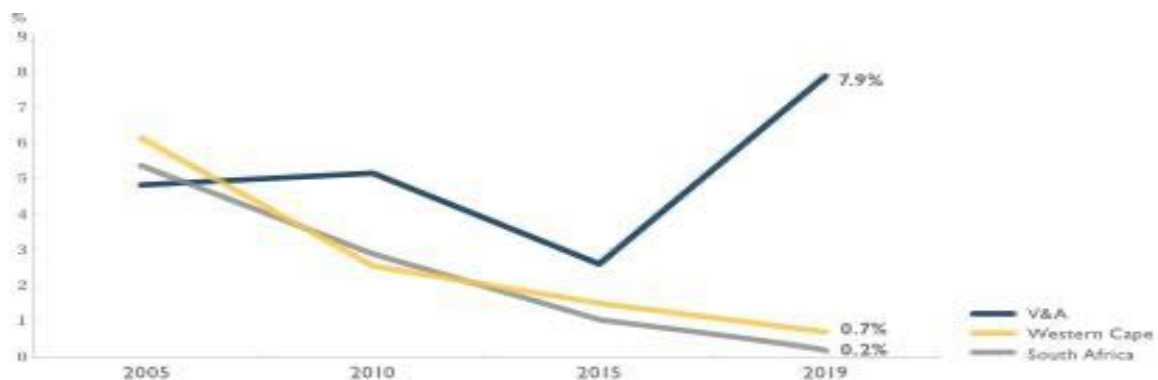


Figure 4.7. V&A Waterfront, provincial and national economic growth

(source: V&A Waterfront, 2020:13)

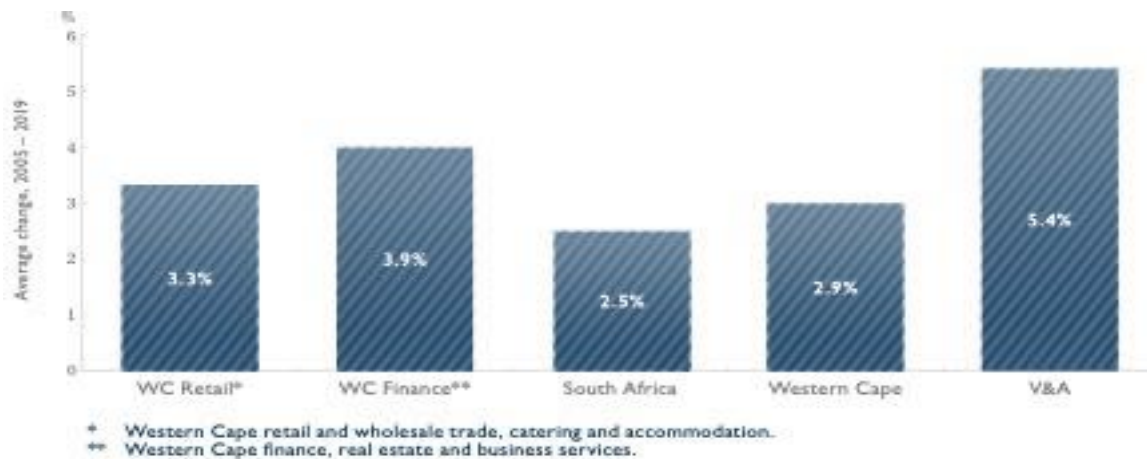


Figure 4.8. Comparative average growth

(source: V&A Waterfront, 2020:13)

b) Employment

Although I have touched on job creation, it is vital to paint a clear picture of the V&A Waterfront’s contribution to employment in a country with one of the world's highest unemployment rates. These contributions are represented in Figure 4.8, which indicates the number of direct jobs created through commercial tenants and the V&A Management company. Figure 4.9 represents how each direct job at the V&A Waterfront creates two or three indirect jobs via things like household spending.

Since the end of 2013, the V&A Waterfront has increased job creation through start-ups and enterprise development which “generally include people from communities where jobs are scarce or unobtainable. Commercial tenants account for about 90% of V&A jobs” (V&A Waterfront, 2020:16). As seen in Figure 13 and Figure 14, the V&A Waterfront contributed 2509 direct jobs and 75070 total jobs, and as stated by the V&A Waterfront (2020: 17) report: “Total jobs have grown by an annual average of 4.9% since 2003 and 3.7% over the past two years – a period during which national unemployment rose from 26.7% to 30.1%.”

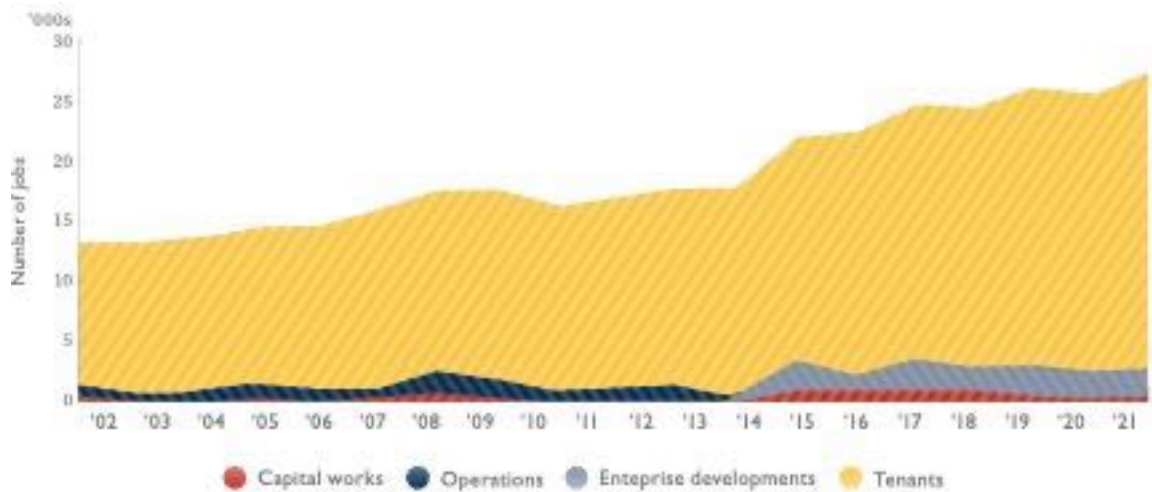


Figure 4.9. Direct jobs at the V&A Waterfront

(source: V&A Waterfront, 2020:17)

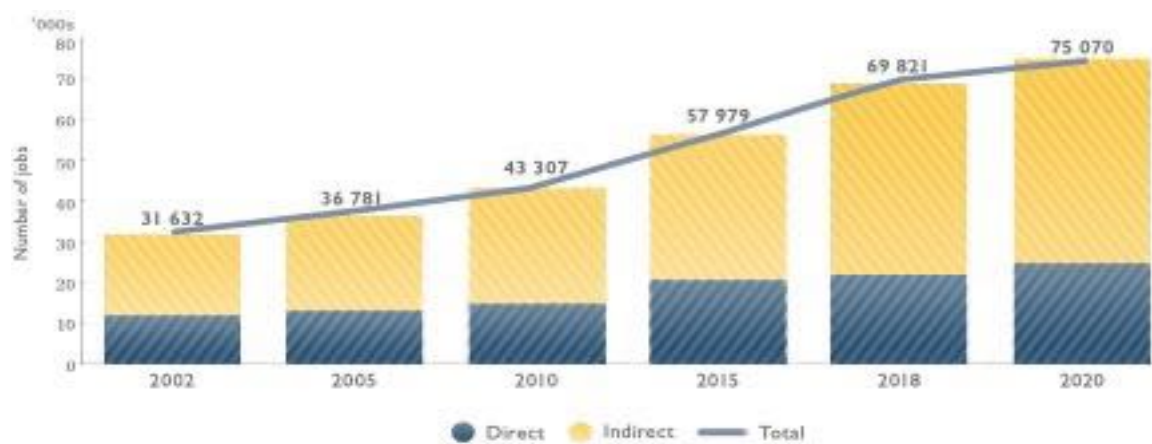


Figure 4.10. Total jobs contributions

(source: V&A Waterfront, 2020:17)

c) Land use

Although the V&A Waterfront contributes almost 2% of the provincial economy, it physically only takes up 0.001% of the provincial land area and 0.2% of the developed land within the urban edge of the city (V&A Waterfront, 2020). The V&A Waterfront has developed into an ecosystem of independent organisations in retail, food, and other sectors that span across the life cycle of these sectors.

Although the largest GDP and employment contributions per hectare of space come from offices, ocean-related work is increasingly important, accounting for nearly 17% of all land use functions, making it the second-largest contributor per hectare to GDP and employment. Figure

4.10 shows the different land uses at the V&A Waterfront and indicates the commitment to provide access to water bodies and public spaces (V&A Waterfront, 2020).

Providing access to water bodies and public spaces has catalysed the regeneration of the entire area in an attempt to reconnect areas of the city. An example of such a development is the Canal District, an area nestled between the City of Cape Town (CCT) and the V&A Waterfront, essentially reconnecting the V&A Waterfront to the city, and restoring the historical roots of the area. This development includes the Roggebaai Canal that “links the Cape Town International Convention Centre to the Waterfront, in turn, connecting the city centre with Green Point, Sea Point and other suburbs on the Atlantic Seaboard” (V&A Waterfront, 2020:1). Figure 4.11 represents the land use by function at the V&A Waterfront.

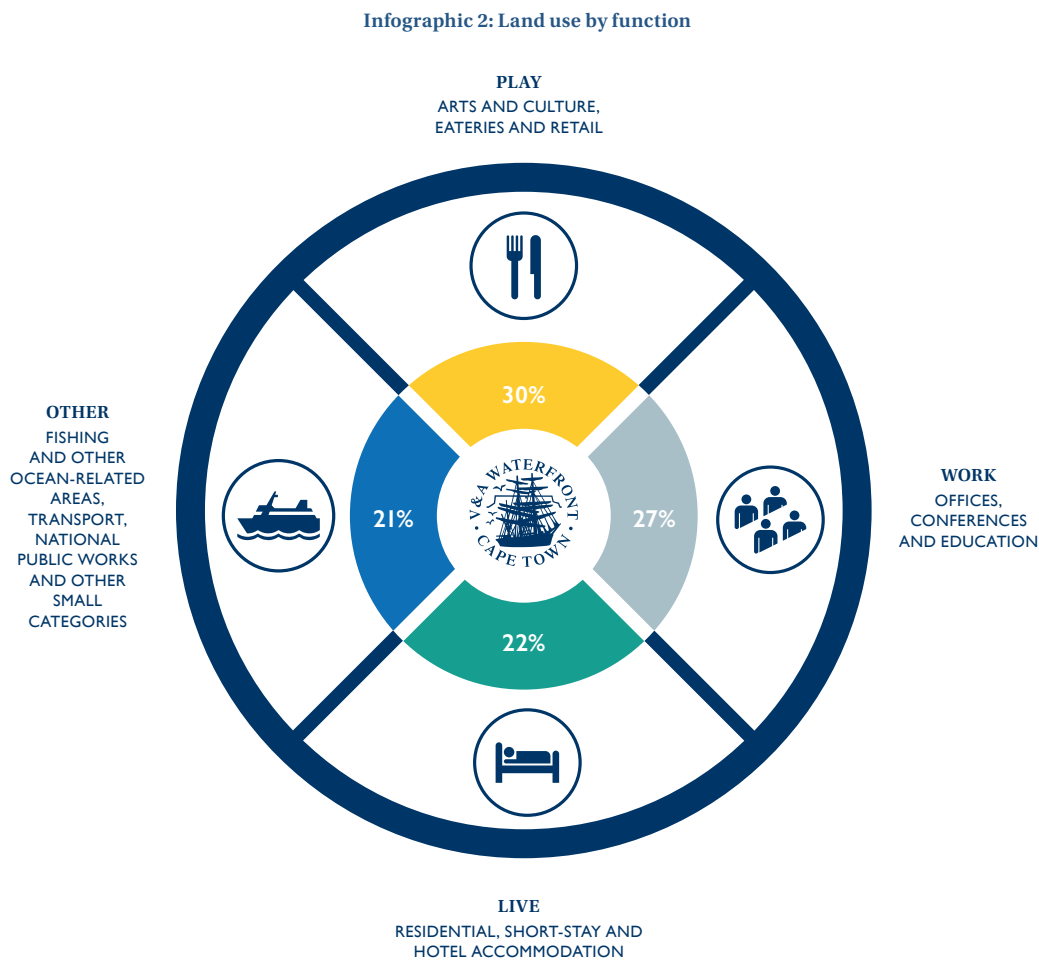


Figure 4.11 Land use by function at the V&A Waterfront

(source: V&A Waterfront, 2020:22)

d) Enterprise development and start-ups

As another means to create income and employment, the V&A Waterfront fosters more than 400 start-ups, emerging/small businesses, and enterprise development with many of these beneficiaries being from disadvantaged backgrounds with limited education and income-generating skills.

Some enterprise development statistics are represented in Table 4.4; these data are suggestive of how the V&A Waterfront mitigates unemployment and poverty, both critical areas of importance in South Africa's National Development Plan (NDP) (V&A Waterfront, 2020).

Table 4.4. Enterprise development statistics at the V&A Waterfront

	2002	2010	2015*	2020**
Firms in enterprise development	39	148	233	421
Total turnover	R47m	R67m	R139m	R375m

* Includes the V&A Food Market

** Includes Workshop17 and the OZCF Market

(source: V&A Waterfront, 2020:24)

e) What is next?

It is clear that the V&A Waterfront has a record of integrating social problems into its business model — an approach that will only expand as management has recently started the implementation of their shared value strategy, which is seen as a natural evolution of the company's social role. According to the V&A Waterfront (2020:26):

Shared value creation is about using an organisation's competitive advantage, skills and business model to address the most important issues facing society. It commits the entire organisation to solving these issues, acknowledging the interdependence between company competitiveness and community health. This philosophy is particularly suited to the V&A ecosystem, which has consistently supported innovation and job creation, notably by incubating small businesses. This transition was already in progress prior to the COVID-19 pandemic but this social crisis has accelerated it, amplifying the need for organisational agility, collaboration, and sustainability with a particular focus on the

following areas within the Waterfront: Food ecosystem, Ocean economy ecosystem, Green sustainable practice.

4.2.1.3 Social-ecological governance

From the previous sections on the ecological and social positioning taken by the V&A Waterfront it is clear that the company has committed its governance structures to establish, maintain, promote, and improve environmental, social, and economic responsibility and sustainability. This is something they wish to achieve through all their stakeholders as it has committed to the very best sustainable governance practices in all of these spheres. As the V&A Waterfront (2022) states:

The organisation sees for itself the opportunity to promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all, in alignment with the United Nation's Sustainable Development Goals. (sustainability overview)

These commitments have led to the development of the V&A Waterfront's Corporate Social Investment (CSI) Strategy, a governance blueprint that aligns with the internal strategies and values of the business, especially with regard to environmental, social, and economic development both locally and globally. According to the V&A Waterfront (2022c: no pagination), their CSI strategy "...supports the National Development Plan (NDP), within the local context, and the Global Goals or Sustainable Development on an international level". The objectives of the CSI Strategy are: "Being an enabler for economic growth, driving meaningful job creation, creating social value, contributing to nation-building and social cohesion, and ensuring environmental sustainability and resilience" (V&A Waterfront, 2022c: no pagination).

The V&A Waterfront is of the position that philanthropic uses alone cannot improve the lives of disadvantaged people. For these reasons, the business emphasises social innovation and entrepreneurship, and it is using the CSI Strategy so that the company can "...create more opportunities for small businesses, to encourage both sustainable economic growth as well as meaningful job creation" (V&A Waterfront, 2022c: no pagination).

4.2.1.4 Synopsis

In essence, the V&A Waterfront's socio-economic positioning of possibility can be summed up with the following words:

Being the unofficial heart of Cape Town, the Waterfront is vital to the South African economy, with some 21,000 people working within it, 1,500 residents, and as many as 180,000 visitors daily. As such, it was in a prime position to not only set an example for the rest of the region, but also make a big impact in the fight to preserve resources (Pierotti, 2018: no pagination).

The V&A Waterfront has made several commitments to environmental and social governance. From a social governance point of view, this includes, among other things, the enactment of green leases, support for SMEs, as well as commitment to a shared value approach and a progressive CSI strategy.

From an ecological point of view, it includes an objective of managing the environment to minimise and improve environmental impacts related to the Waterfront via water, energy, and waste interventions. It also includes a commitment to the monitoring and reporting of environmental objectives by "...including environmental targets in the key performance indicators" (Waterfront, 2022: no pagination).

The question, however, becomes, what governance and management systems have been developed by the V&A Waterfront to achieve these commitments? Following key global trends, the V&A Waterfront Management have realised the need to work in a systemic way across silos as an innovative interventional approach to governance. But how does one achieve such nexus governance?

The argument is that the V&A Waterfront has been successful in developing a nexus governance approach for the sake of governing the WEF Nexus by incorporating GCX into their governance realm. The next section will explore the decision to incorporate GCX into the V&A Waterfront governance structure. This is followed by a section on the nature of GCX as

an organisation, before diving deeper into how their working relationship and the specific use of GCX DASH-, has enabled the V&A Waterfront to develop a nexus governance approach.

4.2.2 V&A Waterfront governance and management systems

The V&A Waterfront Management is responsible for governing and managing all operations that allow their more than 800 tenants (mixed property types, including two functioning fisheries) to conduct day-to-day operations. This is a massive undertaking considering the scale, the challenges faced, as well as the socio-ecological commitments of the V&A Waterfront.

It is, however, more useful to paint the picture of the V&A Waterfront's context/governance structures as a neighbourhood/precinct, rather than a company/organisation. Within this precinct, there are two governing structures/units, namely the V&A Management (with their structures) and their tenants (of whom there are 800 plus each with their own management structures). These two governing units are responsible for managing affairs according to their own goals and mandates, of which some are shared and others are conflicting. One such shared goal is the overarching goal of sustainability. To achieve sustainability the V&A Management and their tenants have to mutually work together. Much of the pressure to do so comes from the V&A Waterfront (as the government) because they set the rules that all tenants need to follow (via their green leases). Yet, these management and tenant spheres mutually benefit in many ways.

As a part of the neighbourhood's governance journey to social and ecological sustainability, the V&A have brought on board Global Carbon Exchange (GCX), a private sustainability solutions company offering innovative sustainability tools and expertise that enable the V&A Waterfront to set meet sustainability targets and achieve reliable sustainability reporting, while also allowing for enhanced performance management.

The partnership has been running since 2018 as part of the V&A Waterfront's green lease system, allowing the measurement of tenants' performance in water and energy consumption

and waste recycling practices through the GCX DASH-. Impressive results have already been achieved³¹.

As mentioned, the partnership between the V&A Waterfront and GCX offers an interesting case study of a nexus governance approach implemented in practice, with the physical analysis of resource flows acting as a catalyst for improved decision-making, governance, behaviour, and meeting of targets, while also having social and practical repercussions. These effects all together impact the ability to govern for social-ecological systems (SES) resilience. Although GCX analyses water, energy, and waste, I believe it is still suited to the nexus literature, as much waste is the problematic remnants of unused food.

In what follows I will expand on who GCX is and what they do, after which I will elaborate on its partnership with the V&A Waterfront and what it encompasses and enables for governance. In the section following that, I will elaborate on the practical, social, and governance (PSG) repercussions of the governance approach accompanied by an exploration into the resilience-enhancing implications.

4.2.2.1 The incorporation of Global Carbon Exchange

Global Carbon Exchange (GCX) has its origins in Australia where it started in 2007 before being incorporated in South Africa in 2012. Here in South Africa GCX grew its offerings with the ever-maturing sustainability landscape. They currently offer a dedicated team of sustainability professionals and data experts, allowing the company to specialise in three areas: “Management and reporting of Environmental, Social and Governance (ESG) Risk”, “Carbon Footprint accounting, reporting, benchmarking and disclosure”, and “Sustainable Waste Management” (GCX, 2022a).

³¹ Using 2010 as a baseline, overall savings of 60% in water consumption were achieved across the precinct as at the end of 2018” (V&A Waterfront; 2021). A reduction of 35% in energy was achieved at the end of 2018 despite the property having increased in size by way of development (V&A Waterfront; 2021). At least 45% of Waterfront waste is recycled, with a commitment to increasing this volume going forward (V&A Waterfront; 2021). The Waterfront currently has 13 Green Star rated buildings, making the V & A Waterfront property the greenest property on the continent of Africa (V&A Waterfront; 2021).

a) Key solutions

GCX offers two key solutions enabling them to achieve resolutions in their three main areas of specialisation. The first solution is what is referred to as “GCX Consult”, essentially the sustainability advisory division of GCX which has fine-tuned its proprietary “Sustainability Hierarchy” to enable clients to address shortfalls that come with setting targets, implementing projects, and improving performance management (GCX, 2022c). GCX Consult seeks to bring structure to the client's sustainability journey by guiding reporting and sustainability performance management. The GCX website notes the following about GCX Consult (GCX, 2022c):

With decades of subject matter experience under our collective belts, we provide guidance and expertise to help companies navigate the complexities associated with the management of ESG, Carbon and Waste across their entire organisation. We understand the varied maturity of the sustainability landscape and the pain points that companies are facing. Our consulting team have the necessary experience working with organisations to co-create a strategic roadmap that will help establish and meet your organisation's sustainability goals.

The second solution is called “The GCX Data Analytics and Sustainability Hub (DASH-)” an interactive, web-based and easy-to-use digital tool that provides interactive and meaningful data analytics in real-time, providing granular and consolidated sustainability reporting and performance management that helps organisations drive their sustainability and business performance (GCX, 2022b). This is where the GCX expertise combines with their client’s data, providing a reporting and performance benchmarking platform. According to the GCX (2022b) website:

The Data Analytics and Sustainability Hub (DASH-) drives sustainability in business and, ultimately, informs Environmental, Social and Governance (ESG) mitigation strategies and processes. As companies are under increasing pressure from investors and legislators to set more ambitious climate change targets and improve their ESG ratings, the need for accurate and reliable data has become vital.

GCX DASH- enables the business intelligence and data confidence needed to make sound commercial decisions, and to align business practice with key ESG indicators. It gives companies control by using their data to track and quantify important activity indicators in their operations that have financial materiality. It lastly “consolidates reporting on a company’s operational activities, and sets dynamic benchmarks to achieve better performance” (GCX, 2022b: no pagination)

b) Areas of specialisation

With regards to ESG, GCX specialises in assisting companies to improve their ESG reporting and performance, while also seeking to unlock additional value for all stakeholders. This positioning stems from the idea that sustainable business implies resource efficiency, future-proofing, and creating shared value (GCX, 2022d).

Investors are increasingly considering ESG problems in order to better manage investment risk, as “ESG performance ratings and reports inform investors about a company’s efforts to mitigate risks and generate sustainable long-term financial returns” (GCX, 2022d: no pagination). It is for this reason that a good ESG positioning can create a large amount of business value across the organisation. Unfortunately, the ESG landscape is very confusing and fragmented, as it consists of many different frameworks, standards and reporting tools.

GCX, therefore, offers a consolidated framework for ESG reporting that assists executives and boards to meet global ESG sector-specific requirements and standards. According to the GCX website (2022d) the process of bringing them on board with regards to ESG management and reporting usually takes the following route:

Typically, GCX’s initial engagement starts with a high-level review of strategic ESG metrics unique to your business. This is then followed by a deeper analysis of your ESG material risks. Depending on your businesses’ ESG maturity journey, this process may involve a review of your company’s ESG risks with one of the ratings providers.

As reporting requirements become stricter, and investors place more pressure on sustainable performance, GCX recommends that businesses begin by filtering their responses according to material ESG risk factors (GCX, 2022d). This approach allows GCX to combine the expertise

of GCX Consult and the intelligence of GCX DASH- (discussed in more detail below) so that “...your material ESG swing factors can be identified and understood with the goal of improving sustainable ESG performance and improved ESG ratings” (GCX, 2022). GCX furthermore assists clients with developing ESG and sustainability strategies, the associated action plans, as well as bespoke “Social and Environmental Management Systems” (GCX, 2022c).

With regards to carbon footprint accounting, reporting, benchmarking and disclosure, GCX makes use of carbon accounting tools for the sustainable measurement of emissions (GCX, 2022e). The team is familiar with all energy and climate protocols, and standards and frameworks, allowing them to align their clients’ environmental reporting with desired reporting standards, assisting them in identifying the most effective strategies to reduce their carbon footprint.

According to the website (GCX, 2022b) “GCX DASH- automates the carbon footprint reporting process, saving time and increasing the efficiency of your reporting”. The GCX DASH- therefore, speaks to all regulatory frameworks, allowing companies to streamline their regulatory reporting with enhanced performance and reporting management.

With regards to sustainable waste management, GCX (2022f) redefines waste value chains, saving their clients’ money, while allowing “Zero Waste” to landfills with expertly designed waste management systems. The problem is landfills are incredibly unsustainable by nature, and due to ever-decreasing space and the related rise in costs associated with waste disposal, there is a very pressing need to explore alternatives. According to the GCX website (2022f):

Existing and emerging solutions to Recycle, Reuse and Beneficiate waste products represents one of the biggest economic opportunities of our time. With tighter legislation on waste, businesses are getting serious about managing their waste. However, there is a growing need for more efficient waste management strategies that save costs while improving the efficiency and transparency of the waste value chain.

GCX has committed to exploring and establishing more efficient waste management strategies, with their GCX DASH- providing insights into tracking waste flows of multiple waste

contractors (GCX, 2022b; GCX, 2022f). This allows them to provide analytics across the entire waste value chain. According to GCX, premium waste analytics has the potential to unlock cost-saving and increased efficiency, while at the same time assisting businesses to understand their waste in order to strive for Net Zero Waste (GCX, 2022f)

c) Synopsis

In general, GCX provides an analytics and reporting platform, namely the GCX DASH- for managing ESG risk and reporting. It, therefore, provides the V&A Waterfront with the reporting functionality to trace/map an array of ESG indicators, including carbon footprint activities, across multiple stakeholders and portfolios of assets. According to the company website, GCX is committed to organising and fixing their clients' data, enabling them to turn it into valuable insights that can assist their clients to make better business decisions.

The most important element for this case study is the GCX DASH- as it provides the V&A Waterfront with real-time, on-demand, meaningful data analytics of resource flows (water, energy, waste, and fugitive gasses) that assist them with decision-making and setting goals. The GCX DASH- is essentially an integrated nexus (specifically water-energy-waste WEW) resource management tool that makes use of material flow analysis (MFA) to help the V&A Waterfront make decisions and reach their targets. The dashboard allows the physical analysis of resource flows to act as a catalyst for improved governance (decision-making and meeting targets). It furthermore seeks to shape behaviour regarding water, energy and waste, with dynamic financial and resource baselines serving as reactants.

GCX DASH- therefore represents a key nexus governance tool which has enabled the V&A Waterfront to strive better towards the various socio-ecological goals to which they are committed. This is because it allows the V&A Waterfront to monitor and report environmental objectives while also allowing departments to work in a systemic nature across silos. This positively affects the management of water, energy, and waste, in turn, improving environmental impacts related to the V&A Waterfront.

I will now go into more detail about the specific use of GCX DASH- at the V&A Waterfront using data collected from two GCX employees. This will be followed by a discussion on the

PSG implication the dashboard is having at the V&A Waterfront, followed by an analysis of the resilience effects of these implications.

4.2.2.2 V&A Waterfront's use of GCX DASH-

According to GCX 1 (2021) the dashboard (DASH-) at the V&A Waterfront currently takes in environmental data, such as data on water, energy, waste and fugitive gasses³² but is expanding to include social data. This is because more and more clients are asking them to have one version of the truth in a centralised space. In essence, GCX does this by taking control of the correlation, the refinement, the analytics, the reporting, and the benchmarking and Key Performance Indicators (KPIs) across an entire social-ecological system, whether it be a portfolio of properties or a precinct like the V&A Waterfront.

The approach encompasses taking the most transactional granular data within the V&A Waterfront, whether it be environmental data (non-financial) or financial data, so that strategies and policies approved by the V&A can be led by a holistic systems perspective.

According to GCX 1 (2021), one of the big issues with their sector (environmental impact reporting) is that companies rely solely on non-financial data to be able to understand their impact. The problem with this is that it is not very well organised because companies have not invested sufficiently into enterprise systems to manage non-financial data because they have been focused on financial management.

It is this gap that led GCX to the creation of GCX DASH-, a proprietary platform that enables them to make sense of disparate data — financial and environmental (non-financial) — by bringing them together. By incorporating financial data into the platform, GCX is taking the lead in addressing a long-lasting issue with sustainability reporting, namely, the poor communication between individuals responsible for financial reporting and individuals responsible for environmental reporting.

³² Gasses from fridges and air-conditioners that escape along the way.

These spheres of reporting speak a different language making it difficult for sufficient communication, something which is crucial for holistic (social, environmental, and economic) business performance. As GCX 2 (2021):

GCX found more and more as we get involved with different stakeholders within the organization, whether it's someone from finance or someone in operations, everyone has a slightly different lens on dealing with things.

There is thus a need to bring together disparate data that ordinarily sits in siloed systems for everyone to get an overall view of the system, allowing them to use the data for what they need. This requires breaking down those barriers and bringing disparate data into one place. This allows, for example, the V&A Waterfront's finance department, risk department, procurement department, sustainability department, asset managers, and facilities managers to all have access to the same data but with different views, as they are interrogating it with different objectives. This is indicative of the systemic approach committed to by the V&A Waterfront.

The solution has thus been to create a shared information platform, namely GCX DASH- where all the V&A Waterfront's disparate data is brought into chiasmic relation to one another, allowing for better-calculated assessment of solutions with consideration for all departments and sources of data (essentially a decision support system (DSS)). GCX is an intermediary in a sense that it creates a wider systems perspective stemming from varied fragmented sources, enabling them to scrutinise the data and raise anomalies and queries according to the lens of particular stakeholders in a certain organisation. This structure and approach enables the V&A Waterfront to analyse, for example, year-on-year growth, recoveries at the site, as well as the performance of tenants in buildings to analyse if the company is still on track to meet its targets.

a) Data collection process

For GCX the process of collecting this data is a massive benchmarking exercise. The first phase is about building confidence in data sets; this requires them to establish relationships with all utility service providers to gain access to the data collected on their smart meters, whether it be for water, energy, waste or fugitive gasses.

This relationship-building process does, however, not come without its hurdles, as all service providers have a stake in their data, giving them a reason to defend it. As GCX 1 (2021: no pagination) stated: “If there’s a problem they’re not necessarily going to disclose it”. There are a vast number of different data service providers, all differing with each client, making it a difficult terrain for GCX to navigate as an independent, internal yet external, audit function. This makes the data confidence phase an iterative process that may take some time.

Once GCX completes the data confidence-building phase, they put in place what is referred to as “Smarts”, enabling them to performance manage decided targets and related activities across all established data sets inside the organisation, or precinct in the case of the V&A Waterfront. In the case of the V&A Waterfront many of their decided-on targets revolve around water, energy, waste, and fugitive gasses, and thus tracking the flows and performance of these resources enables realistic targets as well as a means to track progress in real-time. These “Smarts” include things such as baseline measurements, called dynamic baselines³³, allowing for comparisons (year versus year or tenant versus tenant), and for anomalies to be raised (GCX 2, 2021)

Anomalies are raised via these dynamic baselines which in the case of the V&A Waterfront is reported against square meters (meaning water, energy, waste, and fugitive gasses consumption will be tracked per square meter). GCX can, however, customise these baselines to measure anything from production, turnover, and average rental, meaning these dynamic baseline measurements are able to track the individual performance of every asset or every tenant. The dashboard can therefore take different perspectives, for instance, the entire building, or a specific tenant, enabling them to look at the electricity intensity across all individual tenants. “So we then track either the assets or the tenants, so this is the properties tab. So to show you from a data check, so you can see what we do is we bring in different consumption data” (GCX 2, 2021: no pagination).

What GCX then does is to use these dynamic baselines and the related variance (deviation) to be able to see whether the V&A Waterfront is tracking against their historical usage within the building, making it possible to determine if they are performing better or worse. All of the

³³ Essentially time-lagged calculations (usually average) which provides the basis for comparing past performance with current performance.

visualisations on the dashboard, and the way that performance management data (KPIs) gets used, are against these dynamic baselines (GCX 1, 2021; GCX 2, 2021)

When a user sees a red or yellow line on the dashboard, it means that that particular data set for the given day/month/year is above the baseline, while green is below the baseline. This is called baseline deviation³⁴ (GCX 1, 2021). The platform can display different specified baseline deviations, meaning just as the platform displays baseline deviation for water, energy, and waste individually, it can also display the baseline deviation of them together (as carbon) to which the financial data can be added to pick up materiality (discussed in the next paragraph) (GCX 2, 2021)

When looking at the baseline deviation the V&A Waterfront is able to use the information that is reported inside the baseline deviation, together with the financial data that is reported, to pick up on materiality. As explained by GCX 2 (2021):

So quite often, you'll find like a building, which is a small user, you know, if they go from one kilometre to three kilometres, they've had a 200% increase, but it's only R300 worth of monetary value. So it's not really material for you to be able to look.

With data confidence completed and “Smarts’ in place, GCX can then start to break down the information in order to build a hierarchy of KPIs depending on how and for what they want to report. KPIs are performance measurements that evaluate the success of the V&A Waterfront with regards to overall or a particular activity they engage in, whether it be with regards to water, energy, waste or carbon (GCX 1, 2021). KPIs are, therefore, dependent on baselines making dynamic baselines even more accurate in tracking true performance and enabling more realistic targets.

At the V&A Waterfront, these KPIs are set in relation to buildings (square meters which all together make up the precinct, making it possible for GCX to aggregate the data stemming from buildings across the entire precinct (V&A 1, 2021). This allows GCX to create KPI benchmarking (targets that the company should or wishes to reach, whether it be with regards

³⁴ If the baseline is seen as the current performance or historical performance, baseline deviation refers to the amount of divergence/variance from this baseline, whether it be more or less.

to consumption or recycling practices) within an entire portfolio and with different layers of granularity thereby enabling accurate measurement of performance (GCX 2, 2021).

GCX also automates the V&A Waterfront's reporting to the vast array of different standards in the corporate world, and there are many. The multitude and variety of standards are representative of an early-stage environment where there has not been proper regulation yet, so everyone is starting to make their own standards (GCX 1, 2021). However, what will happen over time is that things will get consolidated and eventually become the domain of the accounting and auditing profession (GCX 2, 2021). For the time being this has not happened meaning companies do not have enough capacity and resources to manage reports internally. GCX, therefore, takes the whole task off their client's hands by automatic reporting to all the different standards in the corporate world (GCX 1, 2021). On top of this, the system also gives the client a monthly carbon footprint tracking as a by-product of what is already tracked; it simply does it in the background.

According to GCX 2 (2021) they have essentially created “an asset, environmental performance management tool”. This means it does not really matter what kind of asset it is nor whether it is for a building or a tenant — making it a very customisable tool that incorporates a deep level of granularity.

Together with many aspects discussed, GCX DASH- has essentially allowed for a nexus governance approach at the V&A Waterfront where the consolidation of interdependent resource data with financial data is projected to disperse departments in the V&A Waterfront for the sake of better collaboration, meeting targets, and better reporting. It, therefore, represents a governance system which has allowed, among other things, for systemic and integrated governance in relation to connected resources.

4.2.3 Synopsis

In presenting my findings for research question 2, it can be concluded that a nexus governance approach has been developed by the V&A Waterfront. This because GCX DASH- represents the required DSS/monitorisation systems mentioned in the nexus literature as an enabling tool for such a form of governance to be possible. GCX DASH- tracks interrelated resources individually and in relation to one another while also including financial data in relation to

these resources. The use of the system at the V&A Waterfront, therefore, represents a practical example of a nexus governance approach because the system is used as an enabling tool for better adaptive co-management among usually isolated departments. GCX furthermore represents a coordination agency that enables the efficient gathering and sharing of information for the sake of efficient and informed decision-making.

With a clear understanding of the type of governance and management systems developed by the V&A Waterfront to govern the WEF Nexus, the next section will be dedicated to unpacking the PSG implications of this nexus governance approach. This will be accommodated by evaluating the potential for enhanced resilience in Cape Town created by these PSG implications.

4.3 What are the practical, social and governance (PSG) implications of the nexus governance approach at the V&A Waterfront, and do these implications hold any potential for enhanced resilience in the Cape Town Context?

4.3.1 Decoupling and resource governance

The United Nations (UN) mandate to the International Resource Panel (outlined by the Sustainable Development Goals (SDGs)), is that the global economy consumes around 100 billion tonnes of material and resources per annum and to stay within a safe operating space, humanity has to reduce consumption by 50% (EDP 1, 2021). This is due to a direct relationship between rising carbon emissions and the total resources consumed (Chontanawat, 2020).

At a global policy level, cities have agreed to reduce the total consumption of resources through the urban metabolic system (EDP 1, 2021). This leads to the goal known as decoupling, and it essentially refers to having continued economic growth at a certain percentage while the growth in resource consumption eventually goes flat or starts to decline (EDP 1, 2021). This means that at the city level, governments are going to have to understand the flow of urban metabolisms (the material and resources that flow through the urban system) for decoupling to become possible (Chontanawat, 2020).

When considering this global perspective, the importance of the dashboard used at the V&A Waterfront becomes all the more apparent, as it is a system that allows for the tracking of

resource flows, essentially a crucial aspect when it comes to decreasing the amount of carbon produced via consumption of resources and material (EDP 1, 2021).

What has occurred at the V&A Waterfront with regards to the GCX DASH- (the use of which was driven by an ESG agenda and financial agenda) was the inadvertent creation of a database for the flow of resources through a precinct, which via data analytics, enables the management of decoupling. In essence, the V&A Waterfront, using GCX DASH--, has to a large extent decoupled the economic and financial growth of a precinct from the growth in carbon emissions (water, waste, and energy). What the V&A Waterfront is doing, perhaps inadvertently, monthly as they report to their board, is what in policy and academic terms is known as decoupled resource governance. Since practical examples of resource governance using a DSS is expressed in the literature as virtually non-existent, the V&A Waterfront presents an example which is significant on a global level.

4.3.2 Bird's eye view of data: saving time

Until the V&A Waterfront decided to partner with GCX, they spent large amounts of time and money on annual carbon footprint exercises, a yearly, once-off calculation for carbon disclosure (V&A 1, 2021). This was a time-consuming exercise, as the V&A Waterfront has a large number of tenants with bills for water, energy, and waste, all in different places in the business (for instance, billing and utilities).

As V&A 2 (2022) describes: “We would run concurrent systems, people have different types of Excel spreadsheets and interpretations of data, which made it quite difficult”. This exercise would therefore cost the V&A Waterfront large amounts of money and time as all this disparate data had to be consolidated to all the different standards by their employees. It was also a once-a-year exercise which was not advanced enough for an accurate monitorisation of carbon performance.

These inefficiencies created a need for change, as V&A 1 (2021) states: “We started saying, well, if we could have a bird's eye view of this [resource data flows], then you can start with what GCX refers to as analytics.” With the ability to offer a birds-eye view of consolidated resources and related carbon emissions data (via GCX DASH-), GCX was incorporated into the V&A governance sphere in 2018. Since then, GCX has provided the V&A Waterfront with

a live online accessible dashboard as well as an Eco-Analytics Report on a monthly basis. There are various different reports produced for different stakeholders including a group report, sector report, manager report, a tenant report etc, with each of these reports exclusively providing data for the selected criteria (GCX, 2022g). Reporting criteria will be displayed on the cover page of each report as well as the top of each page under the Reporting Boundary heading. The boundary will furthermore indicate a summary description of any filters that have been applied in the report, while also indicating the percentage of group consumption that the current report is showing (GCX, 2022g).

For the sake of summarising the contents of a Eco-Analytics report in way which describes how data is displayed, GCX has provided this study with a “Consolidated Group Report” for January 2022 (Appendix F). The report is prefaced with an emissions page followed by detailed sections for each major activity reported on (e.g. water, energy, waste, fugitive gasses). Within each of these sections separate pages are shown for various details within the report, including Consumption, Costs, Intensities, Top 15 Consumption and Intensities, Largest consumption (by Property), Largest Consumption (by Tenant) (GCX, 2022g). For the sake of describing the contents, I have made use electricity section, describing how each page provides a detailed report of electricity at the V&A Waterfront. Financial data and consumption amounts have been redacted for confidentiality

Some terminology used within the report are terms such a Reporting Boundary, Baseline Intensity, and Intensity. Baseline intensity is calculated on the average usage (or consumption) over a period, which is then used in the report (and displayed on the dashboard) to compare and rank current usage and assist in performance management of the properties and tenants (GCX, 2022g). Where intensities are below the baseline, the value (or indicators) are highlighted in green, while intensities exceeding baseline are highlighted in red. Within the report used to make this summary, the baseline was set to the financial year (FY) 19 and FY 20 period for properties (GCX, 2022g). For tenants, the baseline intensity is average usage of all consumption for the full duration of the tenant. The intensity is calculated dividing the consumption by the required metric, with the metric being used in each report being displayed in all relevant places in the report (GCX, 2022g). Some other useful terms used within the report include month-to-date (MTD) and year-to-date (YTD), same period last year (SPLY), same month last year (SMLY), last month (LM), year on year (YoY) and month on month

(MoM). With this in mind the next section will move into a detailed discussion of each page included in the electricity section of the January 2022 report.

The Electricity consumption page displays consumption data for the current reporting fiscal year showing month-to-date (MTD), and year-to-date (YTD) comparative data (GCX, 2022g). The report indicates in percentage if the electricity consumption YTD in kilowatt hour (kWh) is tracking above or below the kWh reported for the SPLY. It also indicates the highest consumer, in this case the Victoria Wharf's reported consumption in kWh YTD, while showing which percentage of the kWh reported for the group that amount represents (GCX, 2022g). It then displays that within the Victoria Warf, Retail reported the highest consumption of x kWh, while indicating in percentage how much that represents the Group's consumption (GCX, 2022g). There is also a consumption recovery section, indicating how much kWh electricity the Waterfront consumed for the 10 months from April 2021 ton January 2022 (GCX, 2022g). This is followed by an indication of the amount billed to clients in kWh, making it possible for a YTD consumption recovery to be displayed in percentage. The same sum (kWh consumed vs amount billed clients) is made for the current month, indicating a consumption recovery for the current month (GCX, 2022g). The consumption page illustrates an Electricity (kWh) Consumption Histogram, with columns showing consumption for electricity (kWh), while intensity and baseline values are shown as kWh per m² (GCX, 2022g). Within the consumption histogram columns in red indicate that the property has exceeded the baseline intensity, while columns in green indicate that the property is below baseline intensity. Lastly the consumption page illustrates Electricity (kWh) consumption from April 2021 to January 2022 (10 months) in a well-organised table that indicates each sector's YTD, SPLY, year on year (YoY) % change, month on month (MoM) % change, YTD consumption recovery %, MTD consumption recovery %, Property count and lastly Tenant count (GCX, 2022g).

The Electricity Costs page displays data for the current reporting fiscal year showing MTD and YTD comparative data. Here the report indicates that within the boundary, January 2022 reported clients billed electricity costs at x amount, which if compared is a MOM increase of x percentage compared to the amount billed in the previous month (GCX, 2022g). The Total Waterfront electricity costs for the 10 months till January 2022 is then shown. This amount is then shown to be a certain percentage below or above the same period last year. This is further broken down into data on the Victoria Wharf electricity cost YTD, which is show to represent

as certain percentage of the group total cost (GCX, 2022g). The retail sector (within the Victoria Wharf property) is shown to have the highest electricity cost, while indicating that it represents a percentage of the group total cost (GCX, 2022g). Victoria Wharf Shopping Centre is once again reported to be the property the accounted for the highest cost, accounting for x amount which is shown to be a certain percentage of the group's total cost. The page then goes into cost recoveries, neatly illustrating how for ten months (April 2022 till January 2022), Waterfront Electricity costs was x amount compared to the recovered amount of x amount (GCX, 2022g). Based on these amounts the YTD cost recovery is then calculated and expressed as a percentage. It is thereafter reports the V&A Waterfront's electricity cost for January 2022, which if compared to the recovered amount, indicates a percentage cost recovery (GCX, 2022g). This is followed by an Electricity Cost Histogram, with columns showing cost for electricity in kWh. It is described that intensities are shown as kWh per m² with columns in red indicate that the property has exceeded the baseline intensity (GCX, 2022g). Columns in green indicate that the property is below the baseline intensity. Lastly the page illustrates Electricity (kWh) cost for April 2021 to January 2022 (10 months) in a well-organised table that indicates each sector's YTD, SPLY, year on year (YoY) % change, month on month (MoM) % change, YTD consumption recovery %, MTD consumption recovery %, Property count and lastly Tenant count (GCX, 2022g).

The Electricity Intensities page displays intensities data for the current reporting fiscal year showing MTD and YTD comparative data, with the reported intensity being kWh per m². It is reported that within the reporting boundary the V&A reports an electricity intensity of x kWh per m² for the group which if calculated represents a percentage below or above the intensity of x kWh per m² for the SPLY (GCX, 2022g). The report then shifts the perspective to MTD, indicating the intensity in kWh per m² reported for January 2022, which is then shown to represent a percentage increase or decrease compared to the previous month's intensity of x kWh per m² (GCX, 2022g). It is then reported that the property with the highest intensity is Unresolved with an intensity of x kWh per m². It is also shown that within the Unresolved property, parking reported the highest intensity as well as the amount in kWh per square meter (GCX, 2022g). It is then indicated that compared to the baseline intensity of x kWh per m², the FY 22 YTD intensity of x kWh per m² is showing a percentage decrease 12.3% for example (GCX, 2022g). This is followed by a Electricity (kWh) Intensity Histogram, with columns showing intensity in kWh per square meter, while the baseline is shown as a dotted line. Again

properties in red are indicative of ones that have exceeded the baseline intensity, while columns in green indicate the property is below baseline intensity. Lastly the page illustrates Electricity (kWh) Intensities from April 2021 to Jan 2022 (10 months) in a well-organised table that indicates each sector's YTD, SPLY, year on year (YoY) % change, month on month (MoM) % change, YTD consumption recovery %, MTD consumption recovery %, Property count and lastly Tenant count (GCX, 2022g).

The Top 15 Electricity Consumption and Intensities page includes graphs and tables showing details of the top 15 consumption properties, as well as a scatter plot table showing details of the top 15 (or highest) intensities. The top consumption section of the page first illustrates the Top Properties by Consumption of Electricity (kWh) based on kWh of electricity reported for the 10 months (April 2022 till January 2022) using a graph and table (GCX, 2022g). In the graph, the x-axis indicates properties that reported the largest consumption of electricity (kWh), while the y-axis shows the consumption in kWh (GCX, 2022g). At the same time, the grey-shaded area shows the consumption for the same period last year, while items shown in red (in both graph and table) are indicative of properties exceeding baseline intensity. On the other hand, green is indicative of a property that is below baseline intensity. The page next moves to Top Properties for Intensities of Electricity (kWh) shown as kWh per square meter. Here the scatter plot and table illustrates the highest intensities for properties based on kWh of electricity reported between April 2021 and January 2022 (GCX, 2022g). In the scatter plot the x-axis is showing the current years intensity in kWh per square meter, while the y-axis shows the baseline intensity in kWh per square meter (GCX, 2022g). Items shown in red (in both the scatter-plot and table) indicate the property has exceeded baseline intensity, while items shown in green indicate the property is below baseline intensity.

The Largest/Highest Electricity Consumption (by Property) page contains a simple table showing monthly consumption for (up to a maximum of 50) properties (GCX, 2022g). Each of these totals are tracked against the Property Baseline Intensity, with red indicating an exceeded intensity and green indicating a value below baseline. The Largest/Highest Electricity Consumption (by Tenant) page also contains a simple table showing monthly consumption for (up to a maximum of 50) tenants (GCX, 2022g). Each of these totals are tracked against the Property Baseline Intensity, with red indicating an exceeded intensity and green indicating a value below the baseline.

The V&A Waterfront is also continuously giving data across to GCX to help them to better the dashboard — which is currently at its fourth iteration (V&A 5, 2022). This iterative, long-lasting, and mutually beneficial relationship not only means the continuous bettering of the platform but also the ability to see four or five years of financial and environmental data on effectively all the V&A Waterfront and their tenant’s water consumption, energy consumption, waste and related CO₂ emissions (see Appendix G and Appendix H³⁵). This enables a far more accurate and up-to-date carbon disclosure than yearly black box carbon exercises, while allowing for comparative analysis against which to track targets and set realistic targets for the years to come.

However, benefits exceed better carbon footprint disclosure, as many decision-supporting effects were enabled due to GCX DASH---. These effects include the ability to see unintended consequences, the enablement of nexus thinking, as well as cultivation of new forms of partnerships between tenants and landlords. These newly formed relational partnerships furthermore point to new ways to create systemic change via the shifting of power dynamics in the political sphere of a business, precinct, and perhaps even a city like Cape Town.

4.3.3 Unintended consequences: recycling

As briefly mentioned, an important possibility opened by the dashboard was the ability to discover unintended consequences. An excellent example of this is the V&A Waterfront’s waste.

To provide some background, the V&A Waterfront’s waste service provider collects waste throughout the precinct about two to three times daily (V&A 2, 2022). Once collection occurs, the service providers give GCX data regarding that waste. This data is then loaded onto GCX DASH-, allowing the V&A Waterfront to track and monitor all their own and their tenants’ data on waste. For the Senior Operations Manager for custodial services at the V&A (V&A 2, 2022), this is very important as this allows her to have access to information that can give her input when making other decisions. As V&A 2 (2022) explains:

³⁵ It must be noted that both Tables 4.6 and 4.7 are not full reports, and do not contain financial data due to confidentiality. Nonetheless these figures illustrating how data across the financial year of 2018 up until the financial year of 2022 can be displayed.

Once you start understanding where the bulk of your waste sits, and that directly links to your cost, it directly links to your recoveries and the direct links to your strategy overall. If we didn't see that kind of picture, and we might have overseen, you know, critical factors of the big waste generators. I think I've always had a fair understanding of that, but the amount of time and energy it would take for me to compile all my little Excel spreadsheets into one. So for me, the best benefit of it all is just that I now have access to that information already consolidated.

This is, however, not the only benefit that was mentioned. When looking at waste, the V&A Waterfront is driving higher landfill diversion rates, but with the platform's help, they realised they would never be able to go higher than 40% to 43% landfill diversion (V&A 2, 2022). The minute they approach 50% to 52%, it costs the V&A Waterfront more. The V&A Waterfront, therefore, recycles very well, but the problem is that there are no off-takers in Cape Town who will resolve their recycled material. This causes the V&A to bin all the recycled material, which leads to a very large gate fee at the landfills. This creates a situation where they essentially pay more when recycling over 43% than it saves them. As V&A 1 (2021) states, “We've proven with the platform that anything above 43% doesn't pay me to recycle”, once again highlighting the importance of picking up materiality rather than pure non-financial data in isolation.

It is the realisation of the unintended consequences that come with recycling that ushered the V&A Management in the direction of seeking alternative means of dealing with their waste. In seeking alternatives GCX DASH- was of critical importance and not only allowed them to find an alternative, but it allowed the V&A Waterfront to use nexus thinking in finding a calculated alternative that will have reverberating effects on water, energy, and waste. This is discussed in the following section.

4.3.4 Nexus thinking: waste-to-energy as a means to desalination

It is important to note that at the V&A Waterfront claims to always try and ensure that their various departments' goals and objectives align with the broader goals and objectives of the business, for example the overarching goal of sustainability (V&A 6). By investigating the viability of these claims it was found that the V&A Waterfront has indeed enacted policies such as their solid waste management policy, green cleaning policy, gardening policy, and

irrigation strategy in a manner that aligns with the overarching goal of sustainability (V&A 3, 2022).

It was found these are not seen as policies for the sake of sustainability as a separate division of the precinct. Instead, sustainability is claimed to be incorporated in all the spheres of the V&A Waterfront making it an aspect conducive to extensive budgets from an operational expenditure perspective, as well as from a capital expenditure (CAPEX) perspective (V&A 6, 2022). This is because the V&A Waterfront wants to ensure that whatever is decided on as a broader strategy for the business gets pulled through into the day-to-day operations. One of these strategies is their waste-to-energy project, a proposal which benefitted from the data provided by GCX DASH-.

Waste forms quite a big part of the V&A Waterfront's carbon footprint, and because of this, they decided some time ago that they need to find an alternative strategy for waste. As explained earlier, they cannot go above 43% landfill diversion. This meant that in 2018 when the V&A Waterfront onboarded GCX from a common monitoring and the dashboard perspective, they also started engaging with the Zero Waste section of GCX. This led to a waste viability assessment using data from GCX DASH-, with consideration of various waste solutions that are currently available in the market.

The viability assessment enabled GCX to see what would be the best way for the V&A Waterfront to move forward regarding the waste that they are unable to recycle. GCX looked at various technologies, such as a company in Denmark that convert waste into brickmaking, as well as other technologies such as techno thermal technology, which is advanced pyrolysis treatment for converting waste into energy. Once the viability was completed, GCX was able to determine that advanced pyrolysis treatment was the way to go for the V&A Waterfront (V&A 2, 2022).

However, in 2020, China banned the import of waste, resulting in a huge crash in the recycling market (V&A 2, 2022). This led to a change in strategy, as the V&A Waterfront asked GCX to perform another waste viability assessment, but this time incorporating 100% of their waste, as the V&A Waterfront wanted to take the matter of waste entirely into their own hands.

GCX then did another viability assessment, with 100% of the V&A Waste in mind, resulting in a different costing model. The technology would remain the same, but the yields looked slightly different because the costs associated with the project escalated. This is because the V&A Waterfront would now recycle all their waste, requiring a bigger advanced pyrolysis plant (V&A 2, 2022).

This final solutions assessment then led to a proposed intervention and, finally, the approved plans for a waste-to-energy plant using advanced pyrolysis treatment where all waste except glass and metal would go into the plant to make energy. In other words, the V&A Waterfront would stop effectively recycling on-site, as everything would be utilised for energy in the long run (V&A 2, 2022).

This is, however, not where the solutions assessment ended.

4.3.4.1 Waste-to-energy to desalination

Due to the scarcity of water and the recent drought in Cape Town, the V&A Waterfront has long indicated it would want to build a desalination plant (V&A 4, 2022). The V&A Waterfront also has development rights for another 400,000 square metres of gross leasable area (GLA), making desalination a serious possibility, especially given their proximity to the Atlantic Ocean (V&A Waterfront, 2022e). However, to approve the building rights for a desalination plant, the CCT would have to approve an application to maintain the resources required to run operations associated with a desalination plant (of which the bulk is electricity).

The V&A Waterfront has installed as many solar PV panels on the property as possible, and they know that even with additional PV that will come from replacing the roof of the Victoria Warf shopping centrum, they will still not have enough electricity to sustain what is needed for a desalination plant (V&A 5, 2022). The assumption is that they do not want to use the national grid because it is expensive and unreliable, and there is a massive carbon footprint associated with it (among many other problems). So, the V&A Waterfront had to find a source of electricity other than their PV and the national grid for the desalination plant to be approved (V&A 3, 2022; V&A 4, 2022)

The V&A Waterfront were without answers until GCX did the waste viability assessment, which led to the commissioned waste to energy plant discussed earlier. During this viability assessment, access to a complete data record of the V&A's MFA (provided by GCX Dash-) enabled them to determine the following in V&A 2's (2022) words:

Once we did the viability for the waste-to-energy, we knew that the amount of energy that we will be able to get from the waste-to-energy plant would be able to provide at least two-thirds of the energy required for the desalination plant. And the other third of that would be coming from the PV installations. So, it was kind of like a no-brainer for us. Because your payback period was within reach of what we were hoping for. And at least from a development perspective, we're not putting additional strain on the system, it would be able to generate our own electricity, which is great.

This indicates an example of how the GCX DASH- allowed for decision-making that takes a nexus perspective: a single intervention was constructed that would have reverberating effects on three mutually inclusive resources, namely waste, energy, and water. Significantly, MFA data underpinned this decision which, in turn, allowed for the appropriate nexus perspective to be possible and is thus a determining factor in enacting accurate nexus thinking. The reasons for this will be explored in more detail in what follows.

4.3.4.2 How GCX DASH- helped with this process

What made the viability assessment so efficient in allowing for an accurate solutions assessment (which allowed a single intervention to have effects on three mutually inclusive resources) was the fact that GCX had a clear understanding of the nature of waste, energy, and water at the V&A Waterfront because of how they made use of GCX DASH-. As V&A 2 (2022) mentioned:

They knew our volumes. They knew the challenges, they knew the monthly results and our diversion ratios. And so I think that the expertise that sat in that space helped us to, I think, first of all, get a good quality report.

This made it possible for GCX to give a very clear projection of the type or the volume of waste that can be generated over the long run, as well as the correlated amount and type of energy that could then be produced given that amount of waste.

As V&A 2 (2022) mentioned:

I think that if we hadn't gone through the process of working with them [GCX] on the dashboard first and established that type of relationship, we might not have been able to consult with them on the Waste-to-Energy Project

The dashboard thus enabled the V&A Waterfront to predict the consequences of a single system intervention on the rest of the systems, enabling them to use these predictions for the sake of accurate and reliable future thinking. It also enabled the V&A Waterfront to make decisions that are in line with their shared value perspective, as well as their circular system thinking approach. The dashboard also allows for the enactment of a shared value ecosystem, as with the building of their waste-to-energy system, they are planning to build it to withstand future growth (with specific knowledge of how much waste they have). This allows them to, up until that point, buy a precisely calculated amount of waste from their neighbours (V&A 2, 2022).

The dashboard thus helped the V&A Waterfront: i) understand the current situation [status of the system]; ii) harmonise this data which, in turn, allowed for solutions assessment (taking a nexus approach that checks for trade-offs), and iii) propose interventions and activities based on the solutions assessment. It also points to a form of policy integration where collaboration is required to achieve the solutions decided. The example indicates a new approach to capital budgeting stemming from intersectional collaboration and long-term capital budgeting.

The example explored above also points to another very interesting finding regarding waste recycling in Cape Town. The reality is that operationally it would be possible for the V&A Waterfront to increase the percentage of recycling to above 43%. However, because of capacity limits within the wider Cape Town urban system that the V&A Waterfront does not control, they cannot increase their recycling level. What this means is that when a major economic precinct like V&A Waterfront has a data-based decision-support system it helps to reveal the

systemic weaknesses of the wider urban systems that they depend on. This, in turn, could help them put pressure on this wider urban system to adjust accordingly. This is a significant finding given the active process of another consortium member, Garth Malan, who is creating a DSS for the City of Cape Town, making any insights into the functionality/dysfunctionality of the city of crucial importance.

4.3.4.3 Blackwater treatment plant

Other proposed interventions stemming from solutions assessment via the dashboard include the commissioning of a blackwater treatment plant (V&A 3, 2022). It was found that the dashboard has allowed for the enactment of circular thinking as it made the V&A Waterfront aware that they have reached a ceiling regarding many of the systems meant to save and recycle resources.

Findings suggest that by knowing exactly what is going on with their resource, the DSS allowed for learning and experimentation, leading to the commissioning of a black water treatment plant called Organica (V&A 4, 2022).

The plant, which is currently being built at the site of the V&A Waterfront's current sewage pump station, will extract all the solids from the sewage, and the water will be treated to level two standard, which means irrigation level treatment (V&A 4, 2022). As V&A 2 (2022) explains:

We'll use it for toilet flushing, but the long-term plan is to use it also for irrigation. And if we ever get to a dire strait again with the drought, and we do need to get it to potable supply, then we can do that. So all I'm trying to say is that everything we do right now focuses on circularity.

On top of allowing the V&A Waterfront management to realise the need for wastewater treatment, the dashboard has also allowed them to calculate exactly how much water will be treated, and how much water will be saved.

4.3.4 Adaptive co-management between land tenants

It is clear that the GCX DASH– has proven to be a very useful tool at the V&A Waterfront, but what about their tenants — have they embraced the system? And if so, how has the system

driven change in tenant behaviour resulting in collective improvements? To a further extent, has the system impacted tenant-landlord relations?

According to V&A 1 (2021), at first, the platform was not targeted at tenants per se, as it was more about having access to consolidated data to make informed decisions at precinct level. It furthermore enabled V&A 1 (2021), for instance, to walk into his Board meeting at the end of the month and show the reports that GCX produces, and for him to say: “This is where the big indicators are”, allowing for better decision-making surrounding these indicators.

Findings, however, suggest that over time the V&A Waterfront management started using the system in response to tenants asking questions. This meant that over time the system became an enabling mechanism for the V&A Waterfront management’s relationship with tenants because of the shorter time it took to respond, as well as the confidence of responding to tenants with accurate and verified data (V&A 3, 2022). Going out proactively to tenants is something the V&A Waterfront started to do; an ability which proved very useful during Day Zero³⁶ (as will be discussed) and with the continued and overall goal of creating a green precinct. As mentioned, the V&A Waterfronts target is to see a decreasing baseline every year when it comes to their carbon footprint; as they soon found out, this cannot be done without the help of the tenants.

The need to adapt given a potential water Day Zero again points towards the way in which the V&A Waterfront is part of a wider dysfunctional urban system which creates the necessity for them to recycle independently (as already pointed out), commission a desalination plant (due to Day Zero), as well as construct PV and waste-to-energy plant (due to loadshedding³⁷). The fact that the V&A Waterfront simultaneously has to work with tenants to achieve their goals points towards not only their embeddedness in a dysfunctional urban system but also how dependent the V&A Waterfront is on granular level sub-systems, i.e., the business of the tenants themselves. This means that in the same way that the V&A 1 (2021) has an interest in

³⁶ Day Zero is a term used during the height of the water crisis in Cape Town between 2017 and 2020 and refers to the looming possibility of the arrival of a moment where all the inhabitants of the city will be without water.

³⁷ The South African energy crisis, most notably manifesting in the form of successive rounds of loadshedding, is an ongoing period of widespread national level rolling blackouts as electricity supply falls behind electricity demand, threatening to destabilise the national power grid.

having a systems perspective, tenants also have, or need to have, the same interest for a shared value perspective to be fruitful. To this end, GCX can produce a more granular tenant view. As GCX 2 (2021) explains:

Whatever the hierarchical structure is, again, we could produce that same report that we produce for V&A 1, and instead of doing it for the whole precinct, we could give it for one unit. So any of the data that you're seeing here will go down depending on the level of detail we got, we can report right to that level

This is a very important point as there is a common interest between the V&A Waterfront and their tenants, they are not working against each other in driving a green precinct. As V&A 1 (2021) states: “The better their [tenant] performance is, the better our [V&A] reporting to our targets is”. This raises an interesting discussion about the chasm between landlord and tenant, something which has traditionally been the biggest obstruction to sustainability in the built environment because it is about whose cost and responsibility it is and who benefits from it.

4.3.5 Green leases, shared value ecosystem and supply chain partnerships

According to GCX 1, smart metres, in congruence with GCX DASH-, did a huge amount to advance a new relational approach between tenants and landlord because the V&A Waterfront can bill tenants accurately based on precise usages. GCX DASH- also enabled green leases with tenants and landlords realising it is their joint responsibility to drive down energy consumption. This was, however, not always possible because accurate measurements did not exist; with smart meters they now know exactly the amount of material flows and where they come from (V&A 3, 2022).

Green leases have been discussed in some detail, but to elaborate: green leases are contracts between Growthpoint (including the V&A Waterfront) as landlord and their tenants, whereby they share the benefits and the expenses of driving efficiencies in water, energy, and waste (V&A Waterfront, 2022c). Concerning waste, the V&A Waterfront is one of the few companies leading by example in taking waste analysis and recycling practices down to tenant level. As GCX 1 (2021) explains:

Each tenant gets a QR code with their name and their details, and they have three bags, one is general waste, the other is organic waste, one is recycling. The waste company picks it up from the tenant, and they'll [the tenant] pay 1000 rand per ton to dispose of the general waste, while they'll pay 200 rands a ton for recycled waste, and they might even get money for the organic waste. Then all of a sudden you'll find less contamination in the overall waste of the precinct as well as more efficiency in waste recycling practices. So, you change the behaviour, you know, that's basically what it comes down to.

These green leases are essential mechanisms for collaborative governance for driving down consumption while also allowing for the enactment of the shared value approach present at the V&A Waterfront. This is because the green leases include minimum requirements to which all new and existing tenants must adhere. It is with regards to justifying these requirements that GCX DASH- once again becomes important, as these requirements are “easier to sell if you can prove to tenants that you have data which supports those requirements” (V&A 2, 2022). The system furthermore allows for efficient conflict resolution between tenants and landlords as a specific viewpoint or argument can be supported by results; you can have “data that underpins why you're saying what it is that you're saying, making it easier to sell your point”.

This shared value and shared responsibility approach is further elaborated on by V&A 1 (2021) who states:

I think, at the V&A, our strategy has been evolved from just being a standard landlord, property developer, to a shared values ecosystem, right. So we've got these clusters, we have a food cluster, we bring all our restaurateurs, all our retailers into a room. And we started to talk about how does the V&A benefit beyond just the shareholders? What is the economic impact on the city? Beyond CSI?

An example of how the V&A Waterfront has been taking this approach forward is a project called Project Soul, where the management together with tenants and researchers is looking at how the V&A Waterfront can leverage the overall social-ecological systems (SES) resilience through food-based initiatives, such as checking where food is sourced from before establishing supply chain partnerships. This enables them to see if it is socially and ecologically sustainable

sourcing before supply chain partnership is agreed upon, allowing for reverberating effects that uplift the local economy and sustain the natural environment. This is an example of how landlords, tenants and even researchers can work together, indicating how the V&A Waterfront has progressed beyond the traditional landlord-tenant relationship to a shared value perspective where problems are solved together.

Another example of the shared value perceptive enacted at the V&A Waterfront relates to when the decision was made to get GCX on board. The decision posed the threat of replacing the meter reader service providers as GCX can do all the billing, causing backlash from these service providers. However, it was found that the V&A 1 (2021) was able to immediately reassure them that they would not be replaced as the management of the V&A claims to have committed to taking a systems view where everyone in the supply chain is seen as important.

As V&A 1 (2021) explains:

Our approach at the V&A is a system-wide view, most traditional accountants would look at it and say, I can get it cheaper, I can get rid of UMFA now, I can cut this and that. We take a different view here at the V&A as we did now through COVID. We don't think it's anyone's interest to get rid of suppliers. Because they all have their own little ecosystem that's creating an economic contribution. So the big thing for us was to get UMFA to settle down and to say, 'your contract is not under threat. So giving data to GCX is not about replacing you.

Evidence, therefore, suggests that green leases and the shared value perceptive have effects that reverberate further than just the tenant-landlord relations; such changes will affect entire supply chain partnerships. In line with this, V&A 1 (2021) makes it clear that it is never in their interests to end a supply chain partnership just because they are capable of procuring services at a less expensive cost. As V&A 1 (2021) describes, "When you kill a contractor, you're losing skills that you might not be able to get back".

4.3.5.1 COVID-19

Evidence suggests that the abovementioned shared value approach is precisely the approach that the V&A Waterfront management claims to have continued to take during the COVID-19

pandemic as they did not stop CAPEX despite huge decreases in customers, tourists and related profits.

The reason, according to V&A 1 (2021) is that:

If we hold back on capital (CAPEX) all these smaller businesses (because we have a huge SMME agenda) will be one month away from bankruptcy, and then when you go back three months later to start your project, they're gone. So we've tried to keep as much CAPEX going as was possible.

In line with this the V&A Waterfront has also launched an SMME support hub in response to the disruption and economic fallout caused by the COVID-19 pandemic by putting measures in place that can support SMMEs in overcoming this crisis (V&A waterfront, 2022d). They realise that although the effects of the pandemic will disrupt lives, businesses, and communities, they are most dramatically experienced by those who are already vulnerable.

The SMME support hub was therefore created to provide information about tenant support interventions implemented during the pandemic so that all SMMEs have equal access to information regarding opportunities for relief (V&A waterfront, 2022d). This information was conveyed via subscription on the V&A Waterfront website, as well as a dedicated SMME support desk which also assisted with queries. Direct support from the V&A Waterfront amazingly included 100% rental relief to SMMEs, while they also consolidated all avenues of assistance in order to provide support for those who apply for aid. According to the V&A Waterfront their support for the smallest SMMEs amounts to around R10m-R15m to date.

Although the decision to continue investment towards SMMEs during COVID-19 stemmed from a value and moral positioning ingrained in the philosophy of the company, evidence suggests that the decision to which SMME the V&A Waterfront directs its CAPEX has been enhanced and refined since the introduction of GCX DASH-, creating positive socio-economic effects. This is discussed in more detail in the next section.

4.3.6 Projecting potential outcomes: better decision-making (CAPEX)

It is the bird's eye view of resource flows and patterns that allows the V&A Waterfront to know exactly what resources are being used on a monthly and yearly basis, in turn, enabling them to make better decisions, as well as to set realistic sustainability-oriented performance targets for the year ahead (V&A 6). These annual targets are improvements on the previous year's performance following a standardised set of metrics (e.g., emissions, water use per person, waste per person, energy use, etc). These targets are not, therefore, wishful thinking targets designed for political performance that can be construed as greenwash; they are rooted in reality and are realistic and achievable. The system, therefore, enables a deep level of learning (principle 5) that enables better decision-making, as well as the better setting of realistic targets.

The dashboard also makes it possible to project potential outcomes over time, for example, 2030, 2040 or 2050, if the rate of improvement is maintained. In the case of the V&A Waterfront this projecting drives their CAPEX budgeting. Evidence suggests that with accurate key performance indicators (KPIs) and dynamic baselines, the V&A Waterfront has been able to compare buildings per square metre enabling them to assess the performance of outliers while finding reasons for why these are outliers.

Previously (before GCX DASH-), CAPEX used to be "...driven by who shouted the loudest" (V&A 1, 2021). However, with the analytics tool in place, guided decisions directing CAPEX have been made that contribute ecologically and socially. As GCX 6 (2022) explains: "You will be able to use data to identify where capital expenditure is required. So, yes, the dashboard does have the ability to indicate where it's required." This leads V&A 1 (2021) to describe the resource data flows enabled by GCX DASH- as "game-changing."

It is important to note that the GCX system did not determine the V&A Waterfront's SMME and ESG agenda but rather provided the data flows to effectively make decisions in support of the efficient enactment of these agendas.

As GCX 6 (2022) explains:

So the tool is also to act as affirmation. So the tool is something that we can also use to say, but you know, it's like path correction, and affirmation, where we can say that we

are on the correct path, we have this tool, it's indicative of what we do. So now we can start looking at other innovations as well. So yep.

It is a system that can help a company or government achieve their predetermined, or perhaps mandated, value perspectives. It is, therefore, a tool that can just as easily be used to support unjust perspectives. It is therefore highly important for a company or government to have a just value perspective when using such a system otherwise it may lead to the re-entrenchment of previously unequal and unjust systems rather than creating liberating effects of social and ecological justice³⁸.

As mentioned, the V&A Waterfront has committed to being an enabler for economic growth, driving meaningful job creation, creating social value, contributing to nation-building and social cohesion, and ensuring environmental sustainability and resilience; these commitments guide how the dashboard is used.

What the above exploration is refereeing to is a form of relational governance where SMMEs are claimed to be valued for the skills that they offer, rather than random selection. After analysis of the evidence, it can be argued that it refers to a relational shared value approach to the governance of resources which has a positive impact on the bottom line, the environment, and the CCT as a whole. It also brings to light the importance of a decision support system, such as GCX DASH-, in allowing for such relational and adaptive co-governance, as the V&A Waterfront's environmental agenda drives a CAPEX agenda that, in turn, is driving a SMME agenda — all of which rely on the accurate measurement of resource flows. This is where the connection between environmental and social agendas starts to become all the more prevalent, indicating how these are not, and should never be, mutually exclusive agendas, as thinking about these spheres reciprocally will yield far better holistic results.

In what follows, I will elaborate on how the nexus governance approach at the V&A Waterfront has driven systems change.

³⁸ The narrative of a just energy transition serves as an example of this, where value perceptiveness taken into account in an energy transition will determine if the transition leads to more equality, justice and jobs, or if it will re-entrench the current system (characterised by unemployment, inequality, and injustice)

4.3.7 Driving systems change: implications during Day Zero

Academic such as Hargreaves (2011), Weitz *et al.* (2017), Berman *et al.* (2019), and Urbinatti *et al.* (2020) all discuss how individuals and institutions resist change, leading to different explorations of ways in which to catalyse systems change given such resistance. The literature makes it clear that institutions have their own data which they defend to the end, making it necessary to explore ways in which to overcome such defensiveness in light of collaboration in the interest of positive change (EDP 1, 2021).

After exploring the reality of the approach at the V&A Waterfront, it can be argued that it is indicative of a very interesting model of how change can happen within not just one company but a precinct comprising a collection of 800 diverse entities that can be corralled into a wider coherent sub-system that is aligned with the goals of a resilient city. There is no reason why it cannot be scaled up to the city level. It is clear that the use of GCX DASH- as a DSS - creates the data flows that drive change in the system.

An example of how such systems change materialised using the GCX DASH- (DSS) can once again be taken from the water crisis in Cape Town (Day-Zero) (Shepherd, 2019) . The reality is that the V&A Waterfront heavily relies on its tenants (the common precinct) for their total water consumption. The V&A Waterfront, however, cannot directly influence the reports of these tenants, so it is of paramount importance to have these tenants participate out of their own free will in driving down water consumption.

During the water crisis, the way to get tenants to participate was to get all the significant users together in a room and to show comparisons in consumption rates using the GCX DASH- while also highlighting who the major users were (V&A 1, 2021). By showing the data, the V&A Waterfront was able to get these large consumers to start asking their own questions, and eventually drive their own changes. For many of these tenants the realisation of how much money their competitors are saving (made possible by showing the materiality of water consumption) is what incentivised the changes over time.

It was found that by using GCX DASH-, the V&A Waterfront could analyse data comparatively in a manner that would never be possible when using separate spreadsheets for different parts of the business. An example of such comparative analysis included why a five-

star hotel in one sector of the precinct used 50% more water than another five-star hotel (V&A 1, 2021). This kind of information proved crucial during the water crisis because it allowed the V&A Waterfront to go to tenants and show their competitive usage, creating an incentive for tenants to automatically drive down their own water consumption.

It can be argued that such comparative analysis proved successful in shaping behaviour, decision-making and planning surrounding common resources. As V&A 1 (2021) explains:

So with the Day Zero crisis, when we were looking to drive that kind of water savings, we were taking it down to a per sector level and meeting per sector. And then you have competitors in the room, who would never talk to each other like we were showing them, Listen, here's the five-star hotels, look at the difference in your water consumption. And you had general managers, who we were being told by the maintenance engineers, basically that they are not doing great. We won't mention names, they come to you after and ask who was that, and you say that was you. So you've been able to use it to change behaviour, change decision-making, and change planning from the tenants themselves.

By taking this approach, the V&A Waterfront, in a sense, created a competitive arena where tenants (institutions) are made aware of their true positioning concerning consumption via comparisons with competitors that are indicative of how much money competitors are saving by consuming less. It was found that by creating a competitive arena, the V&A Waterfront enable tenants to enact self-enforced changes that will, at the same time, save the tenants money and help the V&A Waterfront meet their objectives of reducing consumption and performing better both environmentally and socially. It was also found that the ability to create such a competitive arena stems from three things offered by GCX DASH-: dynamic baselines, confidence in data, and financial value. As GCX 2 (2022) explains:

Without bringing all three of those, you know, you can't kind of paint the picture when you're asking questions. When you go down to tenant level and you tell them that if they save 10 kilowatt hours, they save 3% electricity, it means nothing. The only common denominator everybody in this room would understand is money. Everyone

understands money. So the materiality is a very, very important thing to be able to drive that kind of initiative.

Evidence, therefore, suggests that when it comes to driving systems change, awareness of institutional performance in comparison to competitors is very important. Of equal importance is the ability to make sense of what given operational changes will mean in a value/perspective that makes sense to a given institution (money, CO₂) — all of which is made possible using the GCX DASH-.

One may ask, “why not just legislate and make people do what is needed?” The problem is that individuals find loopholes in legislation; however, what works in a capitalist society is competitive dynamics and awareness of performance. As GCX 1 (2021) explains: “People do not want to be on the bottom 10 list.” In conclusion it can be argued that to a large extent institutional change can be incentivised through awareness of performance, being aware of comparative competitive performances, as well as being aware of what the performance of something (environmental) is against something else (monetary value)”.

4.3.8 Power dynamics: relationships of trust for the goal of systems change

Another very interesting finding regarding the PSG implications of the dashboard is its effects on power dynamics. When asked about power dynamics, EDP 1 (2021) described the difference between hard power, which is about rules and structures and exerting power in a top-down way, and soft power, which is about influencing within the constitution of a relationship.

With regard to soft power, EDP 1 (2021) explains that an abusive or dysfunctional relationship implies the inability to influence. EDP 1 (2021) furthermore expresses that unfortunately, dysfunctional relationships are the case when it comes to many tenant-landlord relations and the relationships that individuals and institutions have with their city or the government. So, the question then becomes, how can institutional relationships be changed in light of more functional relationships between institutions?

In researching this question, it was found that a large constraining factor in the case of most countries, including South Africa, is that governments tend to exercise power in a top-down manner, leading to a rather authoritarian approach which does not allow for a diversity of

opinions to be considered (EDP 1, 2021). It was also found that many private sectors, entrepreneurs and civil society organisations make use of a bottom-up approach, yet evidence suggests there exists lots of naivete in this approach, especially regarding scaling up and accessing resources required to enact real change (EDP 1, 2021). This leads to a situation where there is a lot of idealism but no real systemic change. One suggestion would be for these approaches to change, yet according to EDP 1 (2021): “These systems will not change fundamentally, but if you can create relationships of trust between the top-down and the bottom-up maybe you can drive some change”.

The question then becomes, how can top-down and bottom-up approaches be brought together to create relationships of trust in striving towards the goal of positive systems change?

Investigating how the implementation of GCX was able to influence the relationships between landlord and tenants leads to the logical conclusion that shared information DSS is of critical importance in shaping the required relationships of trust required to bring top-down and bottom-up governance structures into mutual relation. It is therefore argued that a shared DSS that tracks performances and stimulates better collective decision-making may be a part of the answer when it comes to shaping power dynamics via better connection for the goal of enabling real, achievable systems change. According to V&A 1 (2021), this change may be incremental, but in Swilling’s (2020) theory of change, incremental change is the most realistic and proven way in which change is actualised.

4.3.9 Limitations of the system

One limitation of the system is that the GCX-managed approach at the V&A Waterfront currently does not track the flow of food through the V&A Waterfront system. However, it does address multiple resource categories (water, energy, and waste) while also utilising material/technology provision and information as a form of action intervention and thus still qualifying as a nexus approach. However, because of this, quantities and sources of food flows are not clearly understood because waste is the only reflection that gives an indication of food in the system.

Not having a clear picture of food is problematic since an understanding of food quantities in relation to geography is a very crucial necessity in a country with highly unequal food access

(EDP 1, 2021). Food access is very often associated with geography, making it crucial to understand the quantities of food entering different contexts. Food flows also need to be analysed considering understanding sustainable and unsustainable food production systems. If it was possible to track the total quantity of food procured by supermarkets, hotels, and restaurants at the V&A Waterfront (i.e., the large bulk of their daily purchases), this would provide the basis for calculating what proportion is locally procured (within the Cape Town system — most sustainable), within South Africa (less sustainable), and internationally (least sustainable). However, data alone would not reveal the source of the quantities observed and would require qualitative interviews to determine the sources. Another problem with not having a clear picture of food flows is that embedded energy and water in food flowing into the V&A Waterfront is not understood.

Following the transdisciplinary approach of this research project meant identification of the problem (food flows not being tracked) led to immediate consultation with stakeholders to investigate solutions. However, after a meeting with GCX, V&A management, and data analysis experts on the possible inclusion of food flows, it was concluded that it would not be beneficial for the V&A Waterfront to include food flows (GCX 1, 2021; V&A 1, 2021). This is because the energy and water embedded in the food that enters the V&A are not consumed on-site and do not affect their resource consumption and associated carbon use. Although there are many other problems associated with not tracking food flows (discussed above), the V&A Waterfront procured the services of GCX from a resource consumption and carbon analysis point of view. This means that although the problems associated with not tracking food are highly important and noted by the V&A Waterfront, it falls outside the scope of the intention for procuring the services of GCX.

Another limitation is the fact that currently, the dashboard focuses purely on environmental sustainability. Although, as explored, this enables many PSG benefits, there is a need to incorporate Corporate Social Investment (CSI) components into the dashboard more fully. CSI essentially refers to a company's provisioning of cash, products, staff time, service, and more as an investment in social development (EDP1, 2022). Evidence suggests that the V&A Waterfront has an extensive CSI responsibility and budgeting, yet these components are not currently captured on GCX DASH-. According to V&A 6, capturing CSI components would be highly beneficial as it would enable the management team to see environmental, social, and

financial data in relation to one another, creating an advanced ability to make decisions surrounding these highly interrelated facets of the business. The inclusion of CSI components on GCX DASH- is something discussed by the V&A management as an already decided-on step, but unfortunately, the advent of COVID-19 slowed down progress in this regard (V&A 6, 2022).

With a clear understanding of the PSG implications and limitations of the nexus governance approach at the V&A Waterfront, the next section will be dedicated to a discussion of these findings, exploring if these implications hold any potential for enhanced resilience. I will then explore how these findings apply to the CCT, allowing me to understand if these resilience effects apply to the Cape Town Context.

Part C: Transformational Knowledge

Chapter 5: Discussion of Findings

5.1 Resilience implications:

5.1.1 Maintain diversity and redundancy

With regards to maintaining diversity and redundancy, the V&A Waterfront has created a favourable environment for enacting diverse entities/governance units working together on common resource and governance-related issues.

In the case of the V&A Waterfront, the diversity of entities are made up of the V&A Waterfront's management, with all its various departments, as well as the tenants and their various departments. Here the examples of departments, tenants and landlords working in harmony on common resource problems, as well as the enactment of green leases and a shared value perspective (enabled by the data flows that the GCX DASH- system makes possible), are indicative of the institutional diversity proposed as a resilience-enhancing property.

An example of diverse departments working together can be displayed using the words of V&A 6 (2022):

Our strategy in the business is shared value and collaboration. So for us, it's very important to cross-collaborate on information and projects. For example, even though I look after environmental sustainability, and we have a department that specifically focuses on waste, I can take data and information regarding waste out of the dashboard and make informed decisions that will affect that department as well as my own. Similarly, my colleague that works in waste has access to the same information, allowing for decision-making that takes a holistic perspective on all related departments. And so there is definitely cross-collaboration and pollination within our departments.

In this relationship GCX DASH- represents a shared information platform that enables the necessary connectivity among these diverse units of governance, allowing for the adequate enactment of cooperative diversity. It furthermore allows for the enactment of redundancy, as

all governance units share information, making it possible for one governance department to act when another is struggling or has failed. The shared information platform is important since connectivity is a crucial determining factor when it comes to the success of diversity, especially political and institutional diversity, as is the case at the V&A Waterfront. It is Olds *et al.* (2012) who remind us that diversity without connectivity is futile.

Within the V&A management, its various departments share and have direct access to the information provided by GCX, yet with regards to tenants and their various departments, some limitations were identified regarding access to information, which has an impact on how diversity and redundancy is maintained. Although tenants are able to access GCX-provided information, they are still required to do so through the V&A Waterfront, making their access to information less direct and efficient. Some improvements can therefore be made to allow tenants to more direct access GCX information, further strengthening the type of diversity and redundancy conducive to enhanced resilience. This may, however be due to contractual agreements with GCX, possibly requiring alterations to the current agreement.

Despite these limitations, what is remarkable about the enablement of diverse institutions working together at the V&A Waterfront is that they have been connected in a manner which allows these diverse units to maintain autonomy. The governance structure at the V&A Waterfront has therefore not morphed all these diverse structures into one unified structure, but rather allowed them to maintain their autonomy. This autonomy was, however, accompanied by better connectivity using shared information, in turn, enabling better collaboration. This allows for enough diversity to avoid system brittleness (associated with associated with low levels of diversity or redundancy), while at the same time avoiding system stagnation (associated with high levels of diversity and redundancy) (Biggs *et al.*, 2012).

It can therefore be argued that the nexus governance approach at the V&A Waterfront enabled the type of practical, social and governance implications suggested by Principle 1 of Biggs *et al.*'s seven principles for enhanced resilience (Biggs *et al.*, 2015). The nexus governance approach can therefore be argued to have caused, at least to some extent, resilience-enhancing properties in the form of maintaining diversity and redundancy. This is important since diverse system elements (such as species, management approaches, and institutions) are explained to provide the basis for learning, innovation, and adaption (Principle 5) (Biggs *et al.*, 2012).

This demonstrates a practical example of nexus governance indicative of the collaborative nexus framework, suggesting that, in practice, it is a better framework than the suggested integrated nexus framework where all departments are intergraded into one department.

5.1.2 Manage connectivity

Managing connectivity is a crucial aspect to consider when managing the required diversity (Principle 1) and collective action (Principle 6) proposed as resilience-enhancing characteristics (Biggs *et al.*, 2012). After analysis of the PSG implication of the nexus governance approach at the V&A Waterfront it is clear that managing connectivity is not only present but has been a spearhead in transforming their governance structures towards better resilience-enhancing capabilities.

As mentioned, connectivity at the V&A Waterfront has been fostered by introducing an extra unit of governance, namely GCX (Principle 7) and GCX DASH- as a shared information platform manages connectivity among governance units at the V&A Waterfront. This is very important in social-ecological systems (SEs) since it is argued that connectivity facilitates necessary material and/or information exchanges for the functioning of ecological and social processes (Olds *et al.*, 2012; Biggs *et al.*, 2015). This once again justifies the recommended improvement of allowing for more direct access to GCX-provide information among all units of governance present at the V&A Waterfront.

However, GCX DASH- connects not only diverse departments and units of governance but also connects diverse and usually isolated resources, including water, energy, waste, and fugitive gasses. This connectivity enables departments to better collaborate on decisions, while also allowing these departments to consider the effects of their decisions concerning connected resources.

As V&A 6 (2022) indicates:

We definitely look at projects in collaboration. Using the platform we are able to investigate how projects offset one another and how they can feed into one another.

This allows us to think how innovation can be constructed around this for projects to drive forces with one another.

This enables the V&A management to investigate projects in a connected fashion and allows them to see how these projects can feed into one another and complement one another. Here the limitation of not tracking food is once again highlighted, as incorporating food improves the ability of the V&A to investigate and make decisions surrounding projects and resources in a connected fashion. The best example of this is the case of the desalination plant, where diverse departments connected through shared information took a connected view in relation to resources, did an evaluation, and came up with a single intervention that has positive effects on three interrelated resources.

This collaborative approach is important since enhanced governance opportunities enabled by connectivity in social networks can, in turn, facilitate and enhance ES resilience (Fortuna *et al.*, 2010). This is because with higher connectivity between different social groups comes increased information sharing, trust, and reciprocity — all of which are required for collective action (Principle 6) (Biggs *et al.*, 2015).

Given these findings, it can be argued that the practical analysis of a nexus governance approach at the V&A Waterfront strengthens the case against currently isolated water, energy, and food (WEF) departments, warns against complete integration and homogenisation, and sheds light on the resilience-enhancing possibilities of a collaborative nexus framework. This is because the nexus approach at the V&A Waterfront is indicative of the collaborative nexus framework based on existing structures (heterogeneity), yet the institutional setting is reframed towards more collaboration (which must stem from increased connectivity) which, in turn, is enabled by data flows that reveal how the system is working and how actors can benefit from collaboration.

5.1.3 Manage slow variables and feedback

The interplay between slow and fast variables has a significant impact on the dynamics that exist within SES (Li *et al.*, 2018). A good example of this is climate regulation³⁹, a slow variable which has been negatively affected due to the effects of climate change. Climate regulation is, therefore, a shifting ecological slow variable which directly leads to global and local legislative and value-centred slow social variables such as environmental mandates and policies. This, in turn, leads to the need for alternative fast variables that interact with these slow variables in a way that can manage them more successfully — ultimately resulting in a more resilient SES. With regards to the context of the V&A Waterfront, it is clear to see how this interplay has manifested over the years, with continuous innovation taking place to sustain the correct feedback and slow variables for a well-functioning SES to persist.

It is in response to ecological and social slow variables that the V&A Waterfront decided to bring on board GCX DASH-, a fast variable which consequently had a very positive effect on their ability to manage slow variables such as climate regulation because monitoring allows for information on the responses and state of a particular SES which if provided to actors, represents feedback that can directly influence how the SES is managed, affected, and utilised (Biggs *et al.*, 2015).

A specific example of how such an interaction occurs is with regards to the water scarcity in Cape Town. The water scarcity is, among other things, the result of negatively affected climate regulation (slow variables) and directly influenced the decision of the V&A Waterfront to build a desalination plant (fast variable). This is a significant decision since it will lessen the strain the V&A Waterfront as a large consumer, places on Cape Town's water supply, resulting in an increased ability for climate regulation as a slow variable.

In this example, monitorisation allowed for a precise understanding of the state of the SES, creating adequate information for decisions to be made that have a positive effect on the management of slow variables and feedback. Here monitorisation was required to provide information on the current state of the system, informing strategies and decision-making going

³⁹ Climate regulation is an ES service provided by nature through the long-term storage of CO₂ in soil, vegetable biomass and oceans, and through this process regulates the environment in a manner conducive to human life on earth. It is described as a slow variable for the long-term manner in which the process leads to climate regulation.

forward as trade-offs and feedbacks resulting from these decisions could also be predicted (Biggs *et al.*, 2015). Monitorisation provided the necessary shared information that enables the correct connectivity between sectors and departments for these decisions to be adequately carried out. One possible improvement identified in this regard already touched on briefly, is the incorporation of food flows, as this will extend their sphere of consideration for slow variables and feedback. Another possible improvement would be for CSI components to be more adequately captured within the dashboard as this will allow for more holistic monitorisation of social, environmental and financial factors which will have a further strengthening effect on managing slow variables and feedbacks. This is however an already decided on decision by the V&A and will take effect in the near future.

Regardless of the limitation identified, it can still be argued that the nexus governance approach at the V&A Waterfront represents a social regime shift which has positive effects on ecosystems because it allows for the better management of slow variables and feedback. The nexus governance approach, therefore, allows for the right conditions to enable the understanding required for decisions that enhance the resilience of SES and their resultant ES. These conditions were created due to the ability to understand the dynamics of the SES via monitorisation of feedback and slow variables provided by GCX DASH-.

5.1.4 Foster complex adaptive systems thinking

For the V&A Waterfront the argument can be made that they have made a paradigm shift toward adopting complex adaptive systems (CAS) thinking and decision-making in congruence, and perhaps as a result of monitorisation enabled by GCX DASH-. This is exemplified in their shared value approach that views the need for a collaborative approach where a collection of capacities and skill sets are adopted and valued in the face of wicked governance problems. This has furthermore been accompanied by adaptive and collaborative governance approaches that enable learning and experimentation (Principle 5) (Biggs *et al.*, 2015).

An example of how learning and experimentation via adaptive and collaborative governance approaches occurred can once again be presented concerning the commissioning of the waste-to-energy plant and the desalination plant. When investigating the possibility of building a waste-to-energy plant, monitorisation was used to investigate the fast variables, slow variables,

lags, and feedback in SES dynamics (principle 3) that could have a possible effect on the decision (Biggs *et al.*, 2015). This was achievable using environmental and financial data to paint a realistic picture of the reality and context within which to make a governance decision stemming from the social sphere. It is the investigation of these dynamics and the realisation that an adaptation is necessary with regards to the V&A's recycling practices that led to the waste viability assessment and then the subsequent commissioning of the waste-to-energy plant.

When China placed a ban on the import of waste there was, however, a sudden disturbance in the form of a variable that now had to be accounted for. This required the collaboration of various departments in the V& A Waterfront as well as GCX to work on a possible adaptation of the plan to make it viable given the sudden variability and accompanying uncertainty. Using the monitoring of GCX DASH- and the learning that comes from it, these collaborative management units were able to experiment with the idea of testing viability for 100% of the V&A Waterfront's waste, allowing for the successful adaptation of a plan in response to a disturbance.

The adaptive systems thinking did, however, not end here, as GCX DASH- was able to help the managerial team predict the feedbacks and trade-offs that would occur as a result of this decision. One piece of feedback would be an increase in the amount of energy generated on-site at the V&A Waterfront. It is this realisation which led to the further commissioning of the desalination plant, as energy was a restrictive factor in allowing the plans for the plant to go forward.

Another adaptive approach which led to feedback, was the decision to build the waste-to-energy plant in a way that will withstand future growth. Building it in this way was a conscious adaptive decision made by the V&A Waterfront for up until that future growth occurs they will be able to buy waste from their neighbours, a solution that fits perfectly with their shared value approach.

It can once again be argued that more accurate monitorisation of CSI data in relation to environmental and financial data will highly improve the V&A's ability to foster complex adaptive systems thinking, as it will extend their consideration of synergies and trade-offs between social, environmental and financial spheres of impact. Again the incorporation of food

flows will also improve the V&A's ability to foster complex adaptive systems thinking, as it will heighten their ability to oversee synergies and trade-offs between interrelated resources. These recommended improvements do however not deter from the already developed complex adaptive systems thinking present at the V&A Waterfront. It can therefore still be argued that the V&A Waterfront fosters the kind of complex adaptive systems thinking discussed for its resilience enhancing qualities, yet further developments are possible from the social sphere via further monitorisation of CST components on the dashboard, as well as the resource sphere via incorporation of food flows.

5.1.5 Encourage learning

Learning can lead to improved governance processes which impact ES resilience (de Kraker, 2017). This is because participatory learning can help actors understand one another's mental models (P4), in turn, building social capital, which allows for institutional change and conflict resolution (Biggs *et al.*, 2015). Here social learning is an important concept and can be understood as the outcome of intentionally facilitated processes or an emergent outcome.

Monitoring and experimentation are seen as tools for the facilitation of learning (Biggs *et al.*, 2015). This is because monitorisation provides information regarding changes and adaptation in SES and ES, while experimentation allows for the active manipulation of SES process thus enabling outcomes to be compared.

With regards to the V&A Waterfront it is possible to see that different forms of learning have been enabled as a result of their nexus-governance approach, which embraces both monitorisation and experimentation. By looking at the practical, social, governance (PSG) implications as they emerged, examples of learning are found in the V&A Waterfront's ability to see unintended consequences, the enactment of adaptive governance between landlords and tenants, the ability to project potential outcomes, as well as their ability to drive systems change using learning and awareness of performance as reactants.

What has been the key catalyst for learning and experimentation to take place at the V&A Waterfront has been GCX DASH-; it is the monitorisation done by the dashboard that allows for an adequate understanding of the SES and all the processes within it.

Monitorisation firstly enabled the V&A Waterfront to learn about their own consumption patterns and approaches to resource management (provided information regarding changes and adaptation in SES and ES), in turn, enabling them to experiment with different approaches such as the waste-to-energy plant, the desalination plant, and the blackwater treatment plant (active manipulation of SES process, enabling outcomes to be compared). As V&A 6 (2022) explains:

We [The V&A] always say that the Waterfront, because of the position we have within Cape Town, always allows for innovation, experimentation, and then benchmarking. I think, when it came to the desalination plant, I think that was very much an experiment for us or very much innovative because, you know, we are talking about a 5.5 Mega L desalination plant, which in essence, we can become completely self-sustainable from the rest of Cape Town, and if you think about it, in essence, if there is a Day Zero we can operate completely by ourselves. And that was based on a model of 26 million visitors annually. So for me that's quite innovative.

Monitorisation and the learning that came from that furthermore allowed for different governance approaches to take shape at the V&A Waterfront, such as the adaptive co-management approach among departments, as well as between tenants and landlords (this is elaborated on in the section about polycentricity). This is because learning can cause a shift in perceptions and attitudes, forming questions around existing institutions and decision-making processes, creating an eventual transition towards more appropriate governance arrangements which enhance ES resilience (P4) (Biggs *et al.*, 2015; Ramalho, 2019).

The V&A Waterfront presents a clear example of how having a clear understanding of resource data and where it stems from (in a consolidated fashion) allowed for learning which enabled participatory experimentation of new management forms that value collaboration. This can be exemplified in the V&A's green leases and their shared value approach, which values collaboration among different stakeholders in enabling better relational governance. GCX DASH- and its monitorisation furthermore enabled the ability to learn about behaviour and different ways in which to change behaviour, while also presenting a way in which to resolve conflict

As V&A 6 (2022) explains:

I think it [GCX Dash-] has definitely encouraged learning and different types of innovations and approaches that you want to apply across the governance realm of the V&A. I think also learning about people's behaviour and why they behave the way that they behave, and how you can influence that behaviour.

The ability to learn about the reality of the SES and the actors who operate within it also allowed for informed decision-making surrounding CAPEX, which in turn affected the governance approach at the V&A Waterfront. This is because it enables a form of relation governance where small, medium, and micro enterprises (SMMEs) are involved based on evident information stemming from monitorisation. The V&A Waterfront is, therefore, an example of the enactment of participatory and social learning, facilitated via the accurate monitorisation of processes within the SES, in turn leading to the building of social capital, the creation of institutional change and the facilitation of conflict resolution (Bigg *et al.*, 2018).

Some improvements can however once again be made with regards to what is being tracked (with food not being measured), the type of data sets from which the V&A waterfront are learning (with CSI components lacking), the time it takes for all governance units to access the monitored information (including tenants), as well as broadening the scope of external involvement in governance process via policy (as discussed under broadening participation and polycentric governance). Although current data encourages decisions that involve and have an effect on social spheres, as indicated with the SMME example, more direct consideration of CST components could potentially further encourage learning by broadening the horizons of what information is considered when making governance decisions.

These limitations do however not deter from the prevalence of resilience enhancing learning, and should rather be seen as possible further development that can enhance the V&A Waterfront's ability to govern for resilience. It is nonetheless clear that the nexus- governance approach at the V&A Waterfront has allowed for the kind of monitorisation in congruence with learning and experimentation that is critical for adaptive co-management. These characteristics are argued to improve governance processes which, in turn, have a positive effect on the ability to govern for ES resilience (de Kraker, 2017).

What is however important to note with regards to experimentation is that at the V&A Waterfront it has been applied to the correct scale and setting where social capital is adequate. This is important since institutional setting is critical for guarding against maladaptive learning and should instead facilitate learning at different levels (Biggs *et al.*, 2015). As mentioned, a failure to do so can lead to inappropriate management decisions (Biggs *et al.*, 2015; Sengers *et al.*, 2016).

5.1.6 Broaden participation

Participation refers to the process of actively engaging all relevant stakeholders in governance and management process and has already been discussed for its importance with regards to experimentation and learning (principle 5) (Biggs *et al.*, 2015). The prevalence of participation at the V&A Waterfront is very clear when exploring the PSG implication of the nexus governance approach. Since the V&A Waterfront management deployed GCX DASH- it has allowed for departments to work together, tenants and landlords to work together, while also allowing for more informed collaboration with SMMEs.

GCX DASH- has also allowed for better collaboration and participation between the V&A Waterfront and external consultants such as the companies commissioned to build the waste-to-energy plant, desalination plant, and the blackwater treatment plant. This enhanced ability to collaborate is because the V&A has been able to accurately track resource flows and the effects of decisions on these flows, providing accurate and up-to-date information on the function of the SES within which decisions are made. As V&A 6 (2022) explains:

I think both internally and externally GCX DASH- has enabled better participation. From an external point of view it is very useful when it comes to the engagement with consultants, especially on something like mandatory energy performance certification of buildings. Here we can use GCX DASH- to indicate the precise energy consumption of tenants, a necessary step in allowing external consultants to understand what kind of interventions drive that down? And then how do we do mandatory reports on a national level on the building's performance? So yes, it has definitely proven as a useful tool for engagement and participation externally and internally. Initially was only for internal engagement, but it has proven to be so much more.

The key catalyst for the enactment of participation at the V&A Waterfront is once again the GCX DASH- as it is the tool which enabled greater transparency via sharing of information among usually isolated governance units. It has allowed for the higher levels of actor cooperation, in turn, increasing the ability to directly feed information into management decisions. It is for this reason that participation can be argued to be the necessary link between information gathering and decision-making, something argued to be a critical connection for ongoing learning (principle 5) and effective decision-making (Biggs et al., 2015).

It is because of the link among participation, learning, and collective action that makes participation an argued principle for the enhancement of resilience. However, it must be noted that there are demonstrated examples where participation undermines ES resilience. This leads Biggs *et al.*, (2015) to suggest that a key research challenge is to better understand the conditions and institutional setting (resource-poor versus resource-rich contexts, and urban versus rural systems) that determine the success of participation in supporting resilience.

The V&A Waterfront represents an example of an institutional setting where the right kind of conditions were present for the successful facilitation of participation, the effects of which support their ability to govern for resilience. This is firstly because the V&A Waterfront is characterised by a stable governance structure in an urban context that is relatively resource-rich. There are no political power struggles within the governance sphere of the V&A Waterfront, and data is not weaponised because the handling of data has been facilitated by GCX, an external unit of governance which has no political stake in the contents thereof. It therefore creates a shared information platform that all stakeholders can trust and rely on to make informed decisions.

It should however be pointed out that the V&A are not without limitations and can once again further develop the prevalence of participation by allowing for more direct access to information for their tenants. Another possible improvement can stem from increased and evolved policies promoting broadened governance participation at the V&A Waterfront. This can for instance included evolving current green lease systems in order to extend the level of participation of tenants with regards to social and environmental governance. Another example would be to further evolve supply chain partnership policies that ensure for social and

environmental conscious governance on behalf of partners which by affiliation strengthens the V&A Waterfronts social and environmental standing.

It can nonetheless be argued that the successful increased participation at the V&A Waterfront stemmed from adding an extra governance unit (GCX), essentially pointing towards the successful enactment of polycentric governance. This will be discussed in more detail in what follows.

5.1.7 Promote polycentric governance systems

It can be argued that the V&A Waterfront has developed an advanced form of participation that in many regards represents and resembles the polycentric governance system proposed by Biggs *et al.* (2015) for its resilience enhancing abilities. The reality of this polycentric governance structure has been noted after exploration of the PSG implications of the nexus governance approach at the V&A Waterfront. This exploration made apparent the collaborative structure that exists among the V&A's management departments, the V&A as landlord and their tenants, and lastly GCX as the extra unit of governance that acts as a centralised and catalyst structure for the facilitation of collaboration.

As mentioned, there exists an adaptive co-management approach at the V&A Waterfront, where through the enactment of a shared value perspective and green leases, usually isolated actors act in harmony with one another on shared goals. Examples of this can be taken from the way in which tenants and the V&A Waterfront as landlord, with all its various departments, collectively worked together in response to water shortages.

Another example is how the environmental sustainability department and the waste department can make collective decisions, or even individual decisions that take a holistic perspective on all related departments, as data is shared between all the departments at the V&A Waterfront. Similarly, all departments collaborate and adopt a holistic systems perspective, using the platform when investigating how projects may offset or feed into one other.

Although there is a very established form of collaboration present at the V&A Waterfront, governance units have not been morphed into one integrated department, and instead retain their autonomy, coexisting in this collaborative structure. This is what is known as

collaborative autonomy and is regarded as a main determining factor behind the success of the polycentric governance structure present at the V&A Waterfront (Ostrom, 2010; Bauwens, 2017). This is because units maintain their specialised characteristics, but collaborate more harmoniously with other units, creating larger and more diverse social capital (Biggs *et al.*, 2015).

This polycentricity has allowed the V&A Waterfront to match governance levels to the scale of the problem (Biggs *et al.*, 2012) while also allowing the ability to confer functional redundancy thereby resulting in the preservation of key SES elements despite disturbances (Principles 1 & 2). An example of this is how the Environmental Sustainability Department may step in to solve a problem in the Utilities Department, something which is entirely possible since they share the same data platform.

The polycentric governance structures present at the V&A Waterfront have also provided the basis for learning and experimentation (principle 5), while also increasing participation (P6) in governance (Biggs *et al.*, 2015). This, in effect, enables the ability to capitalise on scale-specific knowledge which increases learning through sharing of information, experience, and knowledge across scales. This ability can be exemplified in how the V&A Waterfront in collaboration with GCX consulted various private institutions for the commissioning of a waste solution. This allowed for scale-specific knowledge to be shared, allowing for experimentation with various solutions and the eventual decision to use a particular solution.

Polycentric governance structure are, however, not without problems which, if not considered, can lead to the degradation of ES at one or many scales (Ostrom, 2010). One such challenge is the trade-offs, conflict resolution, and effective coordination that needs to be negotiated between the different ES managers/users/stakeholders (Biggs *et al.*, 2015). In line with this, Cumbers (2015) argues for a centralised structure that can link and scale autonomous units, in turn, enabling effective coordination and cooperation. It is furthermore argued that polycentric governance structures require an overarching system/tool/dashboard⁴⁰ where governance units can be linked via information (Biggs *et al.*, 2015)

⁴⁰ GCX DASH-.

V&A Waterfront has to a large extent been successful in circumnavigating these challenges by adding an extra unit of governance which acts as a centralised structure by using an overarching system to link governance units via information. In this relationship GCX represents such a specialised governance unit, using GCX DASH- for the sake of monitorisation, linking disparate units of governance (various departments and tenants) found at the V&A Waterfront via a DSS. It can therefore be argued that the GCX - V&A Waterfront management-tenant relationship at the V&A Waterfront represents a polycentric governance system where adding an extra governance unit (namely GCX) enabled much better collaboration among largely autonomous governance units, without sacrificing autonomy.

In the case of the V&A Waterfront, governance units — which include an array of 800 tenants and their governance structures, V&A Waterfront and its governance structures, as well as GCX and its governance structure — collectively act and influence decisions surrounding common resource use/management (water, energy, and waste) using a shared information platform (GCX DASH-) that links different scales. It represents a case where conflicts of interest that may come with polycentricity have been correctly handled via open communication, transparency, accountability, and connectivity, all stemming from data on GCX DASH-.

Some improvements to the already developed enactment of polycentricity can however once again stem from tracking and including more elements on the dashboard, including food and CST components, as this will increase the domains observed for possible problem and solution assessment by all stakeholders present at the V&A. This will allow the V&A Waterfront to more accurately match governance levels to the scale of a given problem, as the horizon of consideration is extended. This however needs to be accompanied by more direct access to information on the side of tenants, allowing for more direct polycentric governance and functional redundancy. Other possible improvements include further development of policies allowing for increased collaborative governance between all units of governance related to the V&A, including tenants and external units of governance such as supply chain partners (as discussed under principle 6). Further avenues for possible improvements via policies included more collaborative agreements with external units of governance such as the City of Cape Town government NGOs, private institutions and civil society, developing polycentric agreements between systems that are inextricably interlinked.

It can nonetheless be argued that the nexus governance approach at the V&A Waterfront gave rise to a well-organised and functional polycentric governance structure that builds adequate social capital and trust to face problems through collaborative governance where autonomy remains. It is therefore seen as an example of the correct contextual conditions for the adequate implementation of polycentric governance. These contextual conditions once again include a well-functioning governance system devoid of power struggles and where there is also enough social capital to experiment with different forms of governance. GCX and their dashboard is, however, argued to be the most important contextual condition underlying the success of the polycentric governance structure at the V&A Waterfront.

The nexus governance approach at the V&A has given rise to successful polycentric governance structures. At the same time polycentricity is argued to be an effective governance approach for the enhancement of ES resilience (Biggs *et al.*, 2015), making it possible to conclude that the nexus governance approach at the V&A Waterfront has created governance conditions which increase the V&A Waterfront's ability to govern for resilience.

5.2 Synopsis

In order to synthesise the different degrees of principle prevalence at the V&A Waterfront as a result of nexus governance, Table 5.1 illustrates each principle, as well as the degree of principle prevalence at the V&A as a result of nexus governance (ranging from not prevalent, prevalent or highly prevalent) . This is combined with a column synthesising various possible improvements which if implemented could lead to even greater prevalence of the 7 principles for enhanced resilience.

After exploring the PSG implications and their potential for enhanced resilience, it can be argued that the V&A Waterfront displays highly prevalent degrees of institutional capacity to maintain diversity and redundancy, manage connectivity, manage slow variables and feedbacks, and broaden participation. The V&A Waterfront furthermore displays prevalent degrees of institutional capacity to foster complex adaptive systems thinking, encourage learning and promote polycentric governance.

Table 5.1 Degree of Principle Prevalence and Recommended Improvements

7 Principles for enhanced resilience	Degree of principle prevalence at the V&A Waterfront as result of nexus-governance (not prevalent, prevalent, or highly prevalent)	Possible Improvements
Maintain diversity and redundancy	Highly prevalent level of governance diversity and redundancy while maintaining autonomy.	More direct access to GCX-provided information by all units of governance, including tenants.
Manage connectivity	Highly prevalent level of connectivity via shared information provided by GCX DASH-.	<ul style="list-style-type: none"> • More direct access to GCX-provided information among all units of governance present at the V&A Waterfront, including tenants. • Incorporate the monitorisation of food flows on GCX DASH-.
Manage slow variables and feedback	Highly prevalent levels of management which considers slow variables and feedback, largely underpinned by information provided by GCX DASH-.	<ul style="list-style-type: none"> • Incorporate the monitorisation of food flows on GCX DASH- • Incorporate CSI components in relation to environmental and financial components on GCX DASH-.
Foster complex adaptive systems thinking	Prevalent complex adaptive system thinking within the governance sphere of the V&A Waterfront.	<ul style="list-style-type: none"> • Incorporate the monitorisation of food flows on GCX DASH-. • Incorporate CSI component in relation to environmental and financial components on the GCX DASH-.
Encourage learning	Prevalent levels of learning via monitorisation and experimentation.	<ul style="list-style-type: none"> • Incorporate the monitorisation of food flows on GCX DASH- • Incorporate CSI component in relation to environmental and financial components on the GCX DASH-.

		<ul style="list-style-type: none"> • More direct access to information by all units of governance, including tenants. • Increased and evolved policies promoting broadened governance participation between all units of governance related to the V&A Waterfront.
Broaden participation	Highly prevalent levels of broadened participation with broad range of governance units all working together on shared governance issues.	<ul style="list-style-type: none"> • More direct access to information by all units of governance, including tenants. • Increased and evolved policies promoting broadened governance participation between all units of governance related to the V&A Waterfront.
Promote polycentric governance systems	The V&A Waterfront has developed a prevalent form of participation that in many regards represents and resembles the polycentric governance system proposed by Biggs <i>et al.</i> (2015) for its resilience enhancing abilities	<ul style="list-style-type: none"> • Incorporate the monitorisation of food flows on GCX DASH-. • Incorporate CSI component in relation to environmental and financial components on the GCX DASH-. • More direct access to information by all units of governance, including tenants. • Increased and evolved policies promoting broadened governance participation between all units of governance related to the V&A Waterfront. • More collaborative agreements with relational units of governance such as City of Cape Town, NGO's, private

		<p>institutions and civil society, developing polycentric agreements between systems that are inextricably interlinked.</p>
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(source: Author, 2022)

The V&A Waterfront furthermore displays a developed ability to adapt, collaborate, improve, and continue to function (via adaptive co-management) in the face of wicked problems— all essential characteristics for resilience in an SES. Since the nexus governance approach is responsible for bringing about these resilience-enhancing PSG implications, it can be argued that the practical application of a nexus governance approach does enhance the ability to govern resilience in practice.

5.3 How does this apply to Cape Town?

Before going into the question of how a nexus governance approach enabled by a DSS applies to Cape Town, and if it will bring about the same resilience-enhancing effects experienced by the V&A Waterfront, it is important to explore what changes/decisions in an urban sub-system like the V&A Waterfront reveals about the wider city-wide urban system and how the V&A Waterfront is dependent on reform within the wider system. Examples of this include the limited capacity for the V&A Waterfront to recycle given dysfunctions in the CCT system leading to the commissioning of a waste-to-energy plant to recycle independently. The second example revolves around the need for the V&A Waterfront to hedge against loadshedding (stemming from dependence on two systems – CCT's electricity system and Eskom's energy generation system) via the installation of solar PV and a waste-to-energy plant. The third example refers to the manner in which the V&A Waterfront commissioned a desalination plant due to the failure of the wider system (CCT and national water department) to properly anticipate and prepare for inevitable water shortages.

What these examples illustrate is that in the absence of changes in the urban system catalysed by CCT, the V&A Waterfront has decided to act as an economic power precinct, spearheading transformations despite wider system dysfunctions. Evidence suggests that for the V&A

Waterfront to achieve this, they needed a DSS that completely changes the flow of data from isolated spreadsheets to an integrated user-friendly dashboard. Once data flows were made transparent, it enabled collaboration and systems change in a manner that was conducive to enhanced capacities to govern for resilience. As this economically significant precinct evolved and changed, it continuously came up against the limits and constraints of the wider system (recycling, energy, and water). Still, the limits of the wider system also catalysed the V&A Waterfront into system changes to defend itself against failures in the wider system i.e., resilience. This, in turn, has two consequences. One, it gives the V&A Waterfront the wherewithal to engage with the wider system actors to recommend system changes that would be beneficial to all, significantly enhance the capacity to govern for resilience in the Cape Town Context. Second, it demonstrates what would be possible if other precincts adopted the same approach (e.g., City Improvement Districts) or the CCT for the urban system as a whole, potentially representing one system change that could significantly benefit the capacity to govern for resilience in the Cape Town context.

The question, however, becomes, will the same resilience-enhancing effects be experienced if the CCT implements a nexus governance approach? In other words, will a WEF Nexus governance approach enhance the capacity to govern for resilience in the Cape Town context (as it did at the V&A Waterfront). And if so, can a similar DSS be created that enables the Water, Energy and Food Departments to have holistic systems view for collaborative and adaptive nexus governance? Although answering these questions largely fall outside the scope of this study (and will be more fully addressed in the more extensive study), I will explore these questions in what follows.

Most of the resilience-enhancing benefits associated with the nexus governance approach at the V&A Waterfront are not necessarily context-specific, making it possible to assume that if scaled up these benefits will also be realised in the Cape Town context.

There are, however, some differences that cannot be ignored. This includes the fact that due to political power struggles within the governance sphere, the CCT does not represent an entirely stable governance structure. For this reason, data is weaponised, making it a challenging space for sharing information (EDP 1, 2021). Furthermore, Cape Town is not entirely urban, as agricultural areas such as the Philippi Horticulture Area make up a big part of the city's jurisdiction. Cape Town is also not entirely formal, making it a difficult task to accurately track

resources in an informal area, as so little is understood surrounding the flow of these resources. Cape Town is also a much more unequal setting than the V&A Waterfront, comprising both resource-rich and resource-poor areas, exemplified in the vast inequality experienced throughout Cape Town and, in fact, the whole of South Africa (EDP 1, 2021). Another difference is that if applied to the CCT, food flows would have to be included in the system as the City's jurisdiction traverses many areas, some of which produce food, while others consume it. This means an adequate understanding of food flows would be required to have a clear picture of how food is distributed within the city as well as the embedded energy and water in food. These realities, therefore, point towards a context that is perhaps not as well functioning and devoid of power struggles as the V&A Waterfront, meaning there is less social capital to experiment with different forms of governance.

However, regardless of these contextual variations, it is argued that GCX and their dashboard are the most critical contextual condition underlying the success of the nexus governance approach at the V&A Waterfront, specifically because it represents a centralised structure that can link disparate units of governance via shared information. This also means the handling of data is facilitated by GCX, an external and neutral unit of governance which has no political stake in the contents thereof. It, therefore, creates a shared information DSS which all stakeholders can trust and rely on to make informed decisions without the interference of power struggles.

This is because, like many other governments, including the V&A Waterfront, the CCT is fragmented into separate functions, mandates, and budgets (EDP 1, 2021). This means that no one in the government sees the whole system, and because the city deals with multiple interests it is challenging to enable holistic change. A DSS would therefore allow departments in the CCT to work collaboratively while also presenting the possibility to extend such collaborative efforts to private and civil society, and perhaps provincial and national government.

Adopting and contextually improving the developed nexus analytics and trade-off assessment tools (GCX DASH-) would therefore allow the CCT to be better prepared to address interconnected resource challenges. It would furthermore allow policymakers to have the information needed for informed decisions and would put incentives in place to push towards future sustainable resource allocation. Realising such an analytical DSS would also provide

impetus towards building scientific and institutional capacities for the CCT to carry forward those assessments and communicate them to stakeholders.

The need for shared data analytics within the CCT government therefore becomes all the more apparent and can be summarised in the words of EDP 1 (2021):

I think one of the biggest barriers for people working together is an inability to share the co-production of data or shared analytics of the data. Everyone uses data as a weapon. It's weaponised. And it undermines working together. So the one of the first things to do is to ask what is the data partnership that is needed here? And I think it will come from broadening actors and introducing shared information.

This highlights the importance of accurate consolidated data on a centralised, shared information platform is allowing a whole set of relationships to be managed differently. GCX DASH-essentially allows for a type of adaptive co-management proposed by the WEF Nexus framework and the resilience literature. It, therefore, acts as an insightful example of the type of system needed in governments worldwide, including South Africa and, more specifically, the CCT. This is because by knowing in real time exactly what resources are being used on a monthly and yearly basis, the CCT will be able to set realistic sustainability-oriented performance targets for the year ahead. These annual targets will be improvements on the previous year's performance following a standardised set of metrics (e.g., emissions, water use per person, waste per person, energy use, etc). These targets are not, therefore, wishful thinking targets designed for political performance that can be construed as greenwash. They are rooted in reality and are realistic and achievable. It also makes it possible for the CCT to project potential outcomes over time, for example, 2030 or 2040 or 2050, if the rate of improvement is maintained.

It is therefore argued that the lessons from the V&A Waterfront can be extrapolated to the CCT. This is because although the context is different, a nexus governance approach supported DSS like GCX Dash- will, with some contextual adjustments, bring about the same resilience-enhancing effects experienced by the V&A Waterfront. These effects far outweigh the contextual differences and will bring about change in many of the contextual variant aspects discussed, in effect making the context all the more similar to the V&A Waterfront's. This is because evidence strongly suggests a context-specific DSS will enable policy makers and

water, energy, and food departments to have a holistic systems view for collaborative and adaptive nexus governance, in effect enhancing the ability to govern for resilience. It is therefore argued that a context-specific WEF nexus governance approach, enabled by a DSS, holds the potential to enhance the capacity to govern for resilience in the Cape Town context.

Chapter 6: Concluding Arguments and Recommendations

6.1 Introduction

This chapter concludes this research project by synthesising the findings of this thesis in relation to the research questions identified in Chapter 1. This chapter will also present the implications of these findings for areas of future research.

The primary research question was:

How does the nexus governance⁴¹ approach at the V&A Waterfront enhance the capacity to govern for resilience in the Cape Town context?

In order to answer the primary research question, the following sub-questions were identified:

- How is the WEF Nexus framework understood, with particular reference to the practical, social, and governance (PSG) implications?
- What governance and management systems have been developed by the V&A Waterfront, including the GCX system?
- What are the practical, social and governance implications of the nexus governance approach at the V&A Waterfront, and do these implications hold any potential for enhanced resilience in the Cape Town context?

⁴¹ Here specifically referring to WEF Nexus governance approach, or simply nexus governance as the practical implementation of the WEF Nexus framework in a given governance sphere.

To provide a concise conclusion for the primary research question, the three sub-questions' findings will first be synthesised in relation to each question. This allows for all the necessary information to be needed to answer the primary research question.

6.2 Main arguments

6.2.1 How is the WEF Nexus framework understood, with particular reference to the practical, social, and governance implications?

The first research sub-question was dedicated to producing systems knowledge of the WEF Nexus Framework, with particular reference to practical, social and governance (PSG) implications, and was explored by means of a practitioner workshop (Chapter 2) and a literature review (Chapter 3). The core findings stemming from these two sources were then elaborated in part 4.1 of Chapter 4.

The discussion in Chapter 4.1 demonstrated how the literature and practitioners from various backgrounds identify the WEF Nexus Framework as a new form of integrated resource governance that is proposed in contrast to isolated approaches that have traditionally dominated resource governance. In line with this, it was also found that the WEF Nexus Framework is proposed as a supporting instrument for resilience and the ability to manage resilience in practice.

Despite all the potential identified in the WEF Nexus Framework, it was found that practical adoption of the framework is too underdeveloped⁴², and under researched to back up these resilience-enhancing theoretical claims. The reason for this is that a lack of practical adoption of the WEF Nexus Framework also means there is a knowledge gap concerning the PSG implications of implementing the WEF Nexus Framework. Not having a clear understanding of these implications, in turn, makes it impossible to investigate if the WEF Nexus Framework indeed does enhance the capacity to govern for resilience.

It can therefore be concluded that findings for research sub-question 1 suggest that the WEF Nexus is understood as a form of integrated resource governance for the sake of enhanced

⁴² With the exception of some spheres of society where it develops evolutionarily out of necessity met with economic ability for enactment, such as the case of the V&A Waterfront.

resilience; however, it is not understood well enough regarding PSG implications to substantiate this theoretical claim.

This led to a further logical step which was to identify a practical example of WEF Nexus governance (research sub-question 2) and to eventually conduct PSG analysis of the approach, which is what was set out in research sub-question 3.

6.2.2 What governance and management systems have been developed by the V&A Waterfront, including the GCX system?

The second research sub-question was dedicated to producing target knowledge by exploring the type of governance systems developed by the V&A Waterfront, including the GCX system. These findings were discussed in Chapter 4.2.

By first exploring the V&A Waterfront's context, the management's perception of key business trends, their commitment to ecological governance (including their Sustainability Policy), social governance and socio-ecological governance, the background was set for a more in-depth analysis of the V&A Waterfront's governance and management systems developed to achieve these commitments. It was found that following key global trends, the V&A Waterfront has committed to a nexus governance approach, as they realised the need to work in a systemic nature across siloes. It, therefore, became necessary to investigate how this nexus governance approach has been achieved.

To do so, the researcher conducted an in-depth analysis of the V&A Waterfront's governance and management systems, and it was found that the nexus governance approach has been enabled by the incorporating Global Carbon Exchange (GCX)⁴³ into the governance realm of the V&A Waterfront. This led to a further analysis of GCX, as well as their key solutions and areas of specialisation. After analysis, it was found that the most crucial element for enabling the nexus governance approach at the V&A Waterfront is GCX DASH-, an analytics and reporting platform that provides the V&A Waterfront with real-time, on-demand data analytics of resource flows (water, energy, waste, and fugitive gasses) assisting them with decision-making and setting goals surrounding these interrelated resources.

⁴³ Private sustainability solutions company.

After the identification of GCX DASH- (and related materials flow analysis (MFA)) as a key nexus governance tool, the researcher further explored the V&A Waterfront's use of GCX DASH-, expanding on some of the solutions offered by the platform, as well as describing how the data collection process works. It was found that the dashboard enables departments at the V&A Waterfront to work in a systemic nature across siloes while also bringing disparate data together in a consolidated fashion. This data consolidation is made possible since the dashboard tracks interrelated resources individually and in relation to one another while also including financial data in relation to these resources. It was therefore concluded that a nexus governance approach had been developed by the V&A Waterfront, the success of which stems from the accurate tracking of resource flows using GCX DASH-.

It can therefore be argued that the V&A Waterfront's governance and management systems, including GCX DASH-, represent a practical example of nexus governance. This is because GCX DASH- tracks interrelated resources and is used as an enabling tool for adaptive co-management among typically isolated departments. At the same time, GCX represents a coordination agency that enables the efficient gathering and sharing of information for efficient and informed decision-making.

6.2.3 What are the practical, social and governance implications of the nexus governance approach at the V&A Waterfront, and do these implications hold any potential for enhanced resilience in the Cape Town context?

After analysis of the V&A Waterfront's governance and management, the next research sub-question sought to elaborate on the research target knowledge by exploring the PSG implications of the practical nexus governance approach identified at the V&A Waterfront. Although questions were formulated by the researcher in gaining insights into these implications, exploring the PSG implications as they emerged allowed for a diversity of insights to surface many of which would not have surfaced given a rigid questionnaire.

The first significant findings revolved around the significance of a database tracking the flow of resources (like GCX DASH-) in relation to the global goal of decoupling. It was found that the V&A Waterfront's nexus governance approach represents a novel example of resource

governance enabled by the accurate MFA of resources that enables the decoupling of economic growth from growth in carbon emissions.

Another significant finding revolved around the time-saving abilities opened by the nexus governance approach where having a bird's eye view of data in a consolidated fashion, via an Eco-Analytics Report, has allowed users of the system to see usually disparate data in one place, significantly saving time compared to the past. Furthermore, it was found that this enables users to see financial and environmental data in relation to one another, as well as make month-to-month and year-to-year comparisons. It is therefore argued that the system not only saves time, but also offers a far more accurate and up-to-date carbon disclosure than yearly black box carbon exercises.

Benefits were, however, found to exceed better carbon disclosure, as evidence pointed towards many governance decisions supporting benefits associated with the nexus governance approach. This includes the ability to view SES holistically, while also having the ability to interpret unintended consequences of governance decisions. This is exemplified in the recycling, waste to energy, desalination, and blackwater treatment examples elaborated in Section 4.3.2 and Section 4.3.3. In the beforementioned sections the role of GCX DASH- and related MFA in enabling a nexus perspective for the sake of decision support is also discussed.

Section 4.3.4 demonstrates the implications of the nexus governance approach for adaptive management between tenants and landlords. It is argued that having a systems perspective allowed for mutually beneficial relationships of responsibility to form, a necessity given the wicked problems faced in the Cape Town context. This is followed by a section on the positive implications of nexus governance for enacting the V&A Waterfront's green leases, shared value ecosystem, and supply chain partnerships. This is followed by a section on the implications of nexus governance at the V&A Waterfront on the business' ability to project potential outcomes as a means for better decision-making, specifically using the example of Capital Expenditure (CAPEX). It is argued that a birds-eye view of resource flows and patterns has allowed the V&A Waterfront's CAPEX agenda to be driven by environmental data (assess the performance of outliers) which, in turn, drives their small and medium-sized enterprise (SMME) agenda. It was therefore argued that this implication indicates the harmony that can and should be formed between environmental and social agendas.

More significant findings were elaborated in Section 4.3.7, where the nexus governance implication of enabling institutional and systems change is explored with the example of day zero. Here the ability to make institutions aware of their performance (while also showing consumption patterns and related financial data of competitors) is detailed as a means of incentivising institutional and systems change. Section 4.3.8 further explores systems change as an implication of nexus governance this time using the example of power dynamics and the ability of shared information DSS to stimulate better collective decision-making for the goal of enabling systems change. These changes are discussed as incremental, yet incrementalism is the most realistic and proven way in which change is actualised (Swilling, 2020). Section 4.3.9 demonstrates the limitations of the GCX system, predominantly emphasising food flows not being tracked, as well as the need to include CSI components more fully.

Equipped with an understanding of the PSG implications and limitations of the nexus governance approach at the V&A Waterfront, Chapter 5 was dedicated to discussing these findings in relation to their potential for enhanced resilience, explicitly referring to Biggs *et al.*'s (2015) seven principles for enhanced resilience explored in the literature review. After analysis, it was argued that the V&A Waterfront displays highly prevalent degrees of institutional capacity to maintain diversity and redundancy, manage connectivity, manage slow variables and feedbacks, and broaden participation. It was furthermore argued that the V&A Waterfront displays prevalent degrees of institutional capacity to foster complex adaptive systems thinking, encourage learning and promote polycentric governance.

It was however argued that there is still lots of room for improvement. One improvement discussed is for more direct access to GCX provided information to all units of governance at the V&A Waterfront, including tenants. Another suggested improvement included incorporating the monitorisation of food flows on GCX Dash- , as this will extent the sphere of consideration when making decisions that take into account interrelated resources. Another limitation discussed is the fact that CSI components are currently not fully incorporated on the dashboard. Since this is a large portion of the V&A's responsibility and budgeting, it was argued that the V&A will highly benefit from more accurate tracking of environmental, social and financial data in relation to one another. Another suggested improvement discussed was for the V&A to increase and evolve policies promoting broadened governance participation

between all units of governance related to the V&A. The final recommended improvement discussed was for more collaborative agreements with relational units of governance such as City of Cape Town, NGO's, private institutions and civil society, developing polycentric agreements between systems that are inextricably interlinked. These recommended improvements are important for as it is argued, if they are implemented, it may prove to have a further strengthening effect on the V&A's ability to govern for resilience.

Despite these limitation, it was argued that the V&A Waterfront does display a developed ability to adapt, collaborate, improve, and continue to function (via adaptive co-management) in the face of wicked problems — all essential characteristics for resilience in an SES. Since the nexus governance approach is responsible for bringing about many of these resilience-enhancing PSG implications, it was argued that the practical application of a nexus governance approach does enhance the ability to govern resilience in practice.

6.2.4 How does the nexus governance approach at the V&A Waterfront enhance the capacity to govern for resilience in the Cape Town context?

Having provided findings for all the sub-questions equipped the researcher with the necessary information to present findings in relation to the primary research question. This was set out in Section 5.3 and revolved around what the findings suggest about the Cape Town context, as well as an exploration into the resilience-enhancing potentials for the Cape Town context opened up by the nexus governance approach and its implications.

The main findings revolved around how dysfunctions in the wider urban context of Cape Town, and its related City of Cape Town (CCT) government, are made apparent given system changes at the V&A Waterfront in response to these dysfunctions. These dysfunctions are made apparent because the V&A Waterfront is constantly faced with constraints of the wider system (recycling, water, energy). Yet, the limits of the wider system are also catalysts for the V&A Waterfront to enact systems changes in response to these wider system limitations. This included the V&A Waterfront's innovations with regards to waste to energy, desalination, as well as the installation of solar photovoltaic (PV) and a blackwater treatment plant.

Evidence strongly suggests the necessary role of a DSS, namely GCX DASH-, and its tracking of resource flows (MFA) in firstly revealing the weaknesses of the wider system, while also

allowing for the necessary information to make informed decisions in response to these wider system weaknesses. The consequences of this were argued to be twofold. First, it gives the V&A Waterfront the wherewithal to engage with the wider system actors to recommend system changes that would significantly enhance the capacity to govern for resilience in the Cape Town context. Secondly, it demonstrates the possibility for enhanced capacity to govern for resilience in the Cape Town context that may emerge if other precincts, or perhaps the CCT as a whole, were to implement an MFA-based DSS for nexus governance (similar to the one found at the V&A Waterfront).

Understanding the potential of an MFA-based DSS, however, led to a further question which was: Will the same resilience-enhancing effects be experienced if the CCT implements a DSS-backed (and related MFA) nexus governance approach? Exploring this question demonstrated various contextual differences between Cape Town and the V&A Waterfront, all of which will inevitably make a difference when it comes to how the MFA-based DSS system in support of nexus governance will have to be contextually adjusted. However, the concluding argument was made that with these contextual adjustments, a DSS- (and related MFA) supported nexus governance approach will bring about similar resilience-enhancing effects experienced by the V&A Waterfront and should therefore be implemented.

6.3 Recommendations for future research

Several opportunities for future research emerged throughout this research project. These are outlined as follows:

- Investigate the possibility of including food flows going in and out of the V&A Waterfront on GCX DASH-, as well as the various implications of including food flows.
- Assess how WEF Nexus interactions materialise within the urban level and different urban areas across the Cape Town context. This includes characterising how different areas can be assessed from a multi-dimensional resilience perspective.

- Explore how resilience strategies and resource vulnerabilities traverse different domains, including what vulnerabilities are present due to complex system interdependencies at neighbourhood, city-wide and metropolitan levels.
- Investigate how WEF Nexus strategies can be maximised by livelihood, economic, and household strategies for better resilience resource management.
- Examine the institutional dichotomies inhibiting the implementation of coordinated resilience strategies across WEF domains, territorial jurisdictions, and policy levels, as well as how they can be overcome.
- Research how existing WEF Nexus strategies can inform coordinated resilience strategies, as well as how they can be translated into multi-scale procedural policy guidelines.
- Develop, implement, and test a MFA-based decision support system for Cape Town or other urban spaces in South Africa.

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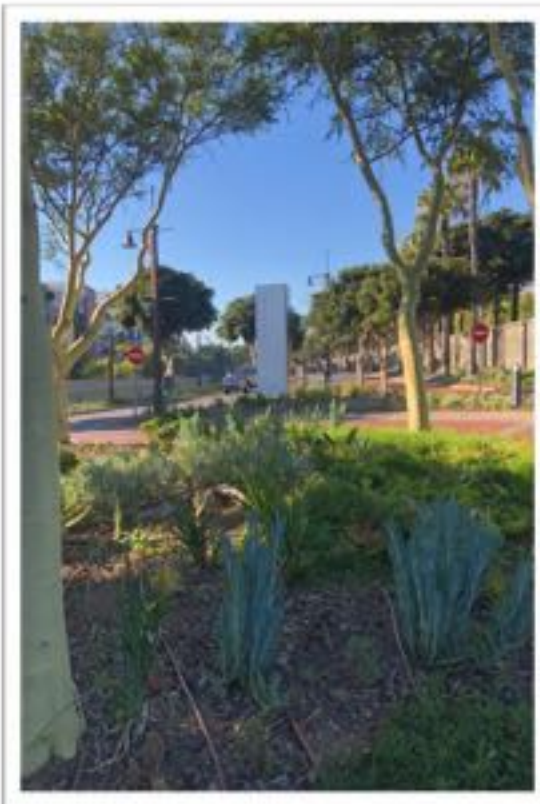
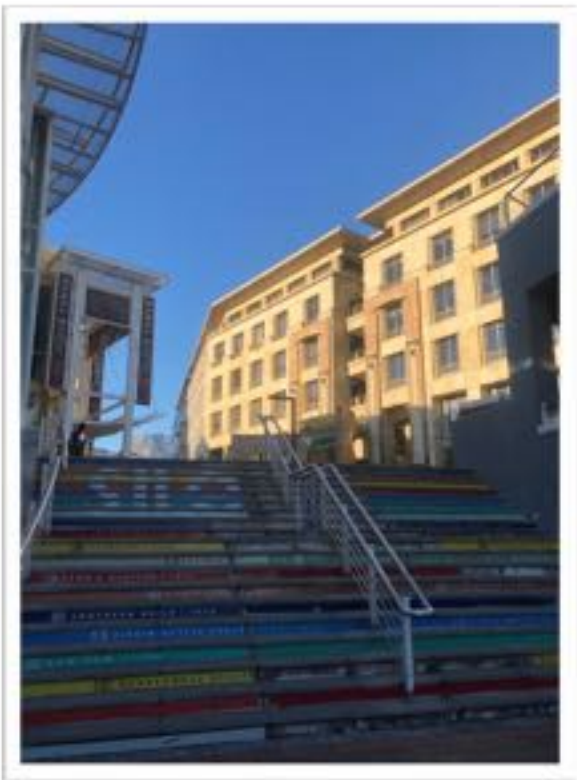
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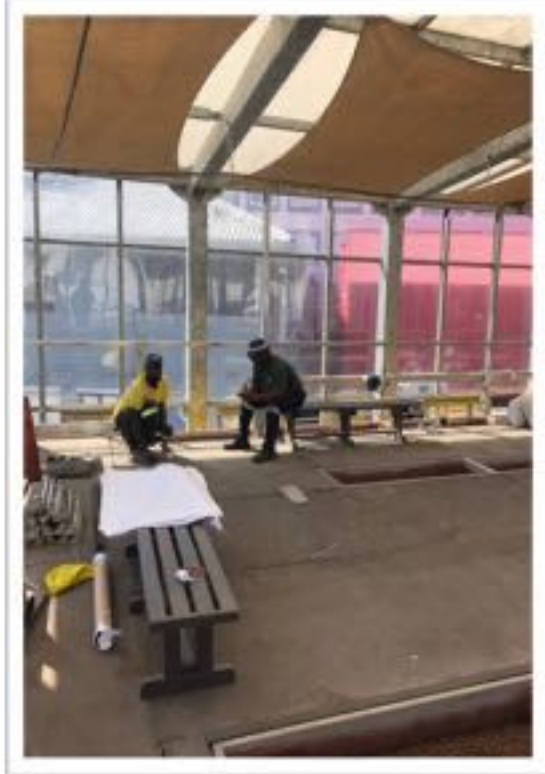
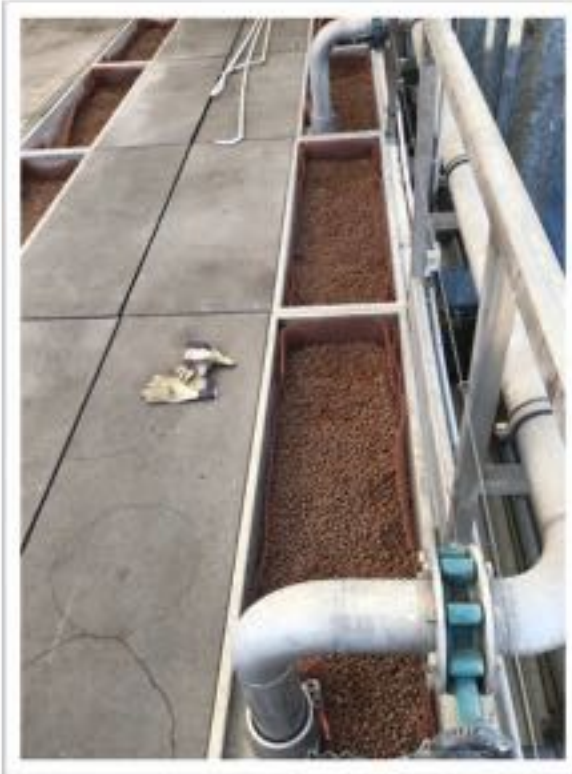
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Appendix A: Pictures of V&A Waterfront site visit







Appendix B: Stakeholder and discipline mapping

Name	Discipline
Maarten Hajer	Interdisciplinary professor of Urban Futures at Utrecht University
Marleen van Rijswijk	Professor of European and Dutch Water Law at Utrecht University Director of Utrecht University Centre for Water, Oceans and Sustainability Law
Shaun Smith	Professor in Human Geography and Spatial Planning at Utrecht University. Coordinator of a Dutch Research Council (NWO)-funded research grant which examines the Water-Energy-Food nexus in Cape Town, South Africa
Nicola Harvey	PhD Researcher of Law at Utrecht University. Legal researcher focused on issues resting at the intersection of law and environmental science with particular specialisation in issues surrounding regulation and governance of water, energy and food systems in developing nation cities.
Johanna Waldenberger	MSc Urban and Economic Geography at Utrecht University. Research Assistant Transforming Cities Community
Nontsikelelo Mngqibisa	PhD Researcher, Sustainable Development at Stellenbosch University. Sustainability Advisor and Engineer, Green Infrastructure
Garth Malan	PhD Researcher, Sustainable Development at Stellenbosch University. Master of Business Administration BSc. Mechanical Engineering
Shadeon Hansen	PhD Developmental studies at University of Western Cape MCom Environmental Economics
Musedzaphanda Khalushi	Honours Developmental Studies at University of Western Cape
Khanyisile Zikhali	Honours Developmental Studies at University of Western Cape
Jessica Wilson	Writer, facilitator, environmental consultant at WCEDP.
Gill Cullinan	Operations Executive at WCEDP. Professional Town and Regional Planner with extensive experience working with local, regional and national government on developmental issues, resilience, human settlements, environmental planning, collaboration and governance matters, and stakeholder engagement processes. Holds a Master's degree in City and Regional Planning from the University of Cape Town, and is an Ecodistricts practitioner.
Andrew Boraine	CEO of the WCEDP.

	Has been involved in South Africa's local government, urban and economic development and transition processes for the past 35 years, as activist, advisor, negotiator, government planner, city manager, chief executive, facilitator, communicator, writer, and photographer.
Daniel Adeoluwa Adeniy	Professional Officer, Urban Systems at ICLEI Africa. PhD degree in Development Studies and was a doctoral scholar of the African Pathways Programme
Paul Currie	Associate Director, Urban Systems ICLEI Africa PhD Sustainability Studies
Ursula Wellman	Practitioner at Atlantis Special Economic Zone
Vuyani Qamata	Project Manager, Gugulethu Urban Farming Initiative
Jo Steenkamp	Head of operations, Lyndoch Eco Village
Bernard Jacobs	Head of Operations, GCX
Kevin James	Chief Executive Officer, GCX
Sherwyn Thompson	Project Manager, Cape Town Fresh Produce Market
Tamsin Farragher	City of Cape Town Resilience Department
Jane Battersby-Lennard	Food Expert, African Centre for Cities: University of Cape Town
Adrian Stone	Energy expert, City of Cape Town Sustainable Energy Markets
Moa Amis	Energy Expert, African Centre for Green Economy: University of Cape Town
Herman Hveke	Water expert, Association of Dutch Water Authorities
Rian Kloosterman	Water expert, Vitens N.S
Julian May	Food expert, University of Western Cape
Scott Drimie	Food expert, Southern Africa Food Lab/Stellenbosch University
Luxon Nhamo	WEF Expert. Water Research Commission
Barry Wood	Water expert, City of Cape Town: Water and Sanitation.
Mike Webster	Executive Director, City of Cape Town: Water & Sanitation
Gareth Morgan	City of Cape Town Resilience Department
Luzuko Mdunyelwa	City of Cape Town, Urban Management Department

Wilna Klopper	Western Cape Government, Department of Environmental Affairs.
Leanne Seeliger	Project Leader, Stellenbosch University Water Institute. Developing a water management plan and set of community-based water monitoring indicators for the Philippi Horticultural Area and its canals.

(source: Author, 2022)

Appendix C: What is Nexus workshop participants list

Organisation & Participants	Reference
Utrecht University	
Jochen Monstadt	Practitioner 1 (2021)
Shaun Smith	Practitioner 2 (2021)
Anoeska Buijze	Practitioner 3 (2021)
Marteen Hajer	Practitioner 4 (2021)
Marleen van Rijswick	Practitioner 5 (2021)
Nicola Harvey	Practitioner 6 (2021)
Johanna Waldenberger	Practitioner 7 (2021)
Stellenbosch University	
Noni Mngqibisa	Practitioner 8 (2021)
Garth Malan	Practitioner 9 (2021)
Mark Swilling	Practitioner 10 (2021)
Lourens Swart	Practitioner 11 (2021)
WCEDP	
Jessica Wilson	Practitioner 12 (2021)
Gill Cullinan	Practitioner 13 (2021)
Andrew Boraine	Practitioner 14 (2021)
ICLEI Africa	
Daniel Adeniyi	Practitioner 15 (2021)
Paul Currie	Practitioner 16 (2021)
University of the Western Cape	
Shadeon Hansen	Practitioner 17 (2021)
Musedzaphanda Kalushi	Practitioner 18 (2021)
Khanyisile Zikhali	Practitioner 19 (2021)

(source: Author, 2022)

Appendix D: Interview Guide

Guiding Questions:

(Remember to record the meeting)

If questions are inapplicable, you can state so, and we can move on. If you don't know the answer to a question, please state so and we can move to the next. There are no right or wrong answers. I want to make it clear that I am holding space for any stakeholder interests or concerns to come forward and progress with the study, if there is anything you would like me to find out please state so at the end and I will make sure to include your concerns/questions in the study.

Questions only to V&A Waterfront:

Please begin by telling me about your department and the role it plays with regards to the V&A Waterfront.

Please elaborate on the role you play in your department and the V&A Waterfront as a whole?

Why has the V&A Waterfront brought on board GCX?

What do their services include?

Eco-Analytics dashboard?

Consultation: Sustainability insights?

GCX Waste systems? (Zero waste technologies)

Do GCX provide the V&A with waste management?

Do they jointly interpret WEW data?

What does it mean for your department to have GCX on board?

What does it mean for the V&A to have GCX on board?

Can you see the consequence of a single system intervention on all systems? (Can their system help make sense of the effects changes in system have on other systems).

Are systems weighted equally?

Have you since appointed a WEW manager, or do departments continue as they existed before?

Please tell me more about the V&A's Net-zero waste to landfill goal. Is there a Roadmap?

What is the role of GCX in enabling/evolving this perspective?

How has the implementation of GCX's approach affected the resource consumption of the V&A?

How has the approach affected tenant resource consumption?

Please tell me more about the dynamic baselines and KPI?

How have the dynamic baseline KPI shaped resource consumption?

Has the system/approach enabled the decoupling of economic development from resource consumption? (As mandated by IRP)

Will you benefit from food flows being incorporated on the dashboard?

Questions

1. How has the implementation of GCX's approach benefitted/disadvantaged your department/V&A from a practical perspective?
 - a. How has it saved you time?
 - b. How has it enabled you to better meet targets?
 - c. How has it Increased confidence?
 - d. How has it effected decision making?
 - e. How has it effected planning?
 - f. How has the system helped to identify unintended consequences (of decisions for example?

2. How has the approach benefitted/disadvantaged your department/V&A form a socio-economic perspective?
 - a. Effects on wasteful expenditure?
 - b. How has it influenced your triple bottom line?
 - c. How has it influenced your operating expenses (Opex)?
 - d. How has it influenced your Capital Expenditure (CapEx)?⁴⁴
 - i. How does this depend on the ESG/data readings provided by GCX?
 - ii. Does the system help to find outliers (problems) that then direct/drive Capex?
 - iii. Has it directed your Capex to specific SMMEs?
 - iv. Has helped to identify capable SMMEs?

⁴⁴ A capital expense is the cost of an asset that has usefulness, helping create profits for a period longer than the current tax year. This distinguishes them from operational expenditures, which are expenses for assets that are purchased and consumed within the same tax year.

For example, printer paper is an operational expense, while the printer itself is a capital expense.

- e. Has it shaped the V&A's shared value strategy?
 - i. How is this strategy shaped/influenced by data provided by GCX?
 - ii. Has the V&A waterfront evolved to a shared value ecosystem?
 - iii. Please tell me more about your shared value ecosystem perspective
 - iv. What is the role of GCX in enabling/evolving this perspective?
 - v. Would you say GCX's system has allowed the V&A waterfront to evolve a shared value ecosystem?
 - vi. Please tell me more about project Soul.
- f. What value chain implications has this approach had?
 - i. Job creation
 - ii. Supply chain partnerships
 - iii. Small, Medium and Micro Enterprises (SMMEs)
- g. Do you believe such a tool can assist in enhancing social cohesion, equity, and justice?
- h. Has economic development been associated with social development?
 - i.
- 3. How has the approach benefitted/disadvantaged your department/V&A from a governance perspective?
 - a. How has it affected the tenant-landlord management relations?
 - i. Have tenants/landlords embraced it?
 - ii. How has it allowed for collaborative management between T-L?
(Participation, P6)
 - iii. How has the system increased participation between T-L? Especially how has it made tenants more participatory?
 - iv. Tell me more about green leases?
 - 1. Have they helped T-L to share benefits and expenses in driving efficiencies?
 - 2. How?
 - b. How has it allowed for collaborative management within your department?
 - c. How has it allowed for collaborative management in the V&A as a whole?

- i. Has it allowed you to collaborate more while remaining autonomous? (How has it allowed for more collaborative autonomy⁴⁵?)
 - ii. Are collaborations synergistic or hierarchical?
 - iii. How do you deal with conflict resolution in the department/V&A? (Communication, transparency, accountability, connectivity)?
 - iv. Has the system/approach helped with this at all?
 - v. How?
- d. How has it impacted the behaviour of management?
- e. How has it impacted the behaviour of tenants?
- f. How have the dynamic baselines KPI shaped behaviour? (*Learning P5*)
- g. How has the system allowed for adaptive management? (*Complex systems thinking, P4*)
- h. How has the system enabled learning (*P5*)?
 - i. How have these learning curbs manifested?
 - ii. How do your learning curbs and technology adjustments work? (*P5 learning*)
- i. How does learning influence your department/business's adaptive management capabilities?
- j. Has it allowed for better adaptive co-management?
- k. How has the system allowed for experimentation? (*P5*)
- l. How has the system increased participation in the department/V&A?
- m. How has the system impacted your company's environmental, social, and corporate governance (ESG)?

Feeds Research Question 3:

- 4. What is the role of GCX (analytical tools and monitorisation) in enabling the various management units at the V&A to work collaboratively and adaptively? (*Polycentricity, P7*)
 - a. Has the system allowed for more connectivity via shared information between management units within the department/business (*P2*)

⁴⁵ A form of governance where a multitude of governance units autonomously coexist in a larger collaborative system

5. Would you say GCX (as a centralised governance structure) with their overarching monitorisation system/dashboard acted as a catalyst for increased connectivity (P2), participation (P6), collaboration (P7), learning and experimentation (P5) via shared information
6. Why?
7. Has GCX as an added governance unit allowed for increased connectivity (P2), participation (P6), collaboration(P7), learning and experimentation (P5) via shared information?
8. Do you think the system has and will allow the management team/ your department/ the V&A to better manage for resilience? Especially when faced with stresses and shocks.
9. How?
10. How has the system allowed you to better deal with the stresses and shocks induced by the covid-19 pandemic?

Questions to GCX:

Do the V&A waterfront make use of your waste systems and expertise?

Do you jointly interpret WEW data?

Can you see the consequence of a single system intervention on all system? (Can their system help make sense of the effects changes in system have on other systems).

Are systems weighted equally?

How do your learning curbs and technology adjustments work? (*P5 learning*)

Does the system include environmental and ESG data?

Do you make use of financial and non-financial data as reactants? (Bringing disparate data together).

Does the system automate reporting to different standards?

What are these standards? (TCFD, CDP, BESB)

What targets are integrated into the system? (Science based, net zero, carbon tax obligations, ESG)

Does GCX collect some data from RMS (Remote monitoring systems/remote metering solutions)? How does this relation work?

Did it take a while to build confidence in GCX data? How was this achieved?

Do you use info reported inside the baseline deviation together with financial data to pick up the materiality⁴⁶? (Small building, 20% increase, but only worth R200).

Elaborate more on how this works (baseline, deviation, financial data and materiality)

Do you monitor tenants across buildings, or just the buildings themselves?

Can you do KPI benchmarking in a portfolio?

Elaborate

Did GCX publish an industry wide realistic benchmark — a KPI that goes down to the tenant level- for real-estate sector?

How does this differ from traditional benchmarks/performance indicators? (Used to be annual benchmarks, now dynamic benchmarks)

How has the system helped to identify unintended consequences?

What is the cognitive, political and value stance of GCX?

Can this system help assist with social cohesion, equity and justice?

It is important to note that the interview process is essentially exploratory and that the questions are mere guidelines for discussion. If through the process insights emerge which I want to explore further, new questions will be posed in order to direct the discussion to that which is most fruitful for the sake of the research. As the process of interviewing evolves, new questions may emerge, or specific question may be constructed for specific interviewees based on prior information gather.

Appendix E: Interview mapping

Date	Interviewee Codename & Occupation
10 September 2021	EDP1: CEO WCEDP
01 October 2021	GCX 1: CEO GCX
04 October 2021	GCX 2: Head of Operations GCX
10 November 2021	V&A 1: Executive Manager: Operations, V&A Waterfront
23 February 2022	V&A 2: Senior Operations Manager for Custodial Services, V&A Waterfront
12 April 2022	V&A 3: Utilities Analyst at V&A Waterfront
12 April 2022	V&A 4: Utilities Analyst at V&A Waterfront
14 April 2022	V&A 5: Senior Manager of Electrical Infrastructure at V&A Waterfront
02 May 2022	V&A 6: Senior Manager: SHE - Sustainability & Utilities V&A Waterfront

⁴⁶ Is the amount big enough to make a difference?

Appendix F: Eco-Analytics Group Report January 2022



Consolidated Group Report

ECO-ANALYTICS REPORT

Waterfront

as at Jan 2022



Details in this report include the following boundaries:
16 Sectors, 20 Regions, 111 Properties, 510 Tenants :
covering 440,502m²

**These boundaries represent 100.00 % of the
Group's reported Data**

5 Milton's Way, 11 Bell Crescent, Westlake Business Park, Westlake, 7945, Cape Town

+27 (0)21 702 4058 | info@gcxafrica.co.za | www.gcx.co.za

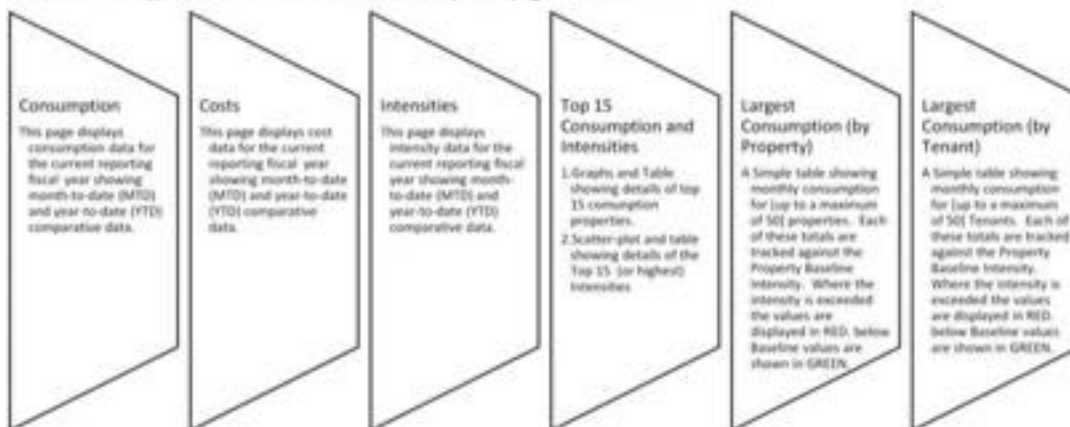


Types of reports and filters

Multiple reports are produced for different stakeholders. (e.g. Group Report, Sector Report, Manager report, etc). Each stakeholder report will only provide the data that for the selected criteria. The reporting criteria will be displayed on the report cover page as well as at the top of each page under the "Reporting Boundary" heading. The boundary will show a summary description of any filters that have been applied in the report. It will also the % of groups consumption that the current report is showing.

Detail in Report

This report is prefaced with an Emissions page followed by detailed sections for each of the major activities reported on (e.g. Water, Electricity). Within each of these sections, separate pages are shown for:



Glossary

Reporting Boundary	<ul style="list-style-type: none"> The reporting boundary is displayed on each page. The boundary describes any filters that are applied to the current report. The % of group's consumption shows the current reports consumption as a percentage (%) of the total group's consumption.
Baseline Intensity	<ul style="list-style-type: none"> The Baseline Intensity is calculated on the average usage (or consumption) over a period. This Baseline Intensity is used in this report (and displayed on the dashboard) to compare and rank current usage and assist in performance management of the properties and tenants. Wherever Intensities are exceeded baseline, the values (or indicators) are highlighted in RED. Wherever intensities are below the baseline, the values (or indicators) are highlighted in GREEN. For Properties, the baseline is set to the FY19 and FY20 period. For Tenants, the baseline intensity is average usage of all consumption for the full duration of the tenant.
Intensity	<ul style="list-style-type: none"> The Intensity is calculated dividing the consumption by the required metric. The metric being used in the report will be displayed in all relevant places in the report.
MTD	<ul style="list-style-type: none"> Month to date
YTD	<ul style="list-style-type: none"> Year to date
SPLY	<ul style="list-style-type: none"> Same period last year
SMLY	<ul style="list-style-type: none"> Same month last year
LM	<ul style="list-style-type: none"> Last Month



Electricity Consumption

From Apr 2021 to Jan 2022 (10 months)

31 February 2022
Final Data



Consumption

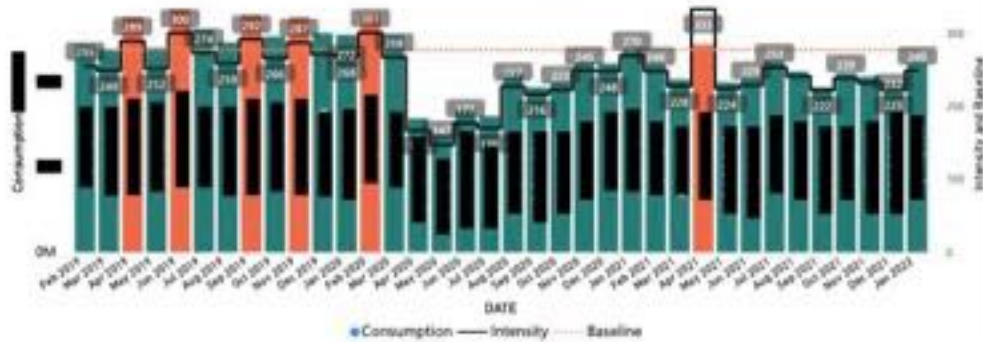
- Within the reporting boundary, Waterfront reported _____ kWh Electricity for Jan 2022. This shows a month-on-month increase/decrease of _____% compared to _____ kWh reported in the previous month.
- Electricity year to date is _____ kWh and is tracking _____% above/below the _____ kWh reported for the same period last year (FY19).
- The VICTORIA WHARF reported consumption of _____ kWh (year to date), which represents _____% of the _____ kWh reported for the group.
- Within the VICTORIA WHARF, the RETAIL reported the highest consumption of _____ kWh. This represents _____% of the Group's consumption.
- The property that had the highest consumption is Victoria Wharf Shopping Centre consuming _____ kWh year to date. This represents _____% of the group's consumption.

Consumption Recovery

- For the 10 months from Apr 2021 to Jan 2022, Waterfront consumed _____ kWh for Electricity. The amount billed to clients was _____ kWh showing a year-to-date consumption recovery of _____%.
- For the current month, Jan 2022, Waterfront consumed _____ kWh for Electricity. The amount billed to clients was _____ kWh showing a consumption recovery of _____% for the current month.

Electricity (kWh) Consumption Histogram

- Columns show consumption for Electricity (kWh).
- Intensity and Baseline values are shown as kWh per m².
- Columns in RED indicate that the property has exceeded the baseline intensity. Columns in GREEN indicate that the property is below the baseline intensity.



Report Boundaries

VICTORIA WHARF

Property Count
14
Tenant Count
281
GLA (m²)
70,231
% of Sector
34.34%
% of Group
34.34%

CLOCK TOWER

Property Count
9
Tenant Count
35
GLA (m²)
50,841
% of Sector
18.04%
% of Group
18.04%

PORTSWOOD

Property Count
14
Tenant Count
20
GLA (m²)
41,279
% of Sector
6.55%
% of Group
6.55%

Electricity (kWh) consumption from Apr 2021 to Jan 2022 (10 months)

Sector	Year-to-date	Same Period Last Year	YoY % Change	Mom % Change	YTD Consumption	MTD Consumption	Property Count	Tenant Count
RETAIL							25	345
OFFICE							20	581
_Parking							1	
HOTELS							4	4
FOOD							2	2
INDUSTRY								
_Air Conditioning							3	
_Solar PV							14	
_Common Area							5	
MARINE MOORINGS							5	7
_Guery							1	
_Vacant							4	
LEISURE							2	2
COMMERCIAL							10	20
_Meerings							3	
_Irrigation							3	
_Unallocated Waste							1	
Total								



Electricity Costs from Apr 2021 to Jan 2022 (10 months)

21 February 2022
Final Data



Costs

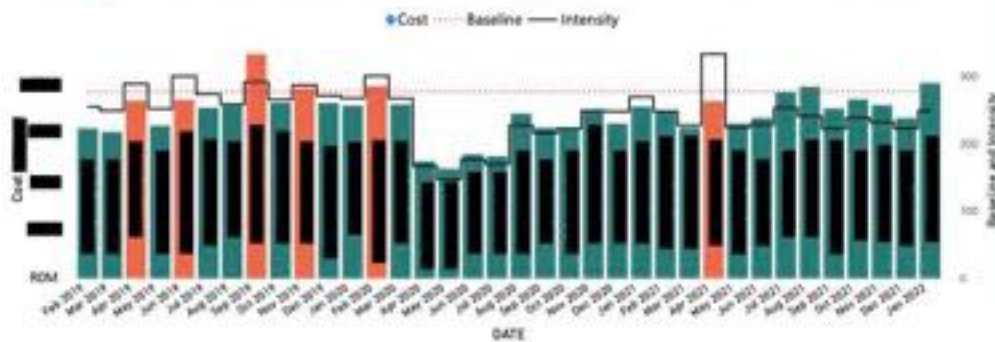
- Within the reporting boundary, Jan 2022 reported clients billed costs at _____. This shows a **month-on-month cost increase/decrease of _____ %** compared to the _____ billed in the previous month.
- Total Waterfront Electricity costs for the 10 months to Jan 2022 is _____. This is _____ % below/above the _____ for the **same period last year**.
- The **VICTORIA WHARF** reported Electricity cost of _____ (year-to-date). This represents _____ % of the _____ reported for the group.
- **Within the VICTORIA WHARF**, the **RETAIL** reported the highest cost of _____. This represents _____ % of the group **total cost**.
- The property that accounted for the highest cost is **Victoria Wharf Shopping Centre** accounting for _____. This is _____ % of the group's **total cost**.

Cost Recoveries

- For the 10 months from Apr 2021 to Jan 2022, Waterfront Electricity cost was _____. Compared to the recovered amount of _____. This shows a **year-to-date cost recovery of _____ %**.
- For the current month (Jan 2022), Waterfront's Electricity cost was _____. Compared to the recovered amount of _____, this shows a **cost recovery of _____ %**.

Electricity (kWh) Cost Histogram

- Columns show costs for Electricity (kWh)
- Intensity is shown as kWh per m²
- Columns in **RED** indicate that the property has exceeded the baseline intensity. Columns in **GREEN** indicate that the property is below the baseline intensity.



Report Boundaries

VICTORIA WH...

Property Count
14
Tenant Count
281
GLA (m²)
70,231
% of Sector
34.34%
% of Group
34.34%

CLOCK TOWER

Property Count
8
Tenant Count
35
GLA (m²)
50,841
% of Sector
18.04%
% of Group
18.04%

FORTSWOOD ...

Property Count
14
Tenant Count
20
GLA (m²)
41,279
% of Sector
6.55%
% of Group
6.55%

Electricity (kWh) costs from Apr 2021 to Jan 2022 (10 months)

Sector	Year-to-date	Same Period Last Year	YoY Change	MoM % Change	YTD Cost Recovery %	MTD Cost Recovery %	Property Count	Tenant Count
RETAIL							25	343
OFFICE							20	101
... Parking							1	
... Air Conditioning							3	
... Vacant							6	
... Common Area							5	
HOTELS							4	4
FISHING INDUSTRY							2	2
MARINE MOORINGS							5	2
... Quays							1	
COMMERCIAL							13	20
LEISURE							2	2
... Meetings							2	
... Irrigation							3	
... Unallocated Waste							1	
Solar PV							14	
Total								



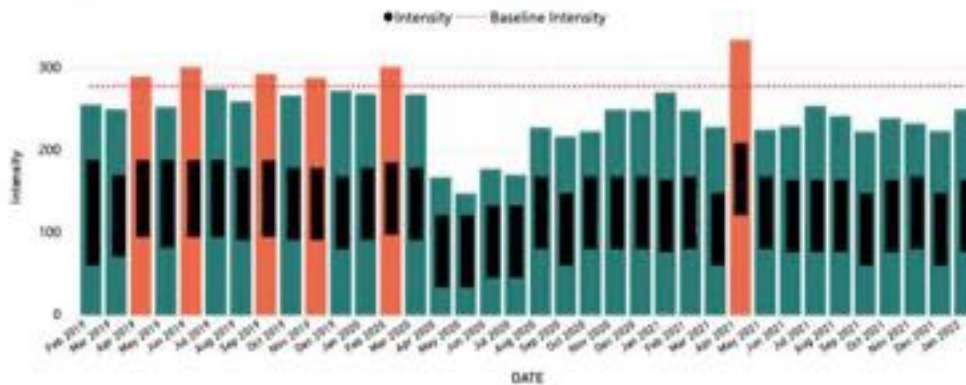
INTENSITY KEY FINDINGS

Reported Intensity: kWh per m²

- Within the reporting boundary Waterfront reports a Electricity Intensity of _____ kWh per m² for the group which is tracking _____% below/above the intensity of _____ kWh per m² for the same period last year.
- Month-to-date (MTD) Jan 2022 reports an intensity _____ kWh per m², showing a decrease/increase of _____% when compared to the previous month's intensity of _____ kWh per m².
- The UNRESOLVED is reporting the the highest intensity of _____ kWh per m²
- Within the UNRESOLVED, the _____Parking reported the highest intensity of _____ kWh per m²
- The property with the highest intensity is Unresolved reporting _____ kWh per m².
- The FY22 year-to-date intensity of _____ kWh per m² is showing a decrease of _____% compared to the baseline intensity of _____ kWh per m².

Electricity (kWh) Intensity Histogram

- Columns show intensity in kWh per m².
- Baseline is shown as a dotted line.
- Columns in RED indicate that the property has exceeded the baseline intensity. Columns in GREEN indicate that the property is below the baseline intensity.



Electricity (kWh) Intensities from Apr 2021 to Jan 2022 (10 months)

Sector	Intensity YTD	Baseline Intensity	Baseline Deviation %	BL Deviation Value	Intensity MTD	Intensity LM	Property Count	Tenant Count
__Parking							1	
__Air Conditioning							3	
__Query							1	
__Common Area							5	
Solar PV							14	
__Vacant							4	
__Irrigation							3	
__Unallocated Waste							1	
MAKING MEETINGS							5	3
__Meetings							3	
RETAIL							25	345
FISHING INDUSTRY							2	2
OFFICE							20	101
HOTELS							4	4
LEISURE							2	2
COMMERCIAL							13	20
Total								

Report Boundaries

VICTORIA WHL...

Property Count
14
Tenant Count
281
GLA (m²)
70,231
% of Sector
34.34%
% of Group
34.34%

CLOCK TOWER

Property Count
8
Tenant Count
35
GLA (m²)
50,841
% of Sector
18.04%
% of Group
18.04%

FORTSWOOD ...

Property Count
14
Tenant Count
20
GLA (m²)
41,279
% of Sector
6.55%
% of Group
6.55%



Report Boundaries

VICTORIA WHARF	CLOCK TOWER	UNRESOLVED	UNDEFINED	PORTSWOOD RIDGE
Property Count 14	Property Count 9	Property Count 1	Property Count 45	Property Count 14
GLA (m ²) 70,231	GLA (m ²) 50,841	GLA (m ²) 6	GLA (m ²) 35,692	GLA (m ²) 41,279
% Sector 34.34%	% Sector 18.04%	% Sector 14.06%	% Sector 10.79%	% Sector 6.55%
% Group 34.34%	% Group 18.04%	% Group 14.06%	% Group 10.79%	% Group 6.55%

Top Properties by Consumption of Electricity (kWh)

The graph and table (below) is showing consumption the top properties based on kWh of Electricity reported for the 10 months ended Jan 2022.

In the graph, the x-axis is showing properties that report the largest consumption of Electricity (kWh). The y-axis is showing the consumption in kWh. The grey shaded area is showing the consumption for the same period last year.

Items that are shown in RED (in both the graph and table) indicate that the property has exceeded the baseline intensity. Items that are shown in GREEN indicate that the property is below the baseline intensity.



Top Properties for Intensities of Electricity (kWh) shown as kWh per m²

The scatter plot and table below is showing the highest intensities for properties based on kWh of Electricity reported for the 10 months ended Jan 2022.

In the scatter-plot the x-axis is showing the current years intensity in kWh per m². The y-axis shows the baseline intensity in kWh per m².

Items that are shown in RED (in both the scatter-plot and table) indicate that the property has exceeded the baseline intensity. Items that are shown in GREEN indicate that the property is below the baseline intensity.



Report Boundaries

Property Name	Property Count	GLA (m ²)	% Sector	% Group
VICTORIA WHARF	2	48,553	27.17%	27.17%
CLOCK TOWER	2	25,573	14.38%	14.38%
UNRESOLVED	1	6	14.06%	14.06%
WEST QUAY	1	131	0.06%	0.06%
UNDEFINED	1	123	0.01%	0.01%

Electricity (kWh)



Appendix G: Annual Emissions Data FY18 to FY22

Scope	Emissions Category	Activity Type	Grouping	Sector	Fiscal Year	EMISSIONS tCO ₂ e
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	HOTELS	FY19	1.712
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	HOTELS	FY20	1.304
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	HOTELS	FY21	0.789
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	HOTELS	FY22	0.792
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	OFFICE	FY19	2.026
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	OFFICE	FY20	1.738
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	OFFICE	FY21	1.221
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	OFFICE	FY22	1.243
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	RETAIL	FY19	12.014
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	RETAIL	FY20	12.065
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	RETAIL	FY21	9.645
Scope 3	Waste Generated in Operations	Dry Mixed Recycling - (kg)	Tenants	RETAIL	FY22	9.376
Scope 3	Waste Generated in Operations	General Landfill SA - (kg)	Tenants	FISHING INDUSTRY	FY19	43.779
Scope 3	Waste Generated in Operations	General Landfill SA - (kg)	Tenants	FISHING INDUSTRY	FY20	35.857

Scope 3	Waste Generated in Operations	General Landfill SA - (kg)	Tenants	FISHING INDUSTRY	FY21	26.962
Scope 3	Waste Generated in Operations	General Landfill SA - (kg)	Tenants	FISHING INDUSTRY	FY22	5.469
Scope 3	Waste Generated in Operations	General Landfill SA - (kg)	Tenants	HOTELS	FY19	472.754
Scope 3	Waste Generated in Operations	General Landfill SA - (kg)	Tenants	HOTELS	FY20	421.368
Scope 3	Waste Generated in Operations	General Landfill SA - (kg)	Tenants	HOTELS	FY21	158.778
Scope 3	Waste Generated in Operations	General Landfill SA - (kg)	Tenants	HOTELS	FY22	271.156
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY18	3021.715
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY19	2456.425
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY20	2115.179
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY21	1627.315
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY22	1553.665
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY19	619.304
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY20	598.688
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY21	470.759
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY22	423.004
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	MARINE (MOORINGS)	FY18	2223.407
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	MARINE (MOORINGS)	FY19	1803.744
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	MARINE (MOORINGS)	FY20	2003.919
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	MARINE (MOORINGS)	FY21	1942.63
Scope 2	Purchased Electricity	Grid Electricity - (kWh)	Tenants	MARINE (MOORINGS)	FY22	1477.093
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Common Area	FY18	20.254
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Common Area	FY19	9.063
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Common Area	FY20	8.237
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Common Area	FY21	6.413
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Common Area	FY22	9.813

Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Irrigation	FY18	18.356
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Irrigation	FY19	1.398
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Irrigation	FY20	6.618
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Irrigation	FY21	6.148
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Common Areas	__Irrigation	FY22	9.265
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY18	143.544
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY19	90.511
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY20	121.859
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY21	111.17
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY22	104.79
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	OFFICE	FY18	23.57
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	OFFICE	FY19	15.554
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	OFFICE	FY20	14.709
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	OFFICE	FY21	8.395
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	OFFICE	FY22	11.953
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	RETAIL	FY18	115.385
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	RETAIL	FY19	99.083
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	RETAIL	FY20	110.094
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	RETAIL	FY21	45.676
Scope 3	Purchased Goods & Services: Water	Water supply - (KL)	Tenants	RETAIL	FY22	64.553

Appendix H: Annual Consumption Data FY18 to FY22

Class	Activity Type	Grouping	Sector	Fiscal Year	Quantity
Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY18	3083383
Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY19	2585710
Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY20	2033826
Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY21	1595407
Electricity	Grid Electricity - (kWh)	Common Areas	__Common Area	FY22	1523201
Electricity	Grid Electricity - (kWh)	Tenants	HOTELS	FY18	4560461
Electricity	Grid Electricity - (kWh)	Tenants	HOTELS	FY19	5480080
Electricity	Grid Electricity - (kWh)	Tenants	HOTELS	FY20	6394739
Electricity	Grid Electricity - (kWh)	Tenants	HOTELS	FY21	2855466
Electricity	Grid Electricity - (kWh)	Tenants	HOTELS	FY22	3124683
Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY18	666332
Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY19	651899
Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY20	575662
Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY21	461528
Electricity	Grid Electricity - (kWh)	Tenants	LEISURE	FY22	414710
Electricity	Renewable Electricity - (kWh)	Solar PV	Solar PV	FY18	2024452
Electricity	Renewable Electricity - (kWh)	Solar PV	Solar PV	FY19	2167797
Electricity	Renewable Electricity - (kWh)	Solar PV	Solar PV	FY20	2002648
Electricity	Renewable Electricity - (kWh)	Solar PV	Solar PV	FY21	2363332
Electricity	Renewable Electricity - (kWh)	Solar PV	Solar PV	FY22	2451565
Waste	General Landfill SA - (kg)	Tenants	FISHING INDUSTRY	FY19	33764
Waste	General Landfill SA - (kg)	Tenants	FISHING INDUSTRY	FY20	27654
Waste	General Landfill SA - (kg)	Tenants	FISHING INDUSTRY	FY21	20794
Waste	General Landfill SA - (kg)	Tenants	FISHING INDUSTRY	FY22	4218
Waste	General Landfill SA - (kg)	Tenants	HOTELS	FY19	364602
Waste	General Landfill SA - (kg)	Tenants	HOTELS	FY20	324972

Waste	General Landfill SA - (kg)	Tenants	HOTELS	FY21	122454
Waste	General Landfill SA - (kg)	Tenants	HOTELS	FY22	209124
Waste	Organic: food and drink waste - Landfill - (kg)	Common Areas	__Waste - FY18	FY18	5580
Waste	Organic: garden waste - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	2180
Waste	Organic: mixed food and garden waste - Composting - (kg)	Common Areas	__Waste - FY18	FY18	69025
Waste	Paper and board: board - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	520690
Waste	Paper and board: paper - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	406881
Waste	Plastics: average plastic film - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	269
Waste	Plastics: average plastics - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	1041
Waste	Plastics: HDPE (incl. forming) - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	54918
Waste	Plastics: LDPE and LLDPE (incl. forming) - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	60334
Waste	Plastics: PET (incl. forming) - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	85365
Waste	Plastics: PP (incl. forming) - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	17899
Waste	Plastics: PS (incl. forming) - Open loop - (kg)	Common Areas	__Waste - FY18	FY18	6523
Water	Water supply - (KL)	Tenants	COMMERCIAL	FY18	26638
Water	Water supply - (KL)	Tenants	COMMERCIAL	FY19	21727
Water	Water supply - (KL)	Tenants	COMMERCIAL	FY20	24204
Water	Water supply - (KL)	Tenants	COMMERCIAL	FY21	3350
Water	Water supply - (KL)	Tenants	COMMERCIAL	FY22	10586
Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY18	155182
Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY19	97850
Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY20	131739
Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY21	120184
Water	Water supply - (KL)	Tenants	FISHING INDUSTRY	FY22	113287
Water	Water supply - (KL)	Tenants	HOTELS	FY18	172549

Water	Water supply - (KL)	Tenants	HOTELS	FY19	140479
Water	Water supply - (KL)	Tenants	HOTELS	FY20	177704
Water	Water supply - (KL)	Tenants	HOTELS	FY21	71725
Water	Water supply - (KL)	Tenants	HOTELS	FY22	101662
Water	Water supply - (KL)	Tenants	OFFICE	FY18	25481
Water	Water supply - (KL)	Tenants	OFFICE	FY19	16815
Water	Water supply - (KL)	Tenants	OFFICE	FY20	15902
Water	Water supply - (KL)	Tenants	OFFICE	FY21	9076
Water	Water supply - (KL)	Tenants	OFFICE	FY22	12922
Water	Water supply - (KL)	Tenants	RETAIL	FY18	124741
Water	Water supply - (KL)	Tenants	RETAIL	FY19	107117
Water	Water supply - (KL)	Tenants	RETAIL	FY20	119020
Water	Water supply - (KL)	Tenants	RETAIL	FY21	49379
Water	Water supply - (KL)	Tenants	RETAIL	FY22	69787